वार्षिक प्रतिवदेन
ANNUAL REPORT
2021

भाकृअनुप- खरपतवार अनुसंधान निदेशालय, जबलपुर (म.प्र.)

ICAR - Directorate of Weed Research, Jabalpur (M.P.)

ISO 9001 : 2015 Certified

Biological control of *Salvinia molesta*

GLOBAL CERTIFICATION SERVICES

Registration Certificate

This is to Certify that

ICAR-DIRECTORATE OF WEED RESEARCH

MAHARAJPUR, ADHARTAL,

JABALPUR-482004, (M.P.), INDIA.

has been assessed by Global Certification services and found to comply the requirements of

ISO 9001 : 2015

Quality Management System

For the following activities :

RESEARCH & TRAINING IN WEED MANAGEMENT

The Validity of Certificate is subject to regular surveillance audit on or before below mentioned dates and it's only valid after successfull surveillance with continuation letter issued by GCS

Initial Date of Certification - 21th December 2016 *Current Date of Certification 21th December 2016*

Date of Expiry : **20 December 2019**

1st Surveillance Audit **November 2017**

2nd Surveillance Audit **November 2018**

Certification Number : **GCS/QMS/0351**

Director

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Limca

Book of Records

World Record

Directorate of Weed Science Research (DWSR), Jabalpur, Madhya Pradesh, established as National Research Centre for Weed Science on April 22, 1989 and upgraded as DWSR on Jan 23, 2009, is the only institute of its kind in the world in field of weed management research.

Vijaya Ghose

Editor, Limca Book of Records

वार्षिक प्रतिवेदन

Annual Report

2021

भाकृअनुप - खरपतवार अनुसंधान निदेशालय

ICAR - Directorate of Weed Research

जबलपुर (मध्य प्रदेश)

Jabalpur (Madhya Pradesh)

ISO 9001 : 2015 Certified

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Dr. Sushil Kumar

Cover theme

Severe infestation of an alien invasive weed *Salvinia molesta* in a water body at Hatti village, Gadchiroli, Maharashtra.

Contents

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Preface

The threat of alien invasive weeds is increasing in India. In addition to the terrestrial weeds like *Parthenium, Chromolaena, Lantana, Mikenia, etc.*, problem of aquatic weeds namely water hyacinth, alligator weed and *Salvinia etc.* is alarming in water bodies. Because of multiple use of water, the chemical control methods, which are otherwise very effective, are not permitted in water bodies. Therefore, biological control offers a long-term sustainable strategy to manage these aquatic weeds. The ICAR-DWR, Jabalpur has done a commendable work on biocontrol of weeds using *Zygogramma bicolorata* against *Parthenium* and *Nochetina* spp. against water hyacinth. Recently, severe infestation of a floating aquatic weed *Salvinia molesta* has been noticed in Madhya Pradesh, Chhattisgarh and Maharashtra in different reservoirs. The weed has been contained successfully within 18 months using an insect bioagent *Cyrtobagous saliviniae* in a 20 ha pond in Katni district of M.P. Encouraged with the success, the Directorate has extended this work in severely infested water bodies of about 500 hectare in Central India. The State Governments have been sensitized with this success, and requested to use this technology under the technical guidance of the ICAR-DWR.

The ICAR-Directorate of Weed Research undertakes strategic and adaptive research on various aspects of weed management in a multi-disciplinary mode, and disseminates the developed technologies in diverse agro-ecological regions of the country benefitting the end users. I am happy to present its 33rd Annual Report for the year 2021, underlining the important research achievements and activities.

In spite of the restrictions posed by the COVID-19 pandemic during 2021, the research and extension activities continued to gain momentum. Emphasis has been given on development of sustainable weed management practices in conservation agriculture-based cropping systems, effect of climate change on crop-weed interactions and efficacy of herbicides, biocontrol of *Parthenium*, water hyacinth and *Salvinia*, evaluation of herbicide-tolerance in rice, maize and soybean, herbicide residue estimation, utilization of weeds, design and development of low-cost weeding tools and

sprayers, on-farm research and demonstration of improved weed management technologies and their impact assessment, *etc.*

To widen the scope of weed research, the Directorate has signed MoUs with 6 national and 01 international organizations. During the period under report, the Directorate has published 40 nos. of research papers in the journals of national and international repute, 10 book chapters, 12 extension folders and 40 popular/technical articles, organized 26 nos. of webinars and brainstorming sessions. For the benefit of farmers and other stakeholders, a total of 17 trainings and 60 Front Line Demonstrations & On-Farm Trials have been conducted. A total of 773 nos. of farmers were benefitted under different programmes such as Farmers FIRST, Biotech KISAN Hub, *Mera Gaon Mera Gaurav* and SCSP.

I profusely thank Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his constant guidance and support in executing the mandate of the Institute. The encouragement, guidance and support provided by Dr. S.K. Chaudhari, DDG (NRM) and Dr. S. Bhaskar (ADG, AAF&CC) are duly acknowledged. All the scientists and officials deserve appreciation for providing their invaluable inputs. I express my appreciation to the editorial team and other staff members for synthesizing this report in time. I hope, this report will provide useful information to the diverse stakeholders and prove to be a helpful compilation for planning future programmes for weed management research in India.

Place : Jabalpur
Date : 7/03/2022

(J.S. Mishra)
Director, ICAR-DWR

Executive Summary

The salient achievements of the Directorate during 2021 are summarized below:

- For weed management in seed spices, application of pendimethalin 675 g/ha, metribuzin 150 g/ha, fenoxaprop 100g/ha and oxadiargyl 100 g/ha were found effective in fennel, and oxadiargyl 100 g/ha, metribuzin 150 g/ha and oxyfluorfen 100 g/ha in *ajwain*.
- In millets, application of pyrazosulfuron 20 g/ha *fb* 1 manual weeding (MW) at 40 days after planting (DAP) in *ragi* and *sawan*, and pendimethalin 675 g/ha fb 1 MW at 40 DAP, or atrazine 750 g/ha fb 1 HW at 40 DAP in *kodo* millet were found safe and effective.
- In minor oilseed crops, oxadiargyl 100 g/ha, metribuzin 200 g/ha, quizalofop 75 g/ha, propaquizafop + imazethapyr 100 g/ha, and atrazine 750 g/ha effectively controlled weeds in safflower. Oxyfluorfen 100 g/ha fb propaquizafop 100 g/ha, or oxyfluorfen 100 g/ha fb 1 MW at 40 DAS were effective in sesamum and niger.
- Because of faster growth and large biomass accumulation capacity, *Alternanthera paronychioides* suppressed the growth of other weeds and emerged as a dominant weed in direct-seeded rice (DSR). Sequential application of pretilachlor + pyrazosulfuron *fb* cyhalofop + penoxsulam was found as effective as twice hand weeding in dry-DSR.
- A seed rate of 40 kg/ha along with the application of pretilachlor + pyrazosulfuron 615 g/ha (pre-em.) fb cyhalofop + penoxsulam 135 g/ha (post-em.), or pretilachlor + pyrazosulfuron 615 g/ha (pre-em.) fb 1 MW at 30 DAS were effective for managing weed and obtaining optimum grain yield of DSR.
- In transplanted rice, post-emergence application of cyhalofop + penoxsulam 135 g/ha was effective in terms of weed control efficiency, grain yield and water productivity.
- In wheat, post-emergence application of clodinafop + metsulfuron recorded the higher grain and straw yields (4.43 and 5.77 t/ha, respectively) and water productivity (19.9 kg/ha/mm) than pendimethalin 678 g/ha (pre-em.) *fb* metsulfuron 4 g/ha (post-em.) and mesosulfuron + iodosulfuron 14.4 g/ha (post).
- In chickpea, drip irrigation provided lower weed parameters, higher seed and haulm yields (1976 and 2258 kg/ha, respectively) and greater water productivity (17.6 kg/ha/mm) as compared to flood irrigation at 80%. Post-emergence application of topramezone at 20.16 g/ha at 20 DAS was better than its application at 30 DAS. Chickpea varieties namely; 'JG 315', 'JG 322', 'JG 63' and 'JG 14' showed phytotoxic symptoms to topramezone initially, but recovered after 14 days of application.
- Weeding tools viz. cycle wheel hoe, hand grubber, nail weeder, twin wheel hoe, evaluated in chickpea and wheat, did not differ significantly in terms of seed yield, but twin wheel hoe recorded the highest field capacity (0.02 ha/h) followed by nail weeder, hand grubber and cycle hoe.
- A magnetic Hall sensor based pre-emergence herbicide application system costing ₹ 3000/- was developed. This system can be adapted to all types of seed drills and planters. It saves around 15-20% of the herbicide application volume.
- A prototype of two-row battery operated weeder was designed and developed by taking into account the ergonomic and agronomic considerations.
- PVP ethanol precipitation method was modified and standardized for isolating good quality and quantity RNA from the *Parthenium* flower bud and root tissues containing high amounts of allelochemicals for downstream molecular biology applications. The developed method performed better than the commercially available *RNA isolation* kits.
- Studies conducted in FACE facility on the effect of climate change on the efficacy of herbicides indicated that the efficacy of 2,4-D to control *Alternanthera paronychioides* was significantly reduced under elevated CO_2.
- In order to predict the future expansion of alien invasive weeds, prediction maps showing the distribution of *Alternanthera sessilis, Phalaris minor* and *Physalis minima* in India were

developed. A model/approach for prediction of geographical distribution of *Parthenium hysterophorus* in India was also derived by using Multinomial Ordered Logistic Regression (MOLR) and different machine learning approaches (MLA).

- Bioagent *Cyrtobagous salviniae* @ 45000 nos. /ha was found effective to control *Salvinia molesta* infestation in the water bodies of central India within one year. A shoot and root borer *Nupserha lenita* showed ability of severely attacking *Parthneium* after first monsoon rains, resulting in drastic reduction in flower and dry weight of plants.
- Herbicide residue studies indicated that pendimethalin residues in chickpea grains and straw were found <0.01 µg/g. Half-life of topramezone, imazethapyr, propaquizafop and pendimethalin in chickpea field soil was found to be 10.34, 14.40, 11.41 and 16.50 days, respectively.
- Half-life of pretilachlor, pyrazosulfuron, ethoxysulfuron, triafamone cyhalofop-butyl and penoxsulam was respectively 13.3, 7.84, 10.36, 10.6, 10.51, and 10.78 days in the soils of transplanted rice fields. After 90 days of application in rice field, residues of pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone in fishes of the adjacent run-off collecting ponds were below the detection limit.
- Suppressing effect of herbicides pretilachlor + pyrazosulfuron, cyhalofop + penoxsulam and triafamone + ethoxysulfuron on soil microbial biomass carbon in rice field was noticed upto 60 days after application.
- A multiresidue method using TLC was developed for determination of rice herbicide combination products, namely, pretilachlor + pyrazosulfuron, cyhalofop-p-butyl + penoxsulam and traifmaone + ethoxysulfruon.
- An user-friendly mobile app named 'DWR-Herbcal' was developed for application of correct amount of herbicide to crop fields. The app automatically calculates the amount of herbicide and quantity of water required in a given area for spray.
- During the year 2021, a total of 17 training programmes and 60 Front Line Demonstrations & On-farm Trials were conducted for the farmers and other stakeholders. A total number of 773 farmers were directly benefitted under different programmes such as Farmers FIRST, Biotech KISAN Hub, *Mera Gaon Mera Gaurav* and Scheduled Caste Sub-Plan. In addition, 13 nos. of *Kisan Mobile Sandesh* containing real time agricultural information and customized knowledge on weed management technologies were delivered to the registered farmers for taking timely action to manage weeds.
- MOUs have been signed with NSC and MPSS&FDC for large-scale seed production of rice, wheat, pulses and oilseed crops. During 2021, 108.9 tones of certified seed of rice (Sahabhagi and JR 81), wheat (MP 3382), field pea (Kashi Nandini), chickpea (JG 12) and greengram (Virat) were produced.
- During the period under report, 29 nos. of webinars and *Sangoshthis* on various aspects of weed management, were organized. A total number of 5356 participants attended these programmes.
- Further, the Directorate published 22 research papers/review articles in journals of national and international repute, 10 book chapters, 03 newsletters, 40 popular articles, 01 Souvenir and 01 Hindi magazine (*Trin Sandesh*).

Introduction

The Indian Council of Agricultural Research-Directorate of Weed Research (ICAR-DWR) works exclusively on weed management in both cropped as well as non-cropped areas of the country. The Directorate generates weed management technologies for different agro-ecosystems through its 23 All India Coordinated Research Project on Weed Management centres (17 regular and 06 volunteer centres) present in different State Agricultural Universities (SAUs). The Directorate is also playing an important role in providing training to different stakeholders, giving consultancy services, performing collaborative programmes on weed management and conducting participatory research at farmers' fields under 'Mera Gaon Mera Gaurav' in two localities, viz. Bargi and Patan. The Directorate has earned the 'ISO 9001: 2015' certificate by implementing the Quality Management System (QMS).

ICAR-Directorate of Weed Research is located at Jabalpur, Madhya Pradesh. Jabalpur is one of the most important tourist and cultural attractions of Madhya Pradesh and also known as the cultural capital (Sanskardhani) of the state. The city is famous for its major tourist attractions such as Madan Mahal, Dhuandhar Falls, Marble rocks in Bhedaghat, Holy River Narmada and 76 feet Shiva Statue at Kachnar City. It falls under the agro-climatic region of Kymore plateau and Satpura hills zone. Directorate is located on the national highway (NH-7) at 22.5-24.8ºN latitude, 78.2-80.6ºE longitude and altitude of 412 m above mean sea level and is 11 km away from Jabalpur railway station and 28 km away from Dumna airport. The climate of the region is sub-tropical, with average rainfall of ~1200 mm. Soils are mostly black and crops grown are rice, soybean, sugarcane, pigeonpea and blackgram during *Kharif* season, and wheat, chickpea, lentil, pea and mustard in *Rabi* season.

For the past 33 years, this Directorate has played a pioneering role in weed management at national level through its focused research programmes i.e. development of sustainable weed management practices in diversified cropping systems; weed dynamics and management under the regime of climate change and herbicide resistance; biology and management of problematic weeds in cropped and non-cropped lands; monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment; and on-farm research and demonstration of weed management technologies and impact assessment. Adoption of weed management technologies has been promoted in large areas through on-farm research and demonstrations, which has resulted in a sizable boost in agricultural productivity and livelihood security of the farmers. Efforts are being made to address emerging issues related to management of weeds in different ecosystems, threats posed by noxious invasive weeds, parasitic weeds, aquatic weeds, changes in weed dynamics in climate change scenarios, herbicide resistance, monitoring of impact of herbicides on environment. The Directorate has adopted all the principles of conservation agriculture in its farm and a "Modern Farm" has been developed to undertake advanced research in different aspects of weed management to meet the international standards.

Vision

Developing innovative, economic and eco-friendly weed management technologies to contain challenges ahead for sustainable agriculture and other societal benefits

Mission

To provide scientific research and technology in weed management for maximizing the economic, environmental and societal benefits for the people of India

Mandates

- Conduct weed management research for developing viable technologies for different agro-ecological regions
- Coordinate the network research and to provide training in weed management in agricultural systems
- Repository of information in weed science and act as a centre for training in weed management

Organization and management

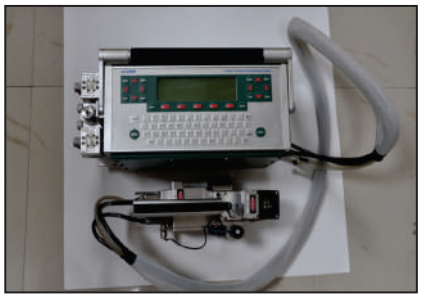
The Director has administrative control over the Directorate. The Quinquennial Review Team (QRT), Research Advisory Committee (RAC), Institute Management Committee (IMC) and Institute Research Committee (IRC) are other advisory bodies for research, teaching/training and extension activities. There are 5 major research sections, 4 administrative sections, and 12 other units and cells for smooth functioning and effective co-ordination.

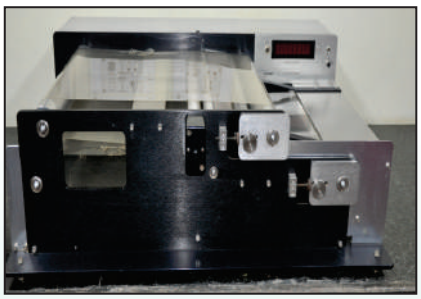
Laboratories and equipment

ICAR-DWR, Jabalpur has dedicated laboratories for research work on soil science, agronomy, plant physiology, plant biotechnology, residue analysis, entomology, microbiology and pathology. Apart from these, one central laboratory is also in place housing all common equipment like ice maker machine, leaf area meter, root scanner, UV spectrophotometers, pH meters, conductivity meters and BOD incubators etc. Laboratories at the Directorate are well-furnished and equipped with modern and sophisticated scientific instruments like LC-MS/MS, GC, HPLC, IRGA, lyophilizer, atomic absorption spectrometer, UV-visible double beam spectrophoto-meter, spectroradiometer, N-auto-analyzer, osmo-meter, thermal cycler, solid phase extraction unit, gel documentation unit, vacuum evaporator, high speed refrigerated centrifuge, water purification system, flame photometer and nano spectrophotometer. Sample storage facilities include liquid nitrogen containers, ultra freezer (-80ºC) and deep freezers (-20 ºC). It has two controlled environmental chambers to facilitate research under controlled environmental conditions. The Directorate has specialized facilities like Containment facility, Free Air CO_2 Enrichment (FACE) facility and six open top chambers to study possible impact of futuristic climate change on crop-weed interaction beside a phytoremediation unit. DWR also has mass multiplication facility for bioagent like *Zygogramma bicolorata, Neochetina* spp. and *Cyrtobagous salviniae* for biological control of Parthenium, water hyacinth and water fern. The Directorate also has a well-developed agricultural engineering workshop with facilities for repair, fabrication, designing and development of tools and implements for manual and mechanical weed management.

Atomic Absorption Spectrometer


Flame photometer


IRGA Photosynthetic System


Leaf Area Meter

Microwave Digestion System

Ultra-Violet Spectrophotometer

Agriculture Knowledge Management Unit, Library and Information Centre

AKMU (Agriculture knowledge Management Unit) is well equipped with computers, video conferencing facility, LAN facilities, color xerox-cum-printer and plotter. All the scientists and co-ordination units have been provided with internet connection and Wi-Fi connectivity. Library has a total collection of 3305 books related to weed science, 16 Indian journals in its subscription, newspapers section and sufficient reading area for students and employees. Reprographic and documentation facilities have also been created for the preparation of documents and reports. One information centre has been developed to display the updated information on weed science and management technologies. Directorate's publications, prototypes of weed management tools and live specimens of weed seeds are also on display for visitors.

Information Centre

Library

Budget during 2021-22 (₹ in lakhs)

Particular	Government grant			
	ICAR-DWR		AICRP-WM	
	Budget Estimate (BE)	Expenditure up to 31st Dec. 2021	Budget Estimate (BE)	Expenditure up to 31st Dec. 2021
(A) Grant in-add Capital	50.00	0.54	30.00	17.94
(B) Grant in-add Salary	803.48	688.98	675.15	555.35
(C) Grant in-add General	389.71	229.88	147.55	104.06
Total	**1243.19**	**919.40**	**852.70**	**677.35**

Resource generation (₹ in lakh)

Particular	Amount
Contract research	-
Consultancy services	-
Sale of farm produce	43.46
Others (auction, guest house, use of transport, tender paper, RTI, interests, license fee, water charges, dissertation fees, etc.)	10.81
Total	**54.27**

Staff position (as on 31.12.2021)

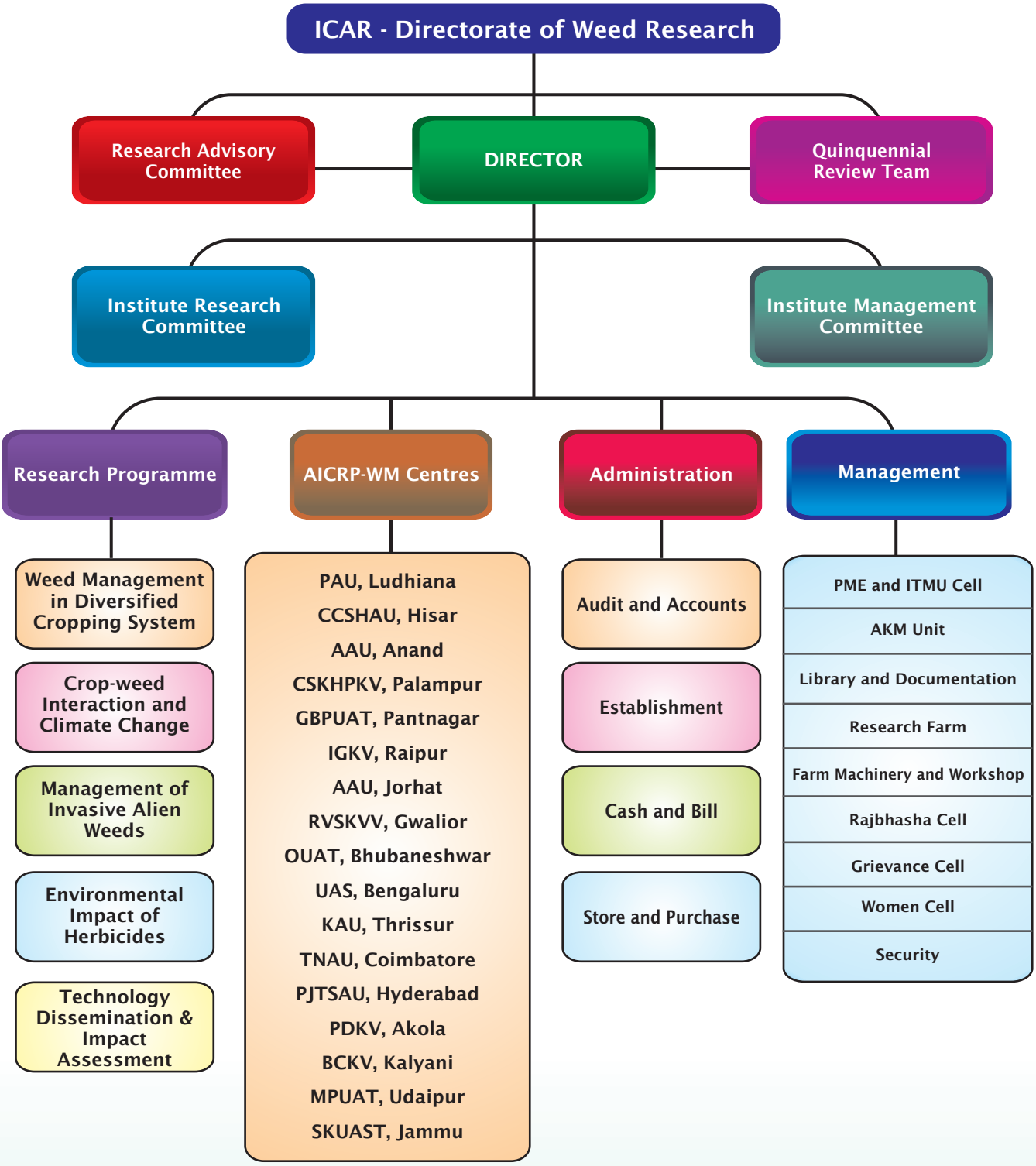
Particular	Sanctioned	Filled	Vacant
Research management position	01	01	-
Scientific staff	27	15	12
Technical staff	23	18	05
Administrative staff	14	06	08
Supporting staff	21	21	00

Discipline-wise position of scientists (as per revised cadre strength dated 02.07.2020) on 31.12.2021

Disciplines	Sanctioned			In Position			Vacant		
	PS	SS	S	PS	SS	S	PS	SS	S
Agricultural Biotechnology	-	01	-	-	-	01*	-	-	-
Agricultural Chemicals	01	-	01	-	-	01	01	-	-
Agricultural Economics	-	-	01	-	-	01	-	-	-
Agricultural Entomology	-	-	02	-	-	01	-	-	01
Agricultural Extension	-	01	01	-	01	-	-	-	01
Agricultural Microbiology	-	-	01	-	-	01	-	-	-
Agricultural Statistics	-	-	01	-	-	01	-	-	-
Agronomy	02	01	03	-	01	02	02	-	01
Economic Botany & Plant Genetic Resources	-	-	02	-	-	-	-	-	02
Farm Machinery and Power	-	-	02	-	-	02	-	-	-
Plant Pathology	-	01	01	-	-	-	-	01	01
Plant Physiology	-	01	01	-	-	01	-	01	-
Soil Science	-	01	01	-	01	01	-	-	-
Computer Application & IT	-	-	01	-	-	-	-	-	01
Total	**03**	**06**	**18**	**-**	**03**	**12**	**03**	**02**	**07**

*- Filled by scientist against senior scientist, PS - Principal Scientist, SS - Senior Scientist, S - Scientist

ORGANOGRAM


ICAR - Directorate of Weed Research
Research Advisory Committee
DIRECTOR
Quinquennial Review Team
Institute Research Committee
Institute Management Committee
Research Programme
AICRP-WM Centres
Administration
Management
Weed Management in Diversified Cropping System
Crop-weed Interaction and Climate Change
Management of Invasive Alien Weeds
Environmental Impact of Herbicides
Technology Dissemination & Impact Assessment
PAU, Ludhiana
CCSHAU, Hisar
AAU, Anand
CSKHPKV, Palampur
GBPUAT, Pantnagar
IGKV, Raipur
AAU, Jorhat
RVSKVV, Gwalior
OUAT, Bhubaneshwar
UAS, Bengaluru
KAU, Thrissur
TNAU, Coimbatore
PJTSAU, Hyderabad
PDKV, Akola
BCKV, Kalyani
MPUAT, Udaipur
SKUAST, Jammu
Audit and Accounts
Establishment
Cash and Bill
Store and Purchase
PME and ITMU Cell
AKM Unit
Library and Documentation
Research Farm
Farm Machinery and Workshop
Rajbhasha Cell
Grievance Cell
Women Cell
Security

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1. Strategic Research for Sustainable Weed Management in Diversified Cropping Systems

Development and upscaling of weed management technologies in cropping systems is important to harness higher productivity. This research programme envisages to develop the practical solutions to the weed management problems in crops and cropping systems through various technological options viz. herbicides, cropping system approach, resource use maximization, development of precision sprarying systems, weeding tools, drudgery reducing weeders and herbicide sprayers.

Research Programme Leader: Dr RP Dubey		
Project	**Experiment**	**Associates**
1.1 Development of weed management practices in minor millets, oilseeds, seed spices and organic cropping systems. **Principal Investigator: RP Dubey**	1.1.1 Evaluation of herbicides for weed management in seed spices *viz.* fennel and ajwain	V.K. Choudhary Chethan C.R.
	1.1.2 Evaluation of herbicides for weed management in minor millets *viz.* finger millet, kodo millet and barnyard millet	
	1.1.3 Evaluation of herbicides for weed management in sesamum, niger and safflower	
1.2 Development of sustainable weed management practices in direct-seeded rice under rice-wheat-greengram cropping system **Principal Investigator : PK Mukherjee**	1.2.1 Development of sustainable weed management practices in direct-seeded rice under rice-wheat -greengram cropping system	R.P. Dubey Shobha Sondhia V.K. Choudhary Dasari Srikanth
1.3 Resource use maximization through water and weed management in rice-based cropping system **Principal Investigator : VK Choudhary**	1.3.1 Water and weed management effect on weed prevalence, water and crop productivity and profitability in transplanted rice-based cropping system	R.P. Dubey Chethan C.R. Dasari Srikanth
	1.3.2 Water and weed management effect on weed prevalence, water and crop productivity and profitability in direct-seeded rice-based cropping system	
	1.3.3 Effect of drip irrigation levels and weed management practices on vegetables	
	1.3.4 Standardization of application timing and varietal evaluation of chickpea against novel herbicide-topramezone (Exploratory trial)	
	1.3.5 Effect of seed rate and weed management practices on weed control, productivity and profitability in direct-seeded rice (Exploratory trial)	
1.4 Development of precision spraying system and weeding tools **Principal Investigator: Chethan C.R.**	1.4.1 Improvisation of different weeding tools under flat bed crop establishment methods 1.4.2 Improvisation of different weeding tools under ridge-furrow based crop establishment methods	R.P. Dubey Vaibhav Choudhary

Project	Experiment	Associates
	1.4.3 Development of cost effective precision spraying systems	
	1.4.4 Evaluation of developed spraying system with existing system for ergonomic friendly operations	
1.5 Design, development and evaluation of drudgery reducing battery operated weeder and double pack weed sprayer for weeding operations in selected crops **Principal Investigator: Vaibhav Choudhary**	1.5.1 Designing and optimizing the operating parameters of the battery operated weeder	PK Mukherjee Yogita Gharde

1.1 Development of weed management practices in minor millets, oilseeds, seed spices and organic cropping systems

1.1.1 Evaluation of herbicides for weed management in seed spices *viz.* fennel and ajwain

Fennel (*var. AF-1*)

An experiment was conducted during *Rabi* 2020-21 to evaluate herbicides for weed management in fennel. Total 11 treatments (**Table 1.1**) were tested under RBD replicated thrice. The major weed flora comprised of *Medicago denticulata, Paspalidium flavidum, Dinebra retroflexa, Physalis minima, Cyperus rotundus, Convolvulus arvensis* and others. Among the herbicides, propaquizafop + imazethapyr 100 g/ha and tembotrion 100 g/ha were highly phytotoxic to the crop. Fenoxaprop, oxyfluorfen and oxadiargyl reduced the weed dry biomass effectively comparable to 2 mechanical weeding (MW). The highest seed yield was recorded under pendimethalin, metribuzin, fenoxaprop and oxadiargyl application. The unweeded control reduced the yield by 45.7%.

Table-1.1: Effect of treatments on weed density, dry weight and seed yield of fennel

Treatment	Dose (g/ha)	Phytotoxicity 1 to 10 scale	Weed density (No./m²) 60 DAS	Weed dry wt. (g/m²) 60 DAS	Seed yield (t/ha)
Pendimethalin	675	0	6.4 (43)	3.7 (14)	1.34
Metribuzin	150	0	6.2 (38.8)	3.8 (14.2)	1.27
Oxadiargyl	100	0	6.9 (47.3)	3.5 (12.1)	1.24
Oxyfluorfen	100	0	5.3 (30.3)	3.3 (11.4)	1.14
Fenoxaprop	100	1	5.9 (36.7)	3.0 (9)	1.26
Propa+imazethapyr	100	8	5.9 (34.7)	3.6 (13.2)	0.42
Clodinafop	60	1	5.7 (33)	3.7 (14)	1.12
Tembotrion	100	7	7.3 (53.3)	4.6 (21.5)	0.75
Quizalofop	50	1	6.0 (36.3)	3.6 (13.1)	1.07
2MW	-	0	4.4 (20)	3.3 (11.5)	1.40
Unweeded	-	0	10.1 (102.3)	8.2 (68)	0.76
CV %			**18.03**	**14.59**	**18.93**
SEm ±			**0.66**	**0.34**	**0.11**
LSD P=0.05			**1.95**	**1.004**	**0.34**

Ajwain (*var. AA-2*)

The experiment conducted during *Rabi* 2020-21 to evaluate herbicides for weed management in ajwain comprised of 11 treatments (**Table 1.2**) tested under RBD replicated thrice. The major weed flora comprised of *Medicago denticulata, Paspalidium flavidum, Dinebra retroflexa, Physalis minima, Cyperus rotundus, Convolvulus arvensis* and others. Propaquizafop + imazethapyr 100 g/ha and tembotrion 100 g/ha were highly phytotoxic to the crop. Among the herbicides, pendimethalin, oxyfluorfen and oxadiargyl reduced the weed dry biomass effectively. The highest seed yield was recorded under oxadiargyl, metribuzin and oxyfluorfen application. The unweeded control reduced the yield by 46.6%.

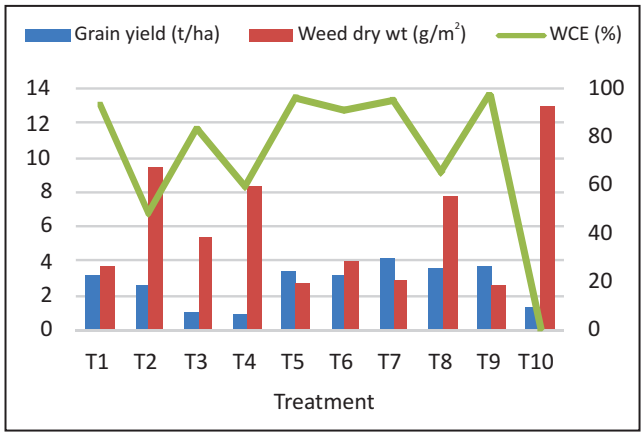
Table 1.2: Effect of treatments on weed density, dry weight and seed yield of ajwain

Treatment	Dose (g/ha)	Phyto 1 to 10 scale	Weed density (No./m²) 60 DAS	Weed dry wt. (g/m²) 60 DAS	Seed yield (t/ha)
Pendimethalin	675	0	5.6 (33)	4.2 (18.4)	1.29
Metribuzin	150	0	7.4 (56.7)	6.2 (38.7)	1.33
Oxadiargyl	100	0	6.6 (43.3)	4.8 (23)	1.37
Oxyfluorfen	100	0	6.8 (47.3)	4.3 (18.5)	1.31
Fenoxaprop	100	0.67	5.8 (33.7)	6.1 (38.7)	1.25
Propa +imazethapyr	100	7	6.5 (43.3)	6.2 (39.5)	0.49
Clodinafop	60	1	6.5 (44)	5.9 (34.8)	1.21
Tembotrion	100	9	8.3 (70)	5.7 (35)	0.00
Quizalofop	50	2	7.0 (50)	5.2 (27.2)	1.11
2HW	-	0	5.1 (26.7)	2.9 (9.8)	1.46
Unweeded	-	0	10.0 (100)	6.6 (43.4)	0.78
CV %			**15.73**	**18.95**	**15.46**
SEm ±			**0.62**	**0.57**	**0.093**
LSD P=0.05			**1.84**	**1.70**	**0.279**

1.1.2 Evaluation of herbicides for weed management in minor millets viz. finger millet, kodo millet and barnyard millet

Finger millet (*var. GPU 45*)

The field experiment on weed management in transplanted ragi (finger millet) crop during *Kharif* 2021 had 10 treatments The experimental site was dominated by weeds *viz. Echinochloa colona, Paspalidium flavidum, Dinebra retroflexa, Cyperus rotundus, Physalis minima, Convolvulus arvensis, Mecardonia procumbens, Mollugo verticillata, Phyllanthus simplex, Alternanthera sessilis, Commelina benghalensis* and others. Metribuzin and oxyfluorfen caused phytotoxicity of 6-8 on a 1-10 scale. Crop phytoxicity due to atrazine was 2-3 rating whereas, pyrazosulfuron was the least phytotoxic (1-2) to ragi crop. At 60 DAP, the least weed biomass was recorded from the application of oxyfluorfen and pyrazosulfuron integrated with 1 MW with WCE of 96.1 and 95.4% (**Figure 1.1**). The higher grain yield among herbicide treatments was recorded from pyrazosulfuron 20 g/ha fb 1 MW 40 DAP (4.17 t/ha). The 2 MW and unweeded control recorded grain yields of 3.64 and 1.33 t/ha, respectively.

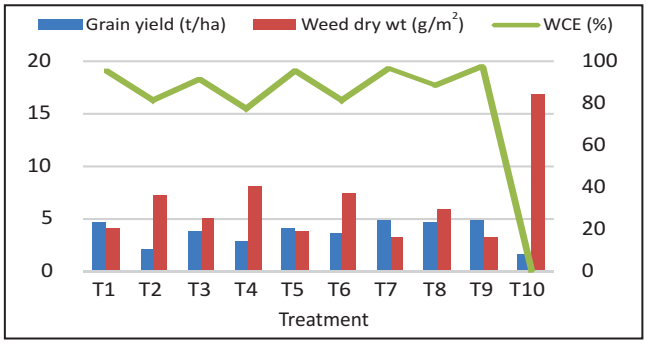


T_1-Atrazin 750 g/ha *fb* 1 HW at 40 DAP, T_2-Atrazin 750 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_3-Metribuzin 150 g/ha *fb* 1 MW 40 DAP, T_4-Metribuzin 150 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_5- Oxyfluorfen 100 g/ha *fb* 1 MW 40 DAP, T_6-Oxyfluorfen 100 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_7-Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAP,T_8-Pyrazosulfuron 20 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_9- 2 MW (20 and 40 DAP) and T_{10}-unweeded.

Figure1.1: Treatment effects on weed dry weight, WCE and grain yield of finger millet

Kodo (*var. JK 137*)

The field experiment during *Kharif* 2021 had 10 treatments. The experimental site was dominated by weeds *viz. Paspalidium flavidum, Dinebra retroflexa Cyperus rotundus Physalis minima, Convolvulus arvensis, Mecardonia procumbens, Mollugo verticillata, Phyllanthus simplex, Alternanthera sessilis, Commelina benghalensis* and others. Metribuzin and oxyfluorfen caused phytotoxicity of 4-6 on a 1-10 scale. At 60 DAP, application of pendimethalin integrated with 1 mechanical weeding or *fb* metsulfuron reduced the weed dry biomass effectively with WCE of 96.2 and 88.3% (**Figure 1.2**). The higher grain yield among herbicide treatments was recorded from pendimethalin 675 g/ha fb 1 MW 40 DA (4.93 t/ha) and pendimethalin 675 g/ha fb metsulfuron 4 g/ha 25 DAP (4.65 t/ha). Atrazin integrated with 1 MW also produced higher grain yield of 4.60 t/ha.

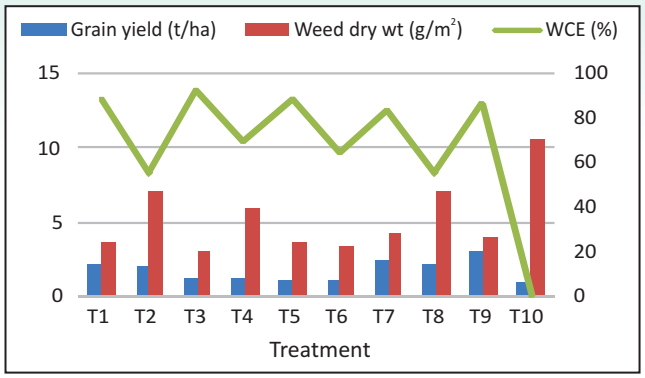


T_1- Atrazin 750 g/ha *fb* 1 HW at 40 DAP, T_2- Atrazin 750 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_3- Metribuzin 150 g/ha *fb* 1 MW 40 DAP, T_4- Metribuzin 150 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_5- Oxyfluorfen 100 g/ha *fb* 1 MW 40 DAP, T_6- Oxyfluorfen 100 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_7- Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAP, T_8- Pyrazosulfuron 20 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_9- 2 MW (20 & 40 DAP) and T_{10}- Unweeded.

Figure 1.2: Treatment effects on weed dry weight, WCE and grain yield of kodo

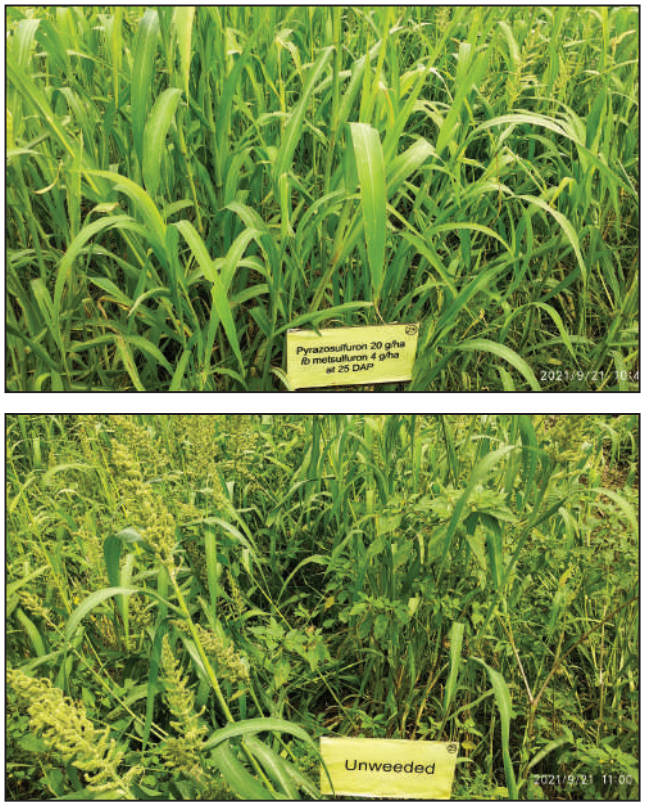
Sanwa (*var. VL 29*)

The field experiment during *Kharif* 2021 had 10 treatments viz. The experimental site was dominated by weeds *viz. Paspalidium flavidum, Dinebra retroflexa, Cyperus rotundus, Physalis minima, Convolvulus arvensis, Mecardonia procumbens, Mollugo verticillata, Phyllanthus simplex* and others. Metribuzin and oxyfluorfen caused phytotoxicity of 5-8 on a 1-10 scale. However, when integrated with 1 mechanical weeding they reduced the weed dry biomass effectively with WCE of 92.3 and 88.0% at 60 DAP. The higher grain yield among herbicide treatments was recorded from pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAP (2.44 t/ha) and pyrazosulfuron 20 g/ha *fb* metsulfuron 4 g/ha 25 DAP (2.19 t/ha) (**Figure 1.3**).



T_1- Atrazin 750 g/ha *fb* 1 HW at 40 DAP, T_2- Atrazin 750 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_3- Metribuzin 150 g/ha *fb* 1 MW 40 DAP, T_4- Metribuzin 150 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_5- Oxyfluorfen 100 g/ha *fb* 1 MW 40 DAP, T_6- Oxyfluorfen 100 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_7- Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAP, T_8- Pyrazosulfuron 20 g/ha *fb* metsulfuron 4 g/ha 25 DAP, T_9- 2 MW (20 & 40 DAP) and T_{10}- Unweeded

Figure 1.3: Treatment effects on weed dry weight, WCE and grain yield of sanwa



1.1.3 Evaluation of herbicides for weed management in sesamum, niger and safflower

Safflower (*var. A1*)

The field experiment conducted during *Rabi* 2020-21 comprised of the major weed flora *viz. Paspalidium flavidum, Cyperus rotundus, Medicago denticulata,, Dinebra retroflexa, Physalis minima,*

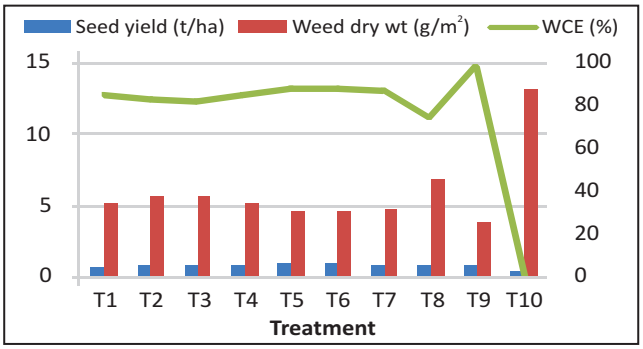
Convolvulus arvensis, Sonchus arvensis and others. Herbicides *viz.* imazethapyr+imazamox, tembotrion, clodinafop+ aclifuorfen, pendimethalin+imazethapyr and oxyfluorfen were phytotoxic to the crop. The treatments pendimethalin, pendimethalin+ imazethapyr, atrazine, oxyfluorfen, fenoxaprop significantly reduced the weed dry biomass (**Table 1.3**). Application of oxadiargyl, metribuzin, quizalofop, propaquizafop+imazethapyr, atrazin produced higher seed yields. The unweeded control reduced the yield by 74.0%.

Table 1.3: Effect of treatments on weed density, dry weight and seed yield of safflower

Treatment	Dose (g/ha)	Phyto 1 to 10 scale	Weed density (No./m²) 60 DAS	Weed dry wt. (g/m²) 60 DAS	Seed yield (t/ha)
Atrazin	750	0	3.9 (16.3)	2.0 (4)	2.5
Pendimethalin	675	0	3.2 (11.7)	1.8 (3.6)	2.3
Oxyfluorfen	200	2	3.9 (15.3)	2.0 (4.3)	1.7
Metribuzin	200	0	5.1 (26.3)	2.8 (8.1)	2.9
Oxadiargyl	100	0	4.0 (17)	2.7 (7.2)	3.0
Pendimethalin+ imaze	960	2	2.9 (9.3)	1.8 (3.4)	1.4
Propa+imaze	100	0.7	5.4 (30)	2.4 (5.8)	2.6
Clod+acifluorfen	245	8.0	5.1 (30.3)	2.2 (5)	0.9
Tembotrion	100	6.3	4.7 (23)	2.5 (7.1)	0.7
Fenoxaprop	100	1.7	4.4 (19.3)	2.0 (4.3)	2.3
Quizalofop	75	0.3	4.3 (18.7)	2.1 (4.8)	2.6
Fluazifop	150	0.0	4.2 (18.3)	2.1 (4.7)	2.2
Clodinafop	60	0.0	3.6 (14)	2.5 (7.1)	2.4
Imaze+imazamox	70	4.7	5.3 (28.3)	2.7 (8.1)	1.8
2HW	-	0	2.9 (8.7)	1.0 (1.1)	2.7
Unweeded	-	0	5.8 (34.3)	6.7 (44.8)	0.7
CV %			**26.61**	**27.58**	**26.6**
SEm ±			**NS**	**0.39**	**0.31**
LSD P=0.05			**NS**	**1.13**	**0.90**

Sesamum (*var. TKG 308*)

The field experiment during *Kharif* 2021 had 10 treatments. The experimental site was dominated by weeds *viz. Mecardonia procumbens, Oldenlandia corymbosa, Mollugo verticillata Dinebra retroflexa, Cyperus rotundus, Convolvulus arvensis, Eclipta alba, Paspalidium flavidum, Phyllanthus simplex* and others. Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAS, pyrazo-sulfuron 20 g/ha *fb* propaquizafop 100 g/ha and metribuzin 150 g/ha *fb* 1 MW 40 DAS and metribuzin 150 g/ha *fb* propaquizafop 100 g/ha caused phytoxi-city of 3-4 rating on a 1-10 scale. Pendimethalin + imazethapyr were least phytotoxic (1-2 on a 1-10 scale). At 60 DAS, among the treatments, oxyfluorfen 100 g/ha *fb* 1 MW 40 DAS, oxyfluorfen 100 g/ha *fb* propaq-uizafop 100 g/ha and pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAS, were best in reducing weed biomass with WCE of 88.4, 88.2 and 87.1%. However, the higher seed yields were recorded under oxyfluorfen 100 g/ha *fb* propaquizafop 100 g/ha (914 kg/ha) and oxyfluorfen 100 g/ha *fb* 1 MW 40 DAS (856 kg/ha) (**Figure 1.4**).



T_1- Pendimethalin + imazethapyr 700 g/ha *fb* 1 MW 40 DAS ,T_2- Pendimethalin + imazethapyr 700 g/ha *fb* propaquizafop 100 g/ha ,T_3- Metribuzin 150 g/ha *fb* 1 MW 40 DAS, T_4- Metribuzin 150 g/ha *fb* propaquizafop 100 g/ha, T_5- Oxyfluorfen 100 g/ha *fb* 1 MW 40 DAS, T_6- Oxyfluorfen 100 g/ha *fb* propaquizafop 100 g/ha, T_7- Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAS, T_8- Pyrazosulfuron 20 g/ha *fb* propaquizafop 100 g/ha, T_9- 2 MW and T_{10}- Unweeded.

Figure 1.4: Treatment effects on weed dry weight, WCE and seed yield of sesamum

Niger (*var. JNS 28*)

The field experiment during *Kharif* 2021 had 10 treatments T_1- pendimethalin + imazethapyr 700 g/ha *fb* 1 MW 40 DAS ,T_2- Pendimethalin + imazethapyr 700 g/ha *fb* propaquizafop 100 g/ha ,T_3- Metribuzin 150 g/ha *fb* 1 MW 40 DAS, T_4- Metribuzin 150 g/ha *fb* propaquizafop 100 g/ha, T_5- Oxyfluorfen 100 g/ha *fb* 1 MW 40 DAS, T_6- Oxyfluorfen 100 g/ha *fb* propaq-uizafop 100 g/ha, T_7- Pyrazosulfuron 20 g/ha *fb* 1 MW 40 DAS, T_8- Pyrazosulfuron 20 g/ha *fb* propaquizafop 100 g/ha, T_9- 2 MW and T_{10}- Unweeded. The experimental site was dominated by weeds viz. *Mecardonia procumbens, Oldenlandia corymbosa, Mollugo verticillata Dinebra retroflexa, Cyperus rotundus, Convolvulus arvensis, Eclipta alba, Paspalidium flavidum, Phyllanthus simplex* and others. Metribuzin and pyrazosulfuron were slightly phytotoxic (3-4) and pendimethalin + imazethapyr (1-2) on a 1-10 scale to the niger at initial stage. At 60 DAS, among treatments, T_5 and T_6 were not phytotoxic to the crop and comparatively better in reducing the weed dry weight and also produced higher seed yield of 350 and 333 kg/ha.

1.2 Development of sustainable weed management practices in direct-seeded rice under rice-wheat-greengram cropping system

1.2.1 Development of sustainable weed management practices in direct-seeded rice under rice-wheat-greengram cropping system

The major research findings under direct-seeded rice were:

- The weed flora recorded in direct-seeded rice were comprised with grasses *Echinochloa colona, Dinebra retroflexa, Digitaria* sp. (*D. sanguinalis* and *D. ciliaris*), sedge *Cyperus iria* and broad-leaf weeds *Alternanthera paronychioides, Mecardonia procumbens, Physalis minima, Phyll-anthus* sp. (*P. simplex, P. niruri* and *P. urinaria*), *Ludwigia* sp. (*L. parviflora* and *L. peruviana*), *Corchorus acutangulus, Euphorbia heterophylla, Convolvulus arvensis, Mollugo* sp. (*M. verticillata* and *M. pentaphylla*).
- At 20 DAS in farmers' practice (FP) treatment comprising the application of premix herbicide cyhalofop-butyl+penoxsulam (135 g/ha) at 20 DAS followed by 1 HW at 42 DAS, the weeds *Alternanthera paronychioides* and *Echinochloa colona* were recorded as dominant weeds with the relative density of 74.5% and 16.1% and percentage contribution to total weed dry biomass of 54.7% and 38.7%, respectively. In recommended weed management practice (RWMP) treatment pendimethalin (680 g/ha 38.7 SC) as PE controlled the emergence of *Alternanthera paronychioides* and other weeds up to 30 DAS, however, emergence of *Physalis minima, Echinochloa colona* and *Cyperus iria* were observed after 20 DAS.
- At, 40 DAS the weeds *Alternanthera paronychioides* (32.3%), *Echinochloa colona* (31.6%), *Commelina* sp. (12.4%), *Phyllanthus* sp. (8.3%), *Corchorus acutangulus* (7.9%) and *Physalis minima* (7.5%) were recorded in FP treatment. Among these weeds, *Echinochloa colona* and *A. paronychioides* registered 58.2% and 29.9% contribution to the total weed dry biomass, respectively. In RWMP treatment *E. colona* (10.1%), *A. paronychioides* (32.2%) and *Cyperus iria* (20.1%) were recorded as dominant weeds with 42.3%,

21.8% and 21.7% contribution to total weed dry biomass at 40 DAS, respectively.

- Application of premix herbicide cyhalofop-butyl +penoxsulam (135 g/ha) at 42 DAS in RWMP treatment controlled existing *A. paronychioides* effectively, however, repeated emergence and faster growth of the weed resulted in 40.3% contribution to total weed dry biomass with 7.9% relative density at 70 DAS. Similarly emergence of *Mecardonia procumbens* was observed before 40 DAS and application of herbicide (cyhalofop-butyl+penoxsulam) controlled the weed effectively. However, after the herbicide treatment, emergence of *Mecardonia procumbens* in several flushes developed large population with the value of 71.4% relative density and contributed 13.8% to total weed dry biomass. *E. colona* contributed 25.5% to total weed dry biomass with 3.4% relative density. In FP treatment *M. procumbens* was not controlled effectively through HW at 42 DAS resulted in large population (71.7%) and huge biomass accumulation (52.6% contribution to total weed dry biomass) at 70 DAS. *A. paronychioides* contributed 27.1% to total weed biomass with 13% relative density.
- Because of faster growth and large biomass accumulation capacity, *A. paronychioides* suppressed the growth of other weeds and emerged as a dominant weed at harvest. It contributed 60.5% and 56.2% to total weed dry biomass with 13.5% and 13.2% relative density in RWMP and FP treatments, respectively. Late emergence of *Ludwigia* sp. was observed. Yield data recorded from weed-free treatment were ranged between 3.2 to 3.8 t/ha whereas in case of RWMP and FP treatments the yield data were recorded between 2.2 to 3.5 t/ha and 1.4 to 2.9 t/ha, respectively.
- Emergence study of *A. paronychioides* from soil seedbank revealed 60, 19 and 11% emergence under normal illumination level (25,000 to 1, 50,000 Lux) from 0 (surface soil), 1 and 2 cm soil depth at 13th, 18th and 25th day, respectively, whereas no emergence was recorded from 3 cm soil depth up to 24th day, however, disturbance of soil led to 8% emergence up to 35th day after that no emergence was recorded. Finally total 67% emergence was recorded at 64th day from 0 cm soil depth after that no emergence was recorded up to 129th day. More staggered emergence was observed from 1 cm and 2 cm soil depth leading to several flushes of weed (**Figure 1.5**). Emergence study of *A.paronychioides* from surface soil under low illumination level (265 to 570 Lux) under laboratory condition revealed 46 and 50% emergence at 7th and 16th day, respectively. However, mortality of the newly emerged seedlings of *A. paronychioides* was started at 15th day and complete mortality of the weed seedlings were recorded at 26th day. After complete mortality of weed seedlings, further exposure of seeds in normal illumination level at 27th day resulted in 9% more emergence up to 71th day and after that no emergence was recorded up to 129th day. Overall, 59% emergence of weed seedlings was recoded from surface soil up to 129th day (**Figure 1.6 and 1.7**).

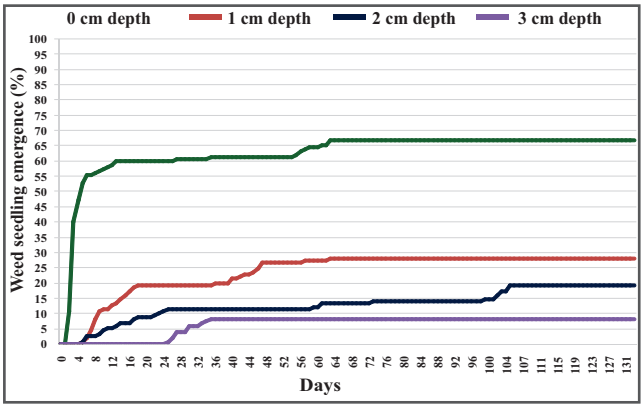


Figure 1.5: Emergence (%) of *Alternanthera paronychioides* seedlings from seeds at different soil depths under normal illumination level (25,000 to 1, 50,000 Lux)

Emergence of *Alternanthera paronychioides* from seeds at different soil depths

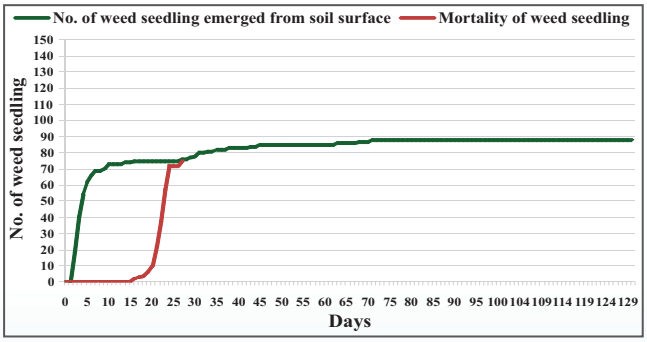


Figure 1.6: Emergence and mortality of *Alternanthera paronychioides* seedlings from surface soil at low illumination level (265 to 570 Lux) up to 26th day followed by normal illumination level (25,000 to 1, 50,000 Lux)

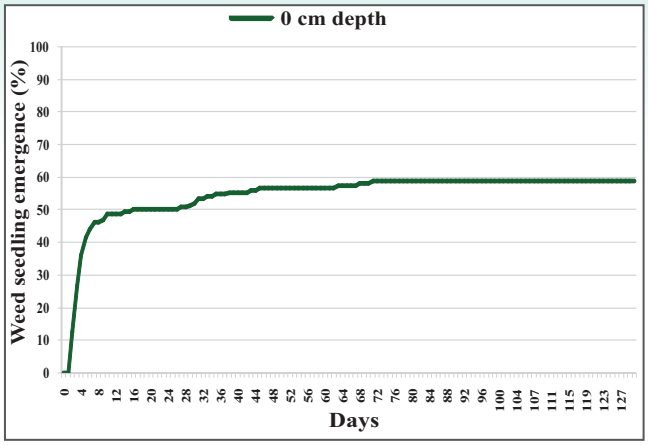


Figure 1.7. Overall emergence (%) of *Alternanthera paronychioides* seedlings from surface soil at low illumination level (265 to 570 Lux) up to 26th day followed by normal illumination level (25,000 to 50,000 Lux)

Weed pressure between farmers' practice (premix of cyhalofop-butyl+penoxsulam (135 g/ha) at 20 DAS *fb* 1 HW at 42 DAS) and weed free treatment

1.3 Resource use maximization through water and weed management in rice-based cropping system

1.3.1 Water and weed management effect on weed prevalence, water and crop productivity and profitability in transplanted rice-based cropping system

The field study was conducted in a split-plot design with three replications, where the main-plot was assigned to water level and sub-plot to weed management practices.

Chickpea (*Rabi* 2020-21)

In chickpea, four water levels [flood irrigation (FI) at 100 and 80%, sprinkler irrigation (80% of FI) and drip irrigation (60% of FI)] and four weed management levels [pendimethalin 678 g/ha (PE), pendimethalin+ imazethapyr 1000 g/ha (PE), topramezone 20 g/ha (post) and weedy check] were evaluated. The study area comprised of grassy weeds like *Avena ludoviciana, Phalaris minor*, *Digitaria sanguinalis, Paspalidium flavidum* broad-leaved weeds like *Medicago denticulata, Chenopodium album, Melilotus indica, Rumex dentatus, Sonchus oleraceus, Vicia sativa, Lathyrus aphaca etc.*

At 60 DAS, total density and biomass of weeds were recorded the lowest with drip irrigation at 60% (36/m^2 and 12 g/m^2, respectively) with 31.5% WCE and 36.7% WCI, whereas the highest weed parameters with flood irrigation at 100% (53/m^2 and 18.9 g/m^2, respectively). Lower weed parameters in drip irrigation helped in synthesizing better growth and yield attributes resulted in higher seed and haulm yield (1976 and 2258 kg/ha, respectively) and water productivity (17.6 kg/ha/mm). The lowest grain and straw yield was obtained with flood irrigation at 80%.

Among weed management practices, application of topramezone 20 g/ha recorded the lowest weed density and biomass (8/m^{2}and 1.4 g/m^2, respectively) with 92.2% WCE and 96.7% WCI. The highest weed density and biomass were recorded with a weedy check (102/m^2 and 42.4 g/m^2, respectively). Application of topramezone recorded the highest grain and straw yield (2411 and 2679 kg/ha, respectively) and water productivity (17.5 kg/ha/mm). Weedy check plots had the lowest yield and water productivity (**Figure 1.8**).

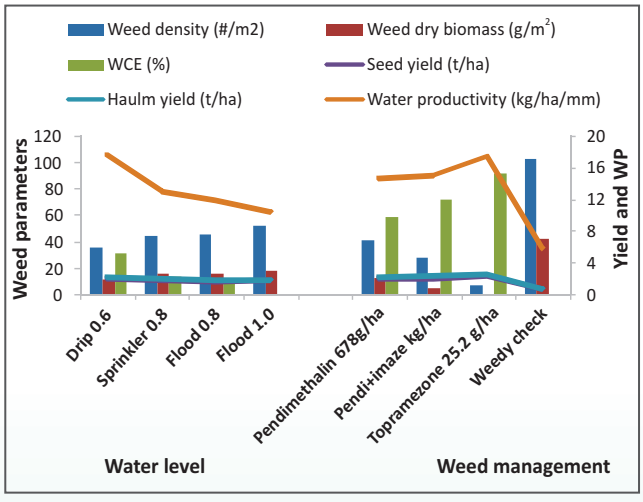


Figure 1.8: Weed parameters, crop and water productivity of chickpea influenced by irrigation methods and weed management practices

Blackgram (summer 2021)

In blackgram, three water levels [flood irrigation (FI), sprinkler irrigation (80% of FI) and drip irrigation (60% of FI)] and four weed management levels (pendimethalin 678 g/ha, imazethapyr 100 g/ha, hand weeding at 20 DAS and weedy check) were evaluated in split-plot with three replications. The study area was infested with grassy weeds like *Echinochloa colona, Dinebra retroflexa, Digitaria sanguinalis* broadleaved weeds like *Alternanthera sessilis, Physalis minima, Euphorbia geniculata, Tridax procumbens, Parthenium hysterophorus* etc.

At 45 DAS, total density and biomass of weeds were recorded the lowest with drip irrigation at 60% (13/m^2 and 9.2 g/m^2, respectively) with 27.1% WCE and 35.9% WCI, whereas the highest weed parameters were recorded with flood irrigation at 100% (17.8/m^2 and 14.3 g/m^2, respectively). Lower weed parameters helped in synthesizing more and wider leaves, more branches, pods/plant and seeds/pod resulted in higher seed and haulm yield (825 and 1863 kg/ha, respectively) and water productivity (3.6 kg/ha/mm). The lowest grain and straw yield was recorded with flood irrigation.

Among weed management practices, hand weeding at 20 DAS recorded the lowest weed density and biomass (3.6/$m^2$and 0.9 g/m^2, respectively) with 90.5% WCE and 97.5% WCI. The highest weed density and biomass were recorded with a weedy check (37.6/m^2 and 35.1 g/m^2, respectively). Imposition of hand weeding at 20 DAS recorded the highest seed and haulm yield (974 and 2059 kg/ha, respectively) and water productivity (3.8 kg/ha/mm). The lowest values of yields and water productivity were recorded with a weedy check (**Figure 1.9**).

Transplanted rice (*Kharif* 2021)

In transplanted rice, three water levels (15 cm withdrawal of water, irrigation at hairline cracks and continuous flooding at 5±2 cm) and four weed management levels (cyhalofop+penoxsulam 135 g/ha, bispyribac-sodium 25 g/ha, hand weeding at 20 and 40 DAS and weedy check) were studied. The study area comprised of grassy weeds like *Dinebra retroflexa, Echinochloa colona, Eleusine indica,* broadleaved weeds like *Alternanthera sessilis, Caesulia axillaris, Eclipta alba, Phasalis minima, Ludwigia parviflora, Acmella* sp., *Mecardonia procumbens* and *Fimbristylis miliacea*, *Cyperus iria* was only sedge present.

Among the water level, at 60 DAS, total weed density and biomass were recorded the lowest in the plots with continuous flooding (78.3/m^2 and 19.3 g/m^2, respectively) with 52.5% WCE and 60.7% WCI, whereas the highest weed parameters were recorded with irrigation at 15 cm withdrawal of water (165/m^2 and 49.1 g/m^2, respectively). Above helped in synthesizing more yield attributes (i.e. panicle length, panicle weight filled grains etc) resulted in higher grain and straw yield (4.52 and 5.73 t/ha, respectively), in contrary, water productivity was recorded highest with irrigation at 15 cm withdrawal of water (3.67 kg/ha/mm), whereas the lowest grain yields were recorded with irrigation at 15 cm withdrawal of water. Among weed management practices, twice hand weeding at 20 and 40 DAT recorded the lowest weed density and biomass (39.6/m^2 and 4.7 g/m^2, respectively) with 84.7% WCE and 94.6% WCI followed by cyhalofop+penoxsulam. The highest weed density and biomass were recorded with a weedy check (258.7/m^2 and 85.8 g/m^2, respectively). Cyhalofop+penoxsulam recorded the highest grain and straw yield (5.26 and 6.29 t/ha, respectively) and water productivity (4.39 kg/ha/mm), whereas the lowest values of yield and water productivity were recorded with a weedy check (**Figure 1.10**).

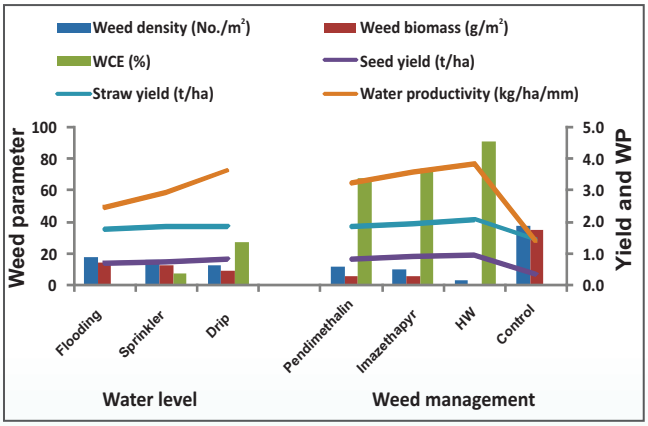


Figure 1.9: Weed parameters, crop and water productivity of blackgram influenced by irrigation methods and weed management practices

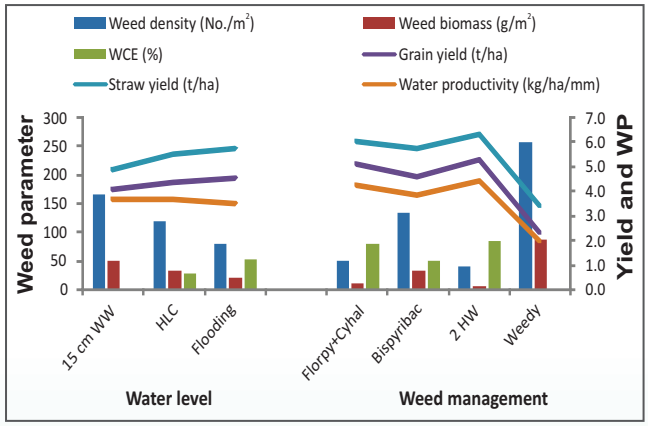


Figure 1.10: Weed parameters, crop and water productivity of transplanted rice influenced by irrigation methods and weed management practices

1.3.2 Water and weed management effect on weed prevalence, water and crop productivity and profitability in direct-seeded rice-based cropping system

Wheat (*Rabi* 2020-21)

In wheat, four water levels [flood irrigation (FI) at 100 and 80%, sprinkler irrigation (80% of FI) and drip irrigation (60% of FI)] and four weed management levels [pendimethalin 678 g/ha (PE) *fb* metsulfuron 4 g/ha (Post), clodinafop+metsulfuron 64 g/ha (Post), mesosulfuron+iodosulfuron 14.4 g/ha (Post) and weedy check] were studied. The study area was infested with grassy weeds like *Avena ludoviciana, Phalaris minor, Digitaria sanguinalis, Paspaladium flavidum* broadleaved weeds like *Medicago denticulata, Chenopodium album, Melilotus indica, Rumex dentatus, Sonchus oleraceus, Physalis minima* etc.

Among water level, at 60 DAS, total density and biomass of weeds were recorded the lowest with drip irrigation at 60% (50/m^2 and 14.2 g/m^2, respectively) with 32.1% WCE and 36% WCI, whereas the highest weed parameters were recorded with flood irrigation at 100% (74/m^2 and 22.1 g/m^2, respectively). Lower weed parameters helped in synthesizing more growth and yield attributes resulted in higher grain and straw yield (4.04 and 5.32 t/ha, respectively) and water productivity (22.6 kg/ha/mm). The lowest grain and straw yield and water productivity were recorded with flood irrigation at 80%. Among weed management practices, application of clodinafop+metsulfuron recorded the highest grain and straw yield (4.43 and 5.77 t/ha, respectively) and water productivity (19.9 kg/ha/mm). The lowest values of yield and water productivity recorded with a weedy check (**Figure 1.13**).

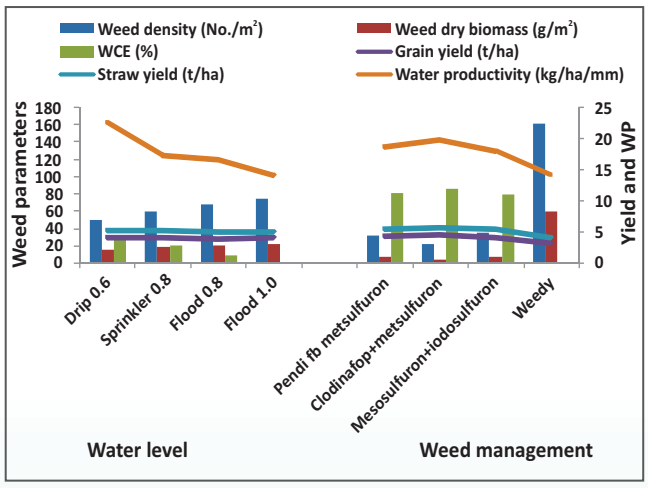


Figure 1.11: Weed parameters, crop and water productivity of wheat influenced by irrigation methods and weed management practices

Dry direct-seeded rice (*Kharif* 2021)

In direct-seeded rice, three water levels (15 kPa, 30 kPa and 45 kPa) and four weed management levels [pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* cyhalofop+ penoxsulam 135 g/ha (Post), pyrazosulfuron 20 g/ha (PE) *fb* bispyribac sodium 25 g/ha (Epost) *fb* fenoxaprop-ethyl 60 g/ha (Lpost), hand weeding at 20 and 40 DAS and weedy check] were evaluated. The study area was infested with grassy weeds like *Dinebra retroflexa, Echinochloa colona, Eleucine indica, Digitaria sanguinalis,* broadleaved weeds like *Alternanthera sessilis, Eclipta alba, Phasalis minima, Phyllanthus urinaria, Mecardonia procumbens* and *Cyperus iria* was only sedge present.

Among water level, lower weed parameters helped in synthesizing more growth and yield attributes resulted in higher grain and straw yield (3.14 and 4.59 t/ha, respectively), whereas water productivity was comparable among water levels. The lowest grain and straw yield were recorded with irrigation at 45 kPa. Among weed management practices, Sequential application of pretilachlor+ pyrazosulfuron *fb* cyhalofop+penoxsulam recorded the highest grain and straw yield (3.74 and 5.43 t/ha, respectively) and water productivity (4.67 kg/ha/mm), but it was comparable to twice hand weeding. The lowest values of yield and water productivity were recorded with a weedy check (**Figure 1.13**).

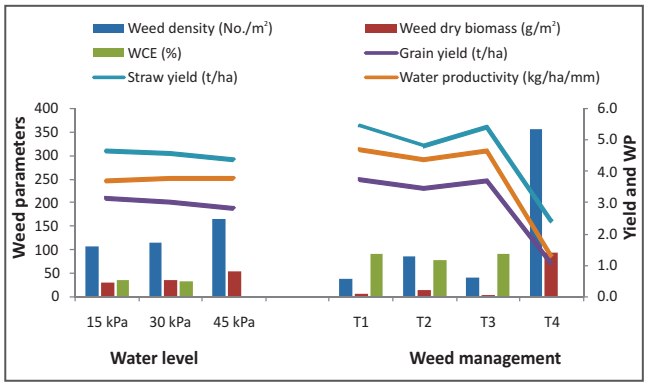


Figure 1.12: Weed parameters, crop and water productivity of direct seed rice influenced by irrigation methods and weed management practices

1.3.3. Effect of drip irrigation levels and weed management practices on vegetables

The present experiment was executed in split-plot design with three replications, where main-plots was assigned to drip irrigation (DI) levels (0.6, 0.8 and 1.0 Epan) and sub-plots have weed management practices [black silver polythene mulch (BSPM), straw mulch (wheat in *Kharif* and rice in *Rabi* at 5 t/ha each), integrated weed management (IWM, pendimethalin *fb*

clodinafop *fb* hand weeding one in *Kharif* and one in *Rabi*) and weedy check]. The experimental field comprised of *Kharif* weeds like *Echinochloa colona, Dinebra retroflexa, Paspaladium flavidum, Alternanthera sessilis, Phasilis minima, Merremia emarginata, Commelina communis*, *Cyperus rotundus* etc. and *Rabi* weeds like *Medicago denticulata, Chenopodium album, Convolvulus arvensis, Lathyrus aphaca, Melilotus indica, Melilotus alba, Rumex dentatus*, *Cyperus rotundus etc.*

Tomato (2020-21)

In *Kharif*, weed density and biomass ranged between 120-142/m^2 and 30-41.3 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 15.7 and 27.3%, respectively over DI at 0.6 Epan. Likewise in *Rabi,* weed density and biomass ranged between 120-153/m^2 and 30.7-41.3 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 21.4 and 25.3%, respectively over DI at 0.6 Epan. Among weed management practices, In *Kharif*, weed density and biomass ranged between 36-298/m^2 and 7.8-92.6 g/m^2, respectively, where BSPM recorded the highest WCE (88.1%) and WCI (91.6%) over a weedy check which had the highest weed values. Similarly, in *Rabi*, weed density and biomass ranged between 60-258/m^2 and 12-81.3 g/m^2, respectively, where BSPM recorded the highest WCE (76.9%) and WCI (84.8%) over a weedy check. Lower weed values and optimum moisture level helped the plants to produce more branches, leaf area, more, longer and heavier fruits led to higher fruit yield by 34.9 t/ha at 1.0 Epan and 42.1 t/ha in BSPM (**Figure 1.13**).

Chilli (2020-21)

In *Kharif*, weed density and biomass ranged between 174-208/m^2 and 48.1-67.5 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 16.5 and 28.7%, respectively over DI at 0.6 Epan. Likewise in *Rabi,* weed density and biomass was ranged between 150-193/m^2 and 45.2-91.7 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 22.2 and 26.7%, respectively over DI at 0.6 Epan. Among weed management practices, in *Kharif*, weed density and biomass ranged between 59-408/m^2 and 15-141.5 g/m^2, respectively, where BSPM recorded the highest WCE (85.6%) and WCI (89.4%) over a weedy check which had the highest weed values. Similarly, in *Rabi*, weed density and biomass ranged between 68-326/m^2 and 17.4-120 g/m^2, respectively, where BSPM recorded the highest WCE (79.1%) and WCI (85.5%) over a weedy check. Lower weed values and optimum moisture level helped the plants to produce more branches, leaf area, more, longer and heavier fruits led to higher fruit yield by 6.5 t/ha in DI at 1.0 Epan and 8.08 t/ha in BSPM followed by IWM (**Figure 1.13**).

Capsicum (2020-21)

In *Kharif*, weed density and biomass ranged between 143-173/m^2 and 38-53.4 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 17.2 and 28.8%, respectively over DI at 0.6 Epan. Likewise in *Rabi,* weed density and biomass ranged between 126-163/m^2 and 35.8-48.7 g/m^2, respectively. The highest weed values obtained in DI at 1.0 Epan by 22.7 and 26.5%, respectively over DI at 0.6 Epan. Among weed management practices, in *Kharif*, weed density and biomass ranged between 42-357/m^2 and 9.8-118 g/m^2, respectively, where BSPM recorded the highest WCE (88.2%) and WCI (91.7%) over a weedy check which had the highest weed values. Similarly, in *Rabi*, weed density and biomass ranged between 52-285/m^2 and 12-98 g/m^2, respectively, where BSPM recorded the highest WCE (81.7%) and WCI (87.8%) over a weedy check. Lower weed values and optimum moisture levels helped the plants to produce higher growth and yield attributes resulted in higher fruit yield by 6.5 t/ha in DI at 1.0 Epan and 8.08 t/ha in BSPM followed by IWM (**Figure 1.13**).

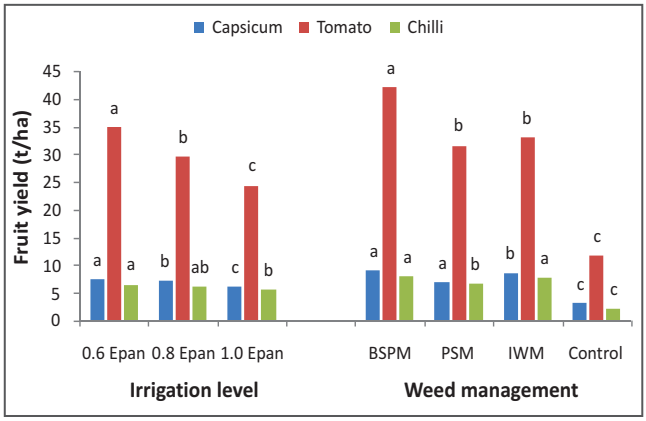


Figure 1.13: Weed parameters, crop and water productivity of vegetables influenced by irrigation methods and weed management practices

1.3.4 Standardization of application timing and varietal evaluation of chickpea against novel herbicide-topramezone (exploratory trial)

Ten chickpea varieties were evaluated against topramezone 20.16 g/ha at two application timing (20 and 30 DAS). It was recorded that application of topramezone at 20.16 g/ha at 20 DAS considerably controlled the weeds and recorded higher weed control over the application at 30 DAS. Some of the varieties (*JG 315, JG 322, JG 63* and *JG 14*) have shown more phytotoxic symptoms to topramezone; however, they gradually started recovering and by 10th days after application many varieties fully recovered and by 14 days after application completely recovered. In general,

30 DAS took more time to get recovered. Irrespective of varieties, seed yield was recorded 1.59 t/ha at 20 DAS which was 17.2% higher than 30 DAS. Among varieties, *JG 14* recorded a seed yield of 1.93 t/ha followed by *JG 16* and *JG 36*. The lowest yield was recorded with JG 11 (**Figure 1.14**).

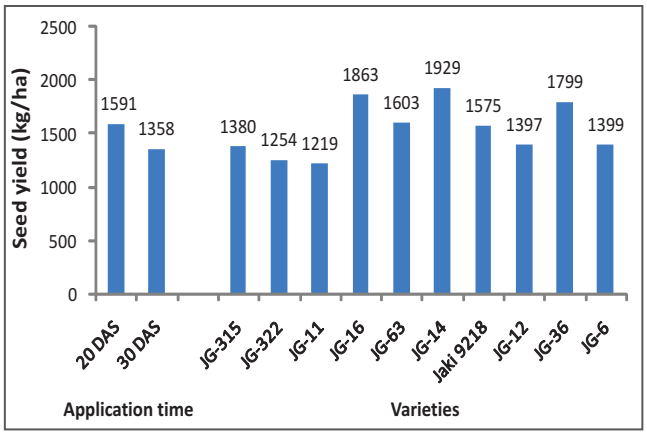


Figure 1.14. Seed yield of chickpea influenced by application timing of topramezone and varieties

1.3.5 Effect of seed rate and weed management practices on weed control, productivity and profitability in direct-seeded rice (exploratory trial)

Study area was comprised with grassy weeds like *Dinebra retroflexa, Echinochloa colona*, Weedy rice, *Brachiaria ramosa* broadleaved weeds such as *Phyllanthus urinaria, Ageratum conyzoides, Ludwigia parviflora, Melacra capitata, Alternanthera sessilis, Commelina communis, Corchorus olitorius, Eclipta alba, Mecardonia procumbens, Merrimia emerginata, Acmela* sp., and *Cyperus iria* was the only sedge present.

Four seed rate (30, 40, 50 and 100 kg/ha) and four weed management practices [pendimethalin 678 g/ha (PE) *fb* bispyribac sodium 25 g/ha (Post), pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* cyhalofop+penoxsulam 135 g/ha (Post), pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* hand weeding at 30 DAS and weedy check] were studied in direct-seeded rice. It was recorded that lower seed rate (30 kg/ha) has higher weed density (57/m^2) and weed biomass (17.7 g/m^2) over higher seed rate (100 kg/ha) (31.1/m^2 and 8.3 g/m^2, respectively). In contrary, higher seed rate has more of ineffective tillers and chaffy grains/panicle. The highest grain yield of rice was recorded with 40 kg/ha (3.97 t/ha) and was comparable to 50 kg/ha. The lowest grain yield recorded with 30 kg/ha (3.51 t/ha). Among weed management practices, pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* hand weeding at 30 DAS recorded with least weed density (15.2/m2) and weed biomass (2.1 g/m2) with higher weed control efficiency (93.7%) which was comparable to pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* cyhalofop+penoxsulam 135 g/ha (Post). Interestingly, pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* cyhalofop+penoxsulam 135 g/ha (Post) recorded the highest grain yield (4.61 t/ha) but was comparable to pretilachlor+pyrazosulfuron 615 g/ha (PE) *fb* hand weeding at 30 DAS (4.54 t/ha) and pendimethalin 678 g/ha (PE) *fb* bispyribac sodium 25 g/ha (Post) was next best treatment (**Figure 1.15**). The weedy check plots had highest weed density (90.2/m^2) and biomass (33.8 g/m^2) and lowest grain yield (2.15 t/ha).

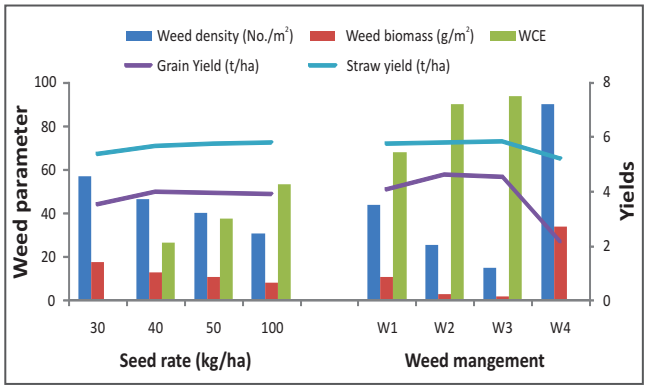


Figure 1.15: Weed control and productivity of direct-seeded rice influenced by seed rate and weed management practices

1.4 Development of precision spraying system and weeding tools

1.4.1 Improvisation of different weeding tools under flat bed crop establishment methods

To improvise the manually operated weeding tools, the existing weeders available at the Directorate such as cycle wheel hoe, hand grubber, nail weeder, twin wheel hoe were selected and were compared with the manual hand weeding under chickpea and wheat crops. A few selected weeders are given below:

Chickpea

A chickpea (crop variety *JG.130*) was selected for the study and sown during the *Rabi* season of 2020-21. The mechanical weeding was executed time to time based on the weed flush appearances. The weed data, crop parameters and physiological load on the operator was recorded and observations were made.

Field evaluations of weeders

The cone index of the soil was measured through soil cone penetrometer before conducting of the weeding operation. It was found field had an that average soil resistance of 1.1 kg/cm^2. It is necessary to estimate the power required by the operator to execute the weeding operations as well as the physiological load imposing on him. Highest weeding efficiency (WE) 97.2% was obtained in hand weeding (HW) followed by hand grubber, twin wheel hoe, cycle hoe and others (**Figure 1.16**). A highest field capacity of 0.02 ha/h was obtained in twin wheel hoe followed by nail weeder, hand grubber and cycle hoe (**Table 1.4**). For seed yield there was no significant difference was observed between the weeders. The highest seed yield of 1.318 t/ha was observed in hand weeding followed by twin wheel hoe. However, because of poor weeding efficiency in nail weeder, a 17.3% reduction in yield was observed (**Figure 1.19**).

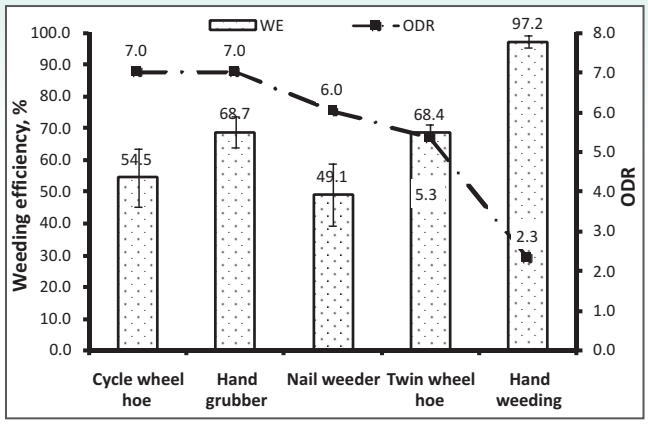


Figure 1.16: Weeding efficiency and overall discomfort rating (ODR) of operator under different weeders

Table 1.4: Field performance of different weeders

Weeder/ method	Weeding efficiency, %	ODR	EFC, ha/h
Cycle wheel hoe	54.5	7.0	0.013
Hand grubber	68.7	7.0	0.015
Nail weeder	49.1	6.0	0.017
Twin wheel hoe	68.4	5.3	0.020
Hand weeding	95.3	2.3	0.009
CV%	10.61	5.7	12.5
LSD (p=0.05)	**13.42**	**0.6**	**0.003**

*EFC: Effective field capacity; ODR: Overall Discomfort Rating

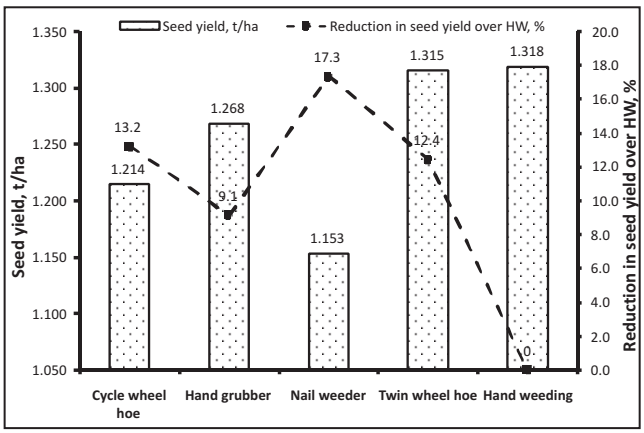


Figure 1.17: Seed yield recorded under different treatments

Wheat

A wheat (crop variety *GW 273*) was selected for the study and sown during the *Rabi* season of 2020-21. The mechanical weeding was executed time to time based on the weed flush appearances. The weed data, crop parameters and physiological load on the operator was recorded and observations were made.

Field evaluations of weeders

The cone index of the soil was measured through soil cone penetrometer before conducting of the weeding operation. It was found that field had an average soil resistance of 1.4 kg/cm^2. The highest weeding efficiency of 94.5% was obtained in hand weeding followed by hand grubber, twin wheel hoe and others. A highest field capacity of 0.021 ha/h was obtained in twin wheel hoe followed by nail weeder, hand grubber and cycle hoe (**Table 1.5**). For grain yield there was no significant difference was observed between the weeders. The highest grain yield of 4.48 t/ha was observed in hand weeding followed by hand grubber, twin wheel hoe and others. However, because of poor weeding efficiency in cycle hoe and nail weeder, a 5.2 to 6.9% reduction in yield was observed.

Table 1.5: Field performance of different weeders

Weeder/ method	Weeding efficiency, %	ODR	EFC, ha/h	Grain yield, t/ha	Reduction in grain yield over HW, %
Cycle wheel hoe	56.1	6.7	0.012	4.17	6.9
Hand grubber	69.6	6.7	0.017	4.46	0.5
Nail weeder	49.5	6.3	0.018	4.25	5.2
Twin wheel hoe	67.6	5.7	0.021	4.42	1.3
Hand weeding	94.5	3.0	0.008	4.48	0.0
CV%	8.15	13.3	13.4	4.78	-
LSD (p=0.05)	**10.36**	**1.4**	**0.004**	**NS**	-

*EFC: Effective field capacity; ODR: Overall Discomfort Rating

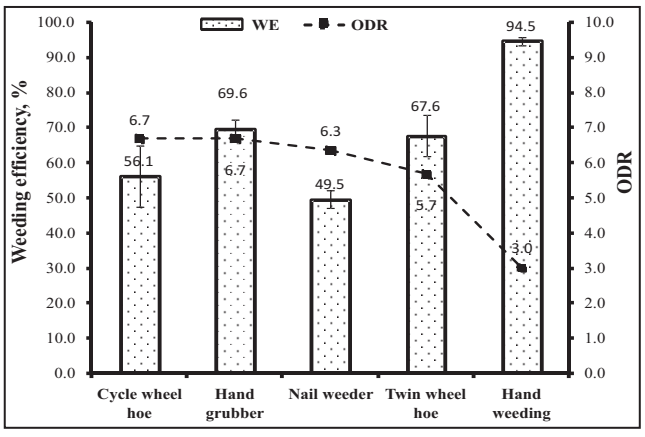


Figure 1.18: Performance of weeder under different treatments

1.4.2 Improvisation of different weeding tools under ridge-furrow based crop establishment methods

To improvise the manually operated weeding tools, the existing weeders available at the Directorate such as brush cutter weeder, cycle wheel hoe, hand grubber, nail weeder, twin wheel hoe were selected and were compared with the manual hand weeding under chickpea and wheat crops. The selected brush cutter weeder is shown below and data recorded are presented below:

Sweet corn

A sweet corn variety (*Sugar 75*) was selected for the study and sown during the Rabi season of 2020-21. The mechanical weeding was executed time to time based on the weed flush appearances The weed data, crop parameters and physiological load on the operator was recorded and following observations were made.

Field evaluations of weeders

The cone index of the soil was measured through soil cone penetrometer before conducting the weeding operation. It was found that field had an average soil resistance of 0.9 kg/cm^2. It was seen that, a highest weeding efficiency of 95.28% was obtained in hand weeding followed by brush cutter weeder, twin wheel hoe, hand grubber and others (**Figure 1.19**). The highest field capacity of 0.063 ha/h was obtained in brush cutter weeder followed by twin wheel hoe and others. For cob yield there was no significant difference was observed between the weeders. The highest cob yield of 18.01 t/ha was observed in hand weeding followed by brush cutter weeder and others.

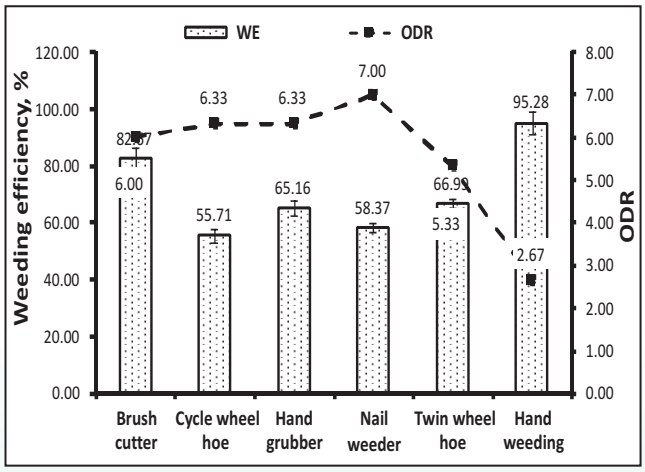


Figure 1.19: Performance of weeder under different treatments

1.5 Design, development and evaluation of drudgery reducing battery operated weeder and double pack weed sprayer for weeding operation in selected crops

1.5.1 Designing and optimizing the operating parameters of the battery operated weeder

A two row battery operated weeder was designed and developed taking into account the ergonomic considerations of the farmer and agronomic considerations of the target crop. Specification of the battery operated weeder is shown in the (**Table 1.8**) and developed prototype is shown in photograph. V type mild steel blades of 5 cm width were used to cut the weeds in inter row region of the crop. Four V type mild steel blades of 5 cm width were set in each row to provide an effective cutting width of 25 cm in each row. 250 watt DC motor coupled with sealed 24 Volt 12.5Ah battery connected to chain and sprocket drive was used as power source to impart rotational motion to circular shaft that carried slotted mild steel flats with triangular steel blades attached at their ends. Provision of depth adjustment of the V type mild steel blades was provided in the machine by the means of adjustable slotted flats attached between the frame and the transport wheels. Sound emanated from the machine components in ambient condition in disengaged and unloaded condition of the steel blades was around 72 db (A) at rotational speed of 200 rpm.

Battery operated weeder

Table 1.8: Specifications of the developed battery operated weeder

Parameter	Specification
Motor	250 Watt DC motor
Battery	24 Volt 12.5 Ah battery
Power transmission	Chain and Sprocket drive (1:1 ratio)
Transport wheels	Rubber type
Frame material	Mild Steel
Bearings	Self aligning bearings
Cutting blade	V shaped Sweep type mild steel blades with 5 cm width of cut
Weeding depth	2-3 cm
Working width	2 inter row regions of 25 cm width each
Noise (unloaded condition)	72 dB(A)
Main shaft rotational Speed	200-300 rpm
Total weight	60 kg

***

2. Weed Biology and Crop-weed Interference under Present and Changing Climate Scenario

It has been predicted that the global surface temperature may rise by 1.5ºC by the end of the 21st century, and the concentration of atmospheric carbon dioxide (CO_2) may exceed 560 ppm by 2050. Elevated temperatures and CO_2 levels are forecasted to impact agricultural production. The growth of both crops and weeds is likely to be affected by elevated CO_2 and temperature, often favoring the crop, sometimes the weeds. In some regions, crop yields will decrease due to increased temperatures and CO_2 or sustained drought times, while weed competition will further increase and crop yield decline. Therefore, an adaptive approach will be required not only to mitigate the negative effects of climate change, but also to improve crop competitiveness against weeds. Weeds are commonly referred to as plants that interfere with crop growth, yield and development. At present, weed control practices account for a substantial proportion of the total operational cost. In weed control, identification of crop characteristics that play a role in the ability to compete with weeds is important. CO_2 level increase in the atmosphere also causes changes in ambient temperature. It is therefore important to study the effects of increased CO_2 and temperature on crop-weed interaction. The information that allows the estimation of the relative strengths and limitations of both crops and weeds under varying climate change conditions is limiting. Therefore, this programme aims to cover this knowledge gap and explore complex interactions between crops and weeds under various climate change scenarios aiming to facilitate decision-making processes toward sustainable crop production systems.

Abiotic stresses like high or low temperature, high salinity, deficient or excessive water, heavy metals, and ultraviolet radiation are hostile to crop growth and development leading to huge crop yield losses worldwide. Weeds can be an invaluable genetic resource for providing tolerance to these abiotic stresses. A herbicide-resistant weed is a weed species that has developed the ability to survive application of a herbicide which previously controlled it. The intensive and continuous use of the same herbicide(s) over the years has resulted in the evolution of herbicide-resistant weeds. The change in the resistant weeds is generally in the form of a mutation or change in plant metabolism that confers resistance to a particular herbicide or a group of herbicides having the same mode of action. Therefore, understanding the evolution of resistance in weeds can be useful for designing future management strategies.

Alien invasive species cause irretrievable harm to biodiversity around the world by displacing native and useful species and changing ecosystems. Biological control of weeds is one of the eco-friendly alternatives to chemical herbicides and involves deliberate use of target-specific insects, pathogens *etc.*, to reduce the economic losses caused by terrestrial and aquatic weeds. These biocontrol agents infest weed plants and either reduce their growth or kill them. It is estimated that the efficacy of bioagents may be reduced or increased under climate change. Therefore, it is desirable to know the effects of climate change on the biology and efficacy of the bioagent.

Programme Leader: Dr. Sushilkumar

Project	Experiment	Associate
2.1 De novo transcriptome analysis of *Parthenium hysterophorus* L. in response to drought/salinity stress and in young flower buds and studies on understanding the molecular basis of herbicide resistance **Principal Investigator: Pawar Deepak**	2.1.1 Comparative assessment of RNA extraction methods and modification to isolate high quality RNA from *Parthenium hysterophorus* L. flower buds	Dasari Sreekanth Shobha Sondhia
	2.1.2 Comparative assessment of RNA extraction methods and modification to isolate high quality RNA from *Parthenium hysterophorus* L. root tissues	Dasari Sreekanth Shobha Sondhia

Project	Experiment	Associates
	2.1.3 Estimation of oxidative stress, antioxidant enzymes and non-enzymatic antioxidants under salinity and drought stress in *Parthenium hysterophorus*	Dasari Sreekanth Shobha Sondhia
2.2 Studies on crop weed interaction under present and changing climate scenario **Principal Investigator:** **Dasari Sreekanth**	2.2.1 Effect of elevated CO_2 on herbicide efficacy and crop-weed interaction in rice	Pawar Deepak Shobha Sondhia

2.1 De novo transcriptome analysis of *Parthenium hysterophorus* L. in response to drought/salinity stress and in young flower buds and studies on understanding the molecular basis of herbicide resistance

2.1.1 Comparative assessment of RNA Extraction methods and modification to isolate high quality RNA from *Parthenium hysterophorus* L. flower buds

Parthenium hysterophorus is one of the most invasive weeds creating a threat to our natural ecosystem and agricultural crops around the world. The first step in devising biotechnological measures for controlling such weeds is to understand the flower developmental biology and identify and characterize genes and gene regulatory networks governing gametes formation using various functional genomics tools. The next step is development of conditional mutants like temperature sensitive male sterile mutants and gene silencing mutants using various gene editing tools. To conduct such studies, functional genomics of flower buds for understanding flower developmental biology and gamete formation is necessary. For this RNA isolation is the preliminary step. However, so far there is no protocol standardized for RNA isolation from *P. hysterophorus* flower buds.

The *P. hysterophorus* were sterilized by treating with 0.1 % $HgCl_2$ for 10 min followed by washing with water several times to remove excess chemicals and dried to eliminate fungal attack. Plastic pots (6"X6") filled with the mixture of SoilriteR (300 g/pot) and used to germinate the *Parthenium* seeds and young flower buds were collected from four to six-weeks old plants. The collected young flower buds were washed with sterile diethyl pyrocarbon (DEPC, Sigma, USA) treated water, blotted on tissue paper, immediately frozen in liquid nitrogen and then stored in an ultra-low temperature freezer at -80 ºC to prevent any kind of enzymatic activity.

Seven RNA isolation methods (Acid guanidium thiocyanate phenol chloroform extraction method, Phenol Li-Cl precipitation method, TRIzol method, Gasic *et al*., 2004 method, Phenol-SDS method, LiCl -SDS method, PVP ethanol precipitation method) and two commercial kits (GeNeiTM plant RNA isolation and RNeasyR Quigen) were compared for quantity as well as the quality of the isolated RNA. Among these methods, Acid guanidium thiocyanate phenol chloroform extraction method, Phenol Li-Cl precipitation method, TRIzol method, Gasic *et al.,* 2004 mthod, Phenol-SDS method, and LiCl -SDS method failed in giving good quality and quality RNA. The commercial kits of RNA isolation were found to be unsatisfactory in giving good quantity and quality RNA. The PVP ethanol precipitation method comparatively gave a good quantity of RNA but with contaminants as indicated by the $A_{260/A280}$ and $A_{260/A230}$ OD values. Therefore, we further modified the PVP ethanol precipitation method for obtaining good quality RNA. The modifications were mainly done in the extraction buffer components, duration of the absolute ethanol precipitation and the tissue: buffer ratio. Among the modified protocols,

modified PVP ethanol precipitation method-4 proved to be efficient for the extraction of improved quality of RNA from the flower buds of *P. hysterophorus*. Sharp intensity and clear resolution of RNA bands on agarose gel, with good quantity (977.60 ng/µL), and absorbance ratio ($A_{260/A280}$= 2.036 and $A_{A260/A230}$= 2.043 for RNA) signifies its superiority over the existing protocols. Therefore, modified PVP ethanol precipitation method-4 can be used for isolating RNA from the flower bud tissues containing high amounts of allelochemicals and the isolated RNA can also be used for downstream molecular biology applications.

The mean ± SE (n=5) concentration of RNA (ng/µL) isolated by using different protocols was compared. Each replication data involves three biological replicates. The data was represented as an average of replicates and the values of mean±SE were used for Duncan's test. Among all the protocols the modified PVP ethanol precipitation method protocol 4 was found to be best and statistically significant, for concentration of RNA (ng/µL), $OD_{A260/A280}$ and $OD_{A260/A230}$ (**Table 2.1, 2.2 and 2.3**).

Table 2.1: Mean±SE (n = 5) concentration of RNA (ng/µl) isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean±SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test.

Sr.No.	Method	Replication 1	Replication 2	Replication 3
1	Guanidium thiocyanate phenol chloroform extraction method	446.33 ±14.33^{f}	454.057±14.13^{efg}	407.62±5.95^{e}
2	Phenol Li-Cl precipitation method	530.12±17.24^{de}	520.37±3.85^{d}	480.73±9.32^{c}
3	TRIzol method	447.31±15.08^{f}	430.76±2.85^{g}	436.10±14.87^{de}
4	Gasic *et al.*, protocol	483.82±40.23^{ef}	513.01±14.34^{de}	441.83±6.21^{cde}
5	Phenol-SDS method	469.69±12.16^{f}	444.95±11.70^{fg}	412±10.06^{e}
6	LiCl -SDS	542.33±13.02^{d}	497.62±31.71^{def}	466.17±8.82^{cd}
7	GeNei™ plant RNA isolation kit	352.41±17.29^{g}	397.54±27.60^{g}	333.63±25.86^{f}
8	RNeasy® Quigen kit	359.73±8.92^{g}	328.96±10.81^{h}	343.95±10.60^{f}
9	PVP ethanol precipitation method	656.66±15.07^{c}	682.77±37.47^{c}	766.29±20.69^{b}
10	Modified PVP ethanol precipitation method-1	653.51±1.11^{c}	641.58±22.92^{c}	749.04±3.61^{b}
11	Modified PVP ethanol precipitation method-2	754.44±18.60^{b}	745.75±26.60^{a}	745.13±21.61^{b}
12	Modified PVP ethanol precipitation method-3	749.33±7.71^{b}	744.36±9.08^{b}	743.07±14.12^{b}
13	**Modified PVP ethanol precipitation method-4**	**974.99±15.31^{a}**	**966.44±9.02^{a}**	**991.36±3.71^{a}**

Table 2.2: Mean±SE (n = 5) A260/A280 optical density (OD) values of RNA isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean ± SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test.

Sr.No.	Method	Replication 1	Replication 2	Replication 3
1	Guanidium thiocyanate phenolchloroform extraction method	e 1.74±0.0120	e 1.68±0.0348	d 1.72±0.006
2	Phenol Li-Cl precipitation method	f 1.61±0.0463	e 1.64±0.0318	e 1.57±0.0410
3	TRIzol method	g 1.42±0.0371	f 1.40±0.0240	f 1.43±0.01
4	Gasic *et al.*, protocol	e 1.76±0.0145	d 1.75±0.0233	d 1.72±0.0351
5	Phenol-SDS method	e 1.79±0.0088	e 1.64±0.0251	c 1.81±0.0120
6	LiCl -SDS	e 1.83±0.0338	c 1.85±0.0120	cd 1.76±0.0145
7	GeNei™ plant RNA isolation kit	f 1.58±0.0371	e 1.65±0.0120	e 1.61±0.0115
8	RNeasy® Quigen kit	e 1.75±0.0208	e 1.68±0.0033	cd 1.76±0.0176
9	PVP ethanol precipitation method	e 1.78±0.0467	d 1.75±0.0088	cd 1.76±0.0145
10	Modified PVP ethanol precipitation method-1	d 1.91±0.0120	b 1.92±0.0240	b 1.92±0.0203
11	Modified PVP ethanol precipitation method-2	d 1.92±0.0306	b 1.91±0.0120	b 1.91±0.0145
12	Modified PVP ethanol precipitation method-3	d 1.94±0.0067	b 1.93±0.0273	b 1.94±0.0058
13	**Modified PVP ethanolprecipitationmethod-4**	**c 2.03±0.0306**	**a 2.01±0.0120**	**a 2.07±0.0186**

Table 2.3: Mean±SE (n=5) A260/A230 optical density (OD) values of RNA isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean ± SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test.

Sr.No.	Method	Replication 1	Replication 2	Replication 3
1	Guanidium thiocyanate phenolchloroform extraction method	h 1.73±0.0219	g 1.65±0.0203	f 1.73±0.0120
2	Phenol Li-Cl precipitation method	i 1.59±0.0120	g 1.64±0.0088	g 1.58±0.0088
3	TRIzol method	j 1.48±0.0290	h 1.52±0.0058	g 1.60±0.0067
4	Gasic *et al.*, protocol	ef 1.86±0.0153	ef 1.85±0.0088	e 1.79±0.0088
5	Phenol-SDS method	cde 1.91±0.0088	de 1.88±0.0058	c 1.92±0.0033
6	LiCl -SDS	de 1.90±0.0153	cd 1.91±0.0088	c 1.92±0.0033
7	GeNei™ plant RNA isolation kit	g 1.79±0.0233	def 1.87±0.0120	e 1.77±0.0088
8	RNeasy® Quigen kit	k 1.33±0.0088	i 1.40±0.0186	h 1.36±0.0067
9	PVP ethanol precipitation method	fg 1.83±0.0115	f 1.84±0.0153	d 1.87±0.0145
10	Modified PVP ethanol precipitation method-1	bcd 1.95±0.0115	bc 1.94±0.0133	c 1.94±0.0088
11	Modified PVP ethanol precipitation method-2	bc 1.95±0.0203	bc 1.93±0.0067	bc 1.95±0.0208
12	Modified PVP ethanol precipitation method-3	b 1.97±0.0088	b 1.97±0.006	b 1.98±0.0058
13	**Modified PVP ethanol precipitation method-4**	**a 2.06±0.0176**	**a 2.02±0.0167**	**a 2.05±0.0233**

The total RNA isolated by using modified 'PVP ethanol precipitation method protocol 4' was used as a template in the present amplification reaction to synthesize the cDNA. Sufficient quantity of cDNA was produced by reverse transcription and further confirmed by good amplification of the target sequence. In the present study, amplification of '*Elongation initiation factor 1α* (*EIF1α*)' housekeeping gene (**Figure 2.1**).

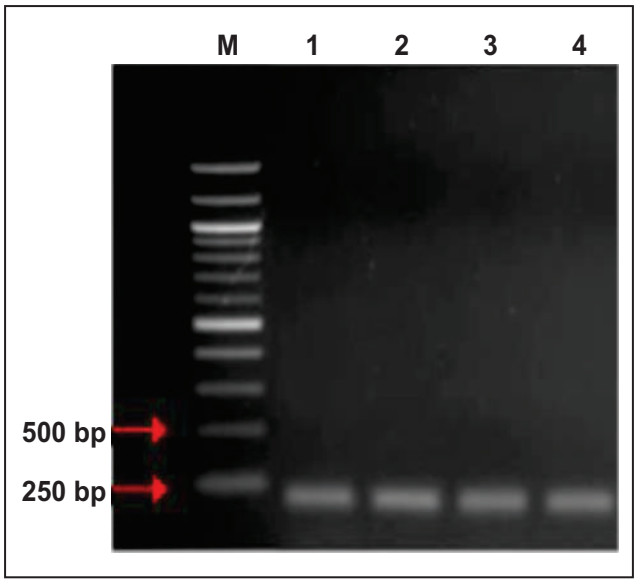


Figure: 2.1: Agarose gel electrophoresis of RT-PCR product of endogenous gene *EIF1α*. Lane 1-1 kb marker, 2-5: RT-PCR with flower bud RNA samples

2.1.2 Comparative assessment of RNA Extraction methods and modification to isolate high quality RNA from *Parthenium hysterophorus* L. root tissues

P. hysterophorus can grow in diverse environments and shows tolerance towards various abiotic stresses due to expression of the stress responsive proteins and anti-stress genes. Plant roots are the primarily organ involved in the abiotic stress sensing, *P. hysterophorus* can be used as model plant to study the molecular and physiological mechanisms of stress tolerance. High quality of RNA is essential for carrying out in various downstream molecular biology experiments. However, isolating high quality RNA from plant tissues, with enough quality and quantity may be challenging, mainly due to their biochemical composition that can obstruct or even prevent the RNA extraction.

The *P. hysterophorus* seeds were sterilized by treating with 0.1 % $HgCl_2$ for 10 min followed by washing with water several times to remove excess of chemical and dried to eliminate fungal attack. Plastic pots (6"X6") filled with the mixture of SoilriteR (300 g/pot) were used to germinate the Parthenium seeds. Root tissues were collected from four to six-week old plants.

To standaridize the RNA isolation from root tissues of *P. hysterophorus*, sixteen RNA isolation methods (Acid guanidium thiocyanate phenol chloroform extraction method, Phenol Li-Cl precipitation method, CTAB-1 method, CTAB-2 method, TRIzol Method, Phenol- SDS method, Gasic et al., 2004 method, LiCl-SDS method, and two commercial kits GeNei™ Plant RNA Isolation and RNeasy® Quigen, Patel *et al*. 2016 method, Xu *et al*. 2016, Zaman *et al*. 2016, Sajeevan *et al*. 2014, Gasic *et al*. 2014, Kumar *et al* 2018 and PVP ethanol method) were compared for quantity as well as the quality of the isolated RNA. Among these methods, acid guanidium thiocyanate phenol chloroform extraction method, Phenol Li-Cl precipitation method, TRIzol method, Gasic *et al*., 2004 method, Phenol-SDS method, and LiCl -SDS method failed in giving good quality and quality RNA. The commercial kits of RNA isolation were also found to be unsatisfactory in giving good quantity and quality RNA.

The PVP-ethanol precipitation method comparatively gave good quantity of RNA but with contaminants as indicated by the $A_{260/A280}$ and $A2_{60/A230}$ OD values. Therefore, we further modified the PVP-ethanol precipitation method for obtaining good quality RNA. The modifications were mainly done in the extraction buffer components, duration of the absolute ethanol precipitation and the tissue: buffer ratio. Among the modified protocols modified PVP-ethanol precipitation method proved to be efficient for the extraction of improved quality of RNA from the root tissues of *P. hysterophorus*. Sharp intensity and clear resolution of RNA bands on agarose gel, with good quantity (974.26 ng/µL), and absorbance ratio ($A_{260/A280}$=2.02 and $A_{260/230}$= 2.05 for RNA) signifies its superiority over the existing protocols (**Table 2.4, 2.5 and 2.6**).

Table 2.4: Mean±SE (n = 5) concentration of RNA (ng/µl) isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean±SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test.

Sr. No.	Method	Replication 1	Replication 2	Replication 3
1	Acid guanidium thiocyanate-phenol-chloroform extraction method	436.66±3.50^{f}	447.73±1.46^{fg}	431.62±5.70^{f}
2	Phenol Li-Cl precipitation method	467.12±2.67^{e}	420.37±3.85^{g}	474.06±5.73^{e}
3	CTAB 1 method	366.85±7.20^{g}	353.70±2.91^{h}	347.40±8.90^{hi}
4	CTAB 2 method	430.13±17.13^{f}	420.31±3.67^{g}	480.81±9.37^{e}
5	TRIzolmethod	433.97±10.63^{f}	460.72±2.97^{f}	452.89±6.34^{ef}
6	Phenol-SDS method	329.72±3.24^{h}	344.93±9.09^{h}	382.36±5.39^{g}
7	LiCl-SDS method	459.65±3.33^{ef}	433.93±9.20^{fg}	452.85±6.22^{ef}
8	GeNei™ plant RNA isolation kit	231.08±7.14^{i}	264.20±6.71^{i}	233.63±25.86^{k}
9	RNeasy®Quigen kit	259.73±8.92^{i}	228.96±10.81^{j}	243.95±10.60^{k}
10	Patel et al., 2016 method	230.12±17.24^{i}	220.37±3.85^{j}	280.73±9.32^{j}
11	Xu et al., 2009 method	230.15±17.22^{i}	220.39±3.85^{j}	280.75±9.32^{j}
12	Zaman et al., 2016 method	430.14±17.23^{f}	420.36±3.85^{g}	480.73±9.32^{e}
13	Sajeevan et al., 2014 method	360.12±2.12^{g}	330.37±3.85^{h}	367.40±4.48^{gh}
14	Gasic et al. 2004 method	550.46±12.14^{d}	546.28±19.02^{e}	542.01±6.34^{d}
15	Kumar et al., 2018 method	349.99±6.38^{gh}	352.77±6.64^{h}	332.96±6.91^{i}
16	PVP-ethanol precipitation method	656.66±15.03^{c}	682.77±37.50^{c}	666.32±20.71^{c}
17	Modified PVP-ethanol precipitation method-1	753.51±1.11^{b}	641.58±22.92^{d}	749.04±3.61^{b}
18	Modified PVP-ethanol precipitation method-2	771.11±5.14^{b}	759.09±1.81^{b}	751.79±1.82^{b}
19	Modified PVP-ethanol precipitation method-3	749.33±7.71^{b}	744.36±9.08^{b}	743.07±14.12^{b}
20	**Modified PVP-ethanol precipitation method-4**	**961.66±3.26^{a}**	**983.11±6.18^{a}**	**978.01±5.12^{a}**

Table 2.5: Mean±SE (n = 5) A260/A280 optical density (OD) values of RNA isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean ± SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test

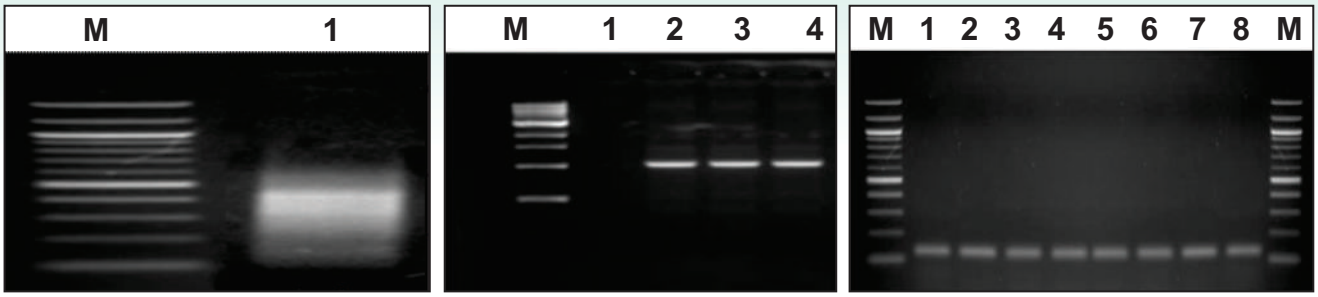
Sr. No.	Method	Replication 1	Replication 2	Replicaion 3
1	Acid guanidium thiocyanate-phenol-chloroform extraction method	1.47±0.03^{j}	1.44±0.05^{l}	1.46±0.03^{i}
2	Phenol Li-Cl precipitation method	1.65±0.02^{gh}	1.68±0.00^{ghi}	1.64±0.02^{gh}
3	CTAB 1 method	1.65±0.02^{h}	1.66±0.01^{hij}	1.68±0.02^{efg}
4	CTAB 2 method	1.61±0.03^{hi}	1.61±0.04^{ijk}	1.58±0.03^{h}
5	TRIzolmethod	1.67±0.01^{fgh}	1.77±0.01^{cde}	1.63±0.01^{gh}
6	Phenol-SDS method	1.79±0.03^{bcde}	1.64±0.01^{hij}	1.81±0.04^{bc}
7	LiCl-SDS method	1.81±0.03^{bcd}	1.82±0.00^{bc}	1.75±0.01^{cde}
8	GeNei™ plant RNA isolation kit	1.73±0.02^{efg}	1.70±0.02^{fgh}	1.66±0.02^{fg}
9	RNeasy®Quigen kit	1.73±0.01^{ef}	1.73±0.01^{efg}	1.77±0.01^{bcd}
10	Patel *et al.*, 2016 method	1.62±0.04^{hi}	1.61±0.03^{jk}	1.58±0.03^{h}
11	Xu *et al.*, 2009 method	1.55±0.02^{i}	1.58±0.00^{k}	1.57±0.04^{h}
12	Zaman *et al.*, 2016 method	1.73±0.00^{efg}	1.78±0.00^{cde}	1.81±0.03^{bc}

Sr. No.	Method	Replication 1	Replication 2	Replicaion 3
13	Sajeevan *et al.*, 2014 method	1.61±0.04^{hi}	1.62±0.04^{ijk}	1.58±0.03^{h}
14	Gasic *et al.* 2004 method	1.74±0.01^{def}	1.74±0.01^{efg}	1.69±0.03^{efg}
15	Kumar *et al.*, 2018 method	1.78±0.01^{cde}	1.75±0.01^{def}	1.75±0.01^{cde}
16	PVP-ethanol precipitation method	1.72±0.03^{efg}	1.74±0.01^{efg}	1.73±0.01^{def}
17	Modified PVP-ethanol precipitation method-1	1.83±0.01^{bc}	1.81±0.01^{bcd}	1.82±0.01^{bc}
18	Modified PVP-ethanol precipitation method-2	1.87±0.01^{b}	1.82±0.02^{bc}	1.82±0.02^{bc}
19	Modified PVP-ethanol precipitation method-3	1.84±0.01^{bc}	1.86±0.03^{b}	1.84±0.01^{b}
20	**Modified PVP-ethanol precipitation method-4**	**2.01±0.01^{a}**	**2.00±0.01^{a}**	**2.05±0.01^{a}**

Table 2.6: Mean±SE (n = 5) A260/A230 optical density (OD) values of RNA isolated by using different protocols. Each triplicate involves three biological replicates. Data represent an average of replicates and the values given are mean ± SE. Mean followed by the same alphabet in a column is not significantly different at P = 0.05 level in Duncan's test.

Sr. No.	Method	Replication 1	Replication 2	Replication 3
1	Acid guanidium thiocyanate-phenol-chloroform extraction method	1.74±0.03^{cdef}	1.74±0.03^{ef}	1.76±0.01^{gh}
2	Phenol Li-Cl precipitation method	1.72±0.03^{g}	1.70±0.03^{fg}	1.71±0.03^{i}
3	CTAB 1 method	1.82±0.01^{bcd}	1.82±0.01^{d}	1.84±0.02^{de}
4	CTAB 2 method	1.59±0.01^{efg}	1.64±0.01^{gh}	1.58±0.01^{k}
5	TRIzolmethod	1.75±0.02^{bcdef}	1.69±0.03^{fg}	1.65±0.02^{j}
6	Phenol-SDS method	1.91±0.03^{abc}	1.83±0.01^{d}	1.93±0.02^{d}
7	LiCl-SDS method	1.85±0.00^{bcd}	1.84±0.02^{d}	1.82±0.01^{ef}
8	GeNei™ plant RNA isolation kit	1.85±0.01^{bcd}	1.85±0.00^{d}	1.83±0.03^{def}
9	RNeasy®Quigen kit	1.77±0.03^{bcde}	1.76±0.05^{e}	1.72±0.04^{hi}
10	Patel *et al.* 2016 method	1.70±0.03^{def}	1.74±0.01^{ef}	1.68±0.01^{ij}
11	Xu *et al.*2009 method	1.56±0.04^{fg}	1.63±0.00^{h}	1.56±0.02^{k}
12	Zaman *et al.*2016 method	1.82±0.08^{bcd}	1.84±0.01^{d}	1.88±0.01^{de}
13	Sajeevan *et al.* 2014 method	1.75±0.01^{bcdef}	1.74±0.01^{ef}	1.78±0.01^{fg}
14	Gasic *et al.* 2004 method	1.81±0.01^{bcd}	1.83±0.02^{d}	1.84±0.01^{de}
15	Kumar *et al.*2018 method	1.83±0.01^{bcd}	1.84±0.02^{d}	1.87±0.01^{de}
16	PVP-ethanol precipitation method	1.83±0.01^{bcd}	1.83±0.01^{d}	1.84±0.01^{de}
17	Modified PVP-ethanol precipitation method-1	1.87±0.01^{bcd}	1.84±0.01^{d}	1.85±0.00^{de}
18	Modified PVP-ethanol precipitation method-2	1.95±0.02^{ab}	1.93±0.01^{c}	1.95±0.02^{c}
19	Modified PVP-ethanol precipitation method-3	1.93±0.02^{abc}	1.92±0.01^{c}	1.94±0.01^{c}
20	**Modified PVP-ethanol precipitation method-4**	**2.08±0.01^{a}**	**2.02±0.01^{b}**	**2.05±0.00^{b}**

The total RNA isolated by using modified 'PVP-ethanol precipitation method' was used as a template in the present amplification reaction to synthesize the cDNA. Sufficient quantity of cDNA was produced by reverse transcription **(Figure 2.2a)** and further confirmed by good amplification of the target gene '*Elongation initiation factor 1α* (*EIF1α*)' housekeeping **(Figure 2.2b)** gene and *Acetolactate synthase* (*ALS*) gene expression **(Figure 2.2c)**. Therefore, 'modified PVP-ethanol precipitation method' can be used for isolating RNA from the root tissues and the isolated RNA can also be used for downstream molecular biology applications.



(a) (b) (c)

Figure 2.2: Validation of the modified RNA isolation protocol by RT-PCR. (a) Agarose gel stained with ethidium bromide showing first strand cDNA after RT-PCR reaction, (b) Agarose gel electrophoresis of RT-PCR product of endogenous gene EIF1 α. Lane 1- 1 kb marker, 2-5: RT-PCR with root tissues RNA samples, (c) Agarose gel electrophoresis of RT-PCR product of ALS gene, Lane 1- 1 kb marker, 1-8: RT-PCR with root tissues RNA samples

2.1.3 Estimation of oxidative stress, antioxidant enzymes and non-enzymatic antioxidants under salinity and drought stress in *Parthenium hysterophorus*

P. hysterophorus Seeds were sterilized with 0.1 % $HgCl_2$ for 10 min, and then washed several times using double distilled water. The pots (6"X6") filled with mixture of Soilrite^R (300 g/pot) were used to germinate 8±10 seeds per pot followed by further growth for 30 days in net house. Drought was imposed by treating the plants for ten days with 10% PEG 6000 prepared in nutrient media. For treatment of salinity, plants were exposed for ten days to 150 mM of NaCl solution prepared in nutrient media.

The level of oxidative damage in terms of peroxidation degradation products in the leaf was measured by the method of Heath and Packer, 1968. The thiobarbituric acid reactive substances (TBARS) were estimated as indicator of magnitude of oxidative damage. Content of H_2O_2 was estimated by the method of Yu *et al.,* 2003. Extraction of antioxidant enzymes and analysis was also carried out. Superoxide dismutase (SOD) assay was performed by the method of Dhindsa *et al.,* 1981. Ascorbate peroxidase (APX) assay was performed as modified by Qureshi *et al.*, 2007. Glutathione reductase (GR) activity was assayed by the method of Foyer and Halliwell, 1976. Catalase (CAT) assay was performed by the method of Aebi, 1984. Glutathione-S-transferase (GST) activity was assayed by the method of Habig, 1976 using 1-chloro-2,4-dinitrobenzene (CDNB) as a substrate. Non enzymatic antioxidants were also assayed. Ascorbate was estimated by the method of Law et al., 1983. Glutathione content was estimated by the glutathione recycling method of Anderson *et al.,* 1985 which measures total glutathione (GSH+GSSG) through a reaction catalysed by glutathione reductase (GR). Proline content in leaf samples was estimated by the method of Bates *et al.,* 1973 using ninhydrin reagent.

Magnitude of oxidative stress was increased by both drought and salinity in *P. hysterophorus*. As compared to control plants (2.56 nmolg^{-1} FW), TBARS were higher under drought (4.43 nmolg^{-1} FW) and salinity (4.15 nmolg^{-1} FW) (**Figure 2.3a**). The H_2O_2 content also increased in both drought and salt stressed plant. H_2O_2 content under drought (2.14 nmolg^{-1} FW) and salinity (1.96 nmolg^{-1} FW) was higher as compared to the control plants (1.45 nmolg^{-1} FW) **(Figure 2.3b)**.

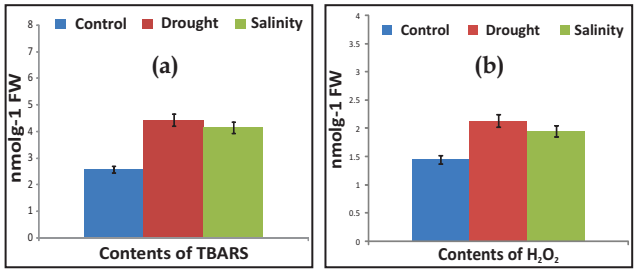


Figure 2.3: Impact of drought and salinity on con-tents of TBARS (A) and H_2O_2 (B) in leaf of *P. hysterophorus.*

Both drought and salinity modulated the activities of antioxidant enzymes (SOD, APX, GR, CAT and GST) in *P. hysterophorus*. As compared to control (18.45 nmolg^{-1} FW), activities of SOD were found to be increased under drought (32.53 nmolg^{-1} FW) and salinity stress (31.24 nmolg^{-1} FW) (**Figure 2.4a)**. Similarly, as compared to control (41.62 nmolg^{-1} FW), activities of APX were found to be increased under drought (65.34 nmolg^{-1} FW) and salinity stress (58.23 nmolg^{-1} FW) (**Figure 2.4b)**. Increased activity of GR was observed under drought (2.13 nmolg^{-1} FW) and salinity stress (1.52 nmolg^{-1} FW) as compared to the control plants (20.36 nmolg^{-1} FW) (**Figure 2.4c)**. Increased activity of CAT was observed under drought (590.21 nmolg^{-1} FW) and salinity stress (540.68 nmolg^{-1} FW) as compared to the control plants (410.26 nmolg^{-1} FW)

(**Figure 2.4d**). Increased activity of GST was observed under drought (2.84 nmolg^{-1} FW) and salinity stress (2.62 nmolg^{-1} FW) as compared to the control plants (1.63 nmolg^{-1} FW) (**Figure 2.4e**).

Levels of non-enzymatic antioxidants including glutathione and ascorbate were also found increased under both drought and salinity. Increased total ascorbate (AsA+DHA) content was observed under drought (650.59 nmolg^{-1} FW) and salinity stress (563.78 nmolg^{-1} FW) as compared to the control plants (370.12 nmolg^{-1} FW) (**Figure 2.4f**). Similarly, increased total glutathione (GSH+GSSG) content was observed under drought (970.72 nmolg^{-1} FW) and salinity stress (840.14 nmolg^{-1} FW) as compared to the control plants (475.34 nmolg^{-1} FW) (**Figure 2.4g**). Increased accumulation of proline was also observed both drought (52.74 nmolg^{-1} FW) and salinity (43.32 nmolg^{-1} FW) as compared to the control (23.25 nmolg^{-1} FW) (**Figure 2.4h**). *P. hysterophorus* showed a good correlation between the enzymatic antioxidant activities and non-enzymatic antioxidant levels which are interdependent for restoring the corresponding pools in stressed cells. Therefore, it can be well inferred that the antioxidative system in *P. hysterophorus* is well established and modulates efficiently to survive drought and salt stress (**Figure 2.4 A-h).** Changes in activities of SOD (A), APX (B), GR (C) CAT (D) GST (E) enzymes and total ascorbate content (F), total glutathione content (G) and proline content (H) in P. hysterophorus leaves under drought and salinity stress

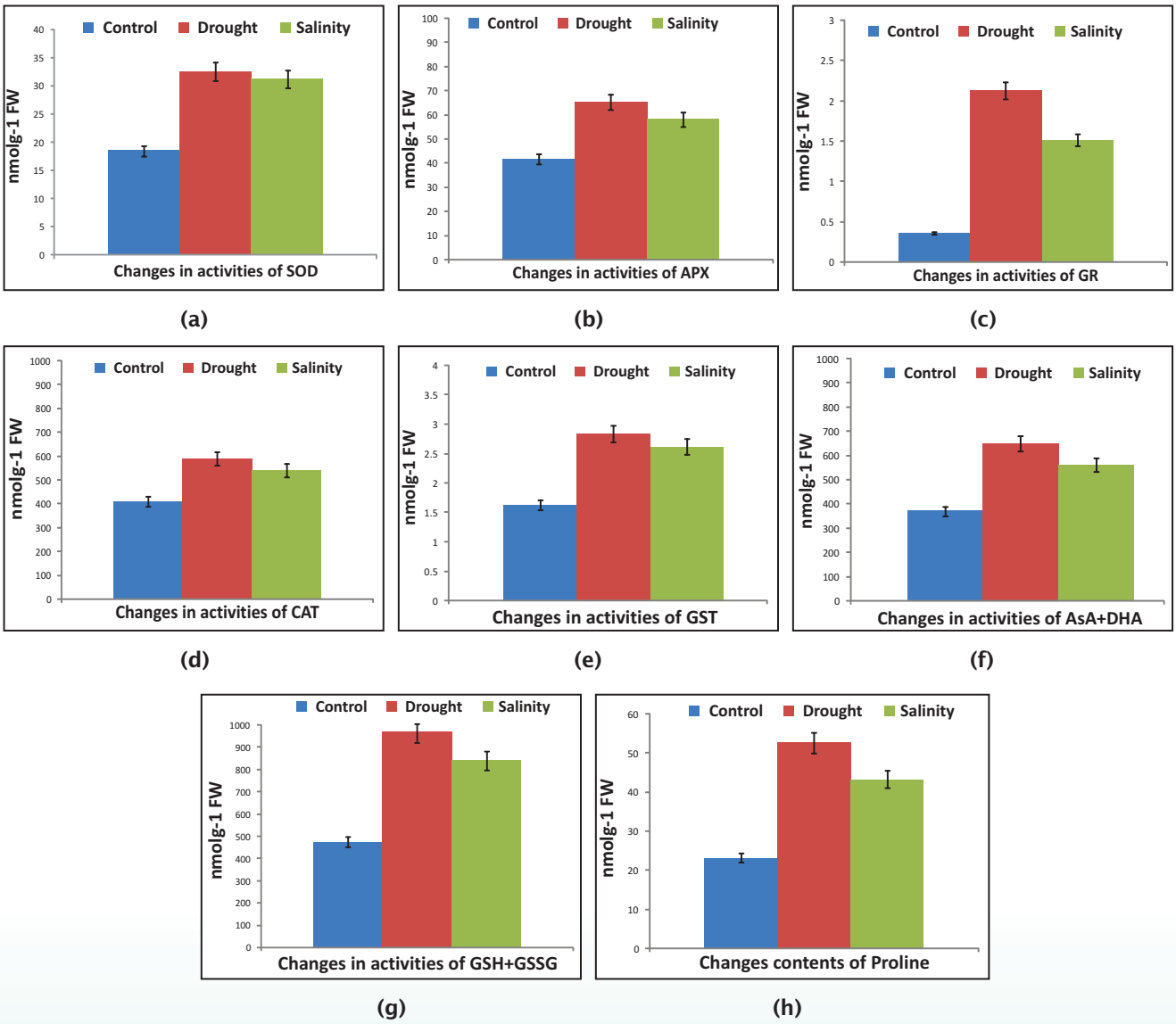
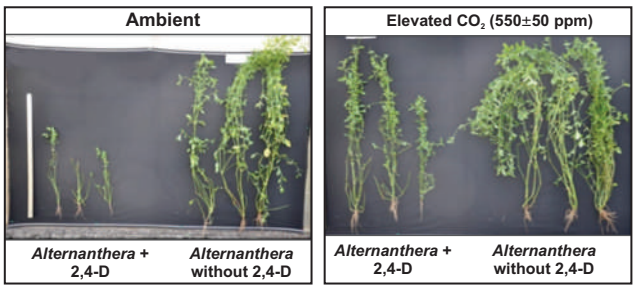


Figure 2.4: Effect of drought and salinity modulated the activities of antioxidant enzymes (SOD, APX, GR, CAT and GST) in *P. hysterophorus*.

2.2 Studies on crop weed interaction under present and changing climate scenario

2.2.1 Effect of elevated CO_2 on herbicide efficacy and crop-weed interaction in rice

An experiment was conducted in *Kharif*-2021 on herbicide efficacy and crop-weed interaction using 2,4-D herbicide on rice and *Alternanthera paronychioides* under CO_2 enriched environments (550±50 ppm) in FACE facility. The results indicated that, the efficacy of herbicide was significantly reduced under elevated CO_2, which resulted in higher growth and biomass in *A. paronychioides* when compared to ambient CO_2 level.



In *A. paronychioides* the growth and biomass attributes were significantly enhanced *i.e.,* plant height (99.33%), fresh weight (1.7 fold) and dry weight (2.7 fold) in herbicide treated region under elevated CO_2 compared to ambient **(Figure 2.5).** However, in herbicide untreated region the growth and biomass of *A. paronychioides* was greatly enhanced in terms of plant height (4.93%), fresh weight (31.80 fold) and dry weight (14.27%) under elevated CO_2 in compared to ambient.

Under elevated CO_2, growth of the rice plants was severely impaired by *A. paronychioides* in terms of plant height, fresh weight and dry weight. The growth and biomass of rice was maximum in weed free region followed by herbicide treated region at elevated CO_2 levels.

The decrease in plant height, fresh weight and dry weight was recorded by 8.18%, 5.05% and 19.31% under elevated CO_2 in herbicide untreated *A. paronychioides* region (**Figure 2.6**). In herbicide treated region, the plant height, fresh weight, and dry weight

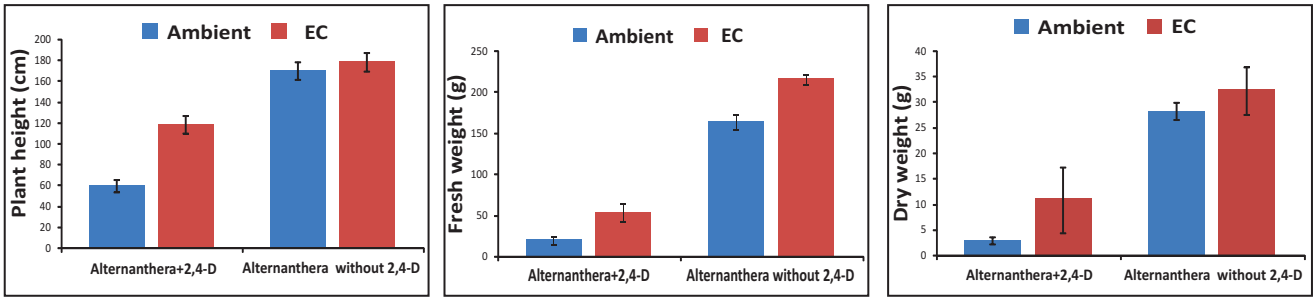
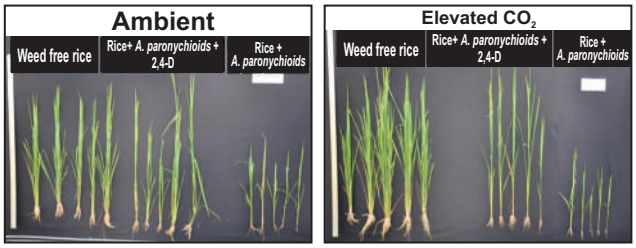


Figure 2.5: Effect of 2,4-D on growth atricbutes of *A. paronychioides*



significantly decreased by 6.24%, 39.89% and 34.50% respectively under elevated CO_2 compared to ambient (**Figure 2.7**). However, a significant increase in plant growth was observed in weed free rice in terms of plant height (10.05%), fresh weight (18.15%) and dry weight (29.56%) was observed under elevated CO_2.

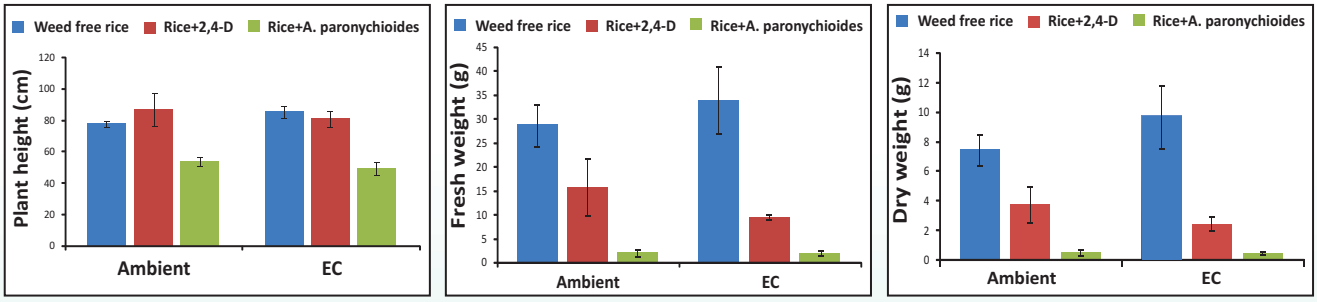


Figure 2.6: Effect of 2,4-D and *A. paronychioides* on Rice under elevated CO_2

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3. Weed Risk Assessment, Utilization and Management of Invasive Alien Weeds

Numerous invasive plant species in cropped lands, grazing lands, public lands, forests, and also in aquatic bodies of India have become weeds of significant economic and ecological impact. *Alternanthera sessilis, Phalaris minor, Physalis minima, Leptochloa chinensis* and *Malva parviflora* have invaded large cropped areas in India. Preventing further spread of such invasive weeds in other locations is to be an important component of management aspects at national level. Prediction model involving climatic and ecological factors responsible for growth and spread of the invasive weeds is a useful tool for this purpose. Water hyacinth and alligator weed are infamous for the aquatic bodies across the country. Presently, *Salvinia molesta* has shown its severe presence in the water bodies of central and North India, which has been considered a threat to ecology and biodiversity of aquatic bodies. Earlier, this weed was restricted to only South India, particularly in Kerala. Biological control of such weeds are the best practical solution as chemical methods are discouraged in aquatic systems for environmental concern, and mechanical/manual removal is highly expensive. Utilization of huge biomass of weeds for economic purpose is an important factor in reducing the overall cost of weed management.

Programme leader: Dr. K.K. Barman

Project	Experiment	Associates
3.1 Biological control of invasive and alien weeds **Principal Investigator: Dr. Sushil Kumar**	3.1.1 Number dependent population dynamics and damage potential of bioagent *Cyrtobagous salviniae* on water fern *Salvinia molesta*	Yogita Gharde
	3.1.2 Release, establishment and impact of bioagent *Cyrtobagous salviniae* on *Salvinia molesta* under natural infestation	-
	3.1.3 Growth study of *Salvinia molesta* during different season	-
	3.1.4 Survey of insects for biological control of problematic weeds	-
3.2 Predicting distribution of alien invasive weeds through statistical models under climate change scenarios **Principal Investigator: Yogita Gharde**	3.2.1 Projecting future expansion of alien invasive weeds through different methodologies for species distribution modelling	R P Dubey P K Singh
	3.2.2 Evaluating machine learning approaches for prediction of suitable climatic conditions for *Parthenium hysterophorus* (L.) in India	Sushilkumar

3.1 Biological control of invasive and alien weeds

3.1.1 Number dependent population dynamics and damage potential of bioagent *Cyrtobagous salvinae* on water fern *Salvinia molesta.*

This experiment was conducted to know the appropriate number of release of bioagents and the time required to control the weed in per hectare area. After release of different numbers of bioagent in the water tanks, substantial increase in adult population was observed after 135 days corresponding to initial number of release. There was not significant increase in population up to 3 months. Initially there was no dry weight found increase in the treatments, but after 135 days it started to show difference in different treatments as per the release load of bioagent. There was increase in brownness corresponding with the increase in number of insects. It was recorded that where insects were released at the rate of 22800/ha, 38.8% brownness was found in 135 days while under 159254/ha adult's release, brownness was observed to the tune of 81.3%.

The trend of increase in insect population and damage on weed was positively correlated. It was interesting to know that there was no significant difference in time taken by release of about 45600/ha to 68400/ha and 91254/ha to 159000/ha. There was significant difference in time required to control the weed completely by release of bioagents in number of 22800, 45000 and 91254/ha, however, difference in time was only about 2.5 months between 22800 and 45600/ha and 1.0 month between 68400, 114000 and 159000/ha **(Table 3.1)** .

Table 1: Time taken in month by different number of release of bioagents for the control of *Salvinia molesta*

Complete control with no. of release	Month taken
2.28/m² (22,800/ha)	15.0
4.56/m² (45600/ha)	12.5
6.84/m² (68400/ha)	12.5
11.40/m² (1,14000/ha)	11.5
15.96/m² (159000/ha)	11.5

3.1.2 Release, establishment and impact of bioagent *Cyrtobagous salviniae* on *Salvinia molesta* under natural infestation

Water fern (*Salvinia molesta*) is an aggressive aquatic weed of Brazil origin. In India, this weed used to occur severely in Kerala and in mild occurrence in other South Indian states. It was not reported in central India. First time, this weed was reported from one of the reservoirs in Sarni (Madhya Pradesh) in 2018. It was considered a threat for water bodies in central and North India. Therefore, physical and literature surveys were made to finds its infestation in other water bodies in the central and North India. Survey revealed severe infestation of weed in 7 water bodies of Maharashtra, 8 of Madhya Pradesh, 1 of Chhattisgarh (CG), 1 each of Haryana and Uttarakhand besides infestation in rice field in Balasore (Odisha). Release of bioagent has been initiated in Madhya Pradesh, Maharashtra and Chhattisgarh.

Effect of release of bioagent on population dynamics and impact on water fern *S. molesta* in the pond of Paduwa village, Katni (MP)

Initially 2000 number of adults were released in 20-hectare pond in December 2019. About 1000 adults were augmented in June 2020. Insect population increased gradually and reached 26.4±5.02, 78.25±11.7, 121.5±35.6/m2 after 6, 9 and 11 month of release. After 11 month, insect population started to decline gradually corresponding to decline in density and dry biomass of the weed. Only 6.5± 2.17/m2 population was found after 18 months (**Figure 3.1**).

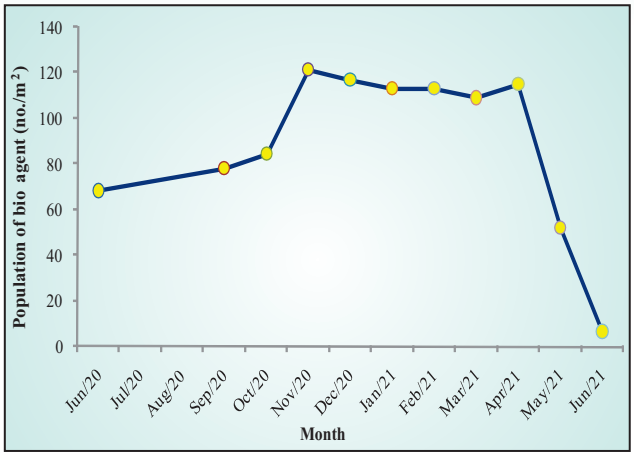


Figure 3.1: Population dynamics of bioagent after release in the pond

The adults are very tiny of about 2 mm only. The control of weed was possible due to feeding of adults on the growing points of *S. molesta* while grubs feeds inside the rhizome due to which growth was hampered drastically and weed is not able to multiply fast and gradually succumbed to death.

Dry weight of weed was also affected differently in different treatment after release of insects due to feeding on the weed. The dry weight of weed was slightly reduced (999.12±113.8 g/m2) after 6 month of release, then the control (1057.75± 72.54), but afterwards it was gradually decreased with the increase of population and by the June, 2021 only 55.2± 61.3/m^2 dry weight was recorded, however which was of the completely dead floated weed. The dry biomass was found increased from December 2019 (1057.75± 72.54) to June 2021 (1163.13± 75.42 g/m^2) in control pond where no bioagents were released.

Water was not visible up to 6 month after release, but onwards it started visible gradually and about 30 to 50 per cent water became visible by 8 month, 80% by 11 months and complete water surface was visible by 18 months (**Figure 3.2**).

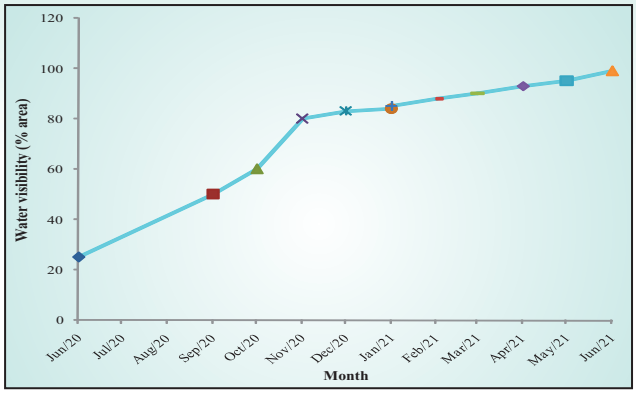


Figure 3.2: Water visibility (%) in the pond after release of bioagent in different month

The biological control of *S. molesta* was achieved as a success story first time in central India under high temperature fluctuations.

***Salvinia molesta* infested pond before release**

Release of bioagent in December 2019

80% control by 13 months after release

Complete control by 18 months after bioagent release

3.1.3 Growth study of *Salvinia molesta* during different season

Experiment was done in water tub of 1.3 m^2 area to see the growth of *S. molesta* during different seasons under the climate of central India. The experiment was done in six treatment. All the fresh biomass was removed from three replications each time at 15 days interval up to two month period. The fresh biomass was dried and weighted. The growth of weed was increased gradually after release but it was different during rainy and winter season (**Table-3.2**). In winter season, slow growth of weed was recorded in comparison to rainy season.

Table 3.2: Growth of *S. molesta* from different initial weight during rainy and winter season

Season	Treatment	Average dry weight after days (g)				
		Initial	15	30	45	60
Rainy	50 g	2.65±0.05	5.40±0.10	7.50±0.30	12.3±1.05	16.45±2.75
	100 g	5.75±0.15	9.75±0.05	23.2±4.60	33.3±12.0	35.00±0.80
	200 g	10.4±0.20	19.1±2.55	54.4±1.80	80.1±21.8	196.45± 5.65
	300 g	15.6±0.20	34.4±1.85	105.7±5.75	152.7±44.0	176.705±1.55
	400 g	19.3±0.70	37.5±2.25	131.8±20.8	217.8±20.5	229.205±3.45
	500 g	24.1±0.90	57.7±8.35	160.85±4.95	200.8±72.5	235.2±9.00
Winter	50 g	2.20±0.05	2.50±0.05	4.5±0.500	7.10±0.30	8.50±0.065
	100 g	4.80±0.30	7.50±0.50	7.00±1.000	11.3±0.25	11.7±0.205
	200 g	9.30±0.30	12.0±1.00	19.5±2.500	18.9±2.90	17.0±0.415
	300 g	13.7±0.70	22.5±0.50	24.0±6.000	34.3±5.70	44.3±0.100
	400 g	16.9±0.35	27.5±0.50	25.0±1.000	49.5±0.60	48.6±0.170
	500 g	21.3±0.70	40.0±4.00	104.0±41.000	79.7±13.2	59.0±0.460

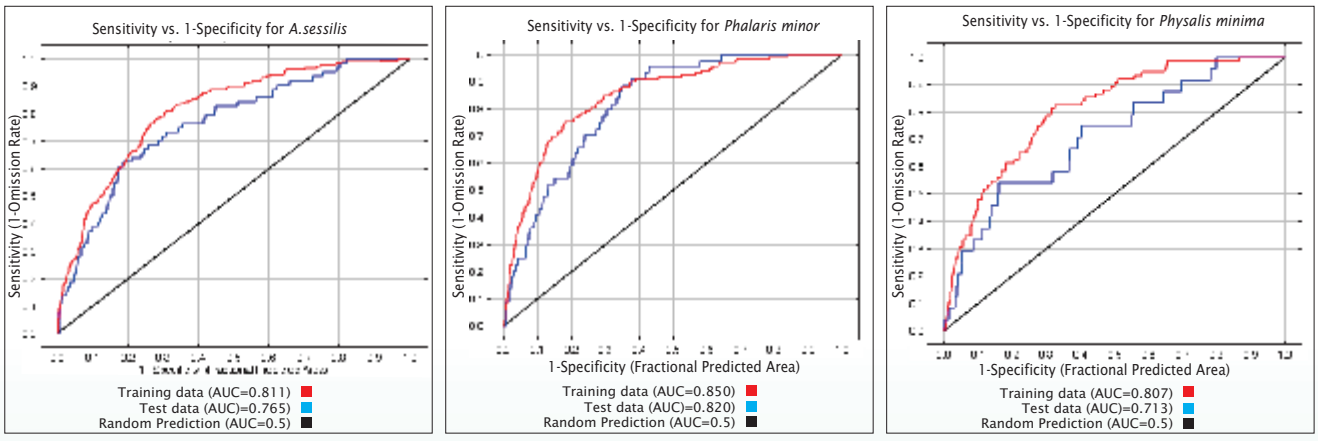
2.5.5. Survey of insects for biological control of weeds

Regular survey were conducted to find the natural enemies of various weeds in and around Jabalpur. As of previous years, severe attack of *Zygoramma biocolorata* was observed on Parthenium in the field in an around Jabalpur. After first monsoon rains, severe attack of shoot and root borer *Nupserha lenita* was observed on Parthneium. In August and September 2021, heavy attack of turtle beetle *Aspidomorpha miliaris* and *A. sanctacercecis* was noticed on *Ipomoea fistula*. This year also sever attack of *Cassida* spp. on alligator weed was observed in natural conditions. The population dynamics of the insect was studied.

3.2 Predicting distribution of alien invasive weeds through statistical models under climate change scenarios

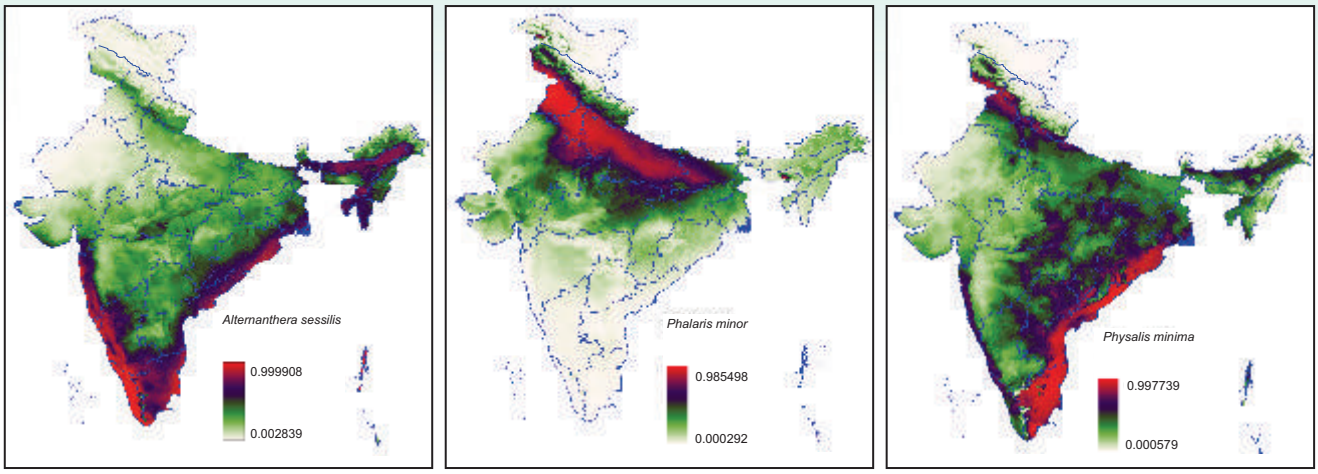
3.2.1 Projecting future expansion of alien invasive weeds through different methodologies for species distribution modelling

For prioritization of early detection and control of alien invasive species in new areas, it is necessary to understand the species' distribution, ecological niche and actual and potential areas of invasion in future. Hence, present study was planned to model the current distribution of alien invasive weeds and to predict their geographical distribution in future climate scenarios. For the purpose, five weed species viz. *Alternanthera sessilis, Phalaris minor, Physalis minima, Leptochloa chinensis* and *Malva parviflora* were selected which have invaded large cropped areas in India. Secondary occurrence data of *Alternanthera sessilis* (301 points), *Phalaris minor* (189 points) and *Physalis minima* (104 points) were collected from sources such as India Biodiversity Portal (https://indiabiodiversity.org/); Flora of Peninsular India, Herbarium JCB, Centre for Ecological Sciences, IISc, Bangalore (http://flora-peninsula-indica.ces.iisc.ac.in/); Global Biodiversity Information Facility GBIF (https://www.gbif.org/); Centre for Agriculture and Bioscience International CABI; Weed Atlas, vol. I and II published by ICAR-DWR and various other research publications. Further, data on 19 bioclimatic variables at a 5.0-arc-minute spatial resolution were downloaded from the WorldClim database using link https://www.worldclim.org/data/worldclim21.html. These variables are derived from the monthly temperature and rainfall values in order to generate more biologically meaningful variables. Multicollinearity test was performed on these 19 variables and variables with Pearson correlation coefficients of > 0.8 or < -0.8 were removed to avoid the consequences due to multicollinearity in the variables. Using this criterion, eight variables out of 19 bioclimatic variables were selected for further analysis and distribution modelling. With the help of secondary occurrence data and 8 bioclimatic variables, prediction map for present distribution of these species were obtained. MaxEnt was used to model species distributions and to create habitat suitability maps of these 3 species for the current-day scenario. The receiver operating characteristic (ROC) curve is obtained by plotting the sensitivity *vs* 1- specificity across the range of different thresholds (**Figure 3.3 a,b,c**). Maps of current distribution of *Alternanthera sessilis, Phalaris minor* and *Physalis minima* are given in **Figure 3.4 a,b,c**. Predictive ability of these models was compared using the area under curve (AUC) measure. AUC measure enables us to test whether the obtained predictions differ significantly from a random prediction. In our study, AUC for *Alternanthera sessilis, Phalaris minor* and *Physalis minima* was found as 0.811, 0.850 and 0.807, respectively.



(a) (b) (c)

Figure 3.3. Sensitivity vs 1 - Specificity graph and AUC value for (a) *Alternanthera sessilis* (b) *Phalaris minor* and (c) *Physalis minima*



(a) (b) (c)

Figure 3.3 : Projected distribution of (a) *Alternanthera sessilis* (b) *Phalaris minor* and (c) *Physalis minima* in India based on occurrence data

In these prediction maps, white colour shows that those areas are not at all suitable for species' occurrence. Green colour shows that these areas may have mild infestation of these species, however violet and red colour shows good and high chances of infestation of species in these areas, respectively. Hence, those areas with red colour are hotspot for occurrence of these species in current climatic scenarios.

3.2.2 Evaluating machine learning approaches for prediction of suitable climatic conditions for *Parthenium hysterophorus* (L.) in India

Parthenium hysterophorus (L.) commonly known as Parthenium is considered as one of the worst weeds of the world. It has invaded most of the states of the country including areas with extreme climatic conditions. Besides extensive documentation on the weed, the details of its current range are not fully known in India. Therefore, in the present study, generalized linear model viz. Multinomial Ordered Logistic Regression (MOLR) and different machine learning approaches (MLA) were used to find out the best model/approach for prediction of geographical distribution of *Parthenium hysterophorus* in India. Data on climatic parameters were collected from Indian Meteorological Department, Pune, India for the period from January, 2010 to December, 2019 (120 months). Climatic variables, namely mean maximum temperature (MMAX), mean minimum temperature (MMIN), relative humidity (RH) and rainfall (RF) of different sites were used as independent variables, whereas, occurrence level of Parthenium (*viz.* Negligible, Moderate, High) was considered as dependent variable (**Figure 3.4**).

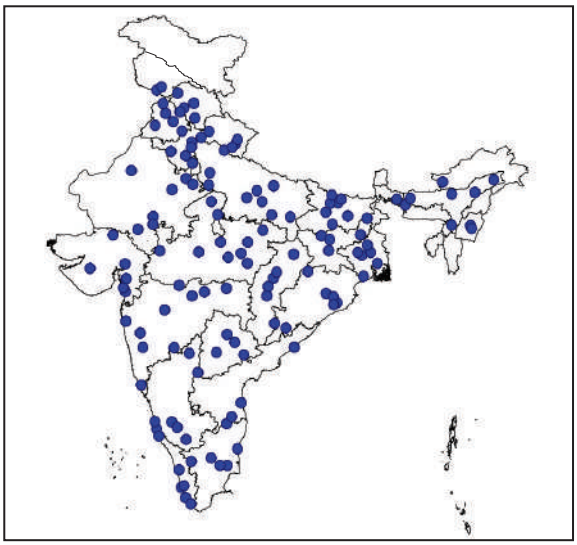


Figure 3.4 : Sites considered for the study

Analysis results obtained from using MOLR reveals that it classified 82.8% (108) instances correctly out of total of 130 instances. It also suggests that rainfall and relative humidity are more important parameters explaining the establishment of Parthenium as compared to other temperature related parameters viz. MMIN and MMAX. Among MLA, decision tree algorithm (J48) classified 80% (104) instances correctly out of total 130 instances and thus chosen to be the best algorithm. It provides rules for classify the instances in three categories of Parthenium occurrences. According to these rules, areas with high humidity (>71%) and high rainfall (>1612 mm) are not favourable for the establishment of Parthenium. Hence, coastal areas may not be suitable for Parthenium establishment. However, MMIN between 11-23ºC along with other parameters, i.e. Relative humidity (55-60%) and Rainfall (<1612 mm) was found to be suitable for the spread of Parthenium.

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4. Environmental Impact of Herbicides, Toxic Chemicals and Mitigation Measures

Presence of herbicide residues in the soil may not only damage the sensitive succeeding crops but also adversely affect human and animal health due to bioaccumulation of residues in crop produce. Due to rain and irrigation, persisting residues are likely to move towards sub surface soil and may contaminate adjacent aquatic fields or ground water. Therefore project on, 'Monitoring and degradation of herbicide residues in soil, water, plants and environment' has been initiated to determine herbicide residues, their degradation and persistence in the soil, plant, water and fishes under field conditions in a rice-chickpea cropping system. Detailed technical program and salient findings are as below:

Program leader: Dr Shobha Sondhia		
Project	**Experiment**	**Associate**
4.1 Monitoring and degradation of herbicide residues in soil, water, plants and environment **Project Investigator: Shobha Sondhia**	4.1.1 Evaluation of herbicide persistence and residues in chickpea field environment during *Rabi* 2020-21	PK Mukherjee Deepak Pawar
	4.1.2 Determination of herbicide residues and persistence in transplanted rice	Dibakar Roy
	4.1.3 Multiresidue method for determination of rice herbicides combination products by TLC	-

4.1 Monitoring and degradation of herbicide residues in soil, water, plants and environment

4.1.1 Evaluation of herbicide persistence and residues in chickpea field environment during *Rabi* 2020-21

Dissipation of herbicides residues in the soil of chickpea field environment in *Rabi* 2020-21

Herbicide residues in soil, chickpea plants, fishes and water samples collected at 0, 5, 10, 20, 30, 60, 90 days and at harvest were determined for persistence of herbicides. Water and fishes samples were collected after herbicide application and rain event in *Kharif* 2021 to evaluate bioaccumulation and persistence of herbicides in the fishes. Effect of herbicides on fish mortality and water quality was also evaluated in the respective days. All samples were processed and analyzed for residues by UFLC methods.

Topramezone (25 g/ha), propaquizafop + imazethapyr (125 g/ha) and pendimethalin (1000 g/ha) were used in the chickpea field for weed management. Pendimethalin residues in *Rabi* were found to be 1.815 to 0.021 µg/g in the chickpea soil at 0 to 90 days, whereas 1.916 to 0.047 µg/g pendimethalin were detected at 0 to 90 days. At harvest, <0.001 µg/g pendimethalin residues were detected in the soil of chickpea field. In chickpea grains and straw, pendimethalin residues were found<0.01 µg/g, (MRL 0.1mg/kg). Topramezone residues were found 0.723 to 0.020 µg/g in the soil at 0 to 90 days. At 90 days and harvest, residues were found to be below 0.01 µg/g. In green plants, 0.678 to 0.0114 µg/g residues were detected and become non-detectable after 90 days (MRL 0.0 mg/kg). An amount of 0.753 to 0.0205 µg/g imazethapyr residues were detected in the soil whereas, 0.752 to 0.0604 µg/g propaquizafop residues were found in the soil of chickpea field at 0 and 60 days (**Figure 4.1 and 4.2**). However, at 90 days residues were found below 0.01 µg/g (MRL 0.2 mg/kg in grains). Residues were not found in the pond water at 30, 60 and 90 days.

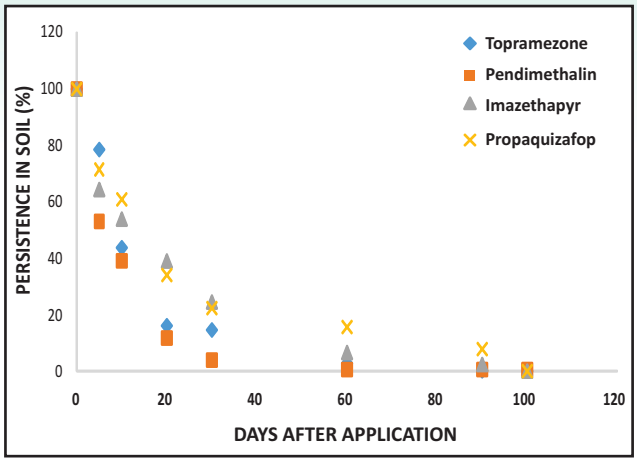


Figure 4.1: Degradation of herbicides residues in the soil in chickpea field during *Rabi* 2020-21

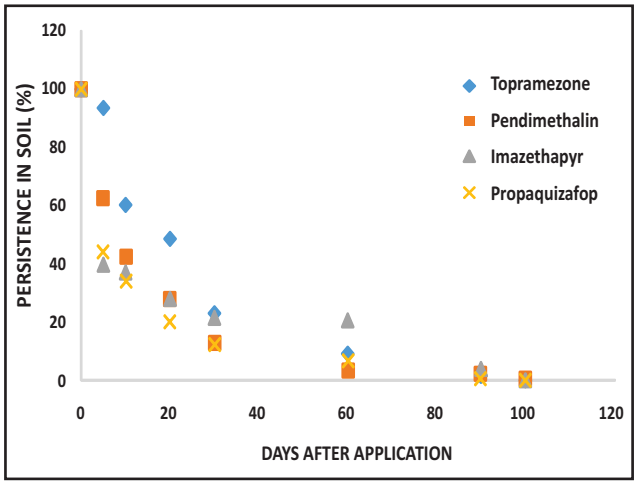


Figure 4.2: Degradation of herbicides residues in the plant in chickpea field during *Rabi* 2020-21

Table 4.1: Dissipation decay constant half life of herbicides in the soil of wheat field during *Rabi* 2020-21

Herbicide	Decay constant (λ)	R^2	Half-life (days)
Topramezone	-0.067	R^2 = 0.984	10.34
Imazethapyr	-0.050	R^2 = 0.937	14.40
Propaquizafop	-0.049	R^2 = 0.763	11.41
Pendimethalin	-0.033	R^2 = 0.917	16.50

Topramezone, propaquizafop + imazethapyr and pendimethalin residues were found to dissipate in the soil of chickpea field during *Rabi* 2020-21 following first order rate kinetics **(Figure 4.1 and 4.2).** Half-life of Topramezone, imazethapyr + propaquizafop and pendimethalin in chickpea field soil was found to be 10.34, 14.40, 11.41 and 16.50 days, respectively **(Table 4.1).**

Effect of herbicides on the pH and EC of the chickpea field soil and pond water during *Rabi* 2020-21

Overall pH of soil varies between 6.89 to 6.95, 6.93 to 6.75 and 7.00 to 6.85 in the corresponding ponds where pendimethalin, topramezone and propaquizafop + imazethapyr residues were entered through runoff and rain. Electrical conductivity of the pond water varied significantly after receiving herbicide as a results of runoff and was found in the range of 543 to 631.5 µS/cm, 979.5 to 826 µS/cm and 1101.5 to 897 µS/cm in the adjacent ponds that received pendimethalin, topramezone and propaquizafop+imazethapyr, respectively (**Table 4.2**). Change in pH of the soil and pond water was found to be non-significant.

Table 4.2: Effect of herbicides on the pH and EC of the chickpea field soil during *Rabi* 2020-21

Treatment	Soil pH and EC (µS/cm) *Rabi* 2020-21													
	Days after application													
	0		5		10		20		30		60		90	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
Weed free	6.80	146.8	6.75	193.3	6.52	189.5	6.71	197	6.71	177.6	6.87	77.9	6.70	94
Weedy	6.71	197	7.34	154.4	6.90	177.6	6.79	72.1	6.79	89.6	6.93	86.6	6.81	83.2
Pendimethalin	6.89	120.6	6.83	131.6	6.68	142	6.83	142	6.83	178.9	6.95	51.2	6.95	61.3
Propaquizafop + imazethapyr	6.93	181.5	6.89	146.2	7.07	81.4	6.95	131	6.95	80.9	7.07	88.9	6.79	87.5
Topramezone	7.00	161	6.87	147.5	6.92	132.7	6.78	135	6.78	81	6.95	78.7	6.83	189.2

Table 4.3: Effect of herbicides on the pH and EC of the pond water during *Rabi* 2020-21

Treatment	Pond water pH and EC (µS/cm) *Rabi* 2020-21													
	Days after application													
	0		5		10		20		30		60		90	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
Weed free	7.75	800.5	7.42	671.5	6.90	804.5	7.37	1012	7.25	750.5	7.43	873	7.31	712
Weedy	7.35	1012	7.24	788	7.21	750.5	7.67	793	7.09	767.5	7.51	801.5	7.54	806.5
Pendimethalin	7.87	543	8.01	450	8.24	686	8.11	697.5	7.99	576	7.79	662.5	7.72	631.5
Propaquizafop + imazethapyr	7.62	979.5	7.45	803	7.51	816.5	7.55	894	7.01	859	7.80	721.5	7.48	826
Topramezone	7.51	1101.5	7.05	923.5	7.44	770.5	7.76	889	7.29	861.5	7.78	771	7.64	897

Fishes were monitored to evaluate any mortality and toxicity. However, fish mortality and toxicity symptoms were not observed in the pond where herbicides were entered through runoff water. At 90 days residues in fishes were below the detection limit (<0.001 µg/g) (**Table 4.3**). Topramezone and propaquizafop + imazethapyr residues were not detected in the pond water collected at 60 and 90 days.

4.1.2 Determination of herbicide residues and persistence in transplanted rice

Residues of herbicides ready mix combinations in the soil of rice field in *Kharif* 2021

Herbicides ready mix, namely, Eros (pretilachlor + pyrazosulfuron), Vivaya (cyhalofop-butyl + penoxsulam) and Councilactiv (triafamone + ethoxysulfuron) were applied at recommended doses 170, 135 and 67.5 g/ha, respectively to study residues and persistence of herbicides in *Kharif* 2021 in thetransplanted rice field environment. Herbicide residues in the soil, rice plants, fishes and water at 0, 5, 10, 20, 30, 60, 90 days and at harvest were determined for persistence of herbicides. Water and fishes samples were collected after herbicide application and rain events in *Kharif* 2021 to evaluate bioaccumulation and persistence of herbicides. Effect of herbicides on fish mortality and water quality was also evaluated in the respective days. All samples were processed and analyzed for residues by UFLC.

At zero days, 1.474 to 0.002 µg/g; 0.828 to 0.009 µg/g, 0.602 to 0.005 µg/g, 0.580 to 0.023 µg/g; 0.628 to 0.001 µg/g and 0.693 to 0.004 µg/g residues of pretilachlor, pyrazosulfuron, ethoxysulfuron, triafamone, cyhalofop-butyl, and penoxsulam, respectively were found in the soil of transplanted rice field between 0 to 90 days. More than 90% dissipation of pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone was found in the soil of rice field up to 90 days (**Figure 4.3**). Herbicides were dissipated in the soil of rice field following of first order rate kinetics and half-life of pretilachlor, pyrazosulfuron, ethoxysulfuron, triafamone cyhalofop-butyl, and penoxsulam, respectively was found 13.3, 7.84, 10.36, 10.6, 10.51, and 10.78 days, respectively (**Table 4.4**). At harvest pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone residues were found below the detection limit in the rice plants. However at harvest residues were found below the detection limit (0.001 µg/g) in the rice grains, soil and straw.

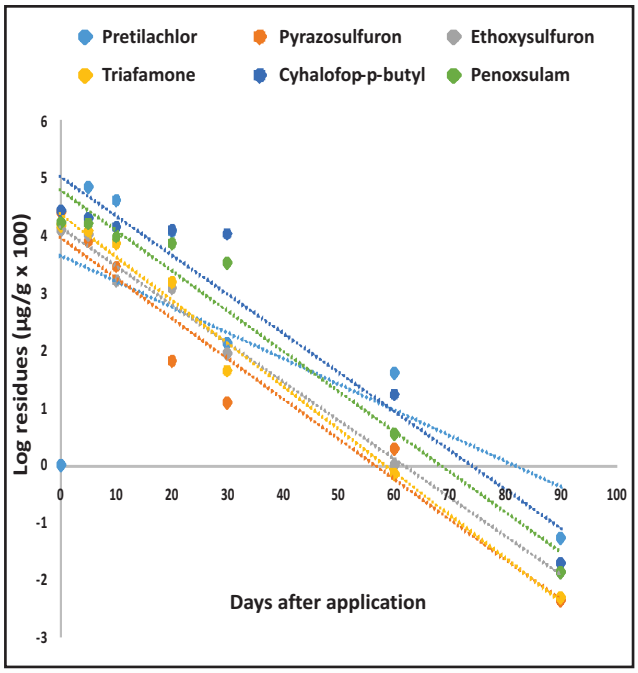


Figure 4.3: Dissipation kinetics of pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone in the soil of rice crop during *Kharif* 2021

Table 4.4: Rate kinetics, R^2 and half-life of ready mix herbicides namely Eros (pretilachlor + pyrazosulfuron), Vivaya (cyhalofop-butyl + penoxsulam) and Councilactiv (triafamone + ethoxysulfuron in the rice soil in *Kharif* 2021

Herbicides	Decay constant (λ)	R	Half-life (days)
Pretilachlor	-0.0686	0.951	13.32
Pyrazosulfuron	-0.0730	0.961	7.84
Ethoxysulfuron	-0.0675	0.992	10.36
Triafamone	-0.0761	0.975	10.62
Cyhalofop-butyl	-0.0683	0.930	10.51
Penoxsulam	-0.0706	0.957	10.78

Residues of pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone in fishes in ponds

Fishes were monitored to evaluate toxicity and any mortality due to herbicide spray. In the fish, 0.025, 0.039 µg/g pretilachlor residues were found at 30 and 60 days, respectively, however, pyrazosulfur residues in the fishes were found to be 0.039 to 0.001µg/g at 30 and 60 days, respectively. Mortality and toxicity symptoms were not recorded in the pond where herbicides were entered through runoff water. At 90 days pretilachlor, pyrazosulfuron, cyhalofop-butyl, penoxsulam and triafamone residues in the fishes were below the detection limit (<0.001 µg/g) (**Table 4.5**)

Table 4.5: Herbicide residues in the fishes of adjoining ponds in *Kharif* 2021

Herbicide	Residues in fishes (µg/g)			
	30 DAS	60 DAS	90 DAS	Harvest
Pretilachlor	0.025	0.0105	<0.001	<0.001
Pyrazosulfuron	0.039	0.001	<0.001	<0.001
Cyhalofop-butyl	0.040	0.024	<0.001	<0.001
Penoxsulam	0.062	0.007	<0.001	<0.001
Triafamone	0.066	0.021	<0.001	<0.001
Ethoxysulfuron	0.072	0.0012	<0.001	<0.001

4.1.2.3 Effect of herbicides on soil and pond water quality during *Kharif* 2021

During *Kharif* season, pH of the rice soil was found to be between 6.50 to 7.10 at zero to 90 days where pretilachlor + pyrazosulfuron, cyhalofop + penoxsulam and triafamone + ethoxysulfuron, were applied to control weeds in transplanted rice crop. Change in pH of soil was found to be non-significant. Electrical conductivity of the soil varied significantly after herbicide application and it was found in the range of 156 to 566 µS/cm, 137.3 to 356 µS/cm and 135.9 to 300.5 µS/cm between zero to 90 days in the pond water that pretilachlor + pyrazosulfuron, cyhalofop + penoxsulam and triafamone + ethoxysulfuron, respectively (**Table 4.6 and 4.7**)

Table 4.6: Effect of herbicides on the pH and EC of the rice soil during *Kharif* 2021

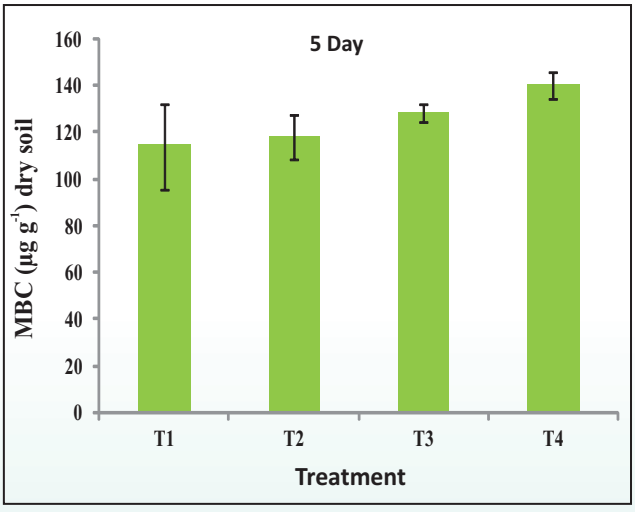
Treatment	Soil pH and EC (µS/cm) *Kharif* 2021													
	Days after application													
	0		5		10		20		30		60		90	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
Weed Free	6.50	156.9	7.05	162.3	6.79	146.05	6.72	247.5	6.68	179.3	6.68	436.5	6.80	382
Weedy	6.61	143.8	6.72	247.5	8.2	177.6	6.99	147.5	7.05	160.1	6.75	407	6.70	382.5
Pretilachlor + pyrazosulfuron-ethyl (Eros)	6.56	170.9	6.81	140.5	6.61	146.9	6.80	237.5	6.60	156.3	6.69	566	6.81	336
Cyhalofop-butyl + penoxsulam (Vivaya)	6.33	137.3	6.95	248.5	6.86	170.5	6.69	143.4	7.02	176.4	6.75	356	6.86	356
Ethoxysulfuron + traifamone) (Council activ)	6.77	135.9	6.77	213.7	6.82	178.5	6.81	141.8	7.10	233.3	6.73	316.8	6.65	300.5

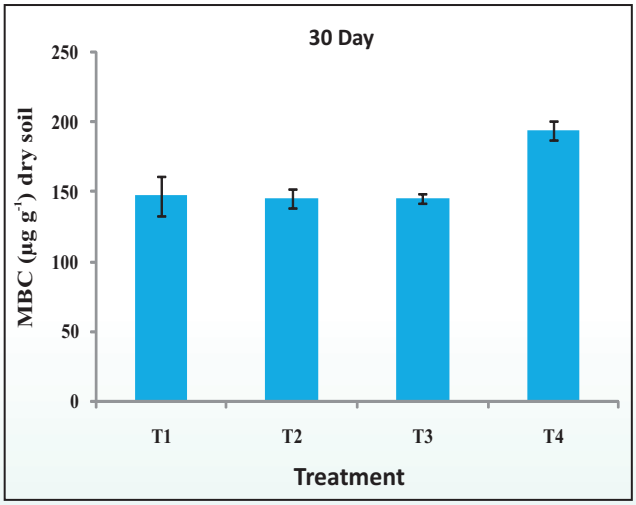
Table 4.7: Effect of herbicides on the pH and EC of the pond water during *Kharif* 2021

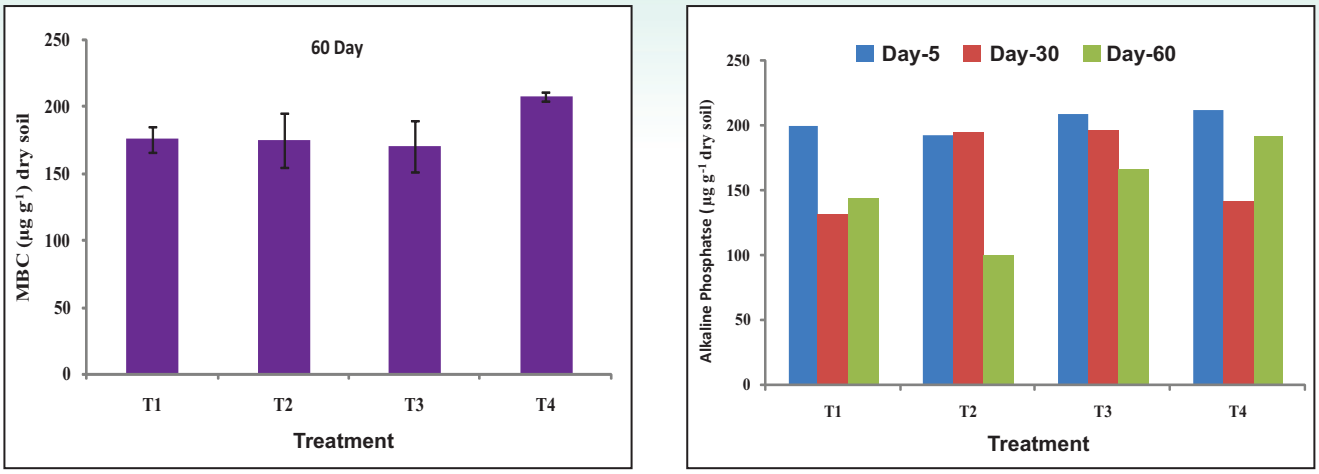
Treatment	Pond water pH and EC (µS/cm) *Kharif* 2021													
	Days after application													
	0		5		10		20		30		60		90	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
Weed Free	6.58	795.5	6.96	791	7.19	901	7.18	715.5	7.60	719.3	8.03	718.5	7.29	827
Weedy	7.11	741.5	6.81	715.5	6.89	709.5	6.76	709.5	7.07	864.5	7.72	755.5	7.45	828.5
Pretilachlor +pyrazosulfuron ethyl (Eros)	6.96	965	7.18	901.3	6.93	893	7.55	928.5	7.44	912.6	7.68	829	7.34	573
Cyhalofop-butyl +penoxsulam (Vivaya)	7.03	708.5	7.03	827.5	7.06	784.5	7.05	1210	7.15	1129	7.42	880.5	7.07	866
Ethoxysulfuron+ traifamone) (Council activ)	6.75	862.5	6.75	997	6.80	874.5	7.07	1135	7.0	1004	7.35	954.5	7.30	857

Effect of herbicides on soil microbial biomass carbon and alkaline phosphatase activity

During *Kharif* 2021, herbicide application initially suppressed Soil Microbial Biomass Carbon (MBC) content and later on gradually increased with time. After 5 days of herbicide application (pretilachlor + pyrazosulfuron, cyhalofop + penoxsulam and triafamone + ethoxysulfuron), least MBC was recorded in the soil of pretilachlor + pyrazosulfuron applied plots (114 µg/g dry soil) compared to cyhalofop + penoxsulam (118 µg/g dry soil) and triafamone + ethoxysulfuron (129 µg/g dry soil) applied plots. At 30 days, MBC content showed gradually increasing trend and almost equal in all herbicide treated plot (145 - 147 µg/g dry soil). At 60 days, those values of MBC under herbicide treated plot further increased (170-175 µg/g dry soil). Irrespective of treatments, maximum MBC (140, 193 and 207 µg/g dry soil) was obtained in control plot where herbicide was not applied in all three sampling days i.e 5, 30 and 60 days after herbicide application. Alkaline phosphatase activity (ALKP) showed definite trend due to herbicide application (**Figure 4.4**).







T_1 (Pretilachlor + pyrazosulfuron),T_2 (Cyhalofop + penoxsulam), T_3 (Triafamone + ethoxysulfuron),T_4: Control

Figure 4.4: Influence of herbicide application on soil MBC and alkaline phosphatase activity at 5, 30 and 60 days

4.1.3 Multiresidue method for determination of rice herbicide combination products by TLC

A multiresidue determination method was developed for determination of herbicides combination namely pretilachlor + pyrazosulfuron, cyhalofop-p-butyl + penoxsulam and traifmaone + ethoxy-sulfruon with the detection limit of below <0.01 µg/g. This method can be used for determination of herbicide residues of commercially available herbicide combinations frequently used in rice crops such as Eros (Pretilachklor + pyrazosulfuron), vivaya (Cyhalofop-p-butyl + penoxsulam) and Council Activ (Traifamone + ethoxysulfuron) (**Figure 4.5, Table 4.7**). This method has the similar applicability to determine herbicide residues in environmental samples.

Table 4.7: detection of herbicides rice herbicide combination products by TLC

Herbicide	Rf, TLC (cm)	Combination product	Qualifying criteria
Pyrazosulfuron	4.4	Eros	yes
Pretilachlor	7.7		yes
Cyhalofop-p-butyl	8.3	Vivaya	yes
Penoxsulam	2.0		yes
Triafamone	5.2	Councilactiv	yes
Ethoxysulfuron	5.7		yes

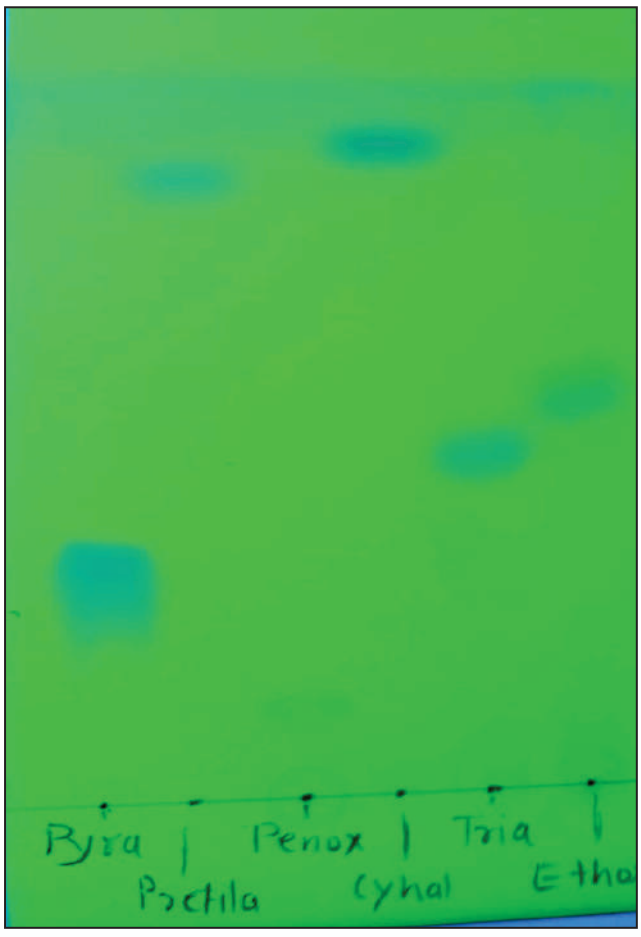


Figure 4.5: Detection of herbicide residues in herbicide combination products of rice by TLC

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5. Dissemination and Socio-economic Impact of Weed Management Technologies

Technology transfer is considered as systematic flow of technical knowledge from the researchers to the farmers, passing through various stages like technology development, dissemination and finally adoption by the farmers. The transfer may be considered to be successful if the farmers/ stakeholders can effectively utilize the technology and ultimately adopt it. However, with the time, the gap between the technology development and adoption is widening due to various factors influencing the process of technology transfer. Hence, it was decided to include the stakeholders/farmers in the process of evaluation of improved packages for management of weeds predominant in their farming situation. Accordingly, on-farm research programme on weed management technologies for important crops has been initiated to understand farmers' problems and undertake necessary technological interventions using farmer's participatory approach

Research Programme Leader : Dr. P.K. Singh		
Project	**Experiment**	**Associates**
5.1 On-farm research and demonstration of weed management technologies for enhancing productivity and income **Principal Investigator: P.K. Singh**	5.1.1 On-farm research and demonstration of weed management technologies in rice-wheat-greengram and maize-chickpea-greengram system under conservation agriculture (Patan Locality)	K.K. Barman P.K. Mukherjee V.K. Choudhary Yogita Gharde Chethan C.R. Himanshu Mahawar Jamaludheen A.
	5.1.2 On-farm research and demonstration of weed management technologies in rice-wheat-greengram and maize-chickpea-greengram system under conservation agriculture (Bargi Locality)	Sushil Kumar, R.P. Dubey, Shobha Sondhia, Deepak Pawar, Dibakar Roy Sreekanth Dasari Vaibhav Choudhary
	5.1.3 Development of Mobile App for herbicide calculation & judicious use (HerbCal)	P.K. Singh, V.K. Choudhary Sandeep Dhagat
5.2 Impact assessment of weed management technologies **Principal Investigator: Jamaludheen A.**	5.2.1 Trends in herbicide research in the world during 2011-2020: A web of science-based scientometric study	P.K. Singh, Yogita Gharde V.K. Choudhary

5.1. On-farm research and demonstration of weed management technologies for enhancing productivity and income

5.1.1 On-farm research and demonstration of weed management technologies in rice-wheat-greengram and maize-chickpea-greengram system under conservation agriculture (Patan Locality)

Wheat (*Rabi*, 2020-21)

Six on-farm research trials cum demonstrations on weed management in wheat under conservation agriculture were undertaken at villages *viz.* Guleda, Purena, Singhaldeep, Lakhna and Raipura of Patan locality during *Rabi* 2020-21. The major weed floras observed in the field were *Medicago polymorpha, Phalaris minor, Avena ludoviciana, Lathyrus aphaca, Vicia sativa, Cynodon dactylon, Cyperus rotundus* and *Chenopodium album*. A very good seed germination and crop establishment was observed in these trials. Under conservation agriculture, application of herbicide (clodinofop + metsulfuron 60+4 g/ha as post-emergence at 30 DAS) along with recommended fertilizer dose (RDF) (120:60:40 N, P_2O_5, K_2O kg/ha) resulted lowest weed density and biomass and provided higher grain yield (4.83 t/ha), higher net income (₹ 65345/ha) and higher B:C ratio of 3.27compared to farmers' practice (conventional tillage + high seed rate + unbalanced fertilizer without proper weed management) (**Table 5.1**).

Table 5.1: Weed management, productivity and economics of OFR treatments in wheat at Patan locality during *Rabi*, 2020-21.

Treatment	Weed density (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	20.20	9.90	80.00	4.83	94224	65345	3.27
FP	41.40	22.02	57.93	4.11	80067	48420	2.53
RDF+CA+Weedy	77.60	53.18	-	3.33	64917	37420	2.36
SEm±	2.64	2.53	2.03	0.08	1647	1647	0.06
LSD (p=0.05)	**8.31**	**7.96**	**6.39**	**0.27**	**5190**	**5191**	**0.18**

CA: Conservation agriculture; FP: Farmers Practice; RDF: Recommended dose of fertilizer; WCE: Weed control efficiency; WM: Weed management

Chickpea (*Rabi*, 2020-21)

During *Rabi*, 2020-21, four OFR cum demonstrations were conducted on weed management in chickpea under conservation agriculture in Guleda, Singhaldeep and Lakhna villages of Patan locality. The major weed flora observed were *Cyperus rotundus, Rumex dentatus, Vicia sativa, Lathyrus aphaca, Chenopodium album, Phalaris minor* and *Avena ludoviciana*. In chickpea grown with recommended fertilizer (20:60:40 N, P_2O_5, K_2O kg/ha) and herbicide (pendimethalin 750 g/ha as pre-em.) under CA, weed density and dry weight were lower than farmers' practice (**Table 5.2**). The seed yield of chickpea was obtained as 2.24 t/ha in this practice. The higher B: C ratio of 2.82 was also recorded with the same treatment, whereas, it was only 2.18 in case of farmers practice.

Table 5.2: Weed management, productivity and economics of OFR treatments in chickpea at Patan locality during *Rabi*, 2020-21 (values are means of 4 farmers)

Treatment	Weed density (no./m²)	Weed dry weight (g/m²)	WCE (%)	Seed yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	37.50	22.33	65.35	2.24	100238	64662	2.82
FP	56.75	34.83	44.50	1.87	83425	45086	2.18
RDF+CA+Weedy	108.25	64.78	-	1.37	61538	27996	1.84

CA: Conservation agriculture; FP: Farmers Practice; RDF: Recommended dose of fertilizer; WCE: Weed control efficiency; WM: Weed management

Greengram (summer, 2021)

During summer 2021, seven OFR cum demonstrations were conducted on weed management in greengram under conservation agriculture at farmers' fields in Guleda, Lakhna and Singhaldeep villages of Patan locality. The major weed flora observed were *Cynodon dactylon, Echinochloa colona, Sporobolus* sp., *Euphorbia geniculata, Alternanthera sessilis,* and *Cyperus rotundus*. Results obtained from OFR trials revealed that RFD (20:60:40 N, P_2O_5, K_2O kg/ha) + CA + imazethapyr 100 g/ha as post-emergence was effective and gave broad spectrum weed control and seed yield of 1.47 t/ha, as compared to 1.18 t/ha under Farmers practice

(Conventional Tillage + 1 hand weeding); and provided an additional net return of ₹ 70239/ha with higher B:C ratio of 3.93 over farmers practice (**Table 5.3**). The cultivation of crop under CA by using Happy seeder enhanced the early sowing of crop by utilizing the residual soil moisture content, effectively managed the crop residue and reduced the excessive tillage operation and operational cost.

Table 5.3: Weed management, productivity and economics of OFR treatments of greengram at Patan locality during summer, 2021

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	16.14	14.96	74.14	1.47	105884	70239	3.93
FP	30.43	26.73	53.72	1.18	85119	53506	2.69
RDF+CA+Weedy	60.14	57.56	-	0.89	58869	41376	2.44
SEm±	2.101	1.45	1.43	0.02	4484	5438	0.08
LSD (p=0.05)	**6.48**	**4.48**	**4.39**	**0.05**	**13816**	**16756**	**0.25**

CA: Conservation agriculture; FP: Farmers Practice; RDF: Recommended dose of fertilizer; WCE: Weed control efficiency; WM: Weed management

Rice (direct-seeded) (*Kharif*, 2021)

Seven OFR trials were undertaken on weed management in direct-seeded rice during *Kharif*, 2021 in Guleda, Mudia, Tikari, Singhaldeep and Raipura villages of Patan locality. Weed management through herbicides with recommended dose of fertilizer was compared with the farmers practice. The major weed flora observed were *Cyperus rotundus, Cyperus iria, Echinochloa colona, Dinebra retroflexa, Paspaladium* sp., *Phyllanthus niruri* and *Commelina communis.* Application of recommended dose of fertilizer (RDF) (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of herbicide (bispyribac-Na 25 g/ha as post-em at 18 DAS) was more effective (weed dry weight 49.01 g/m^2; grain yield 4.18 t/ha; B:C 2.77) than farmers practice (high seed rate + unbalanced fertilizer without proper weed management) (weed dry weight, 74.57 g/m^2; grain yield 3.73 t/ha; B:C 2.25) (**Table 5.4**).

Table 5.4: Weed management, productivity and economics of OFR treatments in direct-seeded rice at Patan locality during *Kharif*, 2021

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	32.57	49.01	66.51	4.18	77995	49825	2.77
FP	44.86	74.57	49.16	3.73	69543	38596	2.25
RDF+CA+Weedy	83.14	147.47	-	2.98	55694	29700	2.14
SEm±	1.39	3.91	2.10	0.05	1015	1013	0.04
LSD (p=0.05)	**4.28**	**12.05**	**6.46**	**0.16**	**3127**	**3120**	**0.11**

CA: Conservation agriculture; FP: Farmers Practice; RDF: Recommended dose of fertilizer; WCE: Weed control efficiency; WM: Weed management

Maize (*Kharif*, 2021)

Two OFR trials were conducted on weed management in maize during *Kharif*, 2021 at farmers' field in Mudia and Singhaldeep villages of Patan locality. The major weed flora observed were *Commelina benghalensis, Cyperus* spp., *Dinebra retroflexa, Echinochloa colona, Eclipta alba* and *Euphorbia geniculata*. Lower weed density (22.5 no./m^2) and dry weight (32.05 g/m^2) in maize were observed with recommended fertilizer (120:60:40 N, P_2O_5, K_2O kg/ha) and herbicide (atrazine 750 g/ha *fb* tembotrione 120 g/ha at 30 DAS) under CA than farmers practice (**Table 5.5**). Grain yield of maize was observed as 4.92 t/ha in CA practice with improved weed management technique. Higher net return (₹ 60391/ha) and B: C ratio (2.98) was recorded with the same treatment as compared to the farmer practice.

Table 5.5: Weed management, productivity and economics of OFR treatments in maize at Patan locality during *Kharif*, 2021 (values are means of two farmers).

Treatment	Weed density (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	22.50	32.05	66.55	4.92	90928	60391	2.98
FP	29.50	41.40	56.79	4.52	83620	49847	2.48
RDF+CA+Weedy	73.50	96.85	-	3.31	67493	36900	2.41

CA: Conservation agriculture; FP: Farmers Practice; RDF: Recommended dose of fertilizer; WCE: Weed control efficiency; WM: Weed management

Environmental benefit of rice-wheat-greengram cultivation under conservation agriculture

Environmental benefit of rice-wheat-greengram cultivation under conservation agriculture was measured by computing the reduction in greenhouse gases (GHG), air pollutants and creation of theoretical energy potential (TEP) from the farmers' fields. Two years data (2019-21) of Patan locality was computed for the study (**Table 5.6** and **Figure 5.1**). A GHG as CO_2 equivalent reduction of 18675 kg/ha, air pollutants reduction of 1232.4 kg/ha and TEP creation of 49.1×10^4 MJ/ha was obtained for two years by practicing the conservation agriculture in rice-wheat-greengram cropping system at farmers' fields.

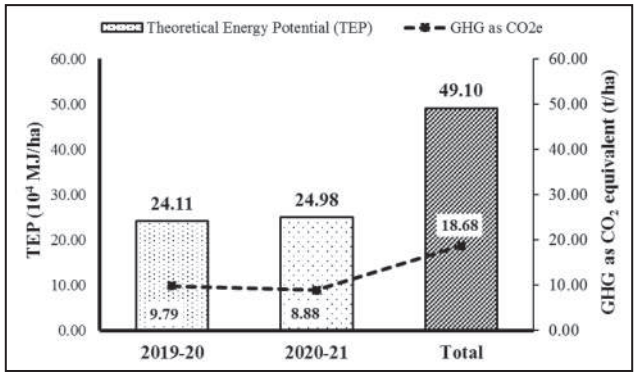


Figure 5.1: TEP generation global warming potential reduction by practicing the CA in rice-wheat-greengram cropping system at farmers' fields of Patan locality

Table 5.6: GHGs and air pollutants reduction by practicing the CA in rice-wheat-greengram cropping system at farmers' fields of Patan locality

Particular		Emission (kg/ha)				
		Rice		Wheat		Total
		2020	2021	2019-20	2020-21	(two year)
GHGs emission	CO_2	5514.25	4678.58	2117.60	2287.36	14597.78
	CH_4	44.93	38.12	4.21	4.54	91.80
	N_2O	2.25	1.91	0.88	0.95	5.98
	GWP (CO_2 e)	7307.62	6200.17	2484.08	2683.23	18675.09
Air pollutants emission	$PM_{2.5}$	38.89	32.99	9.01	9.73	90.61
	PM_{10}	42.63	36.17	6.75	7.30	92.86
	SO_2	0.84	0.72	0.47	0.51	2.54
	CO	435.71	369.68	33.18	35.84	874.40
	NO_x	10.68	9.06	2.01	2.18	23.94
	NH_3	19.21	16.30	1.54	1.66	38.71
	NMVOC	32.80	27.83	8.30	8.96	77.88
	EC	2.39	2.03	0.19	0.20	4.81
	OC	14.01	11.89	0.34	0.37	26.61
	PAH	0.02	0.02	0.00	0.00	0.05
	Total	597.17	506.67	61.80	66.76	1232.41

GWP: Global warming potential, GHG: Greenhouse gas

5.1.2 On-farm research (OFR) and demonstrations of weed management technologies in rice-wheat-greengram and maize-chickpea-greengram systems under conservation agriculture (Bargi locality)

At Bargi locality, OFR trials were conducted at six villages, viz. Mankhedi, Saliwada, Riwa, Nayagaon, Chullaghat and Sahajpuri during *Rabi*, 2020-21 and *Kharif*, 2021 in wheat, chickpea, rice, maize, and greengram under rice-wheat-greengram and maize-chickpea-greengram cropping systems. Improved weed management in crops grown under CA with recommended dose of fertilizer (RDF) and weed control were compared with conventional practice done by the farmers.

Wheat (*Rabi*, 2020-21)

In wheat, major weed flora observed were *Mecardonia* spp., *Paspaladium, Sonchus, Brachiaria* spp., *Convolvulus arvensis*, *Vicia, Lathyrus*, *Medicago* spp., *Melilotus* spp., *Angallis arvensis, Chenopodium* spp., *Cyperus* spp.,*Physalis minima, Cyperus rotundus* and *Phalaris minor*. Application of recommended fertilizer dose (120:60:40 N: P_2O_5: K_2O kg/ha) along with herbicide (clodinafop + metsulfuron 60 + 4 g/ha at 25 DAS) under CA resulted in the lowest weed density and dry biomass accumulation **(Table 5.7).** As compared to farmers practice (conventional tillage, higher seed rate and without proper weed management), the improved weed management techniques in CA produced 13% of higher wheat grain yield (5.10 t/ha), net return (₹73099) and B:C ratio (3.54).



Table 5.7: Weed management, productivity and economics in OFR treatments of wheat at Bargi locality during *Rabi*, 2020-21 (average of 5 farmers)

Treatment	Weed population (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF + CA + WM	17.20	5.57	93	5.10	101980	73099	3.54
FP	27.07	12.13	85	4.51	90000	58353	2.85
RDF+CA+Weedy	115.60	80.17	-	1.18	23620	-6643	0.78

CA: Conservation Agriculture; RDF: Recommended dose of fertilizer; WM: Weed Management; FP: Farmers Practice

Chickpea (*Rabi*, 2020-21)

In chickpea, major weed flora observed were *Convolvulus arvensis, Mecardonia* spp., *Anagllis arvensis, Chenopodium* spp., *Cyperus rotundus, Cyperus iria*, *Medicago* spp. and *Melilotus* spp. In chickpea grown with recommended fertilizer (30:60 N, P_2O_5 kg/ha) and herbicide (pendimethalin 675 g/ha at 2 DAS) under CA, weed density and dry weight was lower than farmers practice **(Table 5.8).** Maximum plant density was observed with farmers practice, whereas, number of pods/plant and branches/plant were higher in plots, with recommended fertilizer and improved weed management practice under CA. Seed yield of chickpea was 1.96 t/ha in CA practice with improved weed management technique. The higher B:C ratio 2.48 was recorded with the same treatment, whereas, the B:C ratio was 1.70 in farmers practice.

Table 5.8: Weed management, productivity and economics of OFR treatments in Chickpea at Bargi locality during *Rabi*, 2020-21 (average of 5 farmers)

Treatment	Weed population (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF + CA + WM	14.67	4.67	97	1.96	87975	52399	2.48
FP	30.36	15.75	89	1.44	64935	26596	1.70
RDF + CA + Weedy	138.42	137.80	-	0.61	27630	8675	0.77

CA: Conservation Agriculture; RDF: Recommended dose of fertilizer; WM: Weed Management; FP: Farmers Practice

Rice (*Kharif*, 2021)

In direct-seeded rice, on-farm research trials were undertaken on weed management under CA. The major weed flora observed were *Echinochloa colona, Dinebra* spp., *Phyllanthus niruri* and *Alternanthera sessilis*. Recommended weed management and fertilizer dose practices were compared with farmers practice. As compared to farmers practice, application of recommended fertilizer dose (120:60:40 N, P_2O_5, K_2O kg/ha) along with herbicide (pyrazosulfuron 20 g/ha as PE *fb* bispyribac sodium 25 g/ha at 20 DAS) effectively reduced the weed density and dry weight **(Table 5.9).** The grain yield (4.14 t/ha) and net return (₹ 48983/ha) was also higher in CA with RDF and herbicide in comparison to farmers practice.

Table 5.9: Weed management, productivity and economics of OFR treatments in rice at Bargi locality during *Kharif*, 2021 (average of 5 farmers)

Treatment	Weed population (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF + CA + WM	45.31	25.10	85	4.14	77335	48983	2.73
FP	51.16	48.86	71	3.30	65287	34840	2.15
RDF + CA + Weedy	142.03	168.36	-	1.08	16401	-8508	0.66

CA: Conservation agriculture; RDF: Recommended dose of fertilizer; WM: Weed Management; FP: Farmers Practice

Maize (*Kharif*, 2021)

During *Kharif*, 2021, five OFR trials in maize were conducted at farmers' field. The major weed flora observed were *Dinebra* spp., *Echinochloa* spp., *Digitaria* spp., *Phyllanthus niruri, Commelina communis, Cynotis* spp., *Cyperus rotundus* and *Cyperus iria*. Weed density and dry weight in maize grown with recommended fertilizer (120:60:40 N, P_2O_5, K_2O kg/ha) and herbicide (atrazine 750 g/ha *fb* tembotrione 120 g/ha at 30 DAS) under CA was lower than farmers practice **(Table 5.10).** The maximum plant height and number of cobs/m² were recorded from the plots received recommended fertilizer and advanced weed management practice under CA. The grain yield of maize was 4.92 t/ha in CA practice with improved weed management technique. As compared to the farmer practice, the higher net return (₹ 60391) and B:C ratio (2.98) were recorded with the same treatment.



Table 5.10: Weed management, productivity and economics of OFR treatments of maize at Bargi locality during *Kharif*, 2021 (average of 4 farmers)

Treatment	Weed population (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF + CA + WM	39.69	28.77	89	4.92	90928	60391	2.98
FP	79.80	89.98	66	4.50	83620	49847	2.48
RDF+CA+Weedy	205.67	262.91	-	2.44	67493	36900	2.41

CA: Conservation agriculture; RDF: Recommended dose of fertilizer; WM: Weed Management; FP: Farmers Practice

Greengram (summer, 2021)

On-farm research trials were undertaken in greengram under conservation agriculture during summer, 2021 at five farmers' fields in Mankhedi, Saliwada, Riwa, Nayagaon and Chullaghat villages of Bargi locality. The major weed flora observed was *Alternanthera sessilis, Echinochloa colona, Oldenlandia* spp., *Euphorbia geniculata*, and *Cyperus rotundus*. Results obtained from OFR trials revealed that RFD (20:60:40 N, P_2O_5, K_2O kg/ha) + CA + imazethapyr 100 g/ha as post-emergence was effective and gave broad spectrum weed control and seed yield of 1.80 t/ha, as compared to 1.38 t/ha under FP (Conventional tillage + 1 hand weeding) and provided net return of ₹ 103340/ha with higher B:C ratio over farmers practice. Beside this, use of Happy Seeder saved time and favoured early sowing of greengram which helped in utilizing residual soil moisture, and saved field preparation cost **(Table 5.11).**

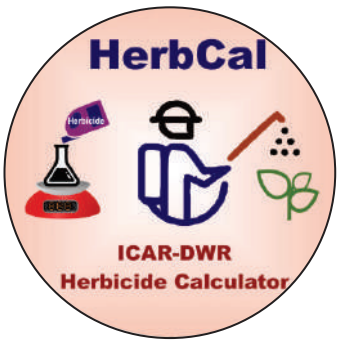
Table 5.11: Weed management, productivity and economics of OFR treatments in greengram at Bargi locality during summer, 2021 (average of 5 farmers)

Treatment	Weed population (no./m²)	Weed dry weight (g/m²)	WCE (%)	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
RDF+CA+WM	20.66	4.28	98	1.80	129744	103340	4.92
FP	45.75	47.02	73	1.38	99521	68408	3.20
RDF + CA + Weedy	112.54	171.14	-	0.31	21948	-6881	0.77

CA: Conservation Agriculture; RDF: Recommended dose of fertilizer; WM: Weed Management; FP: Farmers Practice

5.1.3 Development of Mobile App for herbicide calculation & judicious use (HerbCal)

- Herbicide-based weed management is tricky and little bit technical where appropriate calculation of herbicide and water volume for small farms has always been a problem.
- The amount of herbicide to be applied in a field depends upon herbicide formulation, crop and field size, etc. Farmers and others stakeholders often get confused about this.



- To solve this problem, Directorate has developed a user friendly mobile app named 'DWR-Herbcal' for application of herbicides. Using the app, excessive and under-dose can be prevented and appropriate weed control can be achieved irrespective of field size.
- The basic requirement to operate this app is to have an Android device with net connectivity, and the software of "HerbCal" may be downloaded from the Google play store. After completion of download, setup file has to be run for the installation in a device. An icon will appear on mobile screen after complete installation.
- In this app, from the drop-down menu the farmer has to select season, crop and name of herbicide.
- After that farmer/stakeholder has to enter only area of his farm and formulation of herbicide.
- The app will automatically calculate the amount of herbicide and quantity of water to be taken for spray.
- Till date users such as researchers, extension workers and students have downloaded the App.

5.2 Impact assessment of weed management technologies

5.2.1 Trends in herbicide research in the world during 2011-2020: A web of science-based scientometric study

Herbicide research domain spread across multi-dimensional field such as herbicide efficacy, herbicide residue, herbicide resistant crops, toxicology, environmental sciences etc. In fact, the weed research is more oriented towards herbicides research and more funding is routed in this direction. Nevertheless, this changing scenario necessitated scientists across globe to address emerging issues related to herbicides because weed management has to be considered as continues process in the agricultural system. In this context, the study attempts a scientometric analysis of herbicides research undertaken during the period from 2011 to 2020. For this, we collected the bibliometric data on published literature from ISI Web of science core collection data

base in March 2021. A combination of search strings was used to obtain the appropriate data on herbicide research and VOS viewer software was used for analysing the networks between authors, organizations, journals and countries. The number of published articles on "herbicide research" witnessed an increasing trend during the period from 2011 to 2020 (**Figure 5.2**).

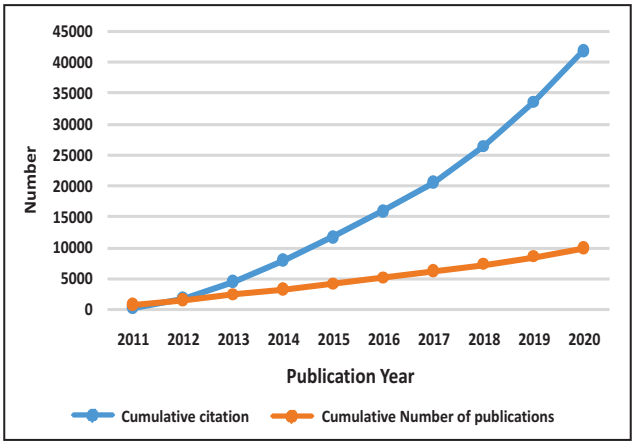


Figure 5.2: Year-wise cumulative number of publications and citations in herbicide research

By 2020, a cumulative number of 9980 research articles were published with an average citation per article of 9.94. Further, there were 71 countries who published at least 10 articles on herbicide research during this period. Of the 71 countries, top 10 countries were ranked based on number of publications and total citations **(Table 5.12).** It was observed that, USA ranked first with 3056 published articles, followed by Peoples R. China and Brazil with 1067 and 1013 articles, respectively. India was positioned at 7th place in terms number of published articles. Whereas with respect citations, the first ranked country was USA (33282 citations) followed by Peoples republic of China and Australia with 11240 and 8688 citations respectively. The interesting fact is that, the Brazil positioned at 6th rank in terms of citations while it was on 3rd position in the ranking based on number of published articles. A co-occurrence network of most frequently used author keywords was constructed **(Figure 5.3)** to find out most focused field in the herbicide research domain.

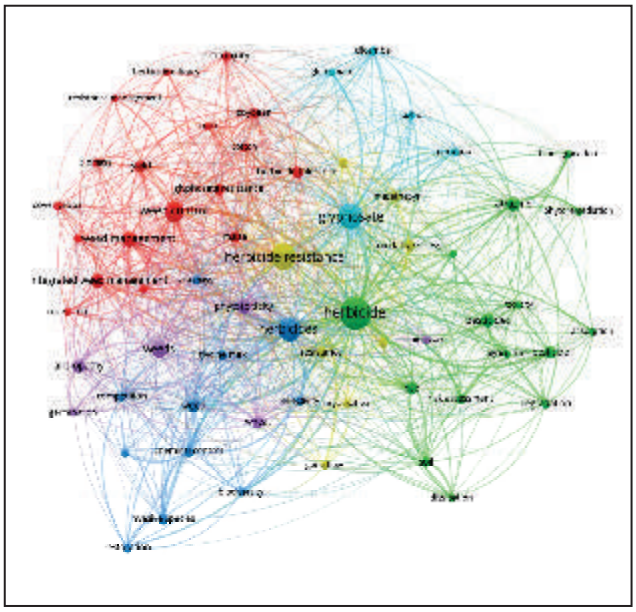


Figure 5.3: Co-occurrence network of the most frequently used author keywords

The analysis indicated that, 63 important keywords met the threshold of 50 as minimum occurrence of a keyword. Four prominent clusters were found in the network wherein as obvious fact "herbicide" is the key word with highest link strength (426). However,the keyword "herbicide resistance" is the leading and significant keyword with a link strength of 256 and other words connected in this cluster are gene flow, oxidative stress and imazethapyr.

Table 5.12: Top 10 countries in terms of their publications and citations

Rank	Country	Number of publications	Rank	Country	Total citations
1	USA	3056	1	USA	33282
2	Peoples R China	1067	2	Peoples R China	11240
3	Brazil	1013	3	Australia	8688
4	Australia	595	4	Spain	8258
5	Spain	510	5	Germany	7264
6	Canada	477	6	Brazil	6124
7	India	468	7	France	5585
8	Germany	462	8	Canada	5201
9	Italy	358	9	Italy	3986
10	France	345	10	England	3962

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6. Externally Funded Projects

Externally funded projects are target oriented projects to carry out research work on focus line in a given time frame. This directorate is having eight such projects. The summary of the projects and the work carried out during 2020-21 under these projects are outlined below:

Sl. No.	Project	Principal Investigator	Funding Agency	Collaborating Institution	Period	Budget (₹ Lakh)
6.1	Development of integrated weed management techniques for conservation agriculture system	Dr. V.K. Choudhary	CRP-ICAR	CRP on CA centres	2015-2021	65.00
6.2	Enhancing crop productivity and livelihood security through improved technological interventions in Jabalpur district of Madhya Pradesh	Dr. R.P. Dubey	Farmer FIRST Programme, ICAR	FFP centres	2017-2021	51.34
6.3	Expansion of activities of Biotech KISAN-Hub in seven aspirational Districts in Madhya Pradesh	Dr. P.K. Singh	DBT, New Delhi	Biotech KISAN-Hub centres	2018-2022 (Completed)	43.40
6.4	Evaluation of the bio-efficacy of imazethapyr 10%SL against weed complex in herbicide-tolerant rice	Dr. V. K. Choudhary	ADAMA India Pvt. Ltd.	ICAR-DWR	2021-22	5.00
6.5	Bio-efficacy and phyto-toxicity evaluation of GPH 1120 on wheat	Dr. V. K. Choudhary	UPL, India Pvt.. Ltd.	ICAR-DWR	2020-22	12.45
6.6	Field demonstration extension oriented activities and research in biological control of *Parthenium* for the Rural Development	Dr. Jaya Singh (Mentor) Dr. Sushil Kumar	DST, New Delhi	None	2018-2021 (Completed)	28.88
6.7	Assessment and monitoring of invasive aien plant species in India and formulation of strategies for management of Key invasive alien plant species in different regions of the country	Dr. Sushil Kumar	ICFRE, Dehradun	TFRI, Jabalpur IFGTB, Coimbatore Bharathidasan University, Trichy, SSN College of Engineering, Chennai FRI, Dehradun	2020-2025	20.40
6.8	Evaluation of impact of elevated CO_2 and temperature on crop and weed interaction, dynamics and herbicide bioefficacy	Dr. Shobha Sondhia	NICRA	UAS, Bengaluru, ICAR-IIHR, PJTSAU, Hyderabad ICAR-CRIDA, Hyderabad	2021-2024	55.00
6.9	Sponsored project on "Bio-efficacy and phyto-toxicity evaluation of 2,4-D sodium salt 80% WP against weed complex in maize crop and its effect on succeeding crop"	Dr Pijush Kanti Mukherjee	ADAMA India Private Limited	None	2021-2023	11.50

6.1 Development of integrated weed management techniques for conservation agriculture system

6.1.1 Weed management in rice-wheat - greengram based cropping system under conservation agriculture

Wheat (2020-21)

Among the crop establishment methods, weed density and biomass were lower in ZT (DSR)+R+S-ZTR-ZTR (102.9 no./m^2 and 41.3 g/m^2, respectively). This resulted in higher WCE (42.6 followed by CT (DSR)+R+S-CTR-ZTR. The highest weed density and biomass were recorded with CT (TPR)-CT-ZT (158.7 no./m^2 and 71.9 g/m^2, respectively). The grain and straw yield was significantly higher in DSR ZT+R+S-ZTR-ZTR (4.12 and 5.74 t/ha, respectively) (**Figure 6.1a**). Among weed management practices, an application of clodinafop+metsulfuron (60+4 g/ha)

has the lowest weed density and biomass (27.7 no./m^2 and 6.5 g/m^2, respectively) with higher WCE (95.7%), whereas the highest values were measured in weedy check (326.1 no./m^2 and 151.0 g/m^2, respectively). Lower weed values with higher weed control efficiency led to obtaining significantly higher grain and straw yield with clodinafop+metsulfuron (60+4 g/ha) (4.41 and 5.90 t/ha, respectively), which was close to mesosulfuron+iodosulfuron (12+2.4 g/ha). However, the lowest yield attributes and yield was recorded with the weedy check (2.50 and 5.20 t/ha, respectively).

Greengram (2021)

At 45 DAS, among the crop establishment methods, the highest weed density and biomass was recorded with TPR-CT-ZT (82.6 no./m^2 and 90.3 g/m^2, respectively), whereas the lowest weed density and biomass was recorded in DSR ZT+R+S-ZTR-ZTR (36.4 no./m^2 and 39.5 g/m^2, respectively). This resulted in achieving 56.3% WCE in DSR ZT+R+S-ZTR-ZTR over TPR-CT-ZT. However, higher seed and straw yield was recorded in CT (DSR) +S-CT-ZT (1.01 and 2.05 t/ha, respectively). The lowest seed and straw yield was recorded with TPR-CT-ZT (0.77 and 1.58 t/ha, respectively). Among weed management practices, weedy check has the highest weed density and biomass (113.3no./m^2 and 143.3 g/m^2, respectively) and the lowest was recorded with pendimethalin 678 g/ha *fb* hand weeding (22.6 no./m^2 and 13.5 g/m^2, respectively) with the highest WCE (90.6%) over weedy check. This led to the highest grain and straw yield with pendimethalin 678 g/ha *fb* hand weeding (1.10 and 2.07 t/ha, respectively) followed by pendimethalin 678 g/ha, whereas the lowest yield attributes and yield was recorded with weedy check (**Figure 6.1b**).

Rice (2021)

The rice field comprised with major grasses like *Echinochloa colona, Dinebra retroflexa, Digitaria sanguinalis, Cynodon dactylon* broad leaved weeds *Alternanthera sessilis, Physalis minima, Caesulia axillaris, Phyllanthus urinaria* and *Trianthema portulacastrum* and *Cyperus iria* was only sedge present. Among the crop establishment methods the highest weed density and biomass were recorded with ZT+R (150.9 no./m^2 and 81.9 g/m^2, respectively), whereas the lowest weed density and biomass was recorded with CT (140.6 no./m^2 and 71.4 g/m^2, respectively) with 6.8% WCE. Lower weed parameters with higher WCE helped in harvesting higher grain and straw yield in CT (1.83 and 2.88 t/ha, respectively). The lowest grain and straw yield was recorded in ZTR. Among weed management practices, the lowest weed density and biomass with highest WCE was recorded in integrated weed management (pretilachlor+ pyrazosulfuron at 615 g/ha *fb* bispyribac sodium 25 g/ha *fb* HW (65.1 no./m^2, 22.2 g/m^2 and 92.2%, respectively) followed by herbicide rotation. The highest weed density and weed biomass was recorded with weedy check (295.3 no./m^2 and 190 g/m^2, respectively). The higher grain and straw yield was recorded with integrated weed management (2.76 and 4.24 t/ha respectively) but was comparable to herbicide rotation, whereas the lowest yield recorded with weedy check (**Figure 6.1c**).

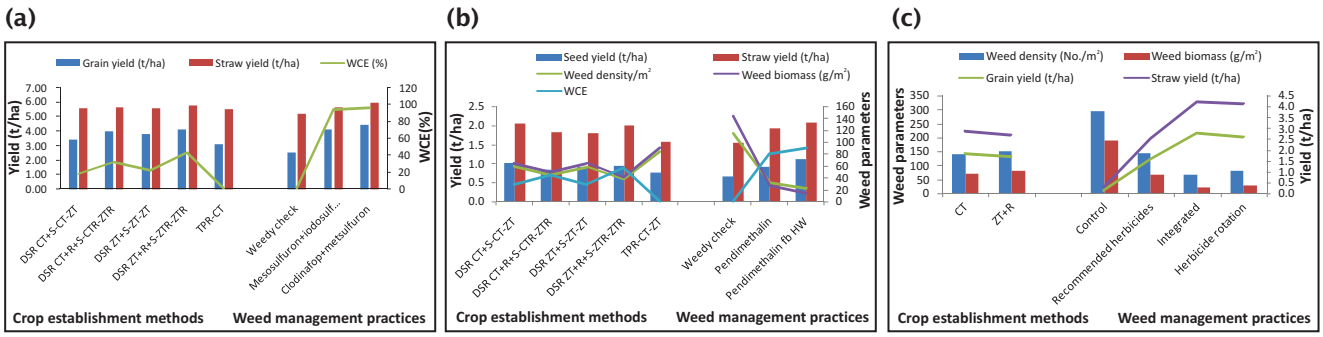

Figure 6.1: Effect of crop establishment methods and weed management practices on rice-wheat greengram cropping system a) wheat, b) greengram and c) rice

6.1.2 Weed management in rice-chickpea/ mustard/pea-greengram cropping system

The study area comprised of *Medicago polymorpha, Chenopodium album, Phasalis minima, Sonchus oleraceous, Rumex dentatus, Convolvulus arvensis, Lathyrus aphaca* were major broadleaved weeds, *Avena ludoviciana, Phalaris minor* and *Digitaria sanguinalis* were major grassy weeds.

Pea (2020-21)

Lower weed parameters in ZT DSR+R+S-ZTR-ZTR recorded higher seed and stover yield (1.39 and 2.33 t/ha, respectively) and the lowest in TPR-CT-ZT. Among weed management practices, pendimethalin 678 g/ha *fb* hand weeding recorded lower weed parameters (20.3 no./m^2, 9.0 g/m^2 and 93.8%, respectively). Lower weed parameters and better weed

control in pendimethalin 678 g/ha *fb* hand weeding recorded with 1.36 and 2.24 t/ha, respectively of seed and haulm yield (**Figure 6.2a**).

Mustard (2020-21)

Seed yield was recorded highest in ZT DSR+R+S-ZTR-ZTR (2.02 t/ha) and lowest with TPR-CT-ZT (1.30 t/ha). Application of pendimethalin 678 g/ha *fb* HW recorded lower weed parameters (25.3 no./m^2, 10.9 g/m^2 and 92.2%). The highest seed yield (1.94 t/ha) was recorded in pendimethalin 678 g/ha *fb* HW and lowest with weedy check (1.55 t/ha) (**Figure 6.2b**).

Chickpea (2020-21)

Better yield attributes gave higher seed yield in ZT DSR+R+S-ZTR-ZTR (2.17 t/ha) and the lowest yield with TPR-CT-ZT (1.45 t/ha) (**Figure 6.2c**). Among weed management practices, higher seed and haulm yield was recorded in pendimethalin *fb* hand weeding (2.09 and 3.33/ha, respectively) whereas the lowest yields were obtained weedy check (0.55 and 1.09 t/ha, respectively).

Greengram (2021)

The lowest seed and straw yield was recorded with TPR-CT-ZT (0.72 and 2.42 t/ha, respectively). Among weed management practices, highest grain and straw yield were recorded with pendimethalin 678 g/ha *fb* hand weeding (1.20 and 3.37 t/ha, respectively) followed by pendimethalin 678 g/ha, whereas the lowest yield attributes and yield was recorded with weedy check (**Figure 6.2d)**.

Maize (2021)

Lower weed parameters with higher WCE helped in harvesting higher grain and straw yield in ZT+R (6.68 and 9.67 t/ha, respectively). The lowest grain and straw yield was recorded in CT. Among weed management practices, The higher yield was recorded with herbicide rotation (7.63 and 10.19 t/ha respectively) but was comparable to integrated weed management, whereas the lowest yield recorded with weedy check (**Figure 6.2e**).

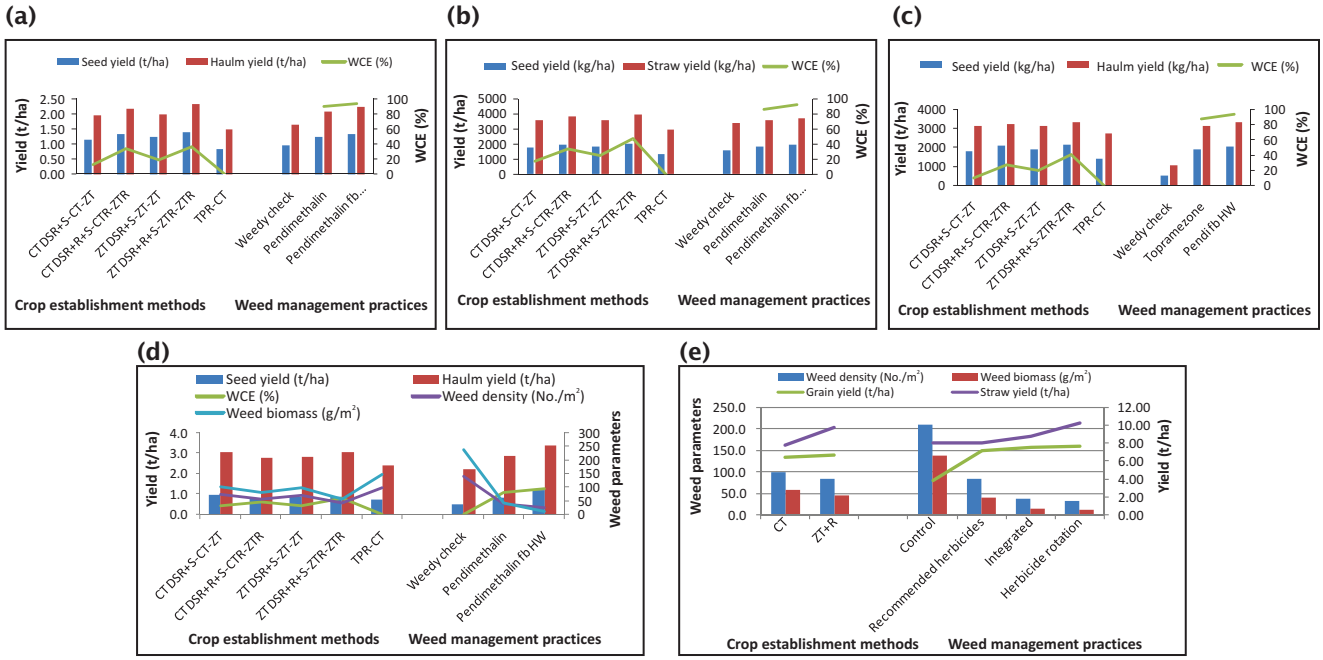

Figure 6.2: Effect of crop establishment methods and weed management practices on rice-pea/mustard/maize-greengram cropping system under conservation agriculture a) pea, b) mustard, c) chick pea, d) greengram and e) maize

6.1.3 Weed management in soybean-wheat-greengram cropping system under conservation agriculture

Wheat (2020-21)

The experiment area comprised with major broadleaved weeds *i.e. Medicago polymorpha, Convolvulus arvensis, Chenopodium album, Rumex dentatus, Euphorbia geniculata, Sonchus oleraceus, Physalis minima, Cichorium intybus, Trifolium sp.* and *Solanum nigrum*, whereas, *Avena ludoviciana, Paspaladium flavidium, Digitaria sanguinalis, Cynodon dactylon* and *Dicanthium annulatum* were major grassy weeds present and *Cyperus rotundus* was only sedge present.

Among crop establishment methods, higher grain and straw yield was recorded in CT-CT-ZT (3.76 and 5.00 t/ha, respectively) followed by CT-ZT-ZT, whereas, the lowest yield obtained in ZT-ZT-ZT (3.17 and 4.4.29 t/ha, respectively) (**Figure 6.3a**). Among weed management practices, lower weed parameters in clodinafop+metsulfuron 60+4 g/ha helped for better yield attributes resulted in higher grain and straw yield in (4.39 and 5.61 t/ha, respectively) followed by mesosulfuron + iodosulfuron 14.4 g/ha. The lowest grain and straw yield were recorded in weedy check (2.17 and 3.91 t/ha, respectively).

Greengram (2021)

Among the crop establishment methods, higher seed and straw yield was recorded in CT-CT-ZT (0.61 and 1.43 t/ha, respectively). The lowest seed and straw yield was recorded with ZT-ZT-ZT (0.36 and 1.01t/ha, respectively). Among weed management practices, highest seed and straw yield was recorded with pendimethalin 678 g/ha *fb* hand weeding (0.68 and 1.39 t/ha, respectively) followed by pendimethalin 678 g/ha, whereas the lowest yield attributes and yield was recorded with weedy check (**Figure 6.3b**).

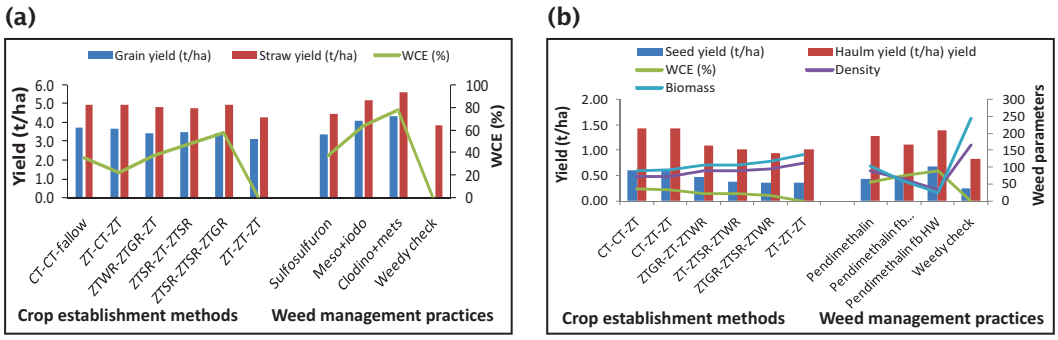

Figure 6.3: Effect of crop establishment methods and weed management practices on soybean-wheat-greengram cropping system under conservation agriculture a) Wheat b) Greengram

6.1.4 Weed management in maize-wheat-greengram cropping system under conservation agriculture

Wheat (2020-21)

Among crop establishment methods, CT-CT-ZT recorded the highest grain and straw yield (3.56 and 5.09 t/ha, respectively). Among weed management practices, higher grain and straw yield was recorded in sulfosulfuron + metsulfuron 30+2 g/ha (3.82 and 5.41 t/ha, respectively), whereas the lowest grain and straw yield was recorded in the weedy check (**Figure 6.4a**).

Greengram (2021)

Among the crop establishment methods, higher seed and straw yield was recorded in CT-CT-ZT (0.61 and 1.66 t/ha, respectively). The lowest seed and straw yield was recorded with ZT-ZT-ZT (0.36 and 1.27 t/ha, respectively). Among weed management practices, highest seed and straw yield was recorded with pendimethalin 678 g/ha *fb* hand weeding (0.70 and 1.60 t/ha, respectively) followed by pendimethalin 678 g/ha *fb* imazethapyr 100 g/ha, whereas the lowest yield attributes and yield was recorded with weedy check (**Figure 6.4b**).

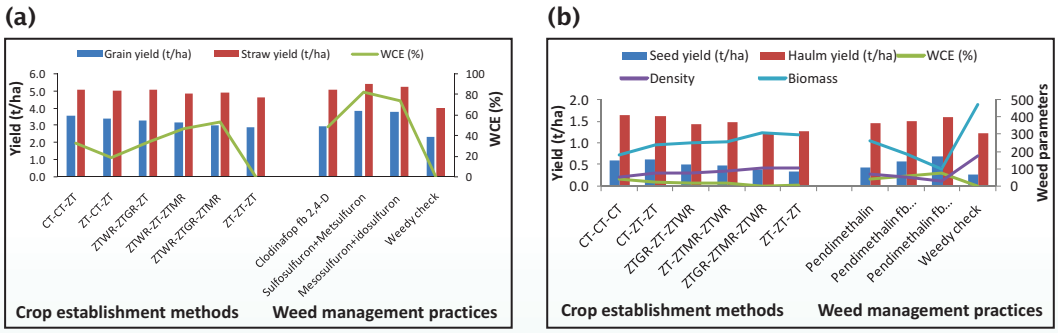

Figure 6.4: Effect of crop establishment methods and weed management practices on maize-wheat-greengram cropping system under conservation agriculture a) wheat, and b) greengram

6.1.5 Weed management in maize-mustard-greengram cropping system

Mustard (2020-21)

Among crop establishment methods, Lower weed parameters and better weed suppression in ZTMsR-ZTGR-ZTMR leads to more yield attributes which, further helped in harvesting more seed and stover yield (1.73 and 3.25 t/ha, respectively) and lowest with ZT-ZT-ZT (1.56 and 2.88 t/ha, respectively). Pendimethalin 678 g/ha *fb* hand weeding recorded more yield attributes *viz*. branches/plant, siliqua/plant and seeds/siliqua resulted in higher seed yield (1.95 t/ha) and straw yield (3.71 t/ha) obtained followed by oxyfluorfen 150 g/ha and pendimethalin 678 g/ha. The lowest seed and straw yield were recorded with weedy check (1.34 and 2.46 t/ha, respectively) (**Figure 6.5a**).

Greengram (2021)

Among crop establishment methods, in CT-CT-ZT obtained higher seed (1.07 t/ha), but stover yield was recorded highest with ZTR-ZTR-ZTR (1.85 t/ha) and was comparable to other crop establishment methods. Among weed management practices, higher grain and straw yield was recorded with pendimethalin 678 g/ha *fb* hand weeding (1.32 and 2.18 t/ha, respectively) followed by pendimethalin 678 g/ha *fb* quizalofop 50 g/ha (**Figure 6.5b**).

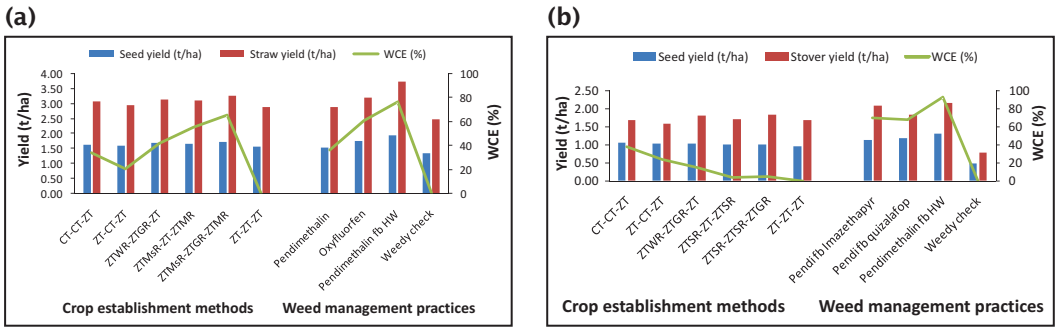

Figure 6.5: Effect of crop establishment methods and weed management practices on maize- mustard-greengram cropping system under conservation agriculture a) mustard and b) greengram

6.2 Enhancing crop productivity and livelihood security through improved technological interventions in Jabalpur district of Madhya Pradesh

The Farmer FIRST Project is being undertaken at two villages viz. Barouda and Umaria Choube of Panagar block of Jabalpur district. The project envisages in uplifting the livelihood security of farmers and landless women by empowering them with the improved technologies in agriculture and allied sectors. During 2021-22, the major activities carried out by the project are

- Mushroom cultivation at village Barouda during January to March 2021.
- Field visit of women farmers to DWR on 8 March 2021 on the occasion of Women's Day.
- Improved greengram seed and DAP fertilizer to 100 farmers in village Baroda and Umaria Choube.
- New generation herbicide (Vivaya) cyhalofop + penoxsulam @ 2250 g/ha for broad spectrum weed control to 50 farmers of the 2 villages.
- Exposure Visit of 30 farmers to research farm DWR on 26-08-2021
- Cattle mineral mixture for improving animal health and milk production to 50 farmers of the 02 villages.
- Interaction with women farmers and exposure visit (15 women farmers) to research farm during Poshan Vatika mahabhiyan and plantation program on 17-09-2021
- Farmer-scientist interface meeting on "Climate resilient agriculture technology held on 28-09-2021 in which forty one farmers participated.
- Field visit of Farmers to composting unit of DWR on 05 December 2021 on the occasion of World Soil health Day.
- New generation herbicide clodinafop propargyl 15% + metsulfuron methyl 1 % WP @ 160 g/ha for broad spectrum weed control to 100 farmers of 02 villages during December 2021
- Distribution of vegetable seed for home garden to 10 farmers during December 2021

Mushroom cultivation at Barouda village

Field exposure visit of farmers to DWR

6.3 Expansion of activities of Biotech KISAN-Hub in seven aspirational districts in Madhya Pradesh

During *Rabi* 2020-21, 13 field demonstrations (7 in wheat and 6 in lentil) were conducted to make the farmers aware about new varieties and production technologies. It was found that wheat demonstration plots recorded with 4.25 t/ha which was about 21% higher than farmers practices along with reduction in 16% of production cost (mainly by reducing seed rate and engagement of labour) and provide 21 % higher net return and 46% better B:C. Similarly, in lentil demonstration plots recorded seed yield of 1.25 t/ha with 46% higher over farmers practices, it also reduced 15% production cost resulting in 51% higher net return and 83% more B:C. During *Kharif* 2021, 13 field demonstrations (7 in soybean and 6 in rice) were conducted to make the farmers aware about new varieties and production technologies. In soybean, demonstration recorded seed yield of 1.5 t/ha which was about 50% more than farmers practices with 7% reduction in production cost resulted in 50% higher net return and 50% better B:C. Similarly, in rice demonstration plots recorded 5.4 t/ha grain yield which was about 74% more than farmer's practices with 3% lesser production cost and provided 74% higher net return and 70% higher B:C.

In order to develop seed hub, during *Kharif* 2021, demonstration on rice (*JR-81, JR-206, IR-64, MTU-1010, Kranti & sahbhagi) and soybean (JS-2098, JS-2069, JS20116, JS-2034 & RVS-2001-4*) were made at Damoh district of Madhya Pradesh. Among the tested varieties, the higher yield was recorded in Kranti of rice (5.25 t/ha) and *JS-2098* variety of soybean (2.8 t/ha) with lesser insect and disease attack, therefore considered good variety for the area. Total 18 training were imparted (13 at Damoh, 4 at Sehore and 1 at Hoshangabad) in which altogether 1150 farmers were participated and benefitted. Similarly, celebrating "Bharat ki Azadi ka Amrit Mahotsav" Directorate of Weed Research also organized six number of farmers webinar on different aspect, under Biotech Kishan hub project, in which more than 1200 farmers including researcher, students and other stakeholders were actively participated.

6.4 Evaluation of the bio-efficacy of imazethapyr 10%SL against weed complex in herbicide- tolerant rice

Imazethapyr was evaluated at different doses and times of application along with a standard check, twice hand weeding and weedy check in herbicide tolerant rice (HTR) under dry direct-seeded ecosystem. The HTR has not shown any phytotoxic symptoms throughout the crop growth period, except at sequential dose of imazethapyr at 200 g/ha at early and late post emergence. The sequential application of imazethapyr at 100-125 g/ha at 14 and 28 days after sowing (DAS) has considerably suppressed the weeds and also provided higher grain yield and was economically viable over the other tested weed management practices. It has also been recorded that single application of imazethapyr at 100-200 g/ha at 20 DAS could not suppress some of the weeds, although an increase in dose has an edge over lower doses. Hence, the application timing of imazethapyr also played important role in suppressing weeds.

6.5 Bio-efficacy and phyto-toxicity evaluation of GPH 1120 on wheat

During *Rabi* 2020-21, newly coded molecule GPH 1120 was evaluated in wheat along with other variables. It was found that among various tested variables hand weeding at 20 and 40 days after sowing was superior over others. This was followed by GPH 1120 at 675 and 421.87 g/ha. However, wheat is a competitive crop resulted in seed yield of 4.86 t/ha in twice hand weeding followed by GPH 1120 at 675 and 421.87 g/ha. The highest weed density and biomass with lowest grain yield recorded in weedy check plots.

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7. Transfer of Technology

7.1 Kisan Mobile Advisory Services (KMAS)

The revolution in Information and Communication Technology (ICT) has made access to the information easy and cost effective to the rural masses in general and farming community in particular. *Kisan* Mobile Advisory Services (KMAS) or *Kisan Mobile Sandesh* (KMS) is one among several methods of ICTs working successfully for dissemination of latest information related to agriculture. This service is based on the linear model of communication which involves mainly four components of the communicatuion process viz. Sender, Message, Channel and Receiver. Directorate is also using this facility for sending weed management related information to the registered farmers. This *Kisan Mobile Sandesh* contains real time agricultural information and customized knowledge on weed management technologies which were delivered during the initial days of cropping seasons and thereby enabling the farmers to take timely action in order to manage weeds. During the year 2021, such messages were delivered during *Kharif*, *Rabi* and summer season to the registered farmers and other stakeholders **(Table 7.1)**. Registration to KMAS may be done by sending an e-mail to director.weed@icar.gov.in which is free for all interested stakeholders of the country.

Table 7.1: Details of the *Kisan Mobile Sandesh* delivered during 2021

क्र.	संदेश	दिनांक
1	सोयाबीन में खरपतवार नियंत्रण हेतु सोडियम एसिफ्लोरफेन + क्लोडिनाफाप प्रोपारजील (आयरिश) 400 मिली/एकड़ का प्रयोग 20 दिन पर करें। खरपतवार निदेशालय, जबलपुर	15/07/2021
2	धान की फसल में खरपतवार प्रबंधन के लिए पिनाक्सुलम + साइहेलोफोप (विवाया) 900 मिली/एकड़ की दर से 20 दिन पर प्रयोग करें। खरपतवार निदेशालय, जबलपुर	15/07/2021
3	धान की फसल में खरपतवार प्रबंधन के लिए बिसपायरीबेक सोडियम 100 मिली/की दर से 20 दिन पर प्रयोग करें। खरपतवार निदेशालय, जबलपुर	15/07/2021
4	रोपाई वाले धान में उचित खरपतवार प्रबंधन के लिए बेनसलफ्युरान + प्रेटिलाक्लोर 4 किग्रा/एकड़ रोपाई के 5 से 7 दिन के भीतर प्रयोग करें। खरपतवार निदेशालय, जबलपुर	16/07/2021
5	मक्का में खरपतवार प्रबंधन हेतु टेम्बोट्रियोन (लाडिस) 115 मिली + एट्राजिन 400 ग्राम/एकड़ बुवाई के 15 से 20 दिन में 150 ली. पानी में घोल कर नैकसेप स्प्रेयर एवं फ्लेटफैन नोजल की सहायता से प्रयोग करें। खरपतवार निदेशालय, जबलपुर	16/07/2021
6	मक्का में खरपतवार प्रबंधन हेतु टोप्रामिजान (टिंजर) 30 मिली + एट्राजिन 400 ग्राम/एकड़ बुवाई के 15 से 20 दिन में प्रयोग करें। खरपतवार निदेशालय, जबलपुर	16/07/2021
7	मूंग एवं उड़द में घास कुल के खरपतवारों के नियंत्रण हेतु क्यूजालोफाप ईथाइल (टरगासुपर) 400 मिली/एकड़ की दर से प्रयोग करें। खरपतवार निदेशालय, जबलपुर	19/07/2021
8	मूंगफली एवं अरहर में खरतपवार नियंत्रण हेतु इमेजाथापायर (परस्युट) 400 मिली/एकड़ का प्रयोग 18 से 20 दिन पर करें। खरपतवार निदेशालय, जबलपुर	19/07/2021
9	मूंग एवं उड़द में खरपतवार नियंत्रण हेतु इमेजाथापायर (परस्युट) 400 मिली/एकड का प्रयोग 150 ली. पानी में घोलकर 20 दिन पर नैपसेक स्प्रेयर एवं फ्लेटफैन नोजल की सहायता से करें। खरपतवार निदेशालय, जबलपुर	19/07/2021
10	खेत खलिहान का कचरा लायें। उससे केंचुआ खाद बनायें। मृदा स्वास्थ्य एवं आय बढ़ायें। खरपतवार निदेशालय, जबलपुर	20/07/2021
11	खेत खलिहान का कचरा लायें। उससे केंचुआ खाद बनायें। खरपतवार निदेशालय, जबलपुर	20/07/2021
12	खरपतवारों से कम्पोस्ट बनायें। एक साथ कई लाभ कमायें। खरपतवार निदेशालय, जबलपुर	20/07/2021

7.2 Farmers' visit

Large number of farmers including farm women and agricultural officers of State Department of Agriculture visited the Directorate during the year. Directorate facilitated the visits to disseminate the latest weed management technologies displayed at the Directorate's farm including Technology Park. During the visit, farmers and agricultural officers were made aware about the technolgies adopted and displayed at the farm of the Directorate. Details about the farmers' visit are given (**Table 7.2**).

Table 7.2: Details of Agricultural Officials/farmers visited the Directorate during 2021

District	Number of agricultural officials/ farmers
Damoh (M.P.)	144
Fatehpur (U.P.)	55
Gujarat	100
Hoshangabad (M.P.)	40
Jabalpur (M.P.)	147
Panna (M.P.)	20
Sagar (M.P.)	18
Sehore (M.P.)	45
Umariya (M.P.)	30

Similarly, Directorate also facilitated the study tour programme of 65 students of Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur and 30 students of Government Science College, Jabalpur.

7.3 *Mera Gaon Mera Gaurav* programme

Directorate successfully continued '*Mera Gaon Mera Gaurav*' programme at five villages of Patan and Bargi localities near to Jabalpur to transfer weed management technologies to the farmers and provide them advisories on weed management. For the purpose, a multi-disciplinary team of scientists along with the technical officers and other associated staff of the Directorate with them visited the selected localities on a fixed day of week on regular basis. Under this programme, scientists remain in touch with the farmers of the selected villages and provide information to them on technical and other related aspects. Under this programme, many activities have been carried out during the year. On-farm research cum demonstration trials were conducted on weed management in wheat, chickpea, greengram, rice and maize crops during *Rabi*, 2020-21; Summer, 2021 and *Kharif*, 2021. Besides, other activities such as *Kisan Sangoshthis*, field day, *Parthenium* awareness week, activities under *Swachh Bharat Abhiyan* and webinars on various topics of relevance were also conducted.

7.4 Schedule Caste Sub Plan (SCSP)

Directorate facilitated various activitites under Schedule Caste Sub Plan (SCSP) in the Patan, Shahpura, Katangi and Majhouli localities for the farmers of Scheduled Caste community. During March 2021, input distribution programmes were organized in these localities where SC farmers were provided with greengram seeds, fertilizers, biofertilizers and herbicides. Agricultural implements such as storage bins, sprayers, herbicide safety kit and farming tools were also distributed to the beneficiaries. During *Kharif*, 2021, agricultural inputs such as rice seeds, fertilizers, herbicides and biofertilizers were distributed among the SC farmers of these localities in order to reduce their burden on purchasing these inputs. To make the farmers aware about advanced farming technologies, a field visit for the farmers of Sahajpur, Shahpura was organized where they visited Krishi Vigyan Kendra, Seoni and also visited the fields of few progressive farmers of Seoni and nearby localities.

Under the ICAR's Special National Swachhta Campaign on the theme "Waste to Wealth (*Apshisht se Khushhaali*)", a programme was organized at Paudi Achloni, Patan followed by an awareness cum distribution programme under SCSP. During *Rabi*, 2021, input distribution programme was organized for the farmers of Sahajpur, Shahpura locality and Semra, Chargawan locality where the SC farmers of these localities where provided with the seeds of wheat and chickpea, fertilizers, biofertilizers along with

herbicides and pesticides. With the aim of enhancing the living standard of farmers and doubling their income through different agriculture related enterprises, a 6 days training programme on "*Krishi uddhyamon ke madhyam se krishakon ki ajivika me sudhar*" was organized at Directorate during 27 December, 2021 - 01 January, 2022 wherein 28 Scheduled Caste farmers were imparted theoretical and practical knowledge on different agro enterprises.

7.5 Programme under 'Farmers FIRST' Project

Two villages *viz*.-Umariya Choubey and Barouda of Panagar block of Jabalpur district were selected and activites were started from February 2017 and Directorate is running the project successfully ever since. Under this project, various activities like exposure visit, trainings, input distributions *etc*. were undertaken during 2021. Mushroom cultivation to promote subsidiary enterprises was done at village Barouda during January to March 2021. A field visit of women farmers to Directorate was organized on the occasion of Women's Day. Input distribution activities undertaken in this project during the year 2021 includes; improved greengram seed and DAP fertilizer to 100 farmers, new generation herbicide (Vivaya) cyhalofop + penoxsulam 2250 g/ha for broad spectrum weed control to 50 farmers, cattle mineral mixture improving animal health to 50 farmers, new generation herbicides clodinafop propargyl 15% + metsulfuron methyl 1 % WP 160 g/ha for broad spectrum weed control to 100 farmers and vegetable seeds for home garden to 10 farmers. Exposure visit of 30 farmers to research farm of Directorate was organized on 26 August, 2021. Interaction with women farmers and exposure visit (15 women farmers) to research farm of Directorate during *Poshan Vatika mahabhiyan* was held on 17 Sepetember, 2021. A farmer-scientist interface meeting on "Climate resilient agriculture technology" was also held on 28 September, 2021 and 41 farmers attended the programme. A field visit of farmers to composting unit of Directorate was organized on 05th December, 2021 on the occasion of World Soil Day.

7.6. Training cum exposure visits of farmers under DBT programme

Under Department of Biotechnology (DBT) sponsored Kisan Biotech Project, 4 one-day training-cum-exposure visits were organized for the farmers of the adopted villages of Damoh, Hoshangabad and Sehore districts during March, 2021.

7.7 Parthenium Awareness Week (16-22 August, 2021)

In view of the seriousness and magnitude of the threat posed by *Parthenium hysterophorus*, Directorate organized a country-wide "Parthenium Awareness Week (PAW)" campaign from 16-22 August, 2021 to make people aware of its ill effects and management options. Posters containing the message and appeal made by Dr. T. Mohapatra, Secretary, DARE and DG, ICAR to keep the Institute's campuses "Parthenium Free" along with extension folders were sent to all the VCs of the State Agricultural Universities (SAUs) and many other Universities under UGC, Directors of ICAR institutes, Principal Investigator of AICRP-Weed Management centres, Heads of regional stations, all KVKs in the country, municipalities of Madhya Pradesh and Chhattisgarh, school and colleges of Jabalpur and surrounding villages, District Panchayat Presidents of Uttar Pradesh, NGOs, Indian Council of Forestry Research & Education and its institutes, Principal Chief Conservator of forests of all the states etc. through e-mails, WhatsApp and uploaded on DWR Website, Facebook and Twitter. Seven webinars on Parthenium management were organized by Directorate in collaboration with other organizations in the country in which more than 1500 people participated.

One international Webinar was organized by Directorate in collaboration with Indian Society of Weed Science on 16 August, 2021 which was graced by Dr. S.K. Chaudhari, DDG (NRM) as the Chief Guest and Dr. S. Bhaskar, ADG (A, AF&CC), ICAR as Guest of Honour. The Keynote lecture was given by one of the renowned weed scientists, Dr. Steve W. Adkins from Queensland

University, Australia. Directorate also organized one Live programme on Parthenium in association with Reliance Foundation on 18 August, 2021 and a training programme on "Integrated Parthenium Management' on 19 August, 2021, wherein more than 236 and 300 stakeholders participated, respectively. All such programmes were also covered by print and electronic media, which further helped to disseminate the message in public. It was estimated that more than one million people have been made aware under this campaign through direct interactions, print and electronic media.

7.8 *Mahila Kisan Diwas*

Directorate celebrated Mahila Kisan Diwas on 15 October, 2021 at the campus. The day was celebrated on the theme 'Equity and Empowerment' with around 50 farm women along with all staff members of the Directorate. To recognize the contribution of women farmers in Indian agriculture and to provide them the information about the government initiatives to empower the women farmers, the programme was organized. Honorable Director and other scientists emphasized the role and importance of *Mahila Kisan* (women farmers) in agriculture and allied activities in addition to their daily household works.

7.9 *Swachhta Pakhwada*

Directorate observed '*Swachhta Pakhwada*' during 16-31 Dec, 2021 by conducting various on and off campus activities. It was launched on 16 Dec, 2021 with *Swachhta* Pledge (oath) which was taken by all staff members to make self, community, society, villages, and cities clean. Cleanliness and sanitation drive was organized at village Mudiya (Khurdh), Patan, Jabalpur. The villagers including farmers were apprised about the motive of *Swachhta Pakhwada* and importance of cleanliness and sanitation in our daily life. Campus of Choudhary Warehouse in Mudiya (Khurdh) was cleaned with the help of villagers and officials of the Directorate. Masks were also distributed to contain the spread of Covid-19. During the Pahwada, Kisan Diwas was also celebrated at Directorate on 23 December 2021. On this occasion, one progressive farmer Mr. Shyam Patel was felicitated for his outstanding work in creating *swachhta* awareness among his villagers and folks from nearby localities with the help of Patel *Kisan* club. As part Involvement of VIP/VVIPs in the *Swachhta* activities, Directorate organized a programme on 30 Dec, 2021 in which Er. S.S. Pathak, Executive Engineer, Divisional Office, CPWD, Jabalpur was invited as the chief guest. He emphasized the importance of inculcating cleanliness in human lifestyle especially in the era of Covid-19 pandemic.

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8. Training and Capacity Building

8.1 Participation in training programme

The scientists and other staff of the Directorate have participated in various training programmes for enriching their knowledge and up-skilling expertise. Mostly online trainings were attended during the reported year due to Covid-19 pandemic. Details of those trainings are given below.

Name & Designation	Training programme	Institution	Date
Dr. Sushil Kumar, Principal Scientist	Production protocol for biofertilizers	NIPHM, Hyderabad	04-08 January, 2021
Mr. Maithile Sharan Hedau, AF&AO	Accrual accounting	ICAR-NRRI, Cuttack	12-14 January, 2021
Mr. V.S. Raikwar, T-1	Advances in weed management	NIPHM, Hyderabad	03-05 February, 2021
Dr. K.K. Barman, Principal Scientist	Integrated soil nutrient and rhizosphere management	NIPHM, Hyderabad.	03-10 February, 2021
Dr. Santosh Kumar, RA	Intellectual property rights for agri startups	MANAGE, Hyderabad	08-12 February, 2021
Dr. P.K. Singh, Principal Scientist	Advances in agricultural technology	JNKVV, Jabalpur	24 February, 2021
Dr. P.K. Mukherjee, Principal Scientist Dr. Yogita Gharde, Scientist Mr. Dibakar Roy, Scientist	Geo-informatics in agriculture using open source data and analysis platforms	ICAR-IARI, New Delhi	01-05 March, 2021
All Scientists of the Directorate	Training-cum-workshop on *Madhya Pradesh me sabji utpadanistar badane hetu kharpatwar prabhandhan evm unnat takniki prayog*	ICAR-DWR, Jabalpur	09 March, 2021
Dr. Yogita Gharde, Scientist Mr. Sandeep Dhagat, CTO	Cyber security	C-DAC, Hyderabad	17 March, 2021
Mr. Dibakar Roy, Scientist	Management of soil health for sustainable production	ICAR-IARI, New Delhi	22-27 March, 2021
Dr. Pawar Deepak Vishwanath, Scientist Dr. Dasari Sreekanth, Scientist	Climate change adaptation in agriculture	MANAGE, Hyderabad	23-26 March , 2021
All Skilled Supporting Staff of the Directorate	Skill up-gradation in good office practices cum general awareness	ICAR-DWR, Jabalpur	24-26 March, 2021
Dr. P.K. Singh, Principal Scientist	Cyber security	Ministry of Electronics & Information Technology, GoI, New Delhi	29 April, 2021
Dr. Pawar Deepak Vishwanath, Scientist	National workshop on writing research proposals	Maharshi Dayanand University, Rohtak	30 April, 2021
All staff of the Directorate	Farmers training and interactive meet on innovation techniques for summer green gram and black gram cultivation	ICAR-DWR, Jabalpur	05 May, 2021
All staff of the Directorate	Farmers training and interactive meet on innovation techniques for soybean cultivation	ICAR-DWR, Jabalpur	11 May, 2021
All staff of the Directorate	Farmers training and interactive meet on innovation techniques for paddy cultivation	ICAR-DWR, Jabalpur	20 May, 2021
Dr. Pawar Deepak Vishwanath, Scientist	Managing le adership & high performing teams	National Productivity Council, New Delhi	20 May, 2021
Dr. P.K. Singh, Principal Scientist Dr. Sushil Kumar,P.S. Dr. R.P. Dubey, P.S. Dr. Shobha Sondhia, P.S. Dr. V.K. Choudhary, Sr. S. Dr. Yogita Gharde, Scientist Er. Chethan C.R., Scientist	Review workshop of FFP	ICAR-ATARI, Jabalpur	03 June, 2021

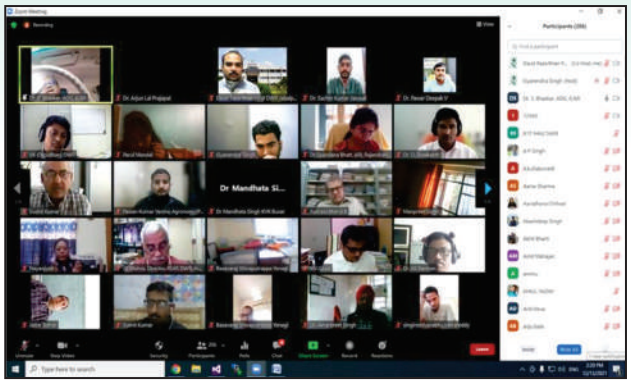
Name & Designation	Training programme	Institution	Date
All scientists and technical officers of the Directorate	Farmers training and interactive meet on integrated insect-pest management in *Kharif* crops	ICAR-DWR, Jabalpur	08 June, 2021
Dr. Himanshu Mahawar, Scientist	Implementation and use of ARMS	ICAR-IASRI, New Delhi	08 June, 2021
All scientists and technical officers of the Directorate	Farmers training and interactive meet on integrated disease management in *Kharif* crops	ICAR-DWR, Jabalpur	13 July, 2021
Mr. B.P. Uriya, Assistant Dr. R.P. Dubey, Principal Scientist	Accrual accounting Cyber security	ICAR-NRRI, Cuttack Ministry of Electronics & InformationTechnology, GoI, New Delhi	26-30 July, 2021 29 July, 2021
Sh. G.R. Dongre, ACTO	Repair and maintenance of office, residential building and guest houses	ICAR-CIAE, Bhopal	10-12 August, 2021
Mr. M.K. Meena, TO	Making a secure and resilient workplace	ICAR-CPRI, Sh imla	01-03 September, 2021
Dr. Pawar Deepak Vishwanath, Scientist	Biosecurity and biosafety:policies, diagnostics, phyto-sanitary treatments and issues	ICAR-NBPGR, New Delhi	15-24 September, 2021
Sh. Francis Xavier, Senior Clerk	Accrual accounting	ICAR-NRRI, Cuttack	20-24 September, 2021
Dr. Pawar Deepak Vishwanath, Scientist	International webinar cum workshop on seed quality enhancement	ICAR-IISS, Mau	27-29 September, 2021
Mr. Dibakar Roy, Scientist Dr. Dasari Sreekanth, Scientist Mr. Jamaludheen A., Scientist	Data analysis in social sciences research	ICAR-NAARM, Hyderabad	04-08 October, 2021
Dr. V.K. Choudhary, Senior Scientist	Review and sensitization workshop of ZTMUs/ITMUs/ PMEs under NAIF scheme	ICAR-NEH, Umiam	05 October, 2021
Dr. K.K. Barman, Principal Scientist	National workshop on and opportunities of crop diversification in rice fallow in NEH region	ICAR-NEH, Dimapur	05-06 October, 2021
Dr. Himanshu Mahawar, Scientist	Implementation & use of ARMS	ICAR-IASRI, New Delhi	11 Octo ber, 2021
Mr. Jamaludheen A., Scientist	MDP on PME in agricultural research projects	ICAR-NAARM, Hyderabad	25-30 October, 2021
All scientists of the Directorate	Mechanized weed management in different field crops	ICAR-DWR, Jabalpur	01-03 November, 2021
Dr. P.K. Singh, Principal Scientist; Mr. Ajay Pal Singh, TO	Workshop on *krishi me pratidarsh taknikon ka anuprayog evam ankando ka vishleshan*	ICAR-IASRI, New Delhi	30 November -02 December, 2021
All scientist s and technical staff of the Directorate	National training programme on advances in weed management for sustainable agriculture	ICAR-DWR, Jabalpur	13-18 December, 2021

8.2 Organization of training programme

The Directorate organized several training programmes for making aware and imparting skill to farmers and other stakeholders in respect to improved weed management technologies. Details of the trainings organized during the year 2021 are given below. Many of these trainings were conducted in online mode due to prevailing Covid-19 pandemic.

Training	Sponsor	Date	No. of Participants	Course Director	Coordinator
Inter-state farmers training cum exposure visit under ATMA sub-mission on agriculture extension and technology	U.P. Govt.	18 February, 2021	55	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and field visit	Manthan Biotech-KISAN Hub	06 March, 2021	49	-	Dr. P.K. Singh Dr. V.K. Choudhary

Training cum workshop on "Madhya Pradesh *me sabji utpadan istar badane hetu kharpatwar prabhandhan evam unnat takniki prayog"*	AgroStar India, Pune	09 March, 2021	44	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and field visit	Manthan Biotech-KISAN Hub	10 March, 2021	44	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and field visit	Manthan Biotech-KISAN Hub	19 March, 2021	30	-	Dr. P.K. Singh and Dr. V.K. Choudhary
Farmers training and field visit	Manthan Biotech-KISAN Hub	23 March, 2021	50	-	Dr. P.K. Singh Dr. V.K. Choudhary
Skill up-gradation in good office practices cum general awareness	ICAR-DWR, Jabalpur	24-27 March, 2021	21	-	Dr. Pawar Deepak Vishwanath Dr. Dasari Sreekanth
Farmers training and interactive meet on innovation techniques for summer green gram and black gram cultivation	Manthan Biotech-KISAN Hub	05 May, 2021	60	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and interactive meet on innovation techniques for soybean cultivation	Manthan Biotech-KISAN Hub	11 May, 2021	45	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and interactive meet on innovation techniques for paddy cultivation	Manthan Biotech-KISAN Hub	20 May, 2021	130	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and interactive meet on integrated insect-pest management in *kharif* crops	Manthan Biotech-KISAN Hub	08 June, 2021	135	-	Dr. P.K. Singh Dr. V.K. Choudhary
Farmers training and interactive meet on integrated disease management in *Kharif* crops	Manthan Biotech-KISAN Hub	13 July, 2021	120	-	Dr. P.K. Singh Dr. V.K. Choudhury
Integrated *Parthenium* management	ICAR-DWR, Jabalpur	19 August, 2021	299	Dr. J.S. Mishra	Dr. Sushil Kumar
Krishi rasayano ke chhidakav me baratne wali savdhaniyo	BASF	30 October, 2021	80	-	Dr. V.K. Choudhary
Mechanized weed management in different field crops	ICAR-DWR, Jabalpur	01-03 November, 2021	134	Er. Chethan C.R.	Dr. V.K. Choudhary Er. Vaibhav Choudhary
Advances in Weed management for sustainable agriculture	ISWS, Jabalpur	13-18 December, 2021	314	Dr. J.S. Mishra Dr. Sushilkumar	Dr. V.K. Choudhary Dr. Pawar Deepak Vishwanath Dr. Dasari Sreekanth
Krishi uddhyamon ke madhyam se krishakon ki ajivika me sudhar	ICAR-DWR, Jabalpur	27 December, 2021 - 01 January, 2022	28	Dr. J.S. Mishra Dr. P.K. Singh	Dr. Yogita Gharde Mr. Jamaludheen A.

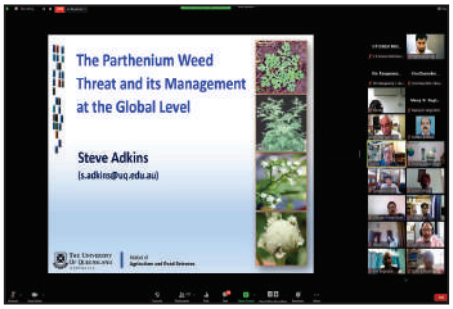


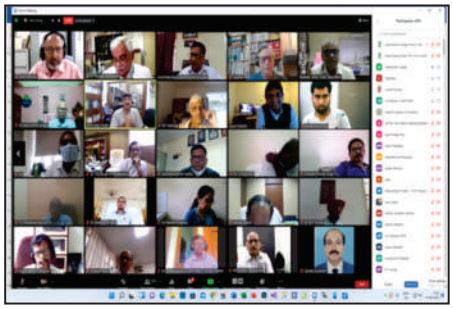
8.3 Organization of webinars and *sangoshthi* (workshop with farmers)

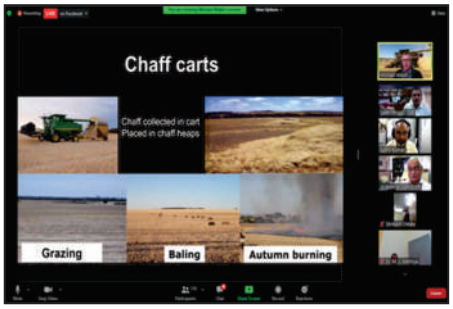
The Directorate organized several webinars and *Sangoshthis* (workshop with farmers) for making its scientific and technical manpower, as well as its stakeholders well informed about the latest developments in the field of weed management and related aspects. The details about those are given below.

Title	Date	Number of participants	Collaborating organization
Webinar on "Herbicide resistance in India: Problems and management"	29 January, 2021	260	ISWS, Jabalpur
Webinar on *"Fasalo me kharpatwar prabandhan ki avashyakta evam mahatva"*	12 February, 2021	243	ICAR-DWR, Jabalpur
National Webinar on "*Fasalo me orobanche kharpatwar prabandhan*"	19 February, 2021	358	AICRP-WM MPUAT, Udaipur
Webinar on "Weeds of national importance".	25 February, 2021	206	ISWS, Jabalpur
National webinar on "Herbicide residue in soils, crops and environment"	03 March, 2021	130	AICRP-WM, TNAU Coimbatore
National webinar on "Parasitic weed management: Challenges and options"	10 March, 2021	166	AICRP-WM, UAS, Bangalore
Webinar on "Quarantined weed and weed risk analysis"	23 March, 2021	157	ISWS, Jabalpur
National webinar on "Alien invasive weeds in India: Threat to agriculture, biodiversity and environment"	30 April, 2021	196	ISWS, Jabalpur
Webinar on "Aquatic weeds: Problems and their management for improving water productivity "	29 May, 2021	500	ISWS, Jabalpur
Webinar on "Water pollution and its mitigation through phytoremediation"	05 June, 2021	141	-
Online farmers *sangoshthi* on "Proper management of soil health and balanced use of fertilizers"	18 June, 2021	176	-
Webinar on "Role of weed biology in improving weed management strategies"	22 June, 2021	504	ISWS, Jabalpur
Brainstorming session on "New areas in basic and strategic research on weed management in direct-seeded rice"	05 July, 2021	20	IRRI, Philippines
Online stakeholder's dialogue on "Restrictions in use of glyphosate: Implications in weed management"	20 July, 2021	55	ISWS, Jabalpur
National webinar on "Weed management"	06 August, 2021	20	AICRP-WM, BCKV, Kalyani
International webinar on "The *Parthenium* problem and its management at the global level"	16 August, 2021	461	-

Title	Date	Number of participants	Collaborating organization
Sangoshthi on *"Khadya evam poshan suraksha me kharpatwar prabandhan ka mahatva"*	26 August, 2021	190	-
Sangoshthi on the occasion of *"Poshan vatika mahaabhiyan"*	17 September, 2021	160	-
Webinar on "Harvesting of weed seeds: a novel preventive way of weed management"	28 September, 2021	187	ISWS, Jabalpur
Sangoshthi on "Climate resilient technologies and methods"	28 September, 2021	187	-
Brainstorming session on "Organic herbicides: Present status and way forward"	07 October, 2021	20	ICT Unit, ICAR-IASRI, New Delhi
Sangoshthi on the occasion of "Special national *swachhta* campaign on waste to wealth"	12 October, 2021	71	-
Sangoshthi on the occasion of *"Mahila kisan diwas"*	15 October, 2021	115	-
Sangoshthi on the occasion of "World food day"	16 October, 2021	120	-
Farmers-scientist interface meeting cum *sangoshthi*	19 October, 2021	75	-
Webinar on "Weed flora and weed management practices of rice and wheat farmers in rice-wheat cropping system"	29 October, 2021	160	ISWS, Jabalpur
Sangoshthi on the occasion of "World soil day"	05 December, 2021	155	-
Sangoshthi on "Natural farming"	16 December, 2021	183	-
Sangoshthi on the occasion of *"Kisan diwas"*	23 December, 2021	150	-







8.4 Lectures delivered by the scientists

Scientists delivered lectures in the various training programmes organized by the Directorate. Besides that the scientists of the Directorate received invitations from other institutions to deliver lectures in different occasions. The details of the lectures delivered by the scientists during the reported year are given below:

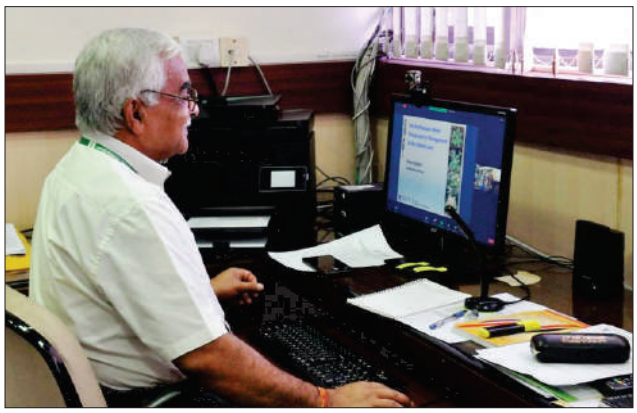
A. Lecture delivered by the scientists in the programmes organized by ICAR-DWR, Jabalpur

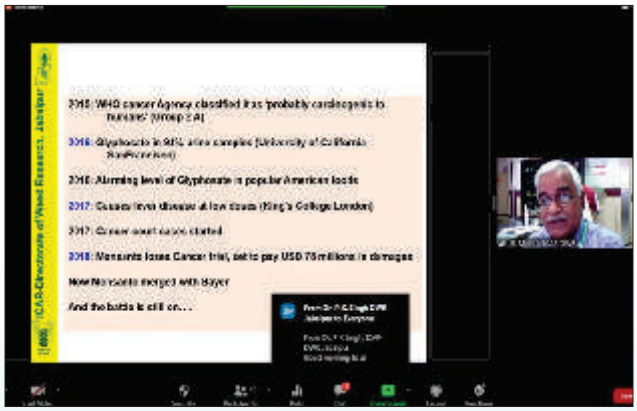
Speaker	Topic	Training/ Meeting	Date
Dr. J.S. Mishra	Weed biology and its importance in weed management	Advances in weed management for sustainable agriculture	13 December, 2021
Dr. Sushilkumar	Aquatic weed problems and their sustainable management	Advances in weed management for sustainable agriculture	14 December, 2021
	Weed utilization	Advances in weed management for sustainable agriculture	18 December, 2021
Dr. R.P. Dubey	Weed management in vegetable crops	Training programme for vegetable growers	09 March, 2021
	Weeds and their integrated management	Mechanized weed management in different field crops	01 November, 2021
	Weed management in organic agriculture	Advances in weed management for sustainable agriculture	18 December, 2021
Dr. Shobha Sondhia	Inter-personnel skill development	Skill up-gradation in good office practices cum general awareness for Skilled Supporting Staff	26 March, 2021
	Herbicide residue: Persistence and degradation	Advances in weed management for sustainable agriculture	16 December, 2021
Dr. V.K. Choudhary	Personal hygiene for healthy life	Skill up-gradation in good office practices cum general awareness for Skilled Supporting Staff	26 March, 2021
	Climate resilient agriculture technologies	Farmers-scientist interface meet	28 September, 2021
	Weed management in Conservation Agriculture	Mechanized weed management in different field crops	02 November, 2021
	Weed management in vegetable crops	Advances in weed management for sustainable agriculture	14 December, 2021
	Weed management in oil seed crops	Advances in weed management for sustainable agriculture	17 December, 2021
Dr. Yogita Gharde	Effective communication skills/soft skills	Skill up-gradation in good office practices cum general awareness for Skilled Supporting Staff	24 March, 2021
Er. C.R. Chethan	Mechanical weed management: Present and new emerging technologies	Mechanized weed management in different field crops	01 November, 2021
Dr. Pawar Deepak Vishwanath	Power of discipline	Skill up-gradation in good office practices cum general awareness for Skilled Supporting Staff	25 March, 2021
Dr. Himanshu Mahawar	Team building exercises	Skill up-gradation in good office practices cum general awareness for Skilled Supporting Staff	25 March, 2021
Er. Vaibhav Choudhary	Importance of ergonomical consideration in weed management	Mechanized weed management in different field crops	03 November, 2021

B. Lectures delivered by the scientists of ICAR-DWR, Jabalpur at other organizations

Speaker	Topic	Organization	Date
Dr. J.S. Mishra	Conservation Agriculture	GD Goenka University, Gurugram	23 February, 2021
	Agronomic intervention for crop intensification in Rice-fallow area	National seminar on "Rice-fallow management in Eastern India" organized by ICAR-RCER, Patna	26 August, 2021
	Climate resilient weed management	National webinar organized by ICAR-RCER, Patna	16 September, 2021
	IFS for enhancing food and nutritional security for small and marginal farmers of Eastern and Central India	National conference on "Integrated farming systems: A tool for enhancing income and nutritional security" organized by ICAR-RCER, Patna	05 October, 2021
	Latest on Weed management studies	Training programme entitled "Modern crop production techniques in rice: Importance of data collection and coordination in AICRP" organized by ICAR-IIRR, Hyderabad	22 October, 2021
Dr. P.K. Singh	*Greeshm kaline Phashlo me kharpatwar prabandhan*	Training programme organized by KVK-Anuppur, Indira Gandhi National Tribal University, Amarkantak	12 April, 2021
	Kans ka prabandhan	Training programme organized by KVK-Seoni, JNKVV, Jabalpur	17 April, 2021
	Weed management	Farmers-scientist connect meet organized by DBT Biotech - KISAN Hub, MP	01 September, 2021
Dr. Sushilkumar	*Videshi Kharpatwar ki samasya aur unka jaivik niyantran*	"Hello kisan" progrmme organized by Doordarshan Kisan	03 February, 2021
	Management of aquatic weeds	Workshop on the management aquatic weeds to save lakes in Mahoba (U.P.) organized by Collectorate Office, Mahoba	03 July, 2021
	Problems and control measures for Parthenium grass	Webinar on Management of Parthenium Grass organized by ICAR-IISR, Indore	17 August, 2021
	Role of insects in biological management of Parthenium: Opportunities and challenges	Parthenium Awareness Week organized by Vikram University, Ujjain	18 August, 2021
	Biological based integrated management of terrestrial and aquatic weeds	Webinar on Parthenium Awareness: Parthenium problem and its management options in India organized by Rani Laxmi Bai Central Agricultural University, Jhansi	19 August, 2021
	Parthenium problem in forests and available options for the management	Parthenium Awareness Week organized by Forest Productivity Institute, Ranchi	19 August, 2021
	Increasing problem of Parthenium in India: Integrated management is the only solution	Weekly academic lecture series organized by Siksha 'O' Anusandhan(Deemed University), Bhubaneswar	21 August, 2021
Dr. R.P. Dubey	Weed management in agricultural and horticultural crops novel approaches and future strategies	Training programme on "Furtherance in integrated pest management approaches for ATARI Zone-X" organized by ICAR-NCIPM, New Delhi	02 March, 2021

Speaker	Topic	Organization	Date
	Weed management in organic farming	Online refresher training program on "Promoting organic farming & business opportunities" organized by National Centre of Organic Farming, Ghaziabad & MANAGE, Hyderabad	20 December, 2021
Dr. K.K. Barman	Recent advances on soil health management in rice based cropping system'	National workshop on "Scope and opportunities of crop diversification in rice fallow in NEH region" organized by ICAR-NEH, Dimapur	06 October, 2021
Dr. P.K. Mukherjee	Entrepreneurship strategies in agriculture, hrticulture, animal husbandry and allied sectors for economic development of India	National training course organized by Uttar Banga Krishi Viswavidyalaya, Coochbehar.	20 December, 2021
Dr. V.K. Choudhary	Types of weeds, weed management in major crop and agrochemical compatibility	DAESI Dealers, JNKVV, Jabalpur	16 May , 2021
	Types of weeds, weed management in major crop and agrochemical compatibility	DAESI Dealers, Agriculture Department, Jabalpur	22 May, 2021
	Weed management in field crops and agrochemical compatibility	DAESI Dealers, Agriculture Department, Narsinghpur	05 June, 2021
	Weed Management in field crop	DAESI Dealers, AETC Campus, Jabalpur	12 December, 2021
Dr. Yogita Gharde	Statistical software available for analysis of agricultural data	Training programme on "Thesis writing and online thesis evaluation" organized by JNKVV, Jabalpur	03 March, 2021





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9. Linkages and Collaborations

Directorate of Weed Research is a leading institute for conducting basic, strategic and applied research in the area of weed science and providing-headship role at the national level. Directo-rate also coordinates the network project on weed management in collaboration with different State Agricultural Universities (SAUs) under "All India Coordinated Research Programme-Weed management" (AICRP-WM) to find out location specific technologies for weed management in different crops, cropping and farming system. Directorate also has association with educational and research institutions for research, teaching and extension. Directorate offers research and training to students, shares expertise and provides consultancy to staff and students of ICAR Institutes, SAUS, industries, NGOs, Forest Depart-ments and other stakeholders. In addition, Directorate also conducts different training programmes for scientists, state agriculture officers, forest officers KVK staff, farmers and students.

9.1 Collaboration with State Agricultural Unive-rsities

ICAR-DWR has 17 regular AICRP-WM centres in different SAUs which are PAU, Ludhiana; UAS, Bengaluru; RVSKVV, Gwalior; CSKHPKV, Palampur; AAU, Jorhat; AAU, Anand; TNAU, Coimbatore; KAU, Thrissur; GBPUAT, Pantnagar; OUAT, Bhubaneswar; PJTSAU, Hyderabad; CCSHAU, Hisar; IGKVV, Raipur; PDKV, Akola; MPUAT, Udaipur; SKUAST, Jammu and BCKV, Kalyani. There are also 6 volunteer centers namely PAJANCOA& RI, Karaikal; SKUAST, Kashmir; BAU, Sabour; UAS, Dharwad; BUAT, Banda and ANGRAU, Guntur. Directorate carries out research and extension programme through these centres in various parts of the country. The nodal officers of the respective zones with selected team from the Directorate monitor the research and extension activities at different centres and provide feedback to the SAUS for effective collaboration.

9.2 Collaboration with other institute and agencies

ICAR-DWR has active collaboration with different ICAR Institutes like ICAR-NIBSM, Raipur, NRRI, Cuttack, ICAR-IISS, IndoreICAR-CIAE, Bhopal; ICAR-IISS, Bhopal; ICAR-ATARI (Zone VII), Jabalpur, and also with other Non-ICAR Institutes like IRRI, Philippines, ICFRE, Dehradoon, TFRI, Jabalpur; CFD, Raipur, SFRI, Jabalpur, and various herbicide industries namely UPL, Syngenta India Ltd, Pune, AG Bio Systems, Hyderabad and ADAMA Private Limited, Hyderabad. Directorate also collaborated with different research agencies such as DST and DBT, Govt. of India for various research programmes. Recently, Directorate has developed active collaboration with National Informatics Centre (NIC), Ministry of Electronics and Information Technology, Government of India for implementation of National Knowledge Network (NKN) Project. The scientists of this Directorate provided consultancy services to Satpura Thermal Power Station (STPS), MP Power Generating Company Limited (MPPCCL), Sarni (MP) for elimination of aquatic weeds. This Directorate also provides imagery information on weed species to "Agri Net Solutions" for weed identification. Directorate also has collaboration with National Seeds Corporation (NSC), Bhopal and Madhya Pradesh Seeds and Farm Development Corporation (MPSFDC), for producing for different crops like wheat and chickpea. Interface meetings with different stakeholders including of Scientists-State Agriculture officers-Industry Farmers are a regular feature of Directorate to strengthen the collaboration among them.

9.3 Education and training programmes

The Directorate has MoUs with several educational and research institutions namely IEHE, Bhopal, Anugrah Narayan College, Patna, Vikram University, Ujjain, Madhya Pradesh, RVSKVV, Gwalior, Mahakushal University, Jabalpur, Mangalayatan University, Jabalpur, JNKVV, Jabalpur; IGKV, Raipur; RDVV, Jabalpur, AKS University, Satna; and MGCGV, Chitrakoot. Directorate has also been recognized by the above universities as post-graduate research centre for their students. The list of MoUs made with other institutions during 2021 are given (**Table 9.1**).

Table 9.1: List of the MoU$_s$ made between ICAR-DWR and other institutions during 2021

Sl. No.	Name of the University/Institute	Date
1.	IEHE, Bhopal	15/01/2021
2.	NIBSM Raipur	16/02/2021
3.	Anugrah Narayan Collage, Patna	08/03/2021
4.	Vikram University, Ujjain	23/06/2021
5.	RVSKVV Gwalior	17/08/2021
6.	Mahakushal University, Jabalpur	28/08/2021
7.	Chhattisgarh Forest Department, Raipur	29/09/2021

8.	International Rice Research Institute, Philippines	01/10/2021
9.	National Rice Research Institute, Cuttack	17/11/2021
10.	Mangalayatan University, Jabalpur	24/12/2021
MoU With Industries – 2021		
1.	ADAMAindia private limited, Telangana, Hyderabad	12/07/2021
2.	Syngenta india ltd., Pune	21/10/2021
3.	AG Bio System, Hyderabad	24/10/2021
4.	ADAMAindia private limited, Telangana, Hyderabad	12/11/2021
5.	ADAMAindia private limited, Telangana, Hyderabad	15/11/2021

9.4 Advisory services

Advisory services were given for the management of crop and non-crop land weeds and aquatic weeds at different places across India. As a regular activity, Directorate provides advisory services to stakeholders for mechanical, chemical, biological and integrated approach of weed control for invasive weeds like *Parthenium hysterophorus*, *Lantana camara*, *Eichhornia crassipes*, *Salvinia molesta, Pista stratiotes*etc. Directorate disseminated season and crop wise weed management technologies to the farmers of the country through 'Kisan Mobile Advisory Services' (KMAS). A new approach of online advisory services on weed management in different crops has also been started through a mobile App 'Herbcal' and 'Weed Manager'.

9.5 Seed Production

In order to increase farm revenue and to provide quality seed to the farmers, the Directorate has signed MOUs with National Seed Corporation (NSC) and Madhya Pradesh State Seed & Farm Development Corporation (MPSS&FDC) for large-scale seed production of rice, wheat, pulses and oilseed crops. During 2021, a total of 108.9 tons of certified seed of rice (Sahabhagi-21.4 t and JR 81-2.8 t), wheat (MP 3382-65.5 t), field pea (Kashi Nandini-1.85 t), chickpea (JG 12-8.85 t) and greengram (Virat-8.50 t) were produced.

10. राजभाषा कार्यान्वयन

राजभाषा कार्यान्वयन समिति की गतिविधियों एवं किये गये प्रयासो का संक्षिप्त विवरण

निदेशालय में राजभाषा हिन्दी के कार्यान्वयन एवं प्रचार–प्रसार तथा समय–समय पर इसके प्रयोग एवं प्रगति का अवलोकन करने हेतु राजभाषा कार्यान्वयन समिति का गठन किया गया है। समिति के प्रयासो के परिणाम स्वरुप संस्थान के सभी अनुभागों में हिन्दी में कार्य करने के लिये जो उत्साह उत्पन्न हुआ है, वह राष्ट्रीय गौरव और स्वाभिमान का विषय है।

राजभाषा हिन्दी के प्रयोग एवं प्रचार–प्रसार के क्षेत्र मे सर्वाधिक व सराहनीय कार्यो के लिए निदेशालय को नगर राजभाषा कार्यान्वयन समिति कार्यालय कमांक 02 द्वारा सर्वश्रेठ संस्थान का प्रथम पुरूस्कार दिनांक 23 दिसम्बर 2021 को आयोजित गरिमामय समारोह मे प्रदान किया गया।

वर्ष 2021 में खरपतवार अनुसंधान निदेशालय की राजभाषा कार्यान्वयन समिति के माध्यम से निदेशालय द्वारा हिन्दी में हुई प्रगति एवं गतिविधियों का विवरण इस प्रकार है–

10.1 त्रैमासिक बैठको का आयोजन

निदेशालय की राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठकों का नियमित आयोजन किया गया। हिन्दी राजभाषा कार्यान्वयन समिति की जनवरी से मार्च 2021 की तिमाही बैठक दिनांक 24/03/2021, अप्रैल से जून 2021 तिमाही की बैठक दिनांक 30/06/2021, जुलाई से सितम्बर 2021 की तिमाही बैठक दिनांक 19/07/2021 एवं अक्टूबर से दिसम्बर 2021 तिमाही की बैठक दिनांक 11/10/2021 को निदेशालय के सभागार में आयोजित की गई।

उक्त बैठकों में निदेशालय के समस्त अनुभाग प्रभारी, अधिकारी एवं समिति के पदाधिकारी सम्मिलित हुए। बैठक में कार्यान्वयन से संबंधित बिंदुओं पर विचार किया गया एवं पिछली बैठक के कार्यवृत्त को पारित किया गया। राजभाषा कार्यान्वयन समिति के प्रभारी द्वारा पिछली तिमाहियों का विस्तृत ब्यौरा प्रस्तुत किया गया, जिसमें राजभाषा अधिनियम 1963 की धारा 3(3) के अनुपालन की स्थिति के संदर्भ में बताया गया, तत्पश्चात् पिछली तिमाहियों के अंतर्गत जारी त्रैमासिक प्रतिवेदनों, कागजातो, मांगपत्रो एवं जांच बिन्दुओं इत्यादि से संबंधित चर्चाएं की गई, साथ ही माननीय संसदीय राजभाषा समिति को दिये गये आश्वासनो के संबंध में संबंधित अनुभागो को उचित कार्यवाही करने हेतु पत्र भी जारी किये गये। बैठकों में राजभाषा वार्षिक कार्यक्रमों में निर्धारित लक्ष्यों को प्राप्त करने तथा राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद से प्राप्त निर्देशो/आदेशो/समीक्षाओं के अनुपालन पर चर्चा की गई और इन बैठकों में लिये गए निर्णयो को लागू करने के लिए कार्यवाही की गई।

10.2 त्रैमासिक हिन्दी प्रतिवेदन का संकलन

भारत सरकार के राजभाषा विभाग, गृह मंत्रालय द्वारा निर्धारित रिपोर्ट के प्रोफार्मा में निदेशालय के विभिन्न अनुभागो में किये जा रहे हिन्दी कार्यो की प्रगति तथा हिन्दी पत्राचार के आंकडे तिमाही समाप्ति पर मंगाये गए और उनको समेकित कर प्रतिवेदन को भारतीय कृषि अनुसंधान परिषद नई दिल्ली, नगर राजभाषा कार्यान्वयन समिति–2 जबलपुर को प्रेषित किये गये। त्रैमासिक प्रतिवेदन से प्राप्त समीक्षा के अनुसार उठाये गये बिन्दुओ पर कार्यवाही की गयी तथा संबंधित अनुभाग को पृष्ठांकित किया गया।

10.3 राजभाषा वार्षिक कार्यक्रम पर क्रियान्वयन

भारत सरकार की राजभाषा नीति के अनुसार संस्थान द्वारा संपादित कार्यो में हिन्दी का क्रियान्वयन सुनिश्चित करने

के लिए गृहमंत्रालय, राजभाषा विभाग द्वारा जारी राजभाषा वार्षिक कार्यक्रम में दिये गये निर्देशों के अनुसार कार्यवाही के लिए सभी अनुभागो को राजभाषा संबंधी नियमों/निर्देशों से अवगत कराया गया तथा इन नियमों के अनुसार कार्यवाही सुनिश्चित करने का अनुरोध किया गया।

10.4 हिन्दी पखवाड़े का आयोजन

निदेशालय में राजभाषा कार्यान्वयन समिति द्वारा दिनांक 14/09/2021 से 29/09/2021 तक हिन्दी पखवाड़े का आयोजन कोविड–19 महामारी के दिशा निर्देशों का पालन करते हुए किया गया। दिनांक 14 सितम्बर 2021 को हिन्दी दिवस का आयोजन किया गया। जिसमें कार्यालय के समस्त अधिकारी एवं कर्मचारी सम्मिलित हुए। इस अवसर पर सभी ने वर्ष भर हिंदी में कार्य करने हेतु राजभाषा प्रतिज्ञा ली।

हिन्दी पखवाड़े के दौरान निदेशालय में तात्कालिक निबंध प्रतियोगिता, हिंदी शुद्धलेखन प्रतियोगिता, कम्प्यूटर में यूनिकोड में टाइपिंग प्रतियोगिता, आलेखन एवं टिप्पण प्रतियोगिता, वाद–विवाद प्रतियोगिता, आशुभाषण प्रतियोगिता एवं क्विंज कांटेस्ट प्रतियोगिता का आयोजन किया गया।

हिन्दी पखवाड़े के समापन सामारोह के दौरान मुख्य अतिथि के रूप में प्रोफेसर कपिलदेव मिश्रा, कुलपति रानी दुर्गावती विश्वविद्यालय, जबलपुर उपस्थित रहे। कार्यक्रम का शुभारंभ मां सरस्वती को माल्यार्पण कर भा.कृ.अनु.प. के महिमागान से किया गया। मुख्य अतिथि महोदय ने अपने उद्‌बोधन मे कहा कि संसार का कोई भी देश अपनी भाषा की अवहेलना करके प्रगति नही कर सकता। भाषा में अद्‌भुत शक्ति होती है यह हमें एक दूसरे से जोड़ती है भाषा केवल भाषा नही होती यह समाज, संस्कृति, इतिहास, राष्ट्र की अस्मिता और उसके भावी लक्ष्यों की अभिव्यक्ति का माध्यम भी होती है। हिन्दी पखवाड़े की सभी को शुभकामनाएं दी, विजयी प्रतिभागियों को भी बधाई दी एवं निदेशालय द्वारा खरपतवार नियंत्रण हेतु किए जा रहे अनुसंधानों की प्रशंसा की। इस अवसर पर निदेशालय द्वारा प्रकाशित वार्षिक हिन्दी पत्रिका "तृण संदेश" के सोलहवे अंक का विमोचन किया गया।

हिन्दी पखवाड़े का समापन एवं पुरस्कार वितरण दिनांक 29/09/2021 को किया गया। समारोह में विजयी प्रतियोगियों को प्रमाणपत्र/पुरस्कार वितरित किये गये। जिसमें विजयी प्रतियोगियों के नाम नीचे सूची में दिये गये है।

1. तात्कालिक निबंध प्रतियोगिता

यह प्रतियोगिता दिनांक 15 सितम्बर, 2021 को निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों हेतु अपरान्ह 3.00 से 4.00 बजे आयोजित की गई।

समूह 'अ'

क्रं.	नाम	स्थान
1.	डॉ. सुशील कुमार	प्रथम पुरस्कार
2.	श्री सुजीत कुमार वर्मा	द्वितीय पुरस्कार
3.	डॉ. हिमांशु महावर	तृतीय पुरस्कार

समूह 'ब'

क्रं.	नाम	स्थान
1.	श्रीमती इति राठी	प्रथम पुरस्कार
2.	श्री जैनपाल राठौर	द्वितीय पुरस्कार
3.	श्री दाउद रजा खान	तृतीय पुरस्कार
4.	श्री वीरेन्द्र विश्वकर्मा	प्रोत्साहन पुरस्कार
5.	सुश्री सौम्या मिश्रा	प्रोत्साहन पुरस्कार

समूह 'ब'

क्रं.	नम	स्थान
1.	श्रीमती कुन्दा विरूलकर	प्रथम पुरस्कार
2.	श्री सुमित गुप्ता	द्वितीय पुरस्कार
3.	श्रीमती इति राठी	तृतीय पुरस्कार
4.	श्री सूरज चक्रवर्ती	प्रोत्साहन पुरस्कार
5.	श्रीमती संगीता उपाध्याय	प्रोत्साहन पुरस्कार

2. हिंदी शुद्धलेखन प्रतियोगिता

इस प्रतियोगिता का आयोजन दिनांक 16 सितम्बर, 2021 को निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों अपरान्ह 3.00 से 4.00 बजे किया गया।

समूह 'अ'

क्रं.	नाम	स्थान
1.	श्री सुजीत कुमार वर्मा	प्रथम पुरस्कार
2.	श्री सौमित्र बोस	द्वितीय पुरस्कार
3.	डॉ. पवार दीपक विश्वनाथ	तृतीय पुरस्कार

3. कम्प्यूटर में यूनिकोड में टाइपिंग प्रतियोगिता

इस प्रतियोगिता का आयोजन दिनांक 17 सितम्बर, 2021 को निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों हेतु अपरान्ह 3.00 से 4.00 बजे किया गया।

समूह 'अ'

क्रं.	नाम	स्थान
1.	श्री सुजीत कुमार वर्मा	प्रथम पुरस्कार
2.	डॉ. पवार दीपक विश्वनाथ	द्वितीय पुरस्कार
3.	डॉ. हिमांशु महावर	तृतीय पुरस्कार

समूह 'ब'

क्रं.	नाम	स्थान
1.	श्री सुमित गुप्ता	प्रथम पुरस्कार
2.	श्री मोहन लाल दुबे	द्वितीय पुरस्कार
3.	श्रीमती इति राठी	तृतीय पुरस्कार
4.	श्री आदर्श रामटेके	प्रोत्साहन पुरस्कार
5.	श्रीमती आरती उपाध्याय	प्रोत्साहन पुरस्कार

4. आशुभाषण प्रतियोगिता

इस प्रतियोगिता का आयोजन दिनांक 18 सितम्बर, 2021 को निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों हेतु अपरान्ह 3.00 से 4.30 बजे तक किया गया।

समूह 'अ'

क्रं.	नाम	स्थान
1.	डॉ. सुशील कुमार	प्रथम पुरस्कार
2.	श्री सुजीत कुमार वर्मा	द्वितीय पुरस्कार
3.	श्री मुनी प्रताप साहू	तृतीय पुरस्कार
4.	श्री पंकज शुक्ला	प्रोत्साहन पुरस्कार

समूह 'ब'

क्रं.	नाम	स्थान
1.	श्री जैनपाल राठौर	प्रथम पुरस्कार
2.	श्रीमती कुंदा विरूलकर	द्वितीय पुरस्कार
3.	सुश्री प्रीति ठाकुर	तृतीय पुरस्कार

5. आलेखन एवं टिप्पण प्रतियोगिता

दिनांक 20 सितम्बर, 2021 को आलेखन एवं टिप्पण प्रतियोगिता का आयोजन किया गया जिसमें निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों ने भाग लिया।

समूह 'अ'

क्रं.	नाम	स्थान
1.	श्री सुजीत कुमार वर्मा	प्रथम पुरस्कार
2.	डॉ सुशील कुमार	द्वितीय पुरस्कार
3.	श्री पंकज शुक्ला	तृतीय पुरस्कार

समूह 'ब'

क्रं.	नाम	स्थान
1.	श्रीमती कुन्दा विरूलकर	प्रथम पुरस्कार
2.	श्री बी.पी. उरिया	द्वितीय पुरस्कार
3.	श्री मोहनलाल दुबे	तृतीय पुरस्कार
4.	श्री धर्मेन्द्र बघेल	प्रोत्साहन

6. वाद–विवाद प्रतियोगिता

दिनांक 21 सितम्बर, 2021 को वाद–विवाद प्रतियोगिता का आयोजन किया गया जिसमें निदेशालय के दोनो समूहो के अधिकारियों एवं कर्मचारियों ने भाग लिया।

क्रं.	नाम	स्थान
1.	डॉ सुशील कुमार	प्रथम पुरस्कार
2.	श्री ए.के. चतुर्वेदी	द्वितीय पुरस्कार
3.	श्री मुनी प्रताप साहू	तृतीय पुरस्कार

7. क्विज कांटेस्ट प्रतियोगिता

दिनांक 24 सितम्बर, 2021 को क्विज कांटेस्ट प्रतियोगिता का आयोजन किया गया जिसमें निदेशालय के सभी अधिकारियों एवं कर्मचारियों ने भाग लिया।

क्रं.	नाम
	प्रथम पुरस्कार
1.	डॉ आर.पी. दुबे
2.	श्री ए.के. चतुर्वेदी
3.	श्री के.के. तिवारी
4.	श्री सूरज चक्रवर्ती
	द्वितीय पुरस्कार
1.	डॉ पवार दीपक विश्वनाथ
2.	श्री संतोष कुशवाहा
3.	श्रीमती इति राठी
4.	श्री सुमित गुप्ता
	उपविजेता–टीम 2
1.	डॉ शोभा सौंधिया
2.	श्री एस.के. बोस
3.	श्री विवेक दुबे
4.	सुश्री सौम्या मिश्रा

8. नगद पुरस्कार

जिन अधिकारियों एवं कर्मचारियों द्वारा वर्ष भर शासकीय कार्यो का संपादन हिन्दी भाषा में किया गया उन्हें सत्यापन समिति द्वारा आवेदित किये गये अनुभागों के अभिलेखों को देखा गया तथा व्यक्तिगत पुरस्कार हेतु 20,000 से अधिक शब्द का निरीक्षण भी किया गया। समिति की अनुशंसा के अनुसार निम्न पुरस्कार निर्धारित किये गए है।

क्रं.	नाम	स्थान
1.	श्री आर. हाडगे	प्रथम पुरस्कार
2.	श्री फ्रांसिस जेवियर	द्वितीय पुरस्कार
3	श्री बी.पी. उरिया	प्रथम पुरस्कार

9. वर्षभर हिन्दी में सर्वाधिक कार्य करने वाले अनुभाग को चलित शील्ड

1. क्रय एवं भण्डार अनुभाग – प्रथम
2. स्थापना अनुभाग – द्वितीय
3. रोकड़ अनुभाग – तृतीय

10. हिंदीत्तरभाषी प्रतियोगी हेतु पुरस्कार

डॉ. दसारी श्रीकांत को प्रदान किया गया।

11. अन्य पुरस्कार / स्मृति चिन्ह

1. राजभाषा कार्यान्वयन समिति का सम्मान
2. हिन्दी पखवाड़े के आयोजन से संबंधित विभिन्न समितियों के सदस्यो का सम्मान
3. निर्णायक मंडल के सदस्यो का सम्मान
4. विशेष सहयोग हेतु वाहन चालकों का सम्मान

10.5 राजभाषा वार्षिक पत्रिका के सोलहवे अंक का प्रकाशन

तृण संदेश पत्रिका के सोलहवे अंक अप्रैल 2020 से मार्च 2021 का प्रकाशन किया गया, जिसमें खरपतवार प्रबंधन से संबंधित महत्वपूर्ण लेखो को स्थान दिया गया है। पत्रिका को स्लोगन एवं महापुरुषो के कथनों से प्रभावशाली बनाया गया।

10.6 हिन्दी कार्यशालाओं का आयोजन

राजभाषा कार्यान्वयन समिति द्वारा वर्ष 2021 के दौरान विभिन्न कार्यशालाओं का आयोजन किया गया, जिसका विवरण निम्नानुसार–

क्र.	तिमाही	दिनांक	कार्यशाला का विषय	वक्ता
1.	जनवरी से मार्च 2021	15 मार्च, 2021	रबी, खरीफ एवं जायद की फसलों में खरपतवार प्रबंधन	श्री आर.एस. उपाध्याय प्रक्षेत्र प्रबंधक
2.	अप्रैल से जून 2021	21 जून, 2021	वर्तमान संक्रमण काल में योग का महत्व	डॉ. आर.के. नेमा (डीन, कालेज ऑफ एग्री. इंजीनियरिंग)
3.	जुलाई से सितम्बर 2021	29 सितम्बर, 2021	आजादी के संघर्ष में हिन्दी की भूमिका	श्री राजेन्द्र चंद्रकांत राय (वरिष्ठ कथाकार)
4.	अक्टूबर से दिसम्बर 2021	13 अक्टूबर, 2021	उत्तर पूर्व राज्यों की प्रगति में ऊर्जा की महत्वता	श्री डी. राधाकृष्णन (चेयरमेन, त्रिपुरा विद्युत नियामक आयोग)
		20 नवम्बर, 2021	जैविक कृषि का इतिहास एवं वर्तमान स्थिति	डॉ. आर.पी. दुबे (प्रधान वैज्ञानिक)
		08 दिसम्बर, 2021	राजभाषा प्रयोग में हमारा योगदान	श्री राज रंजन श्रीवास्तव (सचिव, नराकास कार्या.क्र.02 जबलपुर)

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11. Students' Research Programme

ICAR-DWR has signed MOUs with Jawahrlal Nehru Krishi Vishwavidyalay, Jabalpur (M.P.), Rani Durgavati Vishwavidyalaya, Jabalpur (M.P.), Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhatishgarh), Mahatma Gandhi Chitrakoot Gramoday University, Chitrakoot (M.P.), Anugrah Narayan College, Patna and Institute for Excellence in Higher Educations, Bhopal. Following students were doing their research for Post Graduate and Ph.D. programmes.

Name of the student	Degree (M.Sc. or Ph.D.)	Title of thesis	College/ University	Advisor / Co-Advisor
Abhishek Yadav	M.Sc. (Ag.) (Statistics)	Evaluation of Regression and machine learning approaches for predicting geographical distribution of *Parthenium hysterophorus* (L.) in India	Indira Gandhi Krishi Vishwavidyalaya, Raipur	Dr. Yogita Gharde (Co-Advisor)
Abhisek Gautam	M.Sc. (Ag.) (Plant Pathology)	Identification and Evaluation of beneficial microbial groups as influenced by different weed management practices in Wheat	Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur	Dr. Himanshu Mahawar
Ankita Kumari	M.Sc. (Biotechnology)	"Studies on crop-weed interaction in *Vigna radiate* L. under Climate change scenario"	Anugrah Narayan College, Patna	Dr. Dasari Sreekanth (Advisor)
Khushboo Rajoria	M.Sc. (Biotechnology)	Comparative assessment of RNA extraction methods and modification to isolate high quality RNA from *Parthenium hysterophorus* L. flower buds	Institute for Excellence in Higher Education, Bhopal	Dr. Deepak Pawar (Advisor)
Kalicharan Ahirwa r	M.Sc. (Ag.) (Agronomy)	Effect of seed rate and weed management practices on weed control, productivity and profitability in direct seeded rice (*Oryza sativa* L.)	Indira Gandhi Krishi Vishwavidyalaya, Raipur	Dr. V.K. Choudhary (Co-Advisor)
Narendra Parihar	Ph.D. (Agronomy)	Effect of establishment methods and weed a management practices on weed dynamics, productivity and soil health in maize-wheat-greengram cropping system	Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior	Dr. V.K. Choudhary (Co-Advisor)
Sonali Singh	M.Sc. (Biotechnology)	"Studies on crop-weed interaction in wheat and its associated weeds under climate change scenario"	Institute for Excellence in Higher Educations, Bhopal	Dr. Dasari Sreekanth (Advisor)
Vivek Kumar Dubey	M.Sc. (Ag.) (Agronomy)	Evaluation of the bio-efficacy of imazethapyr against weed complex in herbicide tolerant rice (*Oryza sativa* L.)	Indira Gandhi Krishi Vishwavidyalaya, Raipur	Dr. V.K. Choudhary (Co-Advisor)
Yogendra Mishra	Ph.D. (Agril. Entomology)	Assessment of climate-smart management study for *Helicoverpa armigera* Hub. in chickpea (*Cicer arietinum* L.)	Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur	Dr. Shobha Sondhia (Co-Advisor)

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12. Awards and Recognitions

- Dr. Himanshu Mahawar received "Innovative Article Award" for the article entitled, '*Phyllospheric* microorganisms at the plant-climate interface' by Agriculture & Food e-Newsletter, January 2021 issue.
- Dr. Shobha Sondhia was invited to deliver a 'keynote address' in "National webinar on parasitic weeds management" organized by AICRP-WM TNAU, Coimbatore centre and DWR, Jabalpur on 10th March, 2021.
- Dr. Shobha Sondhia was invited to deliver a 'Presidential address' in an "International webinar of weed science" held on 12th March, 2021 organized by AICRP-WM PAJANCOA & RI, Kariaikal centre and DWR, Jabalpur
- Dr. Shobha Sondhia was invited to deliver a 'Special address' in webinar on "Weed science research in India: way forward and scope for entrepreneurship opportunity" organized by AICRP-WM, RVSKKK, Gwalior centre and DWR, Jabalpur on 17th March, 2021.
- Dr. Shobha Sondhia, Pr. Scientist, Dr. V.K. Choudhary, Sr. Scientist, Er. Chethan C.R., Scientist (Scientific category); Shri R.S. Upadhyay (CTO), Shri Sandeep Dhagat (CTO), Shri G.R. Dongre (ACTO) (Technical category) and Shri Veer Singh (SSS), Shri Mohanlal Dubey (SSS) (Skilled supporting staff category) received 'Best Worker Awards' on the occasion of '33rd Foundation Day' of ICAR-DWR, Jabalpur on 22nd April, 2021 2020-21 based on the outstanding contributions in different categories.
- Dr. P.K. Singh, Dr. K.K. Barman, Sh. Bhagunte Prasad, Sh. Dilip K. Sahu, Sh. B.P. Uriya, Sh. Manoj Gupta, Sh. Chotey Lal Yadav, Sh. Naresh Singh Rajpoot received "Recognition Award" for serving the ICAR for more than 25 years on the occasion of '33rd Foundation Day' of ICAR-DWR, Jabalpur celebrated on 22nd April, 2021.
- Dr. Himanshu Mahawar was conferred 'Young Scientist Award-2021' in the International Conference on 'Advances in Agriculture, Environmental and Biosciences for Sustainable Development (AAEBSD-2021)' organized by the Agro Environment development society during August 05-07, 2021.
- Dr. Sushil Kumar was invited to give a lead lecture on 'Aquatic Weed Management' in the workshop organized by Collectorate office, Mahoba (UP).
- Dr. Sushil Kumar was invited as a lead speaker in the webinar on "Parthenium: Problem and management' on 17 August, 2021, organized by Indian Institute of Soybean Research, Indore (MP).

- Dr. Sushil Kumar was invited to give a lead lecture on 'Integrated Parthenium Management' in the webinar on " Role of insects in biological management of parthenium: Oppurtunitites and Challenges' on 18 August, 2021 organized by Vikram University, Ujjain (MP).
- Dr. Sushil Kumar was invited as a guest speaker in the webinar on " "Parthenium problem and its management options' organized by Rani Lakshmi Bai Central Agricultural University, Jhansi & SPARSH on 19 August, 2021.

- Dr. Sushil Kumar was invited as a guest speaker in the webinar 'Parthenium problem in forests and available options for the management" organized by Forest Productivity Institute, Ranchi (Jharkhand) on 19 August, 2021.
- Dr. Sushil Kumar was invited as a guest speaker in the webinar 'Parthenium problem in forests and available options for the management" organized by Forest Productivity Institute, Ranchi (Jharkhand) on 19 August, 2021.
- Dr. Sushil Kumar was invited as a guest speaker in the webinar on "Increasing problem of Parthenium in India: Integrated management is the only solution" organized by Siksha 'O' Anusandhan (SOA), Bhubaneswar (Odisha) on 21 August, 2021.

- Dr. Sushil Kumar was invited to act as a member in the ' Research Advisory Group' meeting held at TFRI, Jabalpur on 6 October, 2021.
- The ICAR-Directorate of Weed Research, Jabalpur was awarded 2nd prize in the exhibition during the 5th 'International Agronomy Congress' held during 23-27 November, at PJTSAU, Hyderabad.
- Dr. J.S. Mishra received 'Certificate of Honour' from the Indian Society of Agronomy in the 5th 'International Agronomy Congress' held at Hyderabad during 23-27 November, 2021.
- Dr. J.S. Mishra was honored by the Indian Society of Agronomy in the 5th 'International Agronomy Congress' held during 23-27 November, at PJTSAU, Hyderabad for his significant contribution in the field of Agronomy research.

- Dr. V.K. Choudhary was awarded 'ISA Associate ship' for the year 2017 by the 'Indian Society of Agronomy' during the '5th International Agronomy Congress' held at PJTSAU, Hyderabad during 23-27 November, 2021.

- ICAR-Directorate of Weed Research, Jabalpur was awarded 1st prize by Nagar Rajbhash Karyanvayan Samiti (NARAKAS), Jabalpur, Zone-2 on 23rd December, 2021.

- Er. Chethan C.R. received "IEI Young Engineers Award 2021" during 36th Indian Engineering Congress held at Vigyan Bhawan, New Delhi on 26th December, 2021.

- Dr. Yogita Gharde acted as 'reviewer' for International/peer reviewed journals *viz. The Canadian Entomologist* and *Weed Biology and Management.*
- Dr. Yogita Gharde was appointed as an 'external examiner' to evaluate the M.Sc., Agricultural Statistics thesis from Indira Gandhi Krishi Vishwavidyalaya, Raipur and Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Dr. Yogita Gharde was appointed as 'Question paper setter' for PG and Ph.D., Agril. Statistics courses of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Dr. Pawar Deepak Vishwanath acted as Reviewer for International/peer reviewed Journal '*3 Biotech'.*
- Dr. Pawar Deepak Vishwanath was appointed as an 'External Examiner' to evaluate the M.Sc., Molecular Biology and Biotechnology thesis from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Dr. Pawar Deepak Vishwanath was appointed as a 'Question Paper Setter' for PG, Molecular Biology and Biotechnology course at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Dr. Dasari Sreekanth, was appointed as an 'External Examiner' to evaluate the M.Sc., Plant Physiology thesis from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
- Dr. V.K. Choudhary acted as 'Reviewer' for International/peer-reviewed Journals *viz.* '*Archives of Agronomy*', '*Soil Science* and '*Field crop Research*'.
- Dr. V.K. Choudhary was appointed as an 'External Examiner' to evaluate the M.Sc., Agronomy thesis from Indira Gandhi Krishi Vishwavidyalaya, Raipur and Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

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13. Publications

Scientists of the Directorate have published substantial research information in various forms. This chapter contains the information on the publication of research and review articles, book chapters, popular articles, edited books, proceedings, newsletters and also the research paper presented in different conferences.

13.1 Research/ Review Articles

Chhokar R.S., Das T.K., Choudhary V.K., Choudhary A., Raj R., Vishwakarma A., Biswas A.K., Singh G.P. and Choudhari S.K. 2021. Weed dynamics and management in conservation agriculture. *Journal of Agricultural Physics* 21(1) 222-246.

Choudhary V.K. and Dixit A. 2021. Bio-efficacy of sequential herbicide application for weed management in dry direct seeded rice. *Indian Journal of Agricultural Sciences* **91**(1): 79–83.

Choudhary V.K., Dubey R.P. and Singh P.K. 2021. Management of field sow thistle (*Sonchus oleraceus* L.): an emerging threat in winter crops. *Indian Journal of Weed Science* **53**(2): 142–145.

Choudhary V.K., Reddy S.S., Mishra S.K., Kumar B., Gharde Y., Kumar S., Yadav M., Barik S. and Singh P.K. 2021. Resistance in smallflower umbrella sedge (*Cyperus difformis*) to an acetolactate synthase–inhibiting herbicide in rice: first case in India. *Weed Technology* **35**: 710–717.

Das T.K., Singh R., Chhokar R.S., Nayak A.K., Chudhary V.K., Raj R., Singh A., Ravis, Gill S.C., Biswas A.K., Patra A.K. and Choudhary S.K. 2021. Conservation agriculture in cereal systems in the indogeomatric plains. Imports on productivity source use efficiency and soil properly *Journal of Agricultural Physics* 21(1) 74-84.

Gharde Y. and Singh P.K. 2021. Farmers knowledge level and constraints faced in the adoption of weed management technologies. *Indian Journal of Weed Science* **53**(1): 73–77.

Ghosh D., Roy D., Choudhary V.K., Mandal K.G. and Mishra J.S. 2021. Increasing water and nutrient-use efficiency in crops by innovative and low-cost weed management. *Indian Journal of Fertilisers* **17**(11): 1182–1193.

Ghosh P.K., Mallikarjun J., Sivalingam P.N., Parmeshwari B., Singh H.K., Choudhary V.K., Kiran Kumar K., Sahu B., Muthappa S.K., Dixit A. and Das A. 2021. Agronomic innovations in biotic stress management and its combined effect with abiotic stresses in crop production. *Indian Journal of Agronomy* **66**(5th IAC Special issue): S237–S257.

Ghosh D., Brahmachari K., Das A., Mohamed M.H., Mukherjee P.K., Sarkar S., Dinda N.K., Pramanick B., Moulick D., Maitra S., Hossain A. 2021. Assessment of energy budgeting and its indicator for sustainable nutrient and weed management in a rice-maize-greengram cropping system. *Agronomy* **11**(1): 166–178.

Kharte S., Gupta P.K. and Gharde Y. 2021. Exploring seed treatment and foliar of application of fungicides on management of Pea diseases. *Annals of Plant Protection Sciences* **29**(3): 226–230.

Kumar S.P., Roul A.K., Nandede B.M., Jyoti B. and Chethan C.R. 2021. Development of small tractor operated boom sprayer for field crops to control weeds. *Indian Journal of Weed Science* **53**(2): 173–178.

Mishra J.S., Choudhary V.K., Dubey R.P., Chethan C.R., Sondhia S. and Sushilkumar. 2021. Advances in weed management-An Indian perspective. *Indian Journal of Agronomy* **66**(3): 251–263.

Mishra Y.K., Sharma A.K., Ramakrishnan R.S., Sondhia S., Bhowmick A.K., Pahalwan D. and Gharde Y. 2021. Oviposition responses of *Helicoverpa armigera* towards different chickpea varieties as influenced by sowing dates and irrigation levels under field condition. Biological Forum – *An International Journal* **13**(2): 536–539.

Mondal S., Mishra J.S., Poonia S.P., Kumar R., Dubey R., Kumar S., Verma M., Rao K.K., Ahmed A., Dwivedi S., Bhatt B.P., Malik R.K., Kumar V. and McDonlad A. 2021. Can yield, soil C and aggregation be improved under long-term conservation agriculture in the eastern Indo-Gangetic Plain of India? *European Journal of Soil Science* **72**(4): 1742–1761.

Rathore S.S., Mishra J.S. and Bhatt B.P. 2021. Recommended best management practices for potential ecosystem services. *Indian Journal of Agronomy* **66** (5th IAC Special issue): S180–S190.

Rao K.K., Samal S.K., Kumar M., Naik S.K., Bhatt B.P., Prakash V., Mondal S., Choubey A.K., Dalal R.C., Mishra J.S. and Kumar U. 2021. Carbon sequestration potential of rice-based cropping systems under different tillage practices. *Agrochimica* **65**(3): 229–246.

Sondhia S. and Waseem U. 2020. Residue dynamics and degradation behaviour of pyrazosulfuron-ethyl in the rice field environment. *Indian Journal of Weed Science* **52**(4): 362–365

Sharma N., Singh S. and Sondhia S. 2020. Recent advances in mitigation methods for herbicide residues in the soil. *Indian Journal of Weed Science* **52**(4): 300–308.

Soni J.K., Amarjeet Punia S.S. and Choudhary V.K. 2021. Herbicide combinations for management of resistance in *Phalaris minor*. *Indian Journal of Weed Science* **53**(1): 41–48.

Singh B.P., Mukherjee P.K, Chander M., Suman R.S., Singh Y.P. and Pathade S. 2021. Assessment of green fodder of Bajra napier hybrid in terms of availability, milk production and entrepreneurship. *International Journal of Livestock Research* **11**(3): 107–113.

Sushilkkumar, Bhowmick M.K. and Ray P. 2021. Weeds as alternate and alternative, hosts of crop pests. *Indian Journal of Weed Science* **53**(1): 14–29

Yadav A., Gharde Y. and Kumar Sushil. 2021. Evaluating machine learning approaches for prediction of suitable climatic conditions for *Parthenium hysterophorus* (L.) in India. *Journal of the Indian Society of Agricultural Statistics* **75**(2): 121–125.

13.2 Paper presented

Jamaludheen A., Chand P. and Praveen K.V. 2021. Recent developments in the herbicide research domain: A bibliometric assessment, No. 315231, 2021 Conference, August 17-31, 2021, Virtual, International *Association of Agricultural Economists*. DOI: 10.22004/ag.econ.315231.

Choudhary V.K., Dubey R.P. and Mishra J.S. 2021 New generation herbicide influences weed control, crop productivity and profitability in transplanted rice 1050–1051 p. *In*: Extended Summaries: 5th International Agronomy Congress on "Agri Innovations to combat food and nutrition challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Dubey R.P., Choudhary V.K., Ghosh D., Chethan, C.R, Sen J.N., Singh P.K. and Mishra J.S. 2021. Herbicidal weed management in fennel (*Foeniculum vulgare*). 1028–1029 p. *In*: Extended Summaries: 5th International Agronomy Congress on "Agri Innovations to combat food and nutrition challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Ghosh D., Dubey R.P., Roy D., Chander S. and Chethan C.R. 2021. Tillage based crop establishment, nutrient and weed management regimes influence weed density, diversity and yield of rice-wheat cropping system in Central India.1145–1147 p. *In*: Extended Summaries: 5th International Agronomy Congress on "Agri Innovations to combat food and nutrition challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Gharde Y., Yadav A., Kumar Sushil and Singh P.K. 2021. Performance of machine learning approaches for predicting distribution of *Parthenium hysterophorus* (L.) in India. 1072-1073p. *In*: Extended Summaries of 5th International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Gharde Y., Dubey R.P. and Singh P.K. 2021. Modelling potential distribution of alien weeds in India. International Conference on "Recent Application of Statistical Techniques and Analysis (RASTA-2021)" during 15-17 December, 2021 organized by Department of Statistics, Institute of Science, Banaras Hindu University, Varanasi, India.

Mukherjee P.K. 2021. Ecology and management of *Alternanthera paronychioides* A. St.-Hil. (Smooth joyweed), an invasive weed in upland ecosystems. 1079–1080 p. *In*: Extended Summaries: 5th International Agronomy Congress on "Agri Innovations to combat food and nutrition challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Mahawar H., Barman K.K. and Roy D. 2021. Effect of glyphosate on beneficial soil microbial functions in Mung bean. 1349–1350 p. *In*: Extended Summaries of 5th International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Roy D., Ghosh D. and Dubey R.P. 2021. Influence of tillage-based crop establishment, nutrient and weed management regimes on soil quality attributes under rice-wheat cropping system in vertisols of Central India. 447–448 p. *In*: Extended Summaries of 5th International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Singh P.K., Chethan C.R. and Mishra J.S. 2021. Conservation agriculture system reduces the energy consumption and greenhouse gases emission in rice-wheat-greengram cropping system in central India. *In* XV Agricultural Science Congress & ASC Expo' organized by National Academy of Agricultural Sciences and Banaras Hindu University at Institute of Agricultural Sciences, during November 13-16, 2021 at Banaras Hindu University, Varanasi.

Singh P.K., Gharde Y., Barman K.K., Chethan C.R., Choudhary V.K. and Dubey R.P. 2021. Performance of CA based package of practices for rice-wheat-greengram system in farmer's field. *In*: Extended Summaries of 5th International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

Sondhia S. 2021. A multiresidue method for the determination of herbicide residues in environmental samples by LC-MS/MS. *In* XV Agricultural Science Congress & ASC Expo' organized by National Academy of Agricultural Sciences and Banaras Hindu University at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. November 13-16, 2021 abstract 410.

Soni R., Sahu R.P., Sondhia S., Mondal T., Sharma J.K. and Patel H. 2021. Weed management through pyribenzoxim herbicide indirect-seeded rice.

1144-1145p. *In*: Extended Summaries of 5th International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" during November 23-27, 2021 at PJTSAU, Hyderabad, India.

13.3 Book/Book chapter published

Anandakumar T.M., Chethan C.R., Shrinivasa D.J. and Manjunath K. 2021. Advances in Ocean Energy technology. *In:* Advances in Renewable Energy engineering (Eds. Seveda, M.S., Narale, P.D. and Kharpude, S.N.). Narendra Publishing house, New Delhi, Pp. 301-312.

Bijla S., Jamaludheen A., Sen B., Suresh A. and Krishnan P. 2021. agricultural research policy for food security & sustainability in India. *In*: Agricultural Research, Technology and Policy: Innovations and Advances, (Eds Ch. Srinivasarao *et al.*). ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India, Pp. 271-290.

Badole S., Roy D., Singh L.K. and Datta A. 2021. Carbon neutral roadmap for green India. *In*: Innovations in Agriculture for a Self-reliant India. (Eds. Ghosh P.K., Kumar P., Chakraborty D., Mandal D. and Sivalingam P.N.). Pp 191-222.

Dubey R.P. and Mishra J.S. 2021. Weed management in agricultural and horticultural crops: novel approaches and future strategies. *In.* Resource: Book on Furtherance in Integrated Pest Management Approaches (Eds. Sehgal M., Balodi R., Raghavendra K.V. and Chander S.), ICAR-NCIPM, Pp 209.

Gurjar D.S., Singh U. and Choudhary V.K. 2021. Aqua-fertilization: An easy approach for higher nutrients acquisition under arid and semi-arid ecosystem. *In:* nutrient use efficiency through next generation fertilizers. Publisher: Brillion Publishing ISBN 978-93-90757-74-9. 2 Pp. 417-426.

Jeer M., Sahu M.P. and Choudhary V.K. 2021. Novel approaches for biotic stress management in the emerging production system. Theme 4: Innovations and strategies for biotic stress management in Innovations in Agriculture for a self-reliant India. NIPA and CRC publication PP305-330.

Kumar Kiran, Sridhar J., Choudhary V.K., Singh H.K., Parameshwari K.M., Kumar Senthil, Bhimeshwari Sahu, Dokka Narasimham and Shivalingam P.N. 2021. New innovations and approaches for biotic stress management of crops. Theme 4 Innovations: and strategies for biotic stress management in Innovations in Agriculture for a self-reliant India. NIPA and CRC publication. PP 265-292

Manjunath K., Shrinivasa D.J. and Chethan C.R. 2021. Advances in Geothermal Energy Technology. *In*: Advances in Renewable Energy Engineering (Eds. Seveda, M.S., Narale, P.D. and Kharpude, S.N.). Narendra Publishing house, New Delhi, 313-328.

Roy D., Sreekanth D., Pawar D., Mahawar H. and Barman K.K. 2021. Phytoremediation of arsenic contaminated water using aquatic, semi-aquatic and submerged weeds. *In:* Biodegradation, IntechOpen.

Shrinivasa D.J., Manjunath, K., Chethan C.R., Kumar S., Tripathi V.K. and T.M. A.K. 2021. Hydrogen fuel cell technology *In*: Advances in renewable energy engineering (Eds. Seveda, M.S., Narale, P.D. and Kharpude, S.N.). Narendra Publishing house, New Delhi, 259-279.

13.4 Annual report edited

Sushilkumar, Singh P.K., Dubey R.P., Sondhia S. and Dhagat S. 2020. Annual Report (Eds.). 2020. ICAR-Directorate of Weed Research, Jabalpur. 155 p.

Sondhia S. and Mishra J.S. (Eds.). 2020. Annual Report of AICRP-Weed management, ICAR-Directorate of Weed Research, Jabalpur, 158 p.

13.5 News letter edited

Barman K.K., Choudhary V.K., Gharde Y. and Dhagat S. (Eds.). 2020. Weed News 20(2), July-December 2020.

Barman K.K., Choudhary V.K., Gharde Y. and Dhagat S. (Eds.). 2020. Weed News 21(1), January-June 2021.

Mukherjee P.K. (Ed.) 2020. ISWS Newsletter, July-December 2020 and January-June 2021.

13.6 Popular articles

Baghele D., Rathore J., Singh P.K., Choudhary V.K. and Parey S.K. 2021. *Krishi vikash me digital proudhyogiki ka yogdaan. Trin Sandesh* **16**: 105-109.

Bal K., Kumar R. and Mishra J.S. 2021. Parthenium from curse to boon for the farmers. *Indian Farming* **71**(06): 34-36.

Barman K.K., Roy D., Mahawar H. and P.K. Singh. 2021. *Jalkumbhi ka sadupayog kaise krein. Trin Sandesh* **16**: 39-42.

Chaudhary V., Dubey R.P., Sreekanth D. and Dhagat S. 2021. *Electric motor chalit rotri weeder: Jalvayu parivartan niyantran evam krishi majduron ki kami ka vikalp. Trin Sandesh* **16**: 30-32.

Chaudhary V., Dubey R.P., Sreekanth D. and Dhagat S. 2021. *Sensor adharit kharpatwar niyantran machine: Chaynit sodh adhyano ke parinam evam chunoutiyan. Trin Sandesh* **16**: 26-29.

Chethan C.R., Manjunath K., Shriniwas D.J., T.M. A.K. and Chaturvedi S. 2021. *Drone ke madhyam se kharpatwaro ka maanchitran. Trin Sandesh* **16**: 17-20.

Choudhary V.K. 2020. Post emergent chemical weed control in chickpea. *Weed News* **20**(1): 2 January-June 2020.

Choudhary V.K. and Dubey R.P. 2020. Evaluation of imidazolinone group of herbicide in direct-seeded rice. *Weed News* **20**(2): 2 July-December 2020.

Choudhary V.K. and Dubey R.P. 2020. Evaluation of new generation low-dose high potency herbicides in transplanted rice. *Weed News* **20**(2): 2 July-December 2020.

Choudhary V.K. and Dubey R.P. 2021. Post-emergence herbicide to control weeds in blackgram. *Weed News* **21**(1): 2 January-June 2021.

Dongre G.R. 2021. *Kishan. Trin Sandesh* **16**: 120.

Dongre G.R. and Meena M.K. 2021. *Rajbhasha hindi ka vikas or sangharsha. Trin Sandesh* **16**: 117–118.

Dubey R.P., Choudhary V.K. and Chethan C.R. 2021. Evaluation of herbicides for weed management in safflower. *Weed News* **21**(1). p3.

Dubey R.P., Chethan C.R., Choudhary V.K. and Singh P.K. 2020. Enhanced Crop Productivity and environmental benefits by adoption of zero-till cultivation in wheat and summer pulses. Indian Farming (Farmers First Programme) 70(12):10-13.

Gupta P. and Gharde Y. 2021. *Jaivik kheti kya hai?. Trin Sandesh* **16**: 56–61.

Gupta P.K. and Gharde Y. 2021. *Matar ki vaigyanik kheti. Trin Sandesh* **16**: 62–68.

Gupta P.K. and Gharde Y. 2021. *Jaivik rogniyantran: Vartman paridrishya. Krishak Sanjeevani*. October: 6-8.

Gupta P.K., Kharte S. and Gharde Y. 2021. *Kinova: Poshan se bharpoor ek nai fasal. Krishak Sanjeevani*. February: 8.

Khan D.R., Tripathi A. and Choudhary V.K. 2021. *Bhartiya krishi me artificial intelligence ka upyog. Trin Sandesh* **16**: 113–114.

Mahawar H., Roy D., and Barman K.K. 2021. *Mrida sukshamjeev: Kharpatwar prabandhan me paristhitik roop se sthiti drushtikon. Trin Sandesh* **16**: 24–25.

Mishra J.S. 2021. *Jalvayu parivartan evam kharpatwar prabandhan: chunautiyaan evam samadhan. Trin Sandesh* **16**: 1–3.

Mishra Y.K., Sondhia S. and Sharma A.K. 2021. *Dimak: parichay evam niyantran ke upay. Trin Sandesh* **16**: 88–89.

Patel A., Sahu M.P. and Choudhary V.K. 2021. *Dhaan ke fasal ki methane utsarjan me bhumika evam nivaran ke upay. Trin Sandesh* **16**: 79–80.

Pawar D., Sondhia S., Chander S. 2020. Nutritional analysis of different accessions of *Chenopodium* species. *Weed News* **20**(1): 2 January-June 2020.

Pawar D., Sondhia S., Chander S. 2020. Studies on molecular basis of herbicide resistance in *Echinochloa colona*. *Weed News* **20**(1): 3 July-December 2020.

Raghuvanshi M.S., Kharbikar H.L., Malab L.C., Pandey L. and Dongre G.R. 2021. *Corona virus ka krishi par prabhav. Trin Sandesh* **16**: 110–112.

Rathi I. and Gupta S. 2021. *Kharpatwar: mrida ki sthiti ke sanketak. Trin Sandesh* **16**: 44–46.

Roy D., Gupta S., Mahawar H. and Barman K.K. 2021. *Apshisht jal ke upchar hetu upyukt kharpatwar paudho ka sankshipt parichay. Trin Sandesh* **16**: 21–23.

Sahu M.P., Choudhary V.K., Kewat M.L., Jha A.K., Sahu A., Rajoriya A. and Patel A. 2021. *Ganne me antrvarti kheti se kharpatwaro ka daman evam uske labh. Trin Sandesh* **16**: 33–35.

Sen J.N. 2021. *Tilhani fasal kusum, til evam ramtil me kharpatwar niyantran. Trin Sandesh* **16**: 11–13.

Singh P.K., Choudhary V.K. and Chethan C.R. 2021. Economic and environmental benefit of conservation agriculture-based farming. *Weed News* **21**(1): 4 January-June 2021.

Singh P.K., Choudhary V.K., and Sandeep D. 2021. HerbCal: A mobile app for herbicide calculation and judicious use. *Weed News* **21**(1): 4-5 January-June 2021.

Singh P.K., Choudhary V.K., Chethan C.R. and Mishra J.S. 2021. *Kharpatwar ki samasyay evam samadhan. Kheti Patrika* **74**(7): 34–36.

Singh P.K., Choudhary V.K., Chethan C.R., Dubey R.P. and Mishra J.S. 2022. *Sabjiyon me samekit kharpatwar prabandhan ka mahatwa. Unnat Krishi* **55**(1): 7–12.

Singh P.K., Gharde Y. and Parey S.K. 2021. *Sidhi-buwai dhaan me kharpatwaro ki chunauti evam prabandhan. Trin Sandesh* **16**: 4–10.

Singh P.K., Jamaludheen A. and Dhagat S. 2021. *Hightech kirshi samay ki mang- ek tathyatmak vivechana. Trin Sandesh* **16**: 50–55.

Sondhia S. and Mishra S. 2021. *Bhringraj ek kharpatwar ya aushadhiya paudha. Trin Sandesh* **16**: 47–49.

Sondhia S. and Mishra S. 2021. *Paudho evam shaknashi ke dutiyak chayapchay evam unka mahatva. Trin Sandesh* **16**: 14–16.

Upadhyay R.S. 2021. *Beejoutpadan: Labhkari aay ka sadhan. Trin Sandesh* **16**: 115–116.

13.7 Proceedings in souvenir/others

Sekhawat K., Kumari V.V., Rohit J., Srivastava J., Rana D.S., Mishra J.S., Vyas A.K. and Singh V.K. 2021. Agri-Innovations to Combat Food and Nutrition Challenges (Eds. Souvenir), *In:* 5th International Agronomy Congress, 23-27 November 2021 held at PJTSAU, Hyderabad, Telangana, India.

13.8 Other publications

Singh P.K., Choudhary V.K., Gharde Y., Dhagat S., Dongre G.R. and Meena M.K (Eds). 2020-21. *Trin Sandesh- Hindi Patrika* 16. 128p.

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14. Monitoring and Review of Research Programmes

14.1 Monitoring of AICRPWM centers

Physical monitoring of all the AICRPWM centers could not be done due to Covid-19 pandemic. However, physical monitoring of a few centers like, PJTSAU, Hyderabad, IGKVV, Raipur and AAU, Anand was done. The monitoring of PJTSAU, Hyderabad was done by Director, DWR along with Dr. Sushil Kumar and Dr. V.K Choudhary on 25 Nov. 2021 while monitoring of IGKVV, Raipur and AAU Anand was done by Dr. Sushil Kumar. In all the centers, experiments were conducted as per the technical programme. Deficiencies in the experiments were pointed out and PIs were advised to take care of those things in future.

Online monitoring was done by reviewing the progress of the experiments of all the centers on 7th January, 2021, 24-28 August, 2021 and 21-22 December, 2021.



14.2 Institute Research Committee (IRC) meeting

The IRC meeting was convened during 28-30 June, 2021 and 1 July, 2021 to review the progress of ongoing research projects and actions taken on the recommendations of IRC-2020. The meeting was attended by all the scientists of the Directorate. Dr Shobha Sondhia, Member-Secretary, IRC welcomed all the scientists which was followed by the address given by Dr. J.S. Mishra, Director and Chairman, IRC. Dr. Mishra formally welcomed all the scientists. He informed that RAC recommendations have been approved by the council. He appreciated status of experimental and commercial fields' which were well maintained throughout the year and resulted in good crop yield during *Rabi* and *Kharif* in spite of lockdown and limitations due to COVID-19. He said that while preparing new projects focus, should be given on the suggestions given by QRT, RAC and Dr. S.K. Choudhary, DDG, NRM, ICAR, New Delhi during review meeting of the Directorate. Dr. Shobha Sondhia, Member Secretary, IRC presented the action taken report on general recommendations of the IRC 2020, which was approved by the chairman. Thorough discussion was made on ongoing research program of the Directorate. The research programs were approved as below:

Program 1. Strategic research for sustainable weed management in diversifying cropping system (Program Leader: Dr. R.P. Dubey).

Program 2. Crop-weed interaction under changing climate and herbicide resistance (Program Leader (Dr. Sushil Kumar)

Program 3. Weed risk assessment, utilization and management of alien invasive weeds (Program Leader (Dr. K.K. Barman).

Program 4. Environmental impact of herbicides and mitigation measures (Program Leader: Dr. Shobha Sondhia)

Program 5. Dissemination and socio-economic impact of weed management technologies (Program Leader: Dr. P.K. Singh)

Major recommendations of the IRC were as follows:

1. Submit RPP-I of the ongoing projects for the period 2020-21 and RPP-II of the projects.
2. Project PI should present all data of the project undertaken by Co-PI
3. All the scientists are advised to publish quality research paper in high NAAS rated journals.
4. Inclusion of PI and Co-PI should be based on the objectives and experiments of the projects and it should be clearly mentioned in the proposal and RPPs.
5. Research field should be visited regularly by the scientists having field experiments.

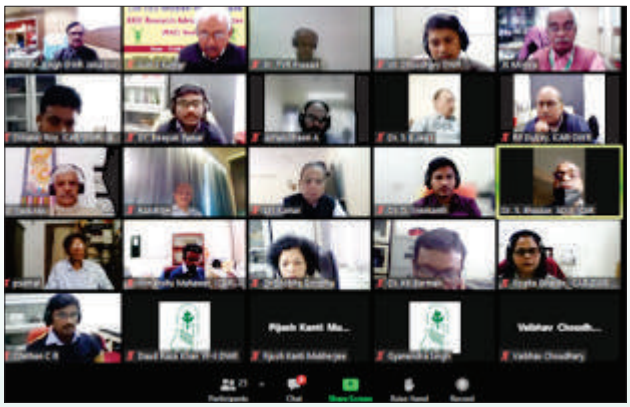
In the end of the IRC meeting, Dr. J. S. Mishra, Director, ICAR-DWR and Chairman, IRC congratulated to all the scientists and member secretary for successful conductance of IRC and urged to work in a team and come up with technologies/techniques and publications as given in future publication plan. In the last, Dr. Shobha Sondhia proposed vote of thanks to IRC Chairman and all other members.

14.3 Institute Research Committee (RAC) Meeting

The XXII RAC meeting of the Directorate was held virtually on 14-15 June, 2021 at ICAR-DWR, Jabalpur. In this meeting Dr. N. T. Yaduraju, Chairman; Dr. S. Bhaskar, Member; Dr. A. Ramesh, Member; Dr. P. Samal, Member; Dr. T.V. Ramachandra Prasad, Member; Dr. S.K. Jalali, Member; Dr. Ajit Kumar, Member and Dr. Sushil Kumar, Member Secretary were present along with Director, DWR and all the scientists. At the outset, Dr. J.S. Mishra, Director, ICAR-DWR, Jabalpur, extended a warm welcome to the Chairman, Dr. N. T. Yaduraju, and other members of RAC. He informed the house about various activities and major initiatives undertaken by the Directorate during the period. Dr. Sushilkumar, Member-Secretary presented the action taken report (ATR) on the recommendations made at the XXI RAC meeting held on 25-26 February, 2020. RAC expressed satisfaction over the ATR presented by the Member-Secretary and opined that most of the points in the recommendations made in the last meetings have been addressed satisfactorily despite having 50% less scientific manpower than the sanctioned and adverse conditions during last one year due to COVID-19 pandemic. Chairman thanked the ICAR and ADG, Dr. S. Bhaskar for taking care of the RAC recommendations. Dr. N.T. Yaduraju, Chairman, RAC asked to relook and rework on the previous recommendations to identify the weeds of national importance and WRA of weeds of quarantined nature. Afterwards, presentations of research findings of *Rabi* 2020 and *Kharif* 2021 along with future research proposals for 2022 were made by all the scientists. There was in-depth discussion between RAC Committee with the Director, DWR and all the programme leaders.

14.4 Recommendations of RAC

1. The ICAR should give priority for filling up vacant positions in the scientist's cadre. The presence of scientists in key disciplines is vital for DWR to carry out multidisciplinary work and in fulfilling the mandated objectives of the Directorate. Filling up the vacant post of scientists in DWR in general and the post of Entomologist in particular to take the place of Existing Entomiologist scientitst who is going to retire in 2022 for taking up the important project on biological control of aquatic weed Salvinia in the central India
2. ICAR-DWR could not make satisfactory progress to identify 15-20 Weeds of national Importance due to Covid-19 pandemic except organising Brain Storming workshop and one lecture on invasive weed. RAC strongly recommended that DWR should take this activity in full swing and send the enquiries to all the stakeholders to identify 15-20 weeds of National importance so that recommendations could be sent to government to make policy for the management of those weeds at priority.
3. Water fern (*Salvinia molesta*) occurrence and its thriving ability in central India has been considered alarming. Preliminary study by DWR on its biological control has sown encouraging results. Therefore, DWR should take up its immediate mapping and release programme of bioagent in the intercepted water bodies.
4. Weed Risk Analysis is very important aspect for identifying quarantine weeds and to check its further spread if already sneaked into India. DWR should take up this study in collaboration with NBPGR and Directorate of Plant Protection Quarantine & Storage, New Delhi.
5. Farmers are adopting Direct Seeded Rice (DSR) technology in many areas of India in general and IGP in particular due to shortage of labour and narrow window to take rabi crops. Weed management is real challenge in DSR. Therefore, DWR should take up an project on mapping the area under DSR, weed management problems and refining of the machinery involved in DSR



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15. Events Organised

Sl.	Event Name	Date
1	Training-cum-exposure visit for Uttar Pradesh farmers	18 February, 2021
2	Study tour programme of the students from Government Science College, Jabalpur.	21 February, 2021
3	Inauguration of "Training-cum-farmers' hostel "	26 February, 2021
4	International Women's Day	08 March, 2021
5	Workshop on "Weed management in vegetable crops"	09 March, 2021
6	Training cum Exposure visits organized for Damoh district farmers under DBT programme	10 March, 2021
7	Training cum exposure visits organized for Hoshangabad district farmers under DBT programme	19 March, 2021
8	World Water Day	22 March, 2021
9	Training cum exposure visits organized for Sehore district farmers under DBT programme	23 March, 2021
10	Training programme for skilled supporting staff	24-26 March, 2021
11	Directorate Foundation Day	22 April, 2021
12	XXIX Institute Management Committee (IMC) meeting	25th May, 2021
13	World Environment Day	05 June, 2021
14	XXII Research Advisory Committee (RAC) meeting	14-15 June, 2021
15	Farmers' awareness *gosthi* was organized in virtual mode on the topic "*Proper management of Soil Health and Balanced Use of Fertilizers*"	18 June, 2021
16	"XXVIII Annual Review Meeting" (ARM) of AICRP on Weed Management	18-19 June, 2021
17	International Yoga Day	21 June, 2021
18	Institute Research Committee (IRC) Meeting	28 June – 01 July, 2021
19	Farmer's training- cum- Sangosthi	13 July, 2021
20	Nation-wide campaign on tree plantation and awareness	16 July, 2021
21	Campaign on utilization of Agro-waste through composting	01-31, July 2021
22	Directorate signed MoU with 12 National and International Institutes	07 August, 2021
23	Press Conference for 16th Parthenium Awareness Week	12 August, 2021
24	Nation-wide 16th "*Parthenium* Awareness Week"	16-22 August, 2021
25	During *Parthenium* Awareness Week, *Parthenium* uprooting programme	18 August, 2021
26	Distribution of saplings to the farmers under SCSP Programme	21 August, 2021
27	Sagosthi organized on "*Khadya avam poshan suraksha me kharpatwar prabhandhan ka mahatva*"	26 August, 2021
28	*Hindi Diwas*	14 September, 2021
29	*Poshan Vatika Mahaabhiyan* and *Vrikshaaropan* programme	17 September, 2021
30	Farmers-Scientist interface on "Climate-Resilient Agriculture"	28 September, 2021

Sl.	Event Name	Date
31	"Hindi Workshop"	29 September, 2021
32	*Hindi Pakhwada*	14 - 29 September, 2021
33	Special National Swachhta Campaign on "Waste to Wealth"	12 October, 2021
34	Hindi Workshop	13 October, 2021
35	*Mahila Kisan Diwas*	15 October, 2021
36	"World Food Day"	16 October, 2021
37	Visit of Assistant Director General (Agronomy, Agroforestry & Climate Change), ICAR at Directorate	18 October, 2021
38	Vigilance Awareness Week-2021	26 October- 01 November, 2021
39	Workshop on "Pesticide protection spray measure"	30 October, 2021
40	'Hindi Workshop'	20 November, 2021
41	'Communal Harmony Week' and 'Flag Day'	25 November, 2021
42	National level campaign on "Agriculture and Environment: The Citizen Face"	26 November, 2021
43	'World Soil Day-2021'	05 December, 2021
44	Hindi Workshop	08 December, 2021
45	Awareness programme on 'Natural Farming'	16 December, 2021
46	*Swachhta Pakhwada* - 2021	16 _ 31 December, 2021
47	Celebration of Special Day – *Kisan Diwas*	23 December, 2021
48	Inauguration of *Krishak Sabhagar* by Dr. Panjab Singh, Ex. Secretary DARE and Director General ICAR	29-12-2021
49	Closing ceremony of "*Swachhta Pakhwada* –2021" at ICAR-DWR	31 December, 2021
50	6 days training programme under Schedule Caste Sub Plan (SCSP) at Directorate	27 December, 2021 – 01 January, 2022


किसान दिवस


World Environment Day
05 June, 2021
विश्व पर्यावरण दिवस


विश्व जल दिवस
World Water Day - 2021


स्थापना दिवस
Foundation Day


किसान दिव


मेरा गांव मेरा गौरव कार्यक्रम के अंतर्गत
वैज्ञानिक - कृषक परिचर्चा


महिला किसान दिवस


स्वच्छता पखवाड़े के दौरान
किसान दिवस


स्वच्छता पखवाड़ा


महिला किसान दिवस

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16. Participation in Meetings, Seminars and Workshops

Dr. J.S. Mishra

- "*Review Meeting of Officers & Staff of DARE & ICAR*" by DG, ICAR & Secretary, DARE organized by ICAR, New Delhi on 1 January, 2021
- "*ISWS Executive Meeting*" organized by ISWS on 2 January, 2021
- "*Review Meeting of NASF Project*" organized by ICAR, New Delhi on 4 January, 2021
- "*Third Party Review Meeting*" organized by ASCI, Hyderabad and NRM Division, New Delhi on 7 January, 2021
- "*Review Meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- "*Review Meeting of Foreign Aided Projects*" organized by NRM Division, New Delhi on 11 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" (Speaker: Dr. Samunder Singh), organized by ISWS and ICAR-DWR, Jabalpur on 29th January, 2021
- Webinar on *"Principles of Good Laboratory Practices"* organized by CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur under AICRP-WM & CAAST on Protected Agriculture and Natural Farming on 10 February, 2021
- Webinar on "*World Pulse Day Celebration*" organized by ICAR, New Delhi on 10 February, 2021
- National Webinar on "*Weed Science*" organized by AICRP-WM, KAU, Thrissur on 16 February, 2021
- Webinar on "*Remote Sensing and Drones Application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" (Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25th February, 2021
- "*Budget Utilization*" chaired by Hon'ble DG organized by ICAR, New Delhi on 5 March, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- "*Budget Expenditure Review Meeting*" under the chairmanship of DDG (NRM) organized by NRM Division, New Delhi on 11 March, 2021
- International Webinar on "*Recent Advances in Weed Science Research*" organized by PAJNACOA&RI, Karaikal, Puducherry & ICAR-DWR, Jabalpur on 12 March, 2021
- "*XXVI Regional Committee Meeting of Region-VI*" organized by ICAR-CSWRI Avikanagar at New Delhi on 13 March, 2021
- Lecture on "*Valuing Water for Agriculture*" in Bharat ka Amrut Mahotsav organized by DDG (Education), ICAR, New Delhi on 17 March, 2021
- Webinar on "*Weed Science Research in India way forward and scope for entrepreneurship opportunity*" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar on "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23rd March, 2021
- "*Mid-term Review Meeting of Regional Committee Zone VII*" held at NBSS & LUP, Nagpur on 25 March, 2021
- National Webinar on "*Weed Management in Rice-fallows*" organized by PJTSAU, Hyderabad on 3 April, 2021
- Meeting on "*Formulation of SFC 2021-2026*" organized by DDG (NRM), ICAR, New Delhi on 8 April, 2021
- "*SFC Meeting*" organized by DDG (NRM), ICAR, New Delhi on 12 April, 2021
- International Webinar on "*Genetics, Genomics and Breeding of Herbicide-Tolerant Grain Sorghum to Address Weed Control Challenges*" organized by PJTSAU, Hyderabad on 19 April, 2021
- Stakeholder Consultation Meeting on "*Impacts and Management of Invasive Alien Species (IAS) in Agro ecosystems of India*" organized by Biodiversity Authority of India on 27 April, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30th April, 2021
- "*5th BPGS Meeting of the Department of Agronomy*" organized by Nagaland University, Medziphema on 18 May, 2021
- "*Project Advisory and Monitoring Committee (PAMS)*" meeting of AICRIP on Maize organized by ICAR-IIMR, Ludhiana on 19, May, 2021
- "*29th IMC Meeting*" held at ICAR-DWR, Jabalpur on 25 May, 2021
- National Webinar on "*Direct-Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021
- "*SFC Meeting*" organized by ICAR-IIFSR, Modipuram on 11 June, 2021
- National Seminar on "*Promotion of Direct Seeded Rice (DSR): Prospect and Challenges amid COVID-19*" organized by DDG (NRM) DDG (Ext), ICAR, New Delhi on 12-13 June, 2021
- "*22nd RAC Meeting*" organized by ICAR-DWR Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed*

Management" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22nd June, 2021

- Webinar on "*Rishi- Krishi*" organized by ICAR, New Delhi on 24 June, 2021
- "*IRC Meting*" held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- "*Director Conference*" organized by ICAR, New Delhi on 2 July, 2021
- AKAM Lecture on '*Genomics and Breeding Innovations in Agriculture*' by Dr. R.K. Varshney, Research Program Director, ICRISAT & Adjunct Professor, Murdoch University, Murdoch, Australia organized by ICAR, New Delhi on 6 July, 2021
- Lecture on "*Corona Viruses: Burgeoning and Enduring Threats*" - Speaker: Dr B. N. Tripathi, DDG (Animal Sciences), ICAR organized by ICAR, New Delhi on 14 July, 2021
- Interface meeting on **"***Enhancing the Preparedness for Agricultural Contingencies during Kharif 2021"* along with DAC&FW and Government of MP organized by ICAR-CRIDA, Hyderabad on 15 July, 20221
- Brain Storming Session on "*Safe Use of Chemical Fertilizers and other Agro-chemicals*" organized by ICAR, New Delhi on 19 July, 2021
- Meeting on "*Regulatory Compliance Burden on Citizens*" under the chairmanship of DDG (NRM), ICAR organized by ICAR, New Delhi on 20 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20th July, 2021
- "*Mid Term Review Meeting: Regional Committee V*" organized by ICAR, New Delhi on 27 July, 2021
- "*SFCs Meeting*" organized by DDG (NRM), ICAR organized by ICAR, New Delhi on 29 July, 2021
- "*Post SOC Divisional*" meeting under the chairmanship of Dr. S.K. Chaudhari, DDG (NRM & Engg.) organized by ICAR, New Delhi on 5 August, 2021
- Annual conference on "*Ensuring Food and Nutrition Security in the context of Climate Change and Corona pandemic*" organized by MSSRF, Chennai on 6-8 August, 2021
- Press Conference for "*16th Parthenium Awareness Week*" on 12 August, 2021, organized by ICAR-DWR, Jabalpur
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August 2021
- "*YouTube Live Phone in Programme on Parthenium"* organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- "*Quarterly AICRP-WM Review Meeting*" held at ICAR-DWR, Jabalpur on 24 & 26-28 August, 2021
- "*XXVI Meeting of Regional Committee No. VII*" organized by ICAR-CIAE, Bhopal on 25 August 2021
- National seminar on "*Rice-fallow management in Eastern India*" organized by ICAR-RCER, Patna on 26 August, 2021
- Series on National level campaign "*Food & Nutrition for Farmers*" organized by ICAR, New Delhi on 26 August, 2021
- National Stakeholders Consultation workshop on "*Development of Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India*" organized by Green India Mission Directorate, Ministry of Environment, Forest & Climate Change, New Delhi on 27 August, 2021
- Webinar on "*Recent Advances in Animal Genetics for Improving Poultry Productivity*" organized by ICAR-RCER, Patna on 28 August, 2021
- AKAM lecture on "*Innovations for Transformation*" by Dr. Krishna Ella, Founder Chairman and Managing Director of Bharat Biotech organized by ICAR, New Delhi on 1 September, 2021
- National Webinar on "*Nutritional Security in India: Issues and Way Forward*" organized by ICAR-RCER, Patna on 4 September, 2021
- "*First Dr. NGP Rao Memorial Lecture & Award Ceremony*" organized by ICAR-IIMR, Hyderabad & Society for Millets Research on 5 September, 2021
- AKAM lecture on "*Improving Phosphorus use Efficiency using large set of Chickpea Germplasm*" delivered by Dr. Kadambot Siddique, Professor of Agriculture & Director, Institute of Agriculture, The University of Western Australia organized by ICAR, New Delhi on 5 September, 2021
- Webinar on "*Rice Area Mapping and Yield Estimation Assimilating Remote Sensing Rroducts with Crop Growth Models*" by Dr. S. Pazhanivelan, Head, RS & GIS Unit, TNAU, Coimbatore organized by IIRR & Society for Advancement of Rice Research, Hyderabad on 7 September, 2021
- "*Regional Committee VIII*" meeting organized by ICAR, New Delhi on 14 September, 2021
- Lecture on "*Agricultural, Food and Nutritional Security: The Changing Technology Landscape*" by Dr. Renu Swarup, Secretary, DBT organized by ICAR, New Delhi on 14 September, 2021
- "*Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR, New Delhi on 17 September, 2021
- National Webinar on "*Scientific Goat Farming: From the Livelihood to Financial Security for the Farmers*" organized by ICAR-RCER, Patna on 18 September, 2021
- "*Scientific Advisory Committee*" meeting of KVK, IGNTU organized by IGNTU, Amarkantak on 20 September, 2021
- Chaired technical session in International Conference on "*Reorientation in Agronomic Research and Education to Combat Current and Future Challenges in Agriculture*" organized by RAU, Pusa on 21-23 September, 2021
- National Webinar on "*Entomophaegi for Livelihood Security and Ecological Engineering for Innovative Pest Management*" ICAR-RCER, Patna on 21 September, 2021
- Webinar on "*Krishi me Nanotechnology ka Upyog: Nano-Fertilizer*" by Dr. Ramesh Raliya, General Manager & Head of Research & Development, IFFCO Nano Biotechnology Research Centre, India organized by ICAR-RCER, Patna on 23 September, 2021
- Lecture on "*Agriculture in Post-independent India: Looking Back and Looking Ahead*" by Prof. Ramesh Chand, Member, NITI Aayog organized by ICAR, New Delhi on 24 September, 2021

- Meeting for "*Assessment Committee*" organized by JNKVV, Jabalpur on 24 September, 2021
- "*Lecture: Talent Search for Manning Agriculture TREE (Teaching, Research and Extension Education)*" by Dr. C.D. Mayee Ex- Chairman, ASRB & Agri. Commissioner, Min. of Agriculture, organized by ICAR, New Delhi on 27 September, 2021
- National Webinar on "*Emerging Challenges and Opportunities in Arid Agriculture*" organized by CAZRI, Jodhpur on 27 September, 2021
- Prime Minister's Virtual address to the farmers and scientists launching the *"Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods"* organized by ICAR-DWR, Jabalpur on 28 September, 2021
- 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September, 2021
- "*Foundation Day*" programme of CAZRI", Jodhpur organized by ICAR-CAZRI, Jodhpur on 30 September, 2021
- "*58th Foundation Day*" Celebration of JNKVV, Jabalpur organized by JNKVV, Jabalpur on 1 October, 2021
- "*SFC Meeting*" organized by IIFSR, Modipuram on 5 October, 2021
- Lecture on "*Science, Technology and Innovation for Transforming Agriculture in India*" delivered by Prof. R B Singh, Former Chancellor, CAU & Past President, NAAS organized by ICAR, New Delhi on 12 October, 2021
- "*World Food Laureates - Discussion on Global Food and Nutrition Security to meet the SDGs during and after Covid 19 Pandemic*" on the occasion of "World Food Day" organized by ICAR, New Delhi on 16 October, 2021
- Lecture "*Issues on Land Degradation in North East India*" delivered by Dr. Rajkumar Ranjan Singh, Hon'ble Minister of State for Education and External Affairs organized by ICAR, New Delhi on 22 October, 2021
- National Consultation on "*Plant-based Local Food Systems for Health and Nutrition to Identify Options and Prepare Action Plan for Achieving, Through Plant-based local food systems, Nutrition and Health for all by 2030*" organized by Alliance of Biodiversity International and CIAT, New Delhi, in collaboration with ICRISAT & TAAS on 22 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM, SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- National Webinar on "*Important Animal Diseases and their Control Program in India*" organized by ICAR-RCER, Patna on 23 October, 2021
- Lecture on "*CGIAR's Engagement in the post-UN Food Systems Summit*" by Dr. Juan Lucas Restrepo, Director General, Alliance of Bioversity International and CIAT Global Director of Partnerships and Advocacy, CGIAR organized by ICAR, New Delhi on 25 October, 2021
- National Webinar on "*Crop Diversification: A way towards Nutritional Security*" organized by ICAR-RCER, Patna on 26 October, 2021
- "*Review meeting on Special Campaign" on Swachhta and Pending Matters*" chaired by Hon'ble Minister (A&FW) organized by ICAR, New Delhi on 27 October, 2021
- Interaction Meeting on *"Our Achievements: A Glimpse"* by Dr. T. Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- *"Post SOC Meeting"* by DDG (NRM) organized by ICAR, New Delhi on 2 November, 2021
- "*Stakeholders dialogue on Restriction in use of Glyphosate*" organized by ICAR, New Delhi on 9 November, 2021
- Assessment Committee meeting as an expert member nominated by Chairman, ASRB organized by ICAR-IISR, Lucknow on 10 November, 2021
- Programme on "*Nutri-Smart Village: An innovative Mode for Strengthening Poshan Abhiyan*" launched by Union Cabinet Minister of Agriculture and Farmer's Welfare, GOI organized by ICAR, New Delhi on 10 November, 2021
- Lecture on "*Talent Search for Manning Agriculture*" by Dr. C.D. Mayee, Former Chairman ASRB organized by ICAR, New Delhi on 11 November, 2021
- 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- "*Executive Committee*" meeting of ISWS at PJTSAU, Hyderabad on 24 November, 2021
- Meeting with Mr. Laxmi Narayan & Dr. Ajay Kumar Singh of A.G. Bio Systems Pvt. Ltd. Hyderabad on 25 November, 2021
- Lecture delivered by Dr. K.V. Prabhu, Chairperson, Protection of Plant Varieties and Farmers' Rights Authority, Govt. of India organized by ICAR, New Delhi on 01 December, 2021
- "*Foundation Day*" programme of ICAR-IISR on 9 December, 2021
- Meeting of "*XXV Regional Committee No. III*" organized by ICAR-Research Complex NEH, Umiam on 11 December, 2021
- Meeting of "*Assessment Committee*" for promotion of scientific staff in discipline of "Agronomy" as Member nominated by DG, ICAR organized by ICAR NEH, Umiam on 13 December, 2021
- Meeting chaired by DG, ICAR on the ICAR Participation in the "*Valedictory Function of Vibrant Gujarat Summit*" organized by ICAR, New Delhi on 13 December, 2021
- Valedictory Function of "*Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- *"Plenary Lecture"* by Dr. T. Mohapatra, Secretary, DARE & Director General organized by ICAR, New Delhi on 17 December, 2021
- "*AICRP-IFS Meeting*" organized by ICAR-IIFSR, Modipuram on 18 December, 2021
- "*Quarterly Review Meeting*" of AICRP-WM centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021.
- Lecture "*Gender and Nutri-sensitive Agriculture*" by Dr. A.K. Singh, DDG Extn. organized by ICAR, New Delhi on 23 December, 2021

Dr. P.K. Singh

- "*Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Institutional Technical Committee Meeting of ICMR at ICMR-National Institute of Research in Tribal Health, Jabalpur on 8 February, 2021
- Webinar on "*Principles of Good Laboratory Practices*" organized by CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur under AICRP-WM & CAAST on Protected Agriculture and Natural Farming on 10 February, 2021
- Webinar on "*Structural Changes Required for Innovative Agriculture Value Chain: Opportunities Ahead for Collectives organized by VAMNICOM*" (A Grant-in-aid Institution under Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India) in collaboration with CNRI at 13 February, 2021
- National Webinar on "*Weed Science*" organized by AICRP-WM, KAU, Thrissur on 16 February, 2021
- Webinar on "*Remote Sensing and Drones Application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25th February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 Mar, 2021
- International Webinar on "*Recent Advances in Weed Science Research*" organized by PAJANCOA&RI, Karaikal, Puducherry in collaboration with ICAR-DWR, Jabalpur on 12 March, 2021
- Research-Entrepreneurs/Start-up-Industry Interface Meet organized by ICAR-IISR, Indore on 13 March, 2021
- Webinar on "*Weed Science Research in India way forward and scope for entrepreneurship opportunity*" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- Mid-term Review Meeting of Regional Committee Zone VII held at NBSS&LUP, Nagpur on 25 March, 2021
- "*Stakeholder Consultation Meeting on Impacts and Management of Invasive Alien Species (IAS) in Agro ecosystems*" of India organized by Biodiversity Authority of India on 27 April, 2021
- 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- Review Meeting of DBT sponsored Biotech Kishan Hub project organized by Manthan, Bhopal, Madhya Pradesh on 14, May, 2021
- "*International Biological Diversity Day*" organized by ICAR-NBPGR, New Delhi on 22 May, 2021
- 29 IMC meeting held at ICAR-DWR, Jabalpur on 25 May, 2021
- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May 2021
- 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- "*IRC Meeting*" held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- Brain Storming Session on "*Safe Use of Chemical Fertilizers and other Agro-Chemicals*" organized by ICAR, New Delhi on 19 July, 2021
- 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20th July, 2021
- MS Swaminathan Research Foundation annual conference on "*Ensuring Food and Nutrition Security in the context of Climate Change and Corona Pandemic*" organized by MSSRF, Chennai on 6-8 August, 2021
- Fifth meeting of Reconstituted PSMC on Biotech-KISAN Hub Project organized by Department of Biotechnology, Ministry of Science & Technology, Govt. of India on 11 August, 2021
- Press Conference for 16th *Parthenium* Awareness Week on 12 August, 2021
- 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- "*Quarterly AICRP-WM Review Meeting*" held at ICAR-DWR, Jabalpur on 24 & 26-28 August, 2021
- National seminar on "*Rice-fallow Management in Eastern India*" organized by ICAR-RCER, Patna on 26 August, 2021
- Webinar on Farmers - Scientist Connect Meet organized by DBT Biotech - KISAN Hub, MP on 1 September, 2021
- National Webinar on "*Nutritional Security in India: Issues and Way Forward*" organized by ICAR-RCER, Patna on 4 September, 2021
- "*Curtain Raiser of International Year of Millets*" 2023 by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- International Conference on "*Reorientation in Agronomic Research and Education to Combat Current and Future Challenges in Agriculture*" organized by RAU, Pusa on 21-23 September, 2021
- Lecture on "*Agriculture in post-independent India: Looking back and Looking Ahead*" by Prof. Ramesh Chand, Member, NITI Aayog organized by ICAR, New Delhi on 24 September, 2021
- "*Lecture: Talent Search for Manning Agriculture*" TREE (Teaching, Research and Extension Education) by Dr. C.D. Mayee Ex- Chairman, ASRB & Agri. Commissioner, Min of

Agriculture, organized by ICAR, New Delhi on 27 September, 2021

- Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" at ICAR-DWR,on 28 September, 2021
- 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Lecture on "*Science, Technology and Innovation for Transforming Agriculture in India*" delivered by Prof. R B Singh, Former Chancellor, CAU & Past President, NAAS organized by ICAR, New Delhi on 12 October, 2021
- "*World Food Laureates - Discussion on Global Food and Nutrition Security to meet the SDGs during and after Covid 19 Pandemic*" on the occasion of "World Food Day" organized by ICAR, New Delhi on 16 October, 2021
- Meeting on *"Implementation and Use of Agricultural Research Management System (ARMS)"* organized by ADG, ICT, ICAR, New Delhi on 22 October, 2021
- *"Interaction Meeting on Our Achievements: A Glimpse"* by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- Farmers-Scientists Connect Meet under "*Azadi ka Amrit Mahotsav*" organized by DBT BioTech - KISAN Hub, MP on 28 October, 2021
- 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th October, 2021
- "*Stakeholder's Dialogue on Restriction in use of Glyphosate*" organized by ICAR, New Delhi on 9 November, 2021
- "*Nutri-Smart Village: An Innovative Mode for Strengthening Poshan Abhiyan*" launched by Union Cabinet Minister of Agriculture and Farmer's Welfare, GOI organized by ICAR, New Delhi on 10 November, 2021
- "XV Agricultural Science Congress & ASC Expo" organized by National Academy of Agricultural Sciences and BHU, Varanasi on 13-16 November, 2021
- Hindi Workshop *"Jaivik Krishi Ka Itihas Evam Vartman Paristithi"* organized by ICAR-DWR, Jabalpur on 19 November, 2021
- 5th International Agronomy Congress on *"Agri Innovations to Combat Food and Nutrition Challenges"* organized by PJTSAU, Hyderabad during 23-27 November, 2021
- Lecture by Dr. K.V. Prabhu, Chairperson, *"Protection of Plant Varieties and Farmers' Rights Authority"*, Govt. of India organized by ICAR, New Delhi on 01 December, 2021
- Webinar on "*Quarantine Weeds*" organized by AICRP-WM centre KAU, Thrissur on 07 December, 2021
- IPCON conference theme "*Building Strong IP Ecosystem for ease of Doing Business*" organized by Confederation of Indian Industry on 10 December, 2021.
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- Plenary Lecture by Dr. T. Mohapatra, Secretary, DARE & Director General organized by ICAR, New Delhi on 17 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021
- Lecture "*Gender and Nutri-sensitive Agriculture*" by Dr. A.K. Singh, DDG Extn. organized by ICAR, New Delhi on 23 December, 2021

Dr. Sushil Kumar

- Online "*ISWS Executive Committee*" meeting organized by ISWS on 2 January, 2021
- Online "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- National Webinar on "*Weed Science*" organized by AICRP-WM, KAU, Thrissur on 16 February, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Webinar on "Weed Science Research in India : Way Forward and Scope for Entrepreneurship opportunity" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- Stakeholder Consultation Meeting on "*Impacts and Management of Invasive Alien Plant Species (IAPS) in Terrestrial Ecosystem*" organized by National Biodiversity Authority, Govt. of India, Chennai on 30 March, 2021
- Webinar on "*Biocontrol of Parthenium*" organized by Feed the Future Innovation Lab for Integrated Pest Management; US Government's Global Hunger & Food Security Initiative on 30 March, 2021
- International Webinar on "*Genetics, Genomics and Breeding of Herbicide-Tolerant Grain Sorghum to Address Weed Control Challenges*" organized by PJTSAU, Hyderabad on 19 April, 2021
- Stakeholder Consultation Meeting on "*Impacts and Management of Invasive Alien Species (IAS) in Agro ecosystems of India*" organized by Biodiversity Authority of India on 27 April, 2021
- "*Executive Committee Meeting" of ISWS*" on 27 April, 2021
- 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30th April, 2021
- "*29th IMC Meeting*" held at ICAR-DWR, Jabalpur on 25 May, 2021
- 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker:

Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021

- Workshop on *"EFC Preparation and Presentation"* organized by ICAR New Delhi on 4 June 2021
- "*SFC Meeting*" organized by ICAR-IIFSR, Modipuram on 11 June, 2021
- "*22nd RAC Meeting*" held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22nd June, 2021
- "*IRC Meeting*" held at ICAR-DWR, Jabalpur on 28-29 June 2021
- Workshop on "*The Management of Aquatic Weeds to Save Lakes in Mahoba District of Uttar Pradesh*" on 3 July, 2021
- Webinar on "*Pesticides Management Bill 2020: Industry Concerns and Issues*" organized by PMFAI & Krishak Jagat, Bhopal on 21 July, 2021
- NIPHM-Biannual subcommittee meeting of National Network of Plant Health Experts organized by NIPHM, Hyderabad on 22 July, 2021
- Meeting on "*CAMPA Chhattisgarh project meeting on Lantana"* organized by Tropical Forest Research Institute, Jabalpur on 27 July, 2021
- Project meeting organized by ICFRE on 29 July, 2021
- 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20th July, 2021
- Press Conference for "*16th Parthenium Awareness Week*" on 12 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium"* organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- Quarterly AICRP-WM Review Meeting held at ICAR-DWR, Jabalpur on 26-28 August, 2021
- National Stakeholders Consultation workshop on "*Development of Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India*" organized by Green India Mission Directorate, Ministry of Environment, Forest & Climate Change, New Delhi on 27 August, 2021
- *"Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR on 28 September, 2021
- 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Meeting organized by ICAR-IIFSR, Modipuram on 5 October, 2021
- "*World Food Laureates - Discussion on Global Food and Nutrition Security to meet the SDGs during and after Covid 19 Pandemic*" on the occasion of "World Food Day" organized by ICAR, New Delhi on 16 October, 2021
- Lecture "*Issues on Land Degradation in North East India*" delivered by Dr. Rajkumar Ranjan Singh, Hon'ble Minister of State for Education and External Affairs organized by ICAR, New Delhi on 22 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- "*Executive Committee*" meeting of ISWS at PJTSAU, Hyderabad on 24 November, 2021
- Monitoring of AICRP-WM Centre at PJTSAU, Hyderabad on 25 November, 2021
- Meeting with Mr. Laxmi Narayan & Dr. Ajay Kumar Singh of A.G. Bio Systems Pvt. Ltd. Hyderabad on 25 November, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. R.P. Dubey

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*World Pulse Day Celebration*" organized by ICAR, New Delhi on 10 February, 2021
- Webinar on "*Remote Sensing and Drones Application in Agriculture*" organized by AICRP on Weed Management, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment"* organized by ICAR, New Delhi on 8 March, 2021
- AKAM lecture by Dr. S.K. Chaudhari, DDG (NRM) on the topic "*Valuing Water for Agriculture*" organized by ICAR on 17 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30th April, 2021
- 29 IMC meeting held at ICAR-DWR, Jabalpur on 25 May, 2021

- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021
- National Seminar on "*Promotion of Direct Seeded Rice (DSR): Prospect and Challenges amid COVID-19*" organized by DDG (NRM, DDG (Ext), ICAR New Delhi on 12-13 June, 2021
- *22nd RAC Meeting*" held at ICAR-DWR Jabalpur on 14-15 June, 2021
- *"XXVIII Annual Review Meeting of AICRP-WM*" organized by PC Unit, ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- Lecture on "*Publication in International Journals*" organized by CCSHAU, Hisar on 23 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- AKAM lecture on *"Genomics and Breeding Innovations in Agriculture"* by Dr. R.K. Varshney, Research Program Director, ICRISAT & Adjunct Professor, Murdoch University, Murdoch, Australia organized by ICAR, New Delhi on 6 July, 2021
- Lecture on "*Corona Viruses: Burgeoning and Enduring Threats*" Speaker: Dr B.N. Tripathi, Deputy Director General (Animal Sciences), ICAR organized by ICAR, New Delhi on 14 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20th July, 2021
- ICAR Lecture Series: *Azadi Ka Amrut Mahotsav* on "*COVID-19 Pandemic: What lies Ahead*", Lecture delivered by Dr Jagdish Chander Suri organized by ICAR, New Delhi on 03 August, 2021
- Webinar on *"Organic Farming*" organized by AICRP-WM", KAU, Thrissur on 07 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- 45th Foundation Day Lecture on "*Soil survey and Land Use Planning for Realizing the Sustainable Development Goals of United Nations*" delivered by Prof. Rattan Lal, The Ohio State University, Columbus, USA organized by ICAR-NBSS & LUP, Nagpur on 23 August, 2021
- "*Quarterly AICRP-WM Review Meeting"* held at ICAR-DWR, Jabalpur on 24 & 26-28 August, 2021
- National seminar on "*Rice-Fallow Management in Eastern India*" organized by ICAR-RCER, Patna on 26 August, 2021
- Webinar on "*Organic Farming in Maharashtra- Challenges and Opportunities*" organized by ICAR-NRCG, Pune on 8 September, 2021
- AKAM Lecture on "*Innovations for Transformation*" by Dr. Krishna Ella, Founder Chairman and Managing Director of Bharat Biotech organized by ICAR, New Delhi on 1 September, 2021
- *"Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- AKAM Lecture on "*Agriculture in Post-independent India: Looking Back and Looking Ahead*" by Prof. Ramesh Chand, Member, NITI Aayog organized by ICAR, New Delhi on 24 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28th September 2021
- "*Scope of Bio-pesticides in Indian Perspective*" organized by ICAR-NIBSM, Raipur on 4-8 October, 2021
- Interaction Meeting on "*Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th October, 2021
- Webinar "*Transforming to Organic Agriculture System: Production, Certification and Trade*" organized by ICAR-CPCRI on 03 November, 2021
- Stakeholders dialogue on "*Restriction in use of Glyphosate*" organized by ICAR, New Delhi on 9 November, 2021
- Programme on "*Nutri-Smart Village: An innovative Mode for Strengthening Poshan Abhiyan*" launched by Union Cabinet Minister of Agriculture and Farmer's Welfare, GOI organized by ICAR, New Delhi on 10 November, 2021
- Webinar- "*Strengthening of Emotional & Mental Wellness*" organized by on ICAR-NIHSAD, Bhopal on 10 November, 2021
- Webinar on "*A Critical Look at Global Hunger Index*" organized by ICAR-IASRI, New Delhi on 11 November, 2021
- 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" Organized by PJTSAU, Hyderabad during 23-27 November, 2021
- Webinar on "*Quarantine Weeds*" organized by AICRP-WM Centre KAU, Thrissur on 07 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- *"Quarterly Review Meeting of AICRP-WM centres*" organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. K.K. Barman

- "*Review Meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29th January, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25th February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23rd March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30th April, 2021
- "29th IMC Meeting" held at ICAR-DWR, Jabalpur on 25 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021
- 22nd RAC meeting held at ICAR-DWR Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22nd June, 2021
- IRC Meeting held at ICAR-DWR, Jabalpur on 28-29 June 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20th July, 2021
- 5th meeting of Reconstituted PSMC on "*Biotech-KISAN Hub Project*" organized by Department of Biotechnology Ministry of Science & Technology, Govt. of India on 11 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- 45th Foundation Day Lecture on Soil survey and Land use Planning for Realizing the Sustainable Development Goals of United Nations delivered by Prof. Rattan Lal, The Ohio State University, Columbus, USA organized by ICAR-NBSS & LUP, Nagpur on 23 August, 2021
- Webinar on "*Farmers - Scientist Connect Meet organized by DBT BioTech - KISAN Hub*", MP on 1 September, 2021
- *"Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India andICAR-New Delhi on 17 September, 2021
- Honorable Prime minister's Virtual address to the farmers and scientists launching the *"Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28th September 2021
- Chaired the technical session: Soil Health Management in Rice Fallow organized by ICAR-NEH, Nagaland Centre on 6 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- *"Interaction Meeting on Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th October, 2021
- Webinar on "*Nutrient Management in Dominant Cropping Systems Under Different Agro-Climatic Zones of India*" organized by ICAR-IISS, Bhopal on 11 November, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. Shobha Sondhia

- "*ISWS Executive Online Meeting*" organized by ISWS on 2 January, 2021
- *"Review Meeting of AICRP-Weed Management"* organized by ICAR-DWR, Jabalpur on 7 January, 2021
- "*Third Party Review Meeting*" organized by ASCI, Hyderabad and NRM Division, New Delhi on 7 January, 2021
- *"Competitive Grant*" under NICRA Project organized by NICRA, ICAR-CRIDA, Hyderabad on 16 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- *"Budget Review Meeting*" of NRM Division organized by NRM Division, ICAR, New Delhi on 2 February, 2021
- Webinar on "*Principles of Good Laboratory Practices*" organized by CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur under AICRP on Weed Management & CAAST on Protected Agriculture and Natural Farming on 10 February, 2021
- National Webinar on "*Weed Science*" organized by AICRP-WM, KAU, Thrissur on 16 February, 2021

- 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Delivered keynote address in National Webinar on "*Parasitic Weed Management: Challenges and Options*" organized by AICRP on Weed Management, UAS, Bangalore in collaboration with ICAR-DWR, Jabalpur on 10 March, 2021
- Presidential Keynote in International Webinar on "*Recent advances in Weed Science Research*" organized by PAJNACOA&RI, Karaikal, Puducherry & ICAR-DWR, Jabalpur on 12 March, 2021
- Lecture on "*Valuing Water for Agriculture*" in Bharat ka Amrut Mahotsav organized by DDG(Education), ICAR, New Delhi on 17 March, 2021
- Webinar on "*Weed Science Research in India Way Forward and Scope for Entrepreneurship Opportunity*" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- Stakeholder Consultation Meeting on "*Impacts and Management of Invasive Alien Plant Species (IAPS)"* in Terrestrial Ecosystem organized by National Biodiversity Authority, Govt. of India, Chennai on 30 March, 2021
- Executive Committee Meeting of ISWS on 27 April, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- '*29 IMC Meeting*' held at ICAR-DWR, Jabalpur on 25 May, 2021
- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- "*22nd RAC Meeting*" held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- '*IRC Meeting*' held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- ICAR Lecture Series-Azadi Ka Amrut Mahotsav on "*Sustainable Agricultural Intensification for Improving Food Security and Climate Resilience*" delivered by P.V. Vara Prasad organized by ICAR, New Delhi on 13 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- '*Quarterly AICRP-WM Review Meeting*' held at ICAR-DWR, Jabalpur on 24 August, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Webinar on "*Krishi me Nanotechnology ka Upyog: Nano-Fertilizer*" by Dr. Ramesh Raliya, General Manager & Head of Research & Development, IFFCO Nano Biotechnology Research Centre, India organized by ICAR-RCER, Patna on 23 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the *"Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods"* organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR-RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- *Interaction Meeting on Our Achievements: A Glimpse* by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- "*XV Agricultural Science Congress & ASC Expo*" organized by National Academy of Agricultural Sciences and BHU, Varanasi on 13-16 November, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- Webinar on "*Gender Sensitization*" organized by ICAR, New Delhi on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. Pijush Kanti Mukherjee

- "*Review Meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021

- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Lecture on "*Application of Remote S `ensing in Agriculture and Water Resources*" delivered by Dr Sat Kumar Tomer CEO, Satyukt Analytics Bangalore organized by Division of Agricultural Physics, ICAR-IARI, New Delhi on 17 March, 2021
- Lecture on "*Best Practices in Radar Remote Sensing for Geo and Biophysical Parameter Retrieval Over Cropland*" delivered by Dr. Dipankar Mandal, Researcher, IIT, Mumbai organized by Division of Agricultural Physics, ICAR-IARI, New Delhi on 20 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- Lecture entitled "*Bharat ka Amrut Mahotsav*" delivered by Dr Anil Prakash Joshi organized by ICAR, New Delhi on 25 May, 2021
- "*29th IMC Meeting*" held at ICAR-DWR, Jabalpur on 25 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021
- Lecture on "*Food and Dietary Concepts of Ayurveda Indian Traditional Wisdom of food for better Nutrition and Health*" organized by ICAR, New Delhi on 01 June, 2021
- Lecture on "*Economy or Environment*" organized by ICAR-NIASM, Baramati on 05 June, 2021
- "*22nd RAC Meeting*" held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting*" of AICRP-WM organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- AKAM lecture on "*Genomics and breeding innovations in agriculture*" by Dr. R.K. Varshney, Research Program Director, ICRISAT & Adjunct Professor, Murdoch University, Murdoch, Australia organized by ICAR, New Delhi on 6 July, 2021
- Lecture on "*Corona Viruses: Burgeoning and Enduring Threats*" Speaker: Dr B.N. Tripathi, Deputy Director General (Animal Sciences), ICAR organized by ICAR, New Delhi on 14 July, 2021
- Lecture on "*Building Resilience against Climate Change: Role of Technologies, Policies and Institutions*" by Dr P K Joshi, Secretary, NAAS, President of Agricultural Economics Research Association and Hon. Director Agro-Economic Research Centre organized by ICAR, New Delhi on 20 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- Webinar on "*Artificial Intelligence for Smart Agriculture*" organized by ICAR-Research Complex for Eastern Region, Patna, Bihar on 22 July, 2021
- Lecture on "*How to Make Effective Communication*" by Dr. Himanshu Pathak, Director, ICAR-NIASM organized by ICAR-NIASM, Baramati on 23 July, 2021
- ICAR-IRRI Brainstorming Session on "Climate Smart Management in rice-based Systems of India: Key Learning, Research Gaps, and Way Forward for Collaborative Research" organized by IRRI, India Office on 27 July, 2021
- ICAR Lecture Series: AKAM on "*COVID-19 Pandemic: What lies Ahead*", Lecture delivered by Dr. Jagdish Chander Suri organized by ICAR, New Delhi on 3 August, 2021
- Talk on "*Agricultural Transformation for Nutritional Security*" by Padma Bhushan Dr. R.B. Singh organized by ICAR-DCFR, Bhimtal, Nainital, Uttarakhand on 7 August, 2021
- Talk on "*Climate Change and Agriculture*" by Dr. Himanshu Pathak organized by ICAR-NIASM, Baramati on 13 August, 2021
- ICAR Lecture Series-AKAM on "*Sustainable Agricultural Intensification for Improving Food Security and Climate Resilience*" delivered by P.V. Vara Prasad organized by ICAR, New Delhi on 13 August, 2021
- Online ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- Online "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- 45th Foundation Day Lecture on "*Soil survey and Land Use Planning for Realizing the Sustainable Development Goals of United Nations*" delivered by Prof. Rattan Lal, The Ohio State University, Columbus, USA organized by ICAR-NBSS & LUP, Nagpur on 23 August, 2021
- AKAM Lecture on "*Innovations for Transformation*" by Dr. Krishna Ella, Founder Chairman and Managing Director of Bharat Biotech organized by ICAR, New Delhi on 1 September, 2021
- Lecture on *Cocoponics: A New Method of Growing Vegetables in Soilless Culture. by Dr. D. Kalaivanan, Scientist* (Soil Science) organized by ICAR-IIHR, Bengaluru on 9 September, 2021
- "*Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021

- International Conference on *"Reorientation in Agronomic Research and Education to Combat Current and Future Challenges in Agriculture"* organized by RAU, Pusa on 21-23 September, 2021
- AKAM Lecture on "*Agriculture in Post-Independent India: Looking Back and Looking Ahead*" by Prof. Ramesh Chand, Member, NITI Aayog organized by ICAR, New Delhi on 24 September, 2021
- National Webinar on "*Emerging Challenges and Opportunities in Arid Agriculture*" organized by ICAR-CAZRI, Jodhpur on 27 September, 2021
- Honorable Prime minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28th September 2021
- ICAR Lecture Series: *AKAM on Future Proofing the Dry Land*". Lectured delivered by Dr. Jacqueline d'Arros Hughes, DG, ICRISAT organized by ICAR, New Delhi on 05 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR-RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- *"Interaction Meeting on Our Achievements: A Glimpse"* by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- Attended "*Nutri-Smart Village: An innovative Mode for Strengthening Poshan Abhiyan*" launched by Union Cabinet Minister of Agriculture and Farmer's Welfare, GOI organized by ICAR, New Delhi on 10 November, 2021
- National Webinar on "*Nutrient Management in Dominant Cropping Systems under Different Agro-climatic Zones of India*" organized by ICAR-IISS, Bhopal on 11 November, 2021
- '*AKAM*' lecture on '*Talent Search for Manning Agriculture*' by Dr. C.D. Mayee, Former Chairman ASRB organized by ICAR, New Delhi on 11 November, 2021
- 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- National Level Campaign on "*Agriculture and Environment: The Citizen Face*" organized by ICAR-DWR, Jabalpur on 26 November, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. V.K. Choudhary

- "*ISWS Executive Meeting*" organized by ISWS on 2 January, 2021
- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- "*Review Meeting of ITMU under NRM SMD*" organized by ZTMC, ICAR, RC for NEH Region, Umiam, Meghalaya on 3 February, 2021
- Webinar on "*Remote Sensing and Drones Application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- International Webinar on "*Recent advances in Weed Science Research*" organized by PAJNACOA & RI, Karaikal, Puducherry & ICAR-DWR, Jabalpur on 12 March, 2021
- "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- National Webinar on "*Weed Management in Rice-Fallows*" organized by PJTSAU, Hyderabad on 3 April, 2021
- International Webinar on "*Genetics, Genomics and Breeding of Herbicide-Tolerant Grain Sorghum to Address Weed Control Challenges*" organized by PJTSAU, Hyderabad on 19 April, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- "*Review Meeting of DBT sponsored Biotech Kisan Hub Project*" organized by Manthan, Bhopal, Madhya Pradesh on 14, May, 2021
- *"29 IMC Meeting"* held at ICAR-DWR, Jabalpur on 25 May, 2021
- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- 22 RAC meeting held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June, 2021

- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- ICAR-IRRI Brainstorming Session on *"Climate Smart Management in Rice-based Systems of India: Key Learning, Research Gaps, and Way Forward for Collaborative Research"* organized by IRRI India Office on 27 July, 2021
- "*5th meeting of Reconstituted PSMC on Biotech-KISAN Hub Project*" organized by Department of Biotechnology Ministry of Science & Technology, Govt. of India on 11 August, 2021
- ICAR Lecture Series-Azadi Ka Amrut Mahotsav on "*Sustainable Agricultural Intensification for Improving Food Security and Climate Resilience*" delivered by Dr. P.V. Vara Prasad organized by ICAR, New Delhi on 13 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- 45th Foundation Day Lecture on *"Soil Survey and Land use Planning for Realizing the Sustainable Development Goals of United Nations"* delivered by Prof. Rattan Lal, The Ohio State University, Columbus, USA organized by ICAR-NBSS & LUP, Nagpur on 23 August, 2021
- "*Quarterly AICRP-WM Review Meeting*" held at ICAR-DWR, Jabalpur on 24 August, 2021
- AKAM Lecture on *"Innovations for Transformation"* by Dr. Krishna Ella, Founder Chairman and Managing Director of Bharat Biotech organized by ICAR, New Delhi on 1 September, 2021
- Webinar on "*Farmers - Scientist Connect Meet organized by DBT Biotech - KISAN Hub*", MP on 1 September, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on **"***Our Achievements: A Glimpse*" by Dr. T. Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- Executive meeting of ISWS at PJTSAU, Hyderabad on 24 November, 2021
- *"Monitoring of AICRP-WM Centre"* at PJTSAU, Hyderabad on 24 and 25 November, 2021
- Meeting with Mr. Laxmi Narayan & Dr. Ajay Kumar Singh of A.G. Bio Systems Pvt. Ltd. Hyderabad on 25 November, 2021
- *"Project Review Meeting"* organized by MP State Biodiversity Board" Bhopal, 2 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. Yogita Gharde

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- *"Meeting of Nodal Officers"* to discuss the issues during implementation and new facilities under KRISHI organized by ICAR-IASRI, New Delhi on 25 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on "*Women Leadership in Agriculture Entrepreneurship, Equity and Empowerment*" on International Woman's Day organized by ICAR, New Delhi on 08 March, 2021
- Webinar/lecture on "*Valuing Water*" on the occasion of "World Water Day" organized by Indian Council of Agricultural Research, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- *"22nd RAC Meeting"* held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- Attended *"IRC Meeting"* held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*",

organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021

- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on **"***Our Achievements: A Glimpse*" by Dr. T. Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR, New Delhi on 28 October, 2021
- Participated in 5th International Agronomy Congress on "*Agri Innovations to Combat Food and Nutrition Challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- *"All ICAR Young Scientist Interaction Meet"* with DG, ICAR organized by Indian Council of Agricultural Research, New Delhi on 8 December, 2021
- Participated in International Conference on "*Recent Application of Statistical Techniques and Analysis (RASTA-2021)*" during 15-17 December, 2021 organized by Department of Statistics, Institute of Science, Banaras Hindu University, Varanasi, India.
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- Webinar on "*Gender Sensitization* "organized by Indian Council of Agricultural Research, New Delhi on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Er. Chethan C.R.

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- Brain Storming Session on "*Automation in Agricultural Engineering*" organized by ICAR-CIAE, Bhopal on 19 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- Lecture on "*Agricultural Mechanization for India in the 21st Century*" organized by ICAR, New Delhi on 31 March, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- Review meeting of "*DBT sponsored Biotech Kishan Hub Project*" organized by Manthan, Bhopal, Madhya Pradesh on 14 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- *"22nd RAC Meeting"* held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- *"IRC Meeting"* held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- 5th meeting of *"Reconstituted PSMC on Biotech-KISAN Hub Project"* organized by Department of Biotechnology Ministry of Science & Technology, Govt. of India on 11 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- Webinar on "*Farmers - Scientist Connect Meet organized by DBT Biotech - KISAN Hub*", MP on 1 September, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Webinar on "*Krishi me Nanotechnology ka Upyog: Nano-Fertilizer*" by Dr. Ramesh Raliya, General Manager & Head of Research & Development, IFFCO Nano Biotechnology Research Centre, India organized by ICAR-RCER, Patna on 23 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- International Webinar Conference on "*Alternate Cropping Systems for Climate Change & Resource Conservation*" organized by ICAR-Indian Institute of Farming Systems

Research, Modipuram from 29th September, 1 October, 2021

- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on "*Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th October, 2021
- *"36th Indian Engineers Congress"*, held at Vigyan bhawan, New Delhi organized by Institute of Engineers India during 26-28, December, 2021

Dr. Deepak Pawar

- "*Review Meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Gene Editing Research in Agriculture: Key Initiatives in India*" organized by Tata Institute for Genetics and Society (TIGS) and Biotech Consortium India Limited (BCIL) on 17 February, 2021
- Webinar on "*Remote Sensing and Drones Application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- International Plant Physiology Virtual Symposium 2021 entitled "*Physiological Interventions for Climate Smart Agriculture*" organized by ICAR-SBI, Coimbatore, ISPP, New Delhi, NAAS-Coimbatore Chapter and SSRD and SAUs South Zone on 11-12 March, 2021
- International Webinar on "*Recent Advances in Weed Science Research*" organized by PAJNACOA&RI, Karaikal, Puducherry & ICAR-DWR, Jabalpur on 12 March, 2021
- Webinar on "*Weed Science Research in India Way Forward and Scope for Entrepreneurship Opportunity*" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- International Webinar on "*Genetics, Genomics and Breeding of Herbicide-Tolerant Grain Sorghum to Address Weed Control Challenges*" organized by PJTSAU, Hyderabad on 19 April, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- Webinar on "*Translating Genomics for Next Generation Crop Improvement*" organized by Tata Institute for Genetics and Society (TIGS) in partnership with BCIL on 10 June, 2021
- *"22nd RAC Meeting"* held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- *"IRC Meeting"* held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- Webinar on "*Agro-biodiversity for Food Security*" organized by ICAR-CTCRI, Bhubaneswar on 16 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- Webinar on "*Genome Editing Tools and its Applications for Targeted Plant Breeding*" organized by APAARI, BCIL, Korea Biosafety Clearing House, APCoAB on 21 July, 2021
- Webinar on "*Artificial Intelligence for Smart Agriculture*" organized by ICAR-Research Complex for Eastern Region, Patna, Bihar on 22 July, 2021
- Kosambi International Webinar Series on "*Plant Genomics*" organized by Sabitribai Phule Pune University during 31 July-01 August, 2021
- Webinar on "*Advancing Genome Edited Plants from Lab to Land*" organized by APAARI in association with KBCH and BCIL on 4 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- Webinar "*Enabling Policies for Genome Editing in Agriculture*" organized by APAARI in association with KBCH and BCIL on 18 August, 2021
- National seminar on "*Rice-Fallow Management in Eastern India*" organized by ICAR-RCER, Patna on 26 August, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Honorable Prime minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021

- International Webinar Conference on "*Alternate Cropping Systems for Climate Change & Resource Conservation*" organized by ICAR Indian Institute of Farming Systems Research, Modipuram from 29 September– 1 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- International Webinar on "*Fighting the Hunger Using smart Technology*" organized by ICAR- IIOPR, Pedavegi, AP on 26 October, 2021
- Interaction Meeting on **"***Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- 2nd International Web-Conference of ANRCM on "*Smart Agriculture for Resource Conservation and Ecological Stability*" organized by Academy of Natural Resource Conservation and Management, India from 29-30 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th October, 2021
- Webinar on "*Planning and Decision Making for Efficient Water Management*" organized by ICAR-RCER, Patna, Bihar on 1 November, 2021
- Webinar on "*Implementation and Use of Agricultural Research Management System (ARMS)*" organized by ICAR-IASRI, New Delhi on 25 November, 2021
- Webinar on "*Quarantine Weeds organized by AICRP-WM*" centre KAU, Thrissur on 07 December, 2021
- *"All ICAR Young Scientist Interaction Meet"* with DG, ICAR organized by Indian Council of Agricultural Research, New Delhi on 8 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Mr. Dibakar Roy

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Principles of Good Laboratory Practices*" organized by CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur under AICRP on Weed Management & CAAST on Protected Agriculture and Natural Farming on 10 February, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP on Weed Management, TNAU, Coimbatore on 18 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- *"International Biological Diversity Day"* organized by Central University of Odisha, Koraput & ICAR-IISWC, Dehradun on 22 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- *"22nd RAC Meeting"* held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- *"IRC Meeting"* held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- *"YouTube Live Phone in Programme on Parthenium"* organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- 45th Foundation Day Lecture on "*Soil Survey and Land use Planning for Realizing the Sustainable Development Goals of United Nations*" delivered by Prof. Rattan Lal, The Ohio State University, Columbus, USA organized by ICAR-NBSS & LUP, Nagpur on 23 August, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- International Webinar Conference on "*Alternate Cropping Systems for Climate change & resource conservation*" organized by ICAR-Indian Institute of Farming Systems Research, Modipuram on 30 September, 2021
- Webinar on *"Agricultural Research Management System*

(ARMS)" for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021

- Interaction Meeting on "*Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- 85th *"Annual Convention on Soil Science"* organized by Indian Society of Soil Science and Palli Siksha Bhavana, Institute of Agriculture, Viswa-Bharati, Santiniketan, West Bengal from 16-19 November, 2021
- 5th International Agronomy Congress on "*Agri Innovations to combat food and nutrition challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- *"All ICAR Young Scientist Interaction Meet"* with DG, ICAR organized by Indian Council of Agricultural Research, New Delhi on 8 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Er. Vaibhav Chaudhary

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- "*Dedication of Technologies to the Farmers & Kritagya Hackathon*" Award Ceremony organized by Ministry of Agriculture & Farmers Welfare, Government of India on 31 May, 2021
- *"22nd RAC Meeting"* held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- Lecture on "*Publication in International Journals*" organized by CCSHAU, Hisar on 23 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16th August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- *"Curtain Raiser of International Year of Millets 2023"* by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Honorable Prime minister's Virtual address to the farmers and scientists launching the *"Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods"* organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on "*Our Achievements: A Glimpse*" by Dr. T Mahapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*"centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. Dasari Sreekanth

- "*Review Meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Remote Sensing and Drones application in Agriculture*" organized by AICRP-WM, TNAU, Coimbatore on 18 February, 2021

- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on Women's day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- International Plant Physiology Virtual Symposium 2021 entitled "*Physiological Interventions for Climate Smart Agriculture*" organized by ICAR-SBI, Coimbatore, ISPP, New Delhi, NAAS- Coimbatore Chapter and SSRD and SAUs South Zone on 11-12 March, 2021
- International Webinar on "*Recent Advances in Weed Science Research*" organized by PAJNACOA & RI, Karaikal, Puducherry & ICAR-DWR, Jabalpur on 12 March, 2021
- Webinar on "*Weed Science Research in India way Forward and Scope for Entrepreneurship Opportunity*" organized by RVSKVV, Gwalior & ICAR-DWR, Jabalpur on 17 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- National Conference "*36th M.P. Young Scientist Congress-2021*" organized by MPCST, Bhopal during 23-26 March, 2021
- International Webinar on "*Genetics, Genomics and Breeding of Herbicide-Tolerant Grain Sorghum to Address Weed Control Challenges*" organized by PJTSAU, Hyderabad on 19 April, 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- "*Weed Smart Webinar -Considerations for Pre-Emergent Herbicides with dry Sowing*" organized by University of Western Australia on 6 May, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- Webinar on "*Translating Genomics for Next Generation Crop Improvement*" organized by Tata Institute for Genetics and Society (TIGS) in partnership with BCIL on 10 June, 2021
- "*22nd RAC Meeting*" held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- "*IRC Meeting*" held at ICAR-DWR, Jabalpur on 28-29 June 2021
- Webinar on "*Agro-Biodiversity for Food Security*" organized by ICAR-CTCRI, Bhubaneswar on 16 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- Webinar on "*Genome Editing Tools and its Applications for Targeted Plant Breeding*" organized by APAARI, BCIL, Korea Biosafety Clearing House, APCoAB on 21 July, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- *"Curtain Raiser of International Year of Millets 2023*" by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- International Dialogue on "*Harnessing Plant Physiology for Crop Improvement*" organized by Department of Crop Physiology, University of Agricultural Sciences, Bangalore on 25 September, 2021
- Honorable Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods"* organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- International Webinar Conference on "*Alternate Cropping Systems for Climate change & Resource Conservation*" organized by ICAR-Indian Institute of Farming Systems Research, Modipuram from 29 September, 1 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on "*Our Achievements: A Glimpse*" by Dr. T Mahapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021
- 2nd International Web-Conference of ANRCM on "*Smart Agriculture for Resource Conservation and Ecological Stability*" organized by Academy of Natural Resource Conservation and Management, India from 29-30 October, 2021
- Webinars on "*Implementation and Use of Agricultural Research Management System (ARMS)*" organized by ICAR-IASRI, New Delhi on 25 November, 2021
- Webinar on "*Quarantine Weeds Organized by AICRP-WM*" centre KAU, Thrissur on 7 December, 2021
- *"All ICAR Young Scientist Interaction Meet*" with DG, ICAR organized by Indian Council of Agricultural Research, New Delhi on 08 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Dr. Himanshu Mahawar

- "*Review meeting of AICRP-Weed Management*" organized by ICAR-DWR, Jabalpur on 7 January, 2021
- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- Webinar on "*Principles of Good Laboratory Practices*" organized by CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur under AICRP-WM & CAAST on Protected Agriculture and Natural Farming on 10 February, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- Webinar on "*Microbial strategies for improving soil health and crop productivity under protected cultivation*" organized by CSKHPKVV, Palampur, NAHEP, CAAST on protected agriculture and natural farming on 10 March, 2021
- Webinar on Women's Day entitled "*Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment*" organized by ICAR, New Delhi on 8 March, 2021
- Lecture on "*Valuing water for Agriculture*" in Bharat ka Amrut Mahotsav organized by DDG (Education), ICAR, New Delhi on 17 March, 2021
- Lecture on "*Valuing Water*" on the occasion of World Water Day organized by ICAR, New Delhi on 22 March, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30 April, 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 May, 2021
- Webinar on "*Microbial Pesticides: A Way towards Crops and Environmental Protection*" organized by Centurion University of Technology and Management, Odisha on 6 June, 2021
- 22nd RAC meeting held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- Webinar on "*Nanotechnology in Agriculture: Opportunities and Challenges*" organized by Bhopal Chapter, NAAS in collaboration with ICAR-IISS, Bhopal on 21 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June 2021
- National Webinar on "*Bio-Decomposer: Wealth from Waste in Farming Systems*" organized by Agri-Business Incubation Centre, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut on 20 July, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- Webinar on, "*Mass awareness campaign on organic farming*" under AKAM organized by ICAR-IISS Bhopal and ICAR-IIFSR, Meerut on 6 August, 2021
- Talk on "*Abiotic Stress Management in Agriculture*" under AKAM organized by CSAUAT, Kanpur on 10 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- Webinar on "Microbial Management of crop residues for improvement of soil health: Useful methodologies to assess compost maturity and quality" in Virtual webinar series on "Application of microorganisms in sustainable agriculture" organized by ICAR- NBAIM, Mau on 13 September, 2021
- International Webinar on "Recent developments of beneficial Microorganisms in food and agriculture" (RDBMFA - 2021) organized by Annamalai University and National Academy of Biological Sciences (NABS) & DST on 14 September, 2021
- Biolog's webinar on "Assessing Ecological Functions of Complex Microbial Communities using Physiological Profiling" organized by Biolog, USA on 16 September, 2021
- Curtain Raiser of International Year of Millets 2023 by Hon'ble Union Minister of Agriculture organized by Ministry of Agriculture and Farmers Welfare, Govt. of India and ICAR-New Delhi on 17 September, 2021
- Webinar on "*Krishi me Nanotechnology ka Upyog: Nano-Fertilizer*" by Dr. Ramesh Raliya, General Manager & Head of Research & Development, IFFCO Nano Biotechnology Research Centre, India organized by ICAR-RCER, Patna on 23 September, 2021
- Prime Minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Sensitization Workshop on "*ARMS and Monthly Reporting in ICAR-Institutions*" organized by ICAR- IISWC, Dehradun on 18 October, 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on **"***Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
- ISWS 10th Webinar "*Weed Flora and Their Management in Rice-Wheat Cropping System*" Speaker: Dr. R.K. Malik & Dr. Virender Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29 October, 2021

- 5th International Agronomy Congress on "*Agri Innovations to combat food and nutrition challenges*" organized by PJTSAU, Hyderabad during 23-27 November, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

Mr. Jamaludheen A.

- ISWS 1st Webinar "*Herbicide Resistance in India: Problems and Management*" Speaker: Dr. Samunder Singh organized by ISWS and ICAR-DWR, Jabalpur on 29 January, 2021
- ISWS 2nd Webinar "*Weeds of National Importance*" Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 25 February, 2021
- ISWS 3rd Webinar "*Quarantined Weeds and Weed Risk Analysis*" Speaker: Dr. Mool C. Singh, organized by ISWS and ICAR-DWR, Jabalpur on 23 March 2021
- ISWS 4th Webinar "*Alien Invasive Weeds in India: Threat to Agriculture, Biodiversity and Environment*" Speaker: Dr. R.M. Kathiresan, organized by ISWS and ICAR-DWR, Jabalpur on 30th April, 2021
- National Webinar on "*Direct Seeded Rice: Opportunities, Constraints, and Solutions*" organized by AICRP-WM, CCSHAU, Hisar on 26 May 2021
- ISWS 5th Webinar "*Aquatic Weeds: Problems and Their Management for Improving Water Productivity*" Speaker: Dr. Sushil Kumar, organized by ISWS and ICAR-DWR, Jabalpur on 29th May, 2021
- 22nd RAC meeting held at ICAR-DWR, Jabalpur on 14-15 June, 2021
- "*XXVIII Annual Review Meeting of AICRP-WM*" organized by ICAR-DWR, Jabalpur on 18-19 June, 2021
- ISWS 6th Webinar "*Role of Weed Biology in Weed Management*" Speaker: Dr. Bhagirath S. Chauhan, organized by ISWS and ICAR-DWR, Jabalpur on 22 June, 2021
- IRC meeting held at ICAR-DWR, Jabalpur on 28-29 June, 2021
- ISWS 7th Webinar Stakeholder's Dialogue "*Restrictions in use of Glyphosate: Implications in Weed Management*", organized by ISWS and ICAR-DWR, Jabalpur on 20 July, 2021
- 31st International Conference of "*Agricultural Economists*" organized by ISAE, AERA, IGIDR, IFPRI and ICAR-NIAP during 17- 31 August, 2021
- ISWS 8th Webinar "*The Parthenium Weed Problem and its Weed Management at Global Level*" Speaker: Dr. Steve W. Adkins, organized by ISWS and ICAR-DWR, Jabalpur on 16 August, 2021
- "*YouTube Live Phone in Programme on Parthenium*" organized by Reliance Foundation, Mumbai and ICAR-DWR, Jabalpur on 18 August, 2021
- Webinar on "*Krishi me Nanotechnology ka Upyog: Nano-Fertilizer*" by Dr. Ramesh Raliya, General Manager & Head of Research & Development, IFFCO Nano Biotechnology Research Centre, India organized by ICAR-RCER, Patna on 23 September, 2021
- Honorable Prime minister's Virtual address to the farmers and scientists launching the "*Mass Awareness Campaign for Large-Scale Dissemination of Climate Resilient Technologies and Methods*" organized by ICAR-DWR, Jabalpur on 28 September, 2021
- ISWS 9th Webinar "*Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management*" Speaker: Dr. Michael Walsh, organized by ISWS and ICAR-DWR, Jabalpur on 28 September 2021
- Webinar on *"Agricultural Research Management System (ARMS)"* for Scientists of Ag. Edn, Ag Engg and NRM SMDs organized by ICAR- RCER, Patna & Indian Farmers Fertilizer Cooperative Ltd, Patna, Bihar on 22 October, 2021
- Interaction Meeting on **"***Our Achievements: A Glimpse*" by Dr. T Mohapatra, Secretary, DARE & DG, ICAR with ICAR Scientist organized by ICT Unit, ICAR on 28 October, 2021
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- All ICAR Young Scientist Interaction meet with DG, ICAR organized by Indian Council of Agricultural Research, New Delhi on 8 December, 2021
- "*Valedictory Function of Vibrant Gujarat Summit*" addressed by Hon'ble Prime Minister and Farmers-Scientist Interaction on Natural Farming in virtual mode at ICAR-DWR, Jabalpur on 16 December, 2021
- "*Quarterly Review Meeting of AICRP-WM*" centres organized by PC unit, AICRP-WM, ICAR-DWR, Jabalpur on 21-22 December, 2021

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17. Summary of All India Coordinated Research Project on Weed Management

The All India Coordinated Research Project on Weed Management (AICRP-WM) is operational at the Directorate which coordinates its network research programme through 17 regular centres and 7 voluntary centres at SAU's under different agro-climatic zones. The salient achievements during the year 2021 are given below:

WP-1: Development of location-specific sustainable weed management practices

- *Phalaris minor* populations showed differential resistance to sulfosulfuron, clodinafop, mesosulfuron + iodosulfuron and/or pinoxaden but not to pendimethalin, pyroxasulfone and metribuzin. Pyroxasulfone sole or mixture with pendimethalin provided best control in wheat.
- Studies at Hisar showed development of resistance to the *P. minor* populations against the recommended dose of sulfosulfuron (25 g/ha), mesosulfuron + iodosulfuron (RM) (14.4 g/ha) and pinoxaden (50 g/ha) herbicides.
- Under pot studies at Hisar, only three populations out of the 12 populations under the testing shows ⩾ 70 % control to the recommended dose of sulfosulfuron (25 g/ha), five to mesosulfuron + iodosulfuron (RM) (14.4 g/ha) and three to pinoxaden (50 g/ha). It shows the development of resistance to the *P. minor* populations against these tested herbicides.
- The pre-emergence uses of pyroxasulfone + pendimethalin (TM) at (127.5 + 1500 g/ha) followed by PoE application of meso + iodosulfuron 14.4 g/ha and pinoxaden 50 g/ha at farmers' fields in rice –wheat growing areas of Haryana provided 91.3 and 90% control of *P. minor*.
- In cotton-greengram cropping system under conservation agriculture at Anand, significantly lower density and dry biomass of monocot (5.74/m^2 and 6.29 g/m^2, respectively) was observed under zero tillage with residue followed by zero tillage with residue. Seed cotton equivalent yield was recorded significantly the highest (2.87 t/ha) under zero tillage with residue followed by zero tillage with residue.
- In *Bt* cotton application of 125% recommended dose of N and K in five splits (P as basal) through drip and directed spray of paraquat 0.3 kg/ha at 30 DAS *fb* 1 HW 15 days after spraying and paraquat 0.6 kg/ha 60 DAS *fb* 1 HW 30 days after spraying found to be best for maximizing the weed control efficiency, seed cotton yield and net returns in Maharashtra.
- In sugarcane ratoon crop, the lowest weed dry weight of grasses was recorded by sequential application of atrazine *fb* topramezone, whereas for BLWs and sedges, with sulfentrazone *fb* 2,4-D EE 38% EC and metribuzine + halosulfuron. The highest cane yield (79.6 t/ha), net return (186400/ha) and BC ratio (2.7) was found under atrazine *fb* topramezone at Pantnagar.
- Application of oxyfluorfen (6%)+ quizalofop-p-ethyl (4%) RM 35 g/ha at 15 DAS was found to be the best combination in controlling the complex weed flora of onion at Bhubaneshwar.
- The highest seed yield of rainfed chickpea was observed under mechanical weeding at 20 and 40 DAS which was at par with imazethapyr + pendimethalin (RM) 1000 g/ha as PE and topramezone 25.2 g/ha at 20-25 DAS with higher net returns, BC ratio at Jammu.
- In organically grown cabbage at Hyderabad, the highest weed control efficiency was observed with polymulch + intra row HW at 30 DAT and it was followed by rice straw mulch and groundnut shell mulch at 25 and 50 DAT. The highest cabbage head diameter was recorded with groundnut shell mulching and significantly superior to hoeing and unweeded check but at par with other treatments.
- In organic cultivation of knoll-khol (variety of the species *Brassica oleracea*), paddy straw mulch 6/ha or 8 t/ha was found suitable for weed management at Jammu.
- At Bhubaneshwar, application of same proportion of organics through FYM, Vermicompost and Neem cake + Azotobacter + PSB to tomato with one mechanical weeding at 25 DAS/DAT and one manual weeding at 50 DAS/DAT in tomato resulted in the maximum fruit yield of tomato (17.79 t/ha).
- Application of glyphosate 25 g/ha at 30 DAS followed by 50 g/ha at 50-60 DAS caused 70% control of *Orobanche* in mustard with yield gain of 25% over untreated control at different demonstrations on farmers' fields of Haryana.

WP-2: Management of weeds in non-cropped and aquatic areas

- An ecofriendly and economic technique for management of submerged aquatic weed Indian star wort *(Hydrilla vertcillata)* was developed which has to be further refined. It was found that lime application either as quick lime or hydrated lime to increase the pH of water to neutrality can give more than 90 % control within 4 days of liming. This was field tested in farmers field and results are promising with same effectiveness as in artificial tanks.
- Biology and management of *Leptochloa chinensis* was studied in detail. It is a C4 grass. Seeds did not germinate under submerged conditions and hence not a serious weed in transplanted rice. However, it can pose serious competition in semi-dry rice, where a dry seed bed condition is available during initial phase of rice crop. In fields where *Leptochloa* is a problem, farmers can opt either pre emergence herbicides like oxyfluorfen or pretilachlor or pyrazosulfuron. For post-emergence control, graminicides like fenoxaprop or cyhalofop may be used.

WP-3: Fate of herbicide residues in different agroecosystem

- The half-lives (DT50) of pyroxasulfone ranged from 20.43 to 40.83 days at application rates of 76.5, 102, 127.5, 204 and 255 g/ ha.
- Initial residues of metribuzin in soil ranged from 0.035 to 0.101 and 0.031 to 0.092 µg/g in recommended herbicide and IWM treatments, respectively. Residues of metribuzin (<0.01 µg/g) and clodinafop-propargyl (<0.05 µg/g) were below the detectable limit in soil and wheat at harvest at Ludhiana.
- At Hyderabad, the initial residues of atrazine varied from 0.403 to 0.412 µg/g in the soil samples 4 hours after herbicide application. In the soil sample and maize grain/plant samples collected at the time of harvest, the atrazine residues were below the detection limit of 0.05 µg/g in all the soil samples.
- At Coimbatore, residues of different herbicides during *Rabi* 2021(*Baby corn*) was analyzed at different periods *viz*., 0,3,7 15,30 45 and at harvest. The conventional tillage plots recorded lower residues when compared to zero tillage with and without residue. The dissipation of all the herbicide molecule was found to follow first order reaction kinetics (R2 > 0.90) with the half-life of 12.8-17.6 days for atrazine, 10.0 to 11.4 days for tembotrione, 7.9 to 9.7 days for topramezone and 5.9 to 6.7 days for 2,4-D, irrespective of tillage practices and weed management methods.
- At Hyderabad, recovery of oxyfluorfen in soil varied from 88.2 to 94.2%. In cabbage, the recovery varied from 84.1 to 86.6 %, respectively. LOQ of oxyfluorfen in soil was 0.05 mg/kg, and in onion bulb LOQ was 0.05 mg/kg. Residues of oxyfluorfen in soil and cabbage samples and soil at the time of harvest were below the detection limit of 0.05 mg/kg.
- Clodinafop and metsulfuron-methyl residues in soil and grain samples from farmers field of Kangra district were analyzed by HPLC-DAD for their residue content which were found below detectable limits. Similarly residues of different herbicides *i.e.* alachlor (0.01-0.04 ppm), pendimethalin (0.012- 0.10 ppm) and metribuzin (0.007- 0.014 ppm) in the samples collected from the farmers fields in the Kullu district were detected in less than 10% of samples and were below MRL values..

WP-4: Demonstration and impact assessment of weed management technologies

- In groundnut at Anand, fluazifop-p-butyl 11.1% w/w + fomesafen 11.1% (premix) *fb* IC+HW at 40 DAS and imazethapyr 35% + imazamox 35% WG 70 g/ha *fb* IC+HW at 40 DAS were found equally effective for weed control as IC *fb* HW at 20 and 40 DAS (farmers practice) with higher B:C (2.87, 2.74, respectively) compared to farmer's practice (2.66).
- On-farm weed management technology demonstration at Palampur revealed 40.7% increase in yield of wheat, 38.7% increase in pod yield of peas, 64% increase in yield of rice, 25.6% increase in yield of maize, 53.5% increase in yield of soybean and 31.3% increase in yield of turmeric over the farmer's technique of weed control.
- In OFR, in wheat, pyroxasulfone 127.5 g/ha proved effective against resistant *P. minor.* In maize, integration of tembotrione (band spray) and inter-culture provided similar weed control to tembotrione (blanket) at Ludhiana.
- In direct-seeded rice, the highest grain yield and BC ratio were recorded in pendimethalin 1000 g/ha (PE) *fb* bispyribac-sodium 25 g/ha + ethoxysulfuron-ethyl 18 g/ha as post-emergence at farmers fields in OFR trials at Jammu.
- Wheat seeds distributed to 200 SC Farmers and herbicide clodinafop + metsulfuron to 150 SC farmers and knapsack sprayer to 8 farmers at Chak Jagtu village of Jammu.
- 'KAU weed wiper' developed by AICRP-WM, KAU Thissur has been awarded Indian Patent and this technology is being popularized through SCSP scheme, also supplying weed wiper to SC farmers and organizing field level demonstrations.

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18. Distinguished Visitors

Sl.No.	Visitor	Date
1	Shri Padmakar Talwar,(Yogacharya) Satyanandyoga Kendra, Jabalpur	21 Jun 2021
2	Prof. Akhilesh Kumar Pandey Vice Chancellor, Vikram University Ujjain	07 Aug 2021
3	Dr. Rajendra Chandrakant Rai, Senior Litterateur	29 Sep 2021
4	Prof. Kapil Dev Mishra, Vice Chancellor, Rani Durgavati Vishwavidyalaya, Jabalpur	14-29 September, 2021
5	Dr. R.C. Mishra, Vice Chancellor, Mahakoshal University, Jabalpur	29 September 2021
6	Shri Radhakrishnan, Chairman, Tripura Vidhyut Niyamak Ayog	13 October 2021
7	Dr. Surya Narayan Bhaskar, Assistant Director General (Agronomy, Agroforestry & Climate Change), ICAR, New Delhi	18 October 2021
8	Shri Satyendra Jyotishi, Senior Advocate, Madhya Pradesh High Court	26 October- 01 November, 2021
9	Shri Raj Ranjan Srivastava Rajbhasha Adhikari, West Central Railway and Secretary Narakas Office No.2 Jabalpur	08 December, 2021
10	Shri Shyam Patel, Magarmuha village, Shahpura, Jabalpur district	23 December, 2021
11	Dr. S.B. Barbudhe, Director, NRC Meet, Hyderabad	28 & 29 December 2021
12	Dr. Panjab Singh, Ex. Secretary, Department of Agriculture Research & Education (DARE), and Director General ICAR, Visited the ICAR-DWR Jabalpur	29 December 2021
13	Shri Sanjay Yadav, Former Chief Justice, Allahabad High Court	31 December, 2021
14	Dr. Atul Srivastava, Dean, College of Agricultural Engineering, J.N.V.V.A., Jabalpur	27 December, 2021 - 01 January, 2022

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19. Personnel

Scientific Staff

Name and Designation	Specializations
 **Dr. J.S. Mishra** Director Email: js.mishra@icar.gov.in Mobile: 09494240904	Conservation Agriculture, Integrated Weed Management, Management of Parasitic Weeds
 **Dr. P.K. Singh** Pr. Scientist (Agriculture Extension) Email: p.singh1@icar.gov.in Mobile: 9425388721	Technology transfer, demonstration, adoption and impact assessment of weed management
 **Dr. Sushil Kumar** Pr. Scientist (Entomology) Email: sushil.kumar2@icar.gov.in Mobile: 9425186747	Biological control of weeds, aquatic weed management, weed utilization
 **Dr. K.K. Barman** Pr. Scientist (Soil Science) Email: kamal.barman1@icar.gov.in Mobile: 09826811536	Integrated weed management and environmental quality
 **Dr. R.P. Dubey** Pr. Scientist (Agronomy) Email: rudra.dubey@icar.gov.in Mobile: 9425412041	Integrated weed management, weed management in organic agriculture
 **Dr. Shobha Sondhia** Pr. Scientist (Organic Chemistry) Email: shobha.sondhiya@icar.gov.in Mobile: 0761-2353934	Environmental impact of herbicide, mode of degradation, bio-molecules, method development for herbicide residues and herbicide mitigation measures
 **Dr. Pijush Kanti Mukherjee** Pr. Scientist (Agronomy) Email: pijush.mukherjee@icar.gov.in Mobile: 08910539322 / 09536551548	Weed Management in Conservation Agriculture & Fodder Crops
 **Dr. Vijay K. Choudhary** Sr. Scientist (Agronomy) Email: vijay.choudhary@icar.gov.in Mobile: 9425244075	Conservation agriculture, weed and water management in different crops
 **Dr. Yogita Gharde** Scientist (Agril. Statistics) Email: yogita.gharde@icar.gov.in Mobile: 8226072727	Modelling on crop weed association

Name and Designation		Specializations
	**Er. Chethan C.R.** Scientist (Farm Machinery and Power) Email: chethan.r@icar.gov.in Mobile: 9800105776	Farm mechanization, precision farming and conservation agriculture
	**Dr. Pawar Deepak Vishwanath** Scientist (Agril. Biotechnology) Email: deepak.pawar@icar.gov.in Mobile: 9650361632	Agricultural Biotechnology
	**Mr. Dibakar Roy** Scientist (Soil Science and Agril. Chemistry) Email: dibakar.roy@icar.gov.in Mobile: 8250834767	Soil Science
	**Er. Vaibhav Chaudhary** Scientist (Farm Machinery & Power) Email: vaibhav.chaudhary@icar.gov.in Mobile No: 9350598347	Farm Mechanization, Design and Analysis of Weeding Tools and Mechanisms
	**Dr. Dasari Sreekanth** Scientist (Plant Physiology) E-mail: sreekanth.dasari@icar.gov.in Mobile No: 9542681028	Plant Physiology
	**Dr. Himanshu Mahawar** Scientist (Agricultural Microbiology) E-mail: himanshu.mahawar@icar.gov.in Mobile No: 8920966597	Agricultural Microbiology
	**Mr. Jamaludheen A.** Scientist (Agricultural Economics) E-mail: jamaludheen.a@icar.gov.in, Mobile No: 9048905457 **Newly joined on 12/01/2021**	Agricultural Economics

Technical Staff

Sh. R.S. Upadhyay	T-9, Chief Technical Officer
Sh. Sandeep Dhagat	T-9, Chief Technical Officer
Sh. G.R. Dongre	T-7-8, Assistant Chief Tech Officer
Sh. Pankaj Shukla	T-7-8, Assistant Chief Tech Officer
Sh. O.N. Tiwari	T-7-8, Assistant Chief Tech Officer **Superannuation 31/08/2021**
Sh. J.N. Sen	T-7-8, Assistant Chief Tech Officer **Promoted on 13/03/2020**
Sh. S.K. Parey	T-7-8, Assistant Chief Tech Officer **Promoted on 15/03/2020**

Sh. Basant Mishra	T-6, Senior Technical Officer
Sh. K.K. Tiwari	T-6, Senior Technical Officer **Promoted on 01/01/2020**
Sh. S.K. Tiwari	T-5, Technical Officer
Sh. S.K. Bose	T-5, Technical Officer
Sh. G. Vishwakarma	T-5, Technical Officer
Sh. Mukesh K. Meena	T-5, Technical Officer
Sh. Ajay Pal Singh	T-5, Technical Officer
Sh. Bhagunte Prasad	T-5, Tech. Officer (Tractor Driver) **Promoted on 29/06/2021**
Sh. Premlal Dahiya	T-5, Tech. Officer (Driver) **Promoted on 29/06/2021**

Sh. Dilip Sahu	T-5, Tech. Officer (Driver) **Promoted on 29/06/2021**
Sh. Sebestene Das	T-3, Technical Assistant (Driver)

Smt. Iti Rathi	T-3, Technical Assistant
Sh. V.S. Raikwar	T-1, Field Assistant **Superannuation 31/08/2021**

Administrative Staff

Sh. Sujeet K. Verma	Administrative Officer **Transferred on 14 Oct. 2021**
Sh. R Hadge	Assistant Admin Officer
Sh. M.S. Hedau	Assistant Finance and Account Officer **Transferred on 06 Nov. 2021**
Smt. Nidhi Sharma	PS to Director

Sh. Manoj Gupta	PA
Sh. T. Lakhera	Assistant
Sh. Beni Prasad Uriya	Assistant
Sh. Francis Xavier	Sr. Clerk

Skilled Supporting Staff

Sh. Veer Singh	Skilled Support Staff
Sh. Raju Prasad	Skilled Support Staff
Sh. Jagoli Prasad	Skilled Support Staff
Sh. Jagat Singh	Skilled Support Staff
Sh. Chhoteylal Yadav	Skilled Support Staff
Sh. Anil Sharma	Skilled Support Staff
Sh. Naresh Singh	Skilled Support Staff
Sh. Shankar Lal Koshta	Skilled Support Staff
Sh. J.P. Dahiya	Skilled Support Staff
Sh. Madan Sharma	Skilled Support Staff
Sh. Jethuram Viswakarma	Skilled Support Staff

Sh. Shiv Kumar Patel	Skilled Support Staff
Sh. Ashwani Tiwari	Skilled Support Staff
Sh. Suresh Chand Rajak	Skilled Support Staff
Sh. Gajjulal	Skilled Support Staff
Sh. Gangaram	Skilled Support Staff
Sh. Santlal Rajak	Skilled Support Staff
Sh. Mahendra Patel	Skilled Support Staff
Sh. Santosh Kumar	Skilled Support Staff
Sh. Nemichand Kurmi	Skilled Support Staff
Sh. Mohan Lal Dubey	Skilled Support Staff

New Joining

- Mr. Jamaludheen A. joined as Scientist (Agricultural Economics) on 12/01/2021 at this Directorate

Promotions

- Sh. O.N. Tiwari was promoted from Sr. Technical Officer to T-7-8 Assistant Chief Technical Officer w.e.f 01/01/2020
- Sh. J.N. Sen was promoted from T-6 Senior Technical Officer to T-7-8 Assistant Chief Technical Officer w.e.f. 13/03/2020
- Sh. S.K. Parey was promoted from T-6 Senior Technical Officer to T-7-8 Assistant Chief Technical Officer w.e.f 15/03/2020
- Sh. K.K. Tiwari was promoted from T-5 Technical Officer to T-6 Senior Technical Officer w.e.f. 01/01/2020
- Sh. Bhagunte Prasad was promoted from T-4 Technical Assistant (Tractor Driver) to T-5 Technical Officer (Tractor Driver) w.e.f. 29/06/2021
- Sh. Premlal Dahiya was promoted from T-4 Technical Assistant (Driver) to T-5 Technical Officer (Driver) w.e.f. 29/06/2021
- Sh. Dilip Shau was promoted from T-4 Technical Assistant (Driver) to T-5 Technical Officer (Driver) w.e.f. 29/06/2021

Farewell to staff members

- Sh. Sujeet Kumar Verma, Administrative Officer was transferred on 14 October, 2021 from ICAR-DWR to ICAR-Central Institute for Subtropical Horticulture (CISH), Lucknow (UP) as Sr. Administrative officer.
- Sh. M.S. Hedau, AF&AO was transferred on 06 November, 2021 from ICAR-DWR to ICAR-National Institute of High Security Animal Diseases (NIHSAD), Bhopal (MP) as Finance and Account Officer.

Superannuation

- Sh. O.N. Tiwari, T-7-8, Assistant Chief Tech Officer retired on 31/08/2021
- Sh. V.S. Raikwar T-1, Field Assistant retired on 31/08/2021

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20. Weather

The climate of Jabalpur is broadly classified as sub-tropical, characterized by very hot summers and cold winters. The maximum temperature was recorded in March to June ranging from 33.9 to 37.9 ˚C, where April being the hottest and minimum temperature was recorded in December to January ranging from 8.9 to 9.7 ˚C, where December being the coldest (Fig.1). The total annual rainfall in the year 2021 was 843.7 mm and most of it (67.34 %) was received during June, July and September, however, rain was received only for 55 days this year. The maximum number of rainy days *i.e.* 10, 14 and 11 were observed in June, July and September, respectively. The total annual evaporation was 44.1 mm (Table 1). Climate change impacts the crop yields both directly and indirectly. Direct effects are mainly due to change in crop duration and fertilization. Whereas, the indirect effect are largely due to changes in water availability, altered insect, diseases and weed dynamics. The maximum and minimum wind speed was observed during the months of June and November, respectively. The mean maximum relative humidity was recorded during July-December ranged from 85-90 % and mean minimum relative humidity was 16-35%. The mean maximum and minimum daily sunshine of 8.95 and 2.52 hr was recorded in February and August, respectively. Weather data was obtained from adjacent meteorological observatory of JNKVV, Jabalpur.

Table 1: Monthly mean maximum and minimum humidity, wind speed, sunshine, rainfall, evaporation and no. of rainy days at Jabalpur during 2021

Month	Humidity (%)		Wind speed (km hr^{-1})	Sun shine (hr day^{-1})	Rainfall (mm)	Evaporation (mm)	No. of rainy days
	Maximum	Minimum					
January	83	43	2.9	6.4	0.9	2.1	0
February	76	33	2.6	8.9	13.5	3.1	1
March	70	23	3.1	7.6	6.2	4.9	1
April	57	16	2.2	8.4	0.6	6.7	0
May	70	35	3.7	8.3	77.5	6.3	5
June	83	57	5.0	4.7	169.0	4.7	10
July	85	68	4.8	3.8	242.6	3.9	14
August	89	73	4.9	2.5	84.2	2.5	9
September	90	72	3.3	4.4	156.6	2.8	11
October	86	47	2.0	8.4	67.0	3.4	2
November	85	38	1.6	6.5	1.8	2.0	0
December	85	46	2.0	5.7	23.8	1.8	2
Total	-	-	-	**75.7**	**843.7**	**44.1**	**55.0**

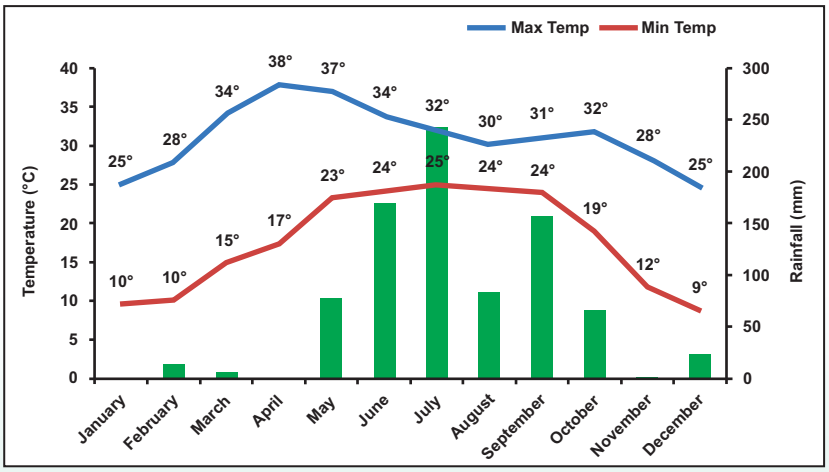

Figure 1: Mean monthly maximum and minimum temperature, and total monthly rainfall at Jabalpur, during 2021

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Appendix - 1

Acronyms

AAS	:	Atomic Absorption Spectrophotometer
AAU - Anand	:	Anand Agricultural University
AAU -Jorhat	:	Assam Agricultural University
ADF	:	Acid Detergent Fiber
AICRP	:	All India Coordinated Research Project
AKMU	:	Agriculture Knowledge Management Unit
APX	:	Ascorbate Peroxidase
ATARI	:	Agricultural Technology Application Research Institute
BAU	:	Birsa Agricultural University
BISA	:	Borlaug Institute for South Asia
CAFT	:	Centre of Advanced Faculty Training
CAS	:	Conservation Agriculture System
CAU	:	Central Agricultural University
CAZRI	:	Central Arid Zone Research Institute
CCSHAU	:	Choudhary Charan Singh Haryana Agricultural University
CeRA	:	Consortium for e-Resources in Agriculture
CIAE	:	Central Institute of Agricultural Engineering
CICR	:	Central Institute for Cotton Research
COD	:	Chemical Oxygen Demand
CRRI	:	Central Rice Research Institute
CSAUAT	:	Chandra Shekher Azad University of Agriculture and Technology
CT	:	Conventional Tillage
CTRI	:	Central Tobacco Research Institute
DAA	:	Days After Application
DBSKKV	:	Dr. Bala Saheb Konkan Krishi Vidhyapeeth
DARE	:	Department of Agricultural Research and Education
DAS	:	Days After Sowing
DAT	:	Days After Transplanting
DBT	:	Department of Biotechnology
DO	:	Dissolved Oxygen
DRDO	:	Defense Research and Development Organization
DRMR	:	Directorate of Rapeseed-Mustard Research
DSR	:	Direct-Seeded Rice
DST	:	Department of Science and Technology
DU	:	Delhi University
DWR	:	Directorate of Weed Research
Dr. PDKV	:	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
Dr. RPCAU	:	Dr. Rajendra Prasad Central Agricultural University
EC	:	Electrical Conductivity
EUE	:	Energy Use Efficiency
FACE	:	Free Air CO_2 Enrichment
FP	:	Farmers Practice
GBPUAT	:	Govind Ballabh Pant University of Agriculture and Technology
GC	:	Gas Chromatography
GLC	:	Gas Liquid Chromatography
GPX	:	Glutathione Peroxidase
GR	:	Glutathione Reductase
HPLC	:	High Performance Liquid Chromatography
HRD	:	Human Resource Development
HW	:	Hand Weeding
IARI	:	Indian Agricultural Research Institute
IASRI	:	Indian Agricultural Statistics Research Institute
ICAR	:	Indian Council of Agricultural Research
ICRISAT	:	International Crops Research Institute for the Semi-Arid Tropics
IFFCO	:	Indian Farmers Fertiliser Cooperative Limited
IGFRI	:	Indian Grassland and Fodder Research Institute
IGKV	:	Indira Gandhi Krishi Vishwavidyalaya
IIOR	:	Indian Institute of Oilseeds Research
IISS	:	Indian Institute of Soil Science
IJSC	:	Institute Joint Staff Council
IMC	:	Institute Management Committee
IRC	:	Institute Research Council
IRGA	:	Infrared Gas Analyzer
ISWS	:	Indian Society of Weed Science
ITMU	:	Institute Technology Mission Unit
IWM	:	Integrated Weed Management
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidyalaya
JNU	:	Jawaharlal Nehru University
KAU	:	Kerala Agricultural University
KMAS	:	Kisan Mobile Advisory Services
KVK	:	Krishi Vigyan Kendra
LAN	:	Local Area Network
LC-MS/MS	:	Liquid Chromatography–Mass Spectroscopy/ Mass Spectroscopy
LD	:	Lethal Dose
LV	:	Low Volume
MAU	:	Marathwada Agricultural University
MGMG	:	Mera Gaon Mera Gaurav
MHV	:	Medium High Volume

MLV	:	Medium Low Volume
MPBT	:	Madhya Pradesh Biotechnology
MPUAT	:	Maharana Pratap University of Agriculture and Technology
MRL	:	Maximum Residue Limits
NAIP	:	National Agricultural Innovation Project
NAARM	:	National Academy of Agricultural Research Management
NASF	:	National Agricultural Science Fund
NASC	:	National Agricultural Science Complex
NBAIR	:	National Bureau of Agricultural Insect Resources
NBSS & LUP	:	National Bureau of Soil Survey and Land Use Planning
NDF	:	Neutral Detergent Fiber
NDUAT	:	Narendra Dev University of Agriculture and Technology
NDVSU	:	Nanaji Deshmukh Veterinary Science University
NGO	:	Non-Governmental Organization
NIPHM	:	National Institute of Plant Health Management
NPK	:	Nitrogen, Phosphorous, Potash
NRM	:	Natural Resource Management
OC	:	Organic Carbon
OE	:	Output Energy
OFR	:	On Farm Research
OTC	:	Open Top Chamber
OUAT	:	Orissa University of Agriculture and Technology
PAU	:	Punjab Agricultural University
PAGE	:	Polyacrylamide Gel Electrophorasis
PCR	:	Polymerase Chain Reaction
PE	:	Pre-emergence
PJTSAU	:	Professor Jayashankar Telangana State Agricultural University
PME	:	Priority Setting, Monitoring and Evaluation
PO	:	Post-emergence
PVP	:	Polyvinyl pyrrolidont
QRT	:	Quinquennial Review Team
RAC	:	Research Advisory Committee
RAU	:	Rajasthan Agricultural University
RCER	:	Research Complex for Eastern Region
RDVV	:	Rani Durgavati Vishwavidyalaya
RFD	:	Results Framework Document
RM	:	Ready Mix
RVSKVV	:	Rajmata Vijayaraje Sindia Krishi Vishwavidyalaya
SADHNA	:	Society for Advancement of Human and Nature
SAR	:	Sodium Adsorption Ratio
SAU	:	State Agricultural University
SD	:	Standard Deviation
SEM	:	Standard Error of Mean
SKUAST	:	Sher-e-Kashmir University of Agricultural Sciences and Technology
SOD	:	Superoxide Dismutase
SRI	:	System of Rice Intensification
SSR	:	Simple Sequence Repeats
TNAU	:	Tamil Nadu Agricultural University
TPR	:	Transplanted Rice
TRRI	:	Tamil Nadu Rice Research Institute
UAS	:	University of Agricultural Sciences
UFLC	:	Ultra Fast Liquid Chromatography
ULV	:	Ultra Low Volume
VB	:	Vishwa Bharati
WAS	:	Weeks after sowing
WCE	:	Weed control efficiency
WP	:	Wettable powder
ZT	:	Zero Tillage

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ICAR - DWR in the NEWS

पीपुल्स समाचार

किसान को फलदार पौधों से होगी अतिरिक्त आय : सिंह

अनु. जाति उप योजना अंतर्गत किसानों को बांटे गए पौधे

हरिभूमि

अजा उप योजना के अंतर्गत किसानों को फलदार पौधे वितरित

राज एक्सप्रेस

गाजरघास से मुक्त भारत के लिए जागरुकता जरूरी : डॉ. सिंह

पीपुल्स समाचार

खाद्यान्न उत्पादन बढ़ाने मृदा स्वास्थ्य का ध्यान रखना आवश्यक : डॉ. मिश्र

खरपतवार अनुसंधान निदेशालय में विश्व मृदा दिवस पर बोले निदेशक

जबलपुर एक्सप्रेस

किसान मृदा की उर्वरक शक्ति बढ़ायें : डॉ.मिश्र

खरपतवार अनुसंधान केन्द्र में विश्व मृदा दिवस का आयोजन

पीपुल्स समाचार

स्वच्छता से ही स्वस्थ समाज का निर्माण

दैनिक भास्कर

अभी मास्क ही वैक्सीन है

हरिभूमि

जलीय खरपतवारों का नियंत्रण स्वच्छता के लिये अति आवश्यक : डॉ. जेएस मिश्र

दैनिक जबलपुर दर्पण

कृषकों की प्राथमिकता सर्वोपरि : डॉ जे.एस.मिश्र

प्रदेश टुडे

खरपतवार अनुसंधान निदेशालय में कृषक वेबिनार का आयोजन

फसल उत्पादन बढ़ाने खरपतवार मैनेजमेंट जरूरी: डॉ. मिश्र

खरपतवार प्रबन्धन आवश्यक : डॉ. मिश्र

एक तिहाई फसल कट कर जाती है खरपतवार

खरपतवार अनुसंधान निदेशालय के प्रशिक्षण सह कृषक आवास का अनावरण

2050 तक जनसंख्या 160 करोड़ होने का अनुमान: तोमर

राज एक्सप्रेस

कृषि अनुसंधान प्रौद्योगिकियों के उपयोग से देश में आया महत्वपूर्ण बदलाव : तोमर

पीपुल्स समाचार

स्वच्छता के लिए जन भागीदारी जरूरी : मिश्र

खरपतवार अनुसंधान निदेशालय में स्वच्छता पखवाड़ा का समापन

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आधुनिक तकनीकों के माध्यम से जल संरक्षण जरूरी : मिश्र

जबलपुर एक्सप्रेस

आधुनिक तकनीकों के माध्यम से जल संरक्षण जरूरी: डॉ.मिश्र

विश्व जल दिवस पर एक दिवसीय कार्यशाला

हरिभूमि

आधुनिक तकनीकों के माध्यम से जल संरक्षण जरूरी : डॉ. जेएस मिश्र

प्रदेश टुडे

आधुनिक तकनीकों के माध्यम से जल संरक्षण जरूरी : डॉ. मिश्र

विश्व जल दिवस पर एक दिवसीय कार्यशाला का आयोजन

अग्निबाण

आधुनिक तकनीकों के माध्यम से जल संरक्षण जरू

विश्व जल दिवस पर एक दिवसीय कार्यशाला का आयोजन

पीपुल्स समाचार

भ्रष्टाचार उन्मूलन के लिए ईमानदार जीवन शैली अपनाना आवश्यक : डॉ सिंह

सतर्कता जागरूकता सप्ताह में बोले खरपतवार के निदेशक

हरिभूमि

भ्रष्टाचार उन्मूलन हेतु ईमानदार जीवन शैली अपनाना आवश्यक : डॉ. सिंह

राज एक्सप्रेस

भ्रष्टाचार उन्मूलन के लिए ईमानदार जीवन शैली अपनाना आवश्यक : डॉ. सिंह

दैनिक भास्कर

अपना कार्य ईमानदारी से करें

अग्निबाण

ईमानदारी को जीवन शैली के रूप में अपनाएं: डॉ पीके सिंह

राज एक्सप्रेस

नए निदेशक पद पर कार्यभार ग्रहण किया

पीपुल्स समाचार

अभी मास्क ही वैक्सीन है

दैनिक भास्कर

हिन्दी में है सभी भाषाओं को समाहित करने की शक्ति : पीके सिंह

हरिभूमि

महात्मा गांधी सादा जीवन उच्च विचारों से बन गये सबके बापू : डॉ. पीके सिंह

उच्च विचारों से गांधी बापू बन गए

प्रदेश टुडे

हमें एक दूसरे से जोड़ती है भाषा

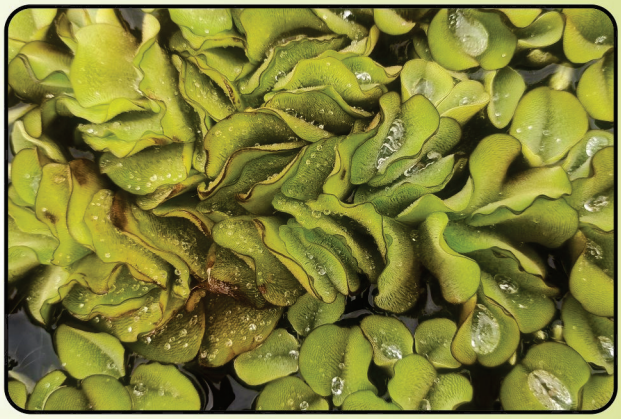
खरपतवार विज्ञान अनुसंधान निदेशालय में मनाया गया हिन्दी पखवाड़ा समारोह

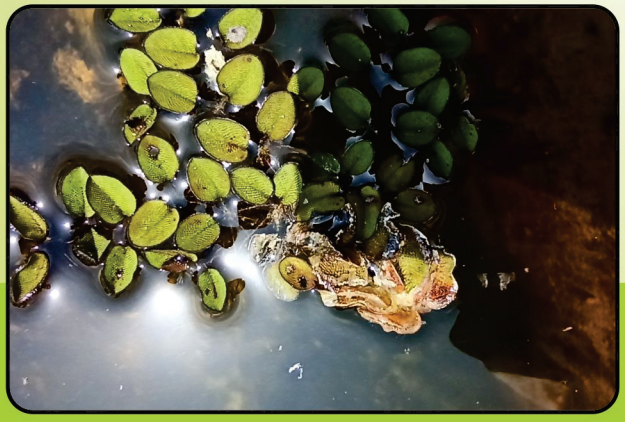
हरिभूमि

कार्यक्षमता में सकारात्मक वृद्धि के लिए तनाव मुक्त होना आवश्यक : डॉ. सिंह

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch





***Salvinia molesta* - Gradual invasion in a water body**

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