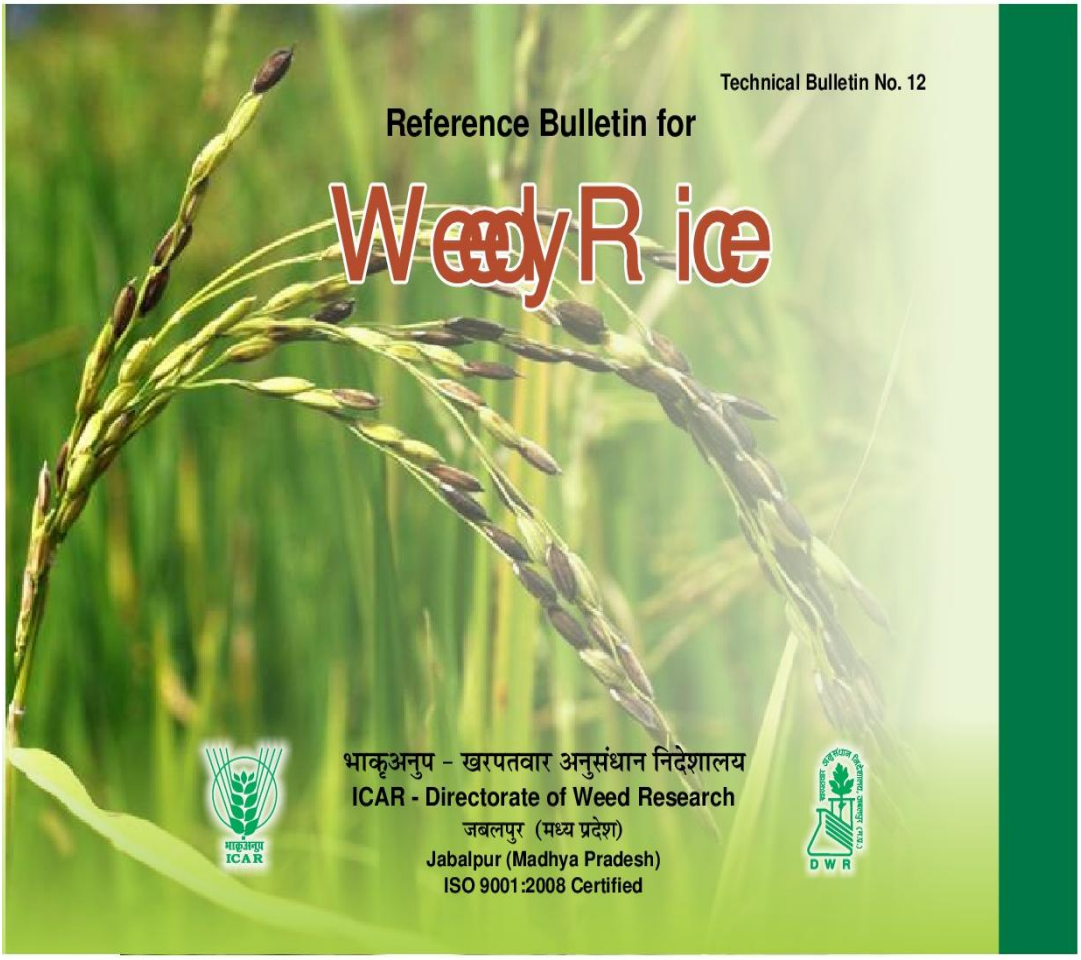
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ICAR - Directorate of Weed Research
जबलपुर (मध्य प्रदेश)
Jabalpur (Madhya Pradesh)
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Reference Bulletin for

# Weedy Rice

भाकृअनुप – खरपतवार अनुसंधान निदेशालय
ICAR - Directorate of Weed Research
जबलपुर (मध्य प्रदेश)
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**Compiled and edited by:**
Meenal Rathore
Raghwendra Singh
Bhumesh Kumar

**Technical assistance:**
Sandeep Dhagat

**Published by:**
Director
ICAR-Directorate of Weed Research
Jabalpur 482004 (M.P.)
Phone : 0761-2353934, 2353101
Fax : 0761-2353129
Email : dirdwsr@icar.org.in
Website : http://www.dwr.org.in

# Foreword

Weeds, a major contributor to losses in crop productivity due to biotic stresses, are actually responsible for more than 30% of the loss. Despite development of improved weed management technologies and their adoption on large areas, weed problems remain and the challenge to manage them becomes more complex with changing climatic conditions. Weedy rice is emerging as a serious threat to rice cultivation, particularly in areas where direct-seeding of rice is practiced and where water accumulates during rainy season. This weed is a menace in specific situations of lowland areas of central, eastern and southern India, and has forced farmers to abandon rice cultivation in such regions.

Weedy rice is presumed to originate by natural hybridization between cultivated and wild rice, and hence the plants are different from wild rice. Large variations are observed amongst the morphotypes of weedy rice in growth habit and height; leaf size, shape and colour; grain attributes, shattering and maturity. These plants not only affect crop yield but also reduce grain quality rendering it unsuitable for marketing. Weedy rice can be distinguished from cultivated or wild rice only after flowering. As both the rice types belong to the same genus and species i.e. *Oryza sativa*, no available selective herbicide can distinguish between them. These facts make management of weedy rice a difficult task.

Characterization of weedy rices for morphological, physiological and phenological parameters is essential for developing a strategy for their integrated control through preventive, cultural, mechanical and chemical means. A large number of weedy rice biotypes are found in rice-growing regions all over the country but there is no systematic information available about them. An initiative was taken in this regard in 2011 and more than 100 weedy rice biotypes were collected from all over the country. These were grown in isolated plots at the Directorate's research farm over the last 4 years and characterized for 21 different parameters.

This manual contains information on 53 morphotypes of weedy rice including 40 from Madhya Pradesh along with picture of the panicle for easy identification. I am hopeful that this information will be useful to researchers, extension workers and farmers for identification of weedy rice and undertaking control measures suited to the local conditions. Comments on this bulletin and suggestions for undertaking research on management of weedy rice biotypes are welcome.

30 June, 2016

**A.R. Sharma**
Director

# Preface

Weedy rice, a menace in rice growing areas globally, is biosimilar having attributes similar to cultivated and wild rice, and therefore is difficult to identify at initial stages. Variations existing in weedy rice population are a major reason for its wider adaptability to varied environmental conditions and also a problem in its management. Weedy rice, evolved largely by natural hybridization between wild and cultivated rice, has became an emerging threat to rice cultivation as it affects crop production, harvest quality and thereby farmers' income. With diverse biotypes, this conspecific weed has already infested large rice growing areas across the globe. As no selective herbicide is available for control of weedy rice, various preventive and cultural practices are being used to manage it. However, an integrated approach is essential to manage weedy rice as the problem is yet to aggravate with changing climatic conditions.

With a shift to direct seeding of rice and increasing infestation of weedy rice, the weedy rice has emerged as a potential threat to rice cultivation in India as well. In the context of climate regime the problem is bound to aggravate. Hence, it would not be wrong to say that weedy rice demands immediate attention from scientists in different fields to work on its biologoy and management strategies.

Since last five years, Directorate has made efforts in characterizing different biotypes of weedy rice collected from different places. Information gathered on different biotypes have been compiled in this document which can serve as a ready-reference for different stakeholders.

Editors acknowledge the help received from staff of DWR and different AICRP-WM centres especially Gwalior, Faizabad, Pusa, Ranchi, Sriniketan, Raipur, and Coimbatore. Critical help received from Dr. C.T. Abraham and his team from Thrissur centre is fully acknowledged.

**30 June, 2016** **Editors**

# Contents

# 1. *Introduction*

Rice is a major staple food crop of India cultivated widely under varying climatic conditions and altitude. Rice is grown in upland/dry/semidry soil by either direct dry seeding (broadcasting the seed or seeding behind the plough) or direct wet-seeded (in wet/lowland soil by broadcasting sprouted seedlings) or transplanting in puddled fields. Recent increase in labor costs and water scarcity has caused a shift from puddle transplanting to direct seeding. As a result, weed infestation has enhanced with simultaneous increase in herbicide use for managing these weeds. However, as the herbicides cannot manage weedy rice, it has emerged as a serious threat in direct seeded rice (DSR).

Agronomic and ecological conditions under DSR are favourable to weedy rice and with no selective herbicide or effective control measure available to manage it, the nonspecific biosimilar weed is flourishing.

Transplanting of rice

Direct seeding of rice in puddled conditions



## Major attributes of weedy rice

- Early panicle initiation & maturity
- Asynchronous maturity
- High seed shattering
- Seed dormancy
- Diversity in phenotye and genotype
- Vigorous nature & competitive capability

Majority of weedy rice share traits with both cultivated and wild rice.

## Grains of weedy rice

- May or may not bear awns varying in length and colour.
- Vary in hull color, grain size and pericarp colour.


a


b


c


d


e

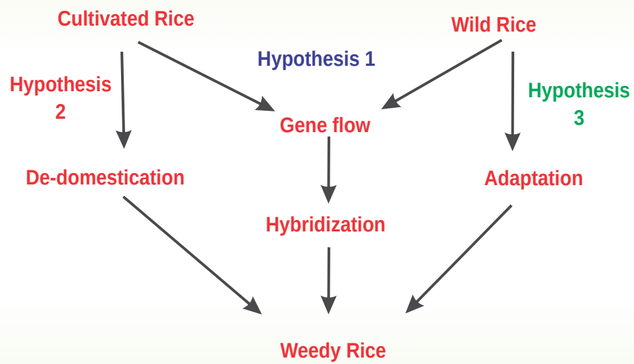

f

Variations among weedy rice morphotypes in plant height and tiller number (a,b,c), asynchronous maturity in panicles (d), grain shattering (e), and increasing weed seed bank in soil (f).



## The origin of weedy rice

There are three hypotheses for origin of weedy rice:




Of the three,

- The first hypothesis of natural hybridization between cultivated and wild rice is largely accepted.
- There is also possibility of evolution of weedy rice during development of hybrid rice.
- However, a single route of origin of weedy rice cannot be established and it may vary with geographical boundaries.

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 91.27 |
| Tiller number | 34.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.68 |
| SPAD meter value | 42.12 |
| Tl-Ta ($^0$C) | -1.20 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 9.91 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 75.27 |
| DT50PE | 77.80 |
| Flag leaf length (cm) | 21.54 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 16.12 |
| Grains per panicle | 82.93 |
| Grain lb ratio | 2.34 |
| 100 grain weight (g) | 2.69 |
| Awn length (cm) | 4.50 |
| Germination (%) under flooding (15 cm) | 23.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 102.47 |
| Tiller number | 34.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.60 |
| SPAD meter value | 37.31 |
| Tl-Ta ($^0$C) | -1.80 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 6.17 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 80.26 |
| DT50PE | 87.80 |
| Flag leaf length (cm) | 29.47 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 26.18 |
| Grains per panicle | 61.26 |
| Grain lb ratio | 2.01 |
| 100 - grain weight (g) | 2.27 |
| Awn length (cm) | 3.20 |
| Germination (%) under flooding (15 cm) | 3.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 99.37 |
| Tiller number | 28.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.85 |
| SPAD meter value | 37.32 |
| Tl-Ta ($^0$C) | -1.59 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 6.10 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.056 |
| DTPE | 77.26 |
| DT50PE | 80.80 |
| Flag leaf length (cm) | 41.84 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 25.08 |
| Grains per panicle | 86.93 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 2.23 |
| Awn length (cm) | 4.00 |
| Germination (%) under flooding (15 cm) | 0.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 86.775 |
| Tiller number | 48.03 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.09 |
| SPAD meter value | 36.91 |
| Tl-Ta ($^0$C) | -1.82 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.88 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 75.26 |
| DT50PE | 77.80 |
| Flag leaf length (cm) | 32.10 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 21.72 |
| Grains per panicle | 104.59 |
| Grain lb ratio | 3.01 |
| 100 grain weight (g) | 2.47 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 10.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 75.57 |
| Tiller number | 48.03 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.10 |
| SPAD meter value | 37.31 |
| Tl-Ta ($^0$C) | -1.68 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 6.65 |
| Conductance (mol $H_2O$ m-2 $s^{-1}$) | 0.05 |
| DTPE | 87.26 |
| DT50PE | 87.80 |
| Flag leaf length (cm) | 44.29 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 26.92 |
| Grains per panicle | 67.93242 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.12 |
| Awn length (cm) | 2.80 |
| Germination (%) under flooding (15 cm) | 20.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 95.07 |
| Tiller number | 39.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.28 |
| SPAD meter value | 34.31 |
| Tl-Ta ($^0$C) | -1.97 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 10.67 |
| Conductance (mol $H^2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 65.26 |
| DT50PE | 68.80 |
| Flag leaf length (cm) | 27.41 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 24.78 |
| Grains per panicle | 62.26 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.44 |
| Awn length (cm) | 2.60 |
| Germination (%) under flooding (15 cm) | 13.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 88.87 |
| Tiller number | 41.33 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.37 |
| SPAD meter value | 36.91 |
| Tl-Ta ($^0$C) | -2.09 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.69 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 75.26 |
| DT50PE | 80.80 |
| Flag leaf length (cm) | 27.60 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 20.32 |
| Grains per panicle | 62.93 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 2.66 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 3.00 |



## Morphotype collected from DWR farm, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 103.47 |
| Tiller number | 33.83 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.89 |
| SPAD meter value | 37.21 |
| Tl-Ta ($^0$C) | -1.43 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 6.87 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.056 |
| DTPE | 90.26 |
| DT50PE | 92.8 |
| Flag leaf length (cm) | 38.44 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 26.87 |
| Grains per panicle | 100.59 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.81 |
| Awn length (cm) | 4.50 |
| Germination (%) under flooding (15 cm) | 17.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 112.87 |
| Tiller number | 37.33 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 4.14 |
| SPAD meter value | 36.71 |
| Tl-Ta ($^0$C) | -2.35 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 14.01 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.08 |
| DTPE | 80.26 |
| DT50PE | 84.80 |
| Flag leaf length (cm) | 38.09 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 25.47 |
| Grains per panicle | 147.93 |
| Grain lb ratio | 2.26 |
| 100 - grain weight (g) | 2.82 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 20.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 95.37 |
| Tiller number | 29.83 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.75 |
| SPAD meter value | 40.11 |
| Tl-Ta ($^0$C) | -1.36 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.00 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 92.26 |
| DT50PE | 97.80 |
| Flag leaf length (cm) | 30.59 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 25.68 |
| Grains per panicle | 333.26 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.56 |
| Awn length (cm) | 5.40 |
| Germination (%) under flooding (15 cm) | 3.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | purple |
| Collar colour | purple |
| Auricle colour | light purple |
| Ligule shape | 2-cleft |
| Plant height (cm) | 78.97 |
| Tiller number | 34.33 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.69 |
| SPAD meter value | 37.51 |
| Tl-Ta ($^0$C) | -2.59 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.43 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.066 |
| DTPE | 68.26 |
| DT50PE | 75.80 |
| Flag leaf length (cm) | 40.4401 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 27.08 |
| Grains per panicle | 127.26 |
| Grain lb ratio | 4.01 |
| 100 - grain weight (g) | 2.00 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 3.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 87.27 |
| Tiller number | 19.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.57 |
| SPAD meter value | 40.81 |
| Tl-Ta ($^0$C) | -2.15 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.92 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.066 |
| DTPE | 87.26 |
| DT50PE | 97.8 |
| Flag leaf length (cm) | 45.37 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 28.82 |
| Grains per panicle | 279.26 |
| Grain lb ratio | 4.01 |
| 100 - grain weight (g) | 2.12 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 0.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 78.07 |
| Tiller number | 12.33 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.96 |
| SPAD meter value | 46.21 |
| Tl-Ta ($^0$C) | -2.89 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 13.05 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.077 |
| DTPE | 54.27 |
| DT50PE | 59.80 |
| Flag leaf length (cm) | 29.67 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 22.98 |
| Grains per panicle | 56.26 |
| Grain lb ratio | 3.01 |
| 100 - grain weight (g) | 2.53 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 27.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 89.87 |
| Tiller number | 42.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.42 |
| SPAD meter value | 37.11 |
| Tl-Ta ($^0$C) | -2.30 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.47 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 65.26 |
| DT50PE | 68.80 |
| Flag leaf length (cm) | 0.84 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 23.35 |
| Grains per panicle | 137.26 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 2.57 |
| Awn length (cm) | 5.00 |
| Germination (%) under flooding (15 cm) | 3.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 78.07 |
| Tiller number | 12.33 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.96 |
| SPAD meter value | 46.21 |
| Tl-Ta ($^0$C) | -2.89 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 13.05 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.077 |
| DTPE | 54.27 |
| DT50PE | 59.80 |
| Flag leaf length (cm) | 29.67 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 22.98 |
| Grains per panicle | 56.26 |
| Grain lb ratio | 3.01 |
| 100 - grain weight (g) | 2.53 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 27.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | purple |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 85.87 |
| Tiller number | 47.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.28 |
| SPAD meter value | 34.71 |
| Tl-Ta ($^0$C) | -2.01 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.41 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 77.26 |
| DT50PE | 80.80 |
| Flag leaf length (cm) | 35.50 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 27.58 |
| Grains per panicle | 60.93 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 1.99 |
| Awn length (cm) | 6.20 |
| Germination (%) under flooding (15 cm) | 7.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | pinkish |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 93.07 |
| Tiller number | 29.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.26 |
| SPAD meter value | 38.21 |
| Tl-Ta ($^0$C) | -1.87 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 4.23 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.04 |
| DTPE | 65.26 |
| DT50PE | 68.80 |
| Flag leaf length (cm) | 27.94 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 19.42 |
| Grains per panicle | 62.59 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 2.41 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 10.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 88.67 |
| Tiller number | 23.03 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.58 |
| SPAD meter value | 39.91 |
| Tl-Ta ($^0$C) | -1.37 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.63 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 85.26 |
| DT50PE | 92.80 |
| Flag leaf length (cm) | 21.50 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 20.22 |
| Grains per panicle | 76.59 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 2.19 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 0.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 105.67 |
| Tiller number | 20.83 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.49 |
| SPAD meter value | 40.91 |
| Tl-Ta ($^0$C) | -1.50 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.19 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 87.26 |
| DT50PE | 87.80 |
| Flag leaf length (cm) | 30.44 |
| Flag leaf attitude | Horizontal |
| Panicle length (cm) | 30.47 |
| Grains per panicle | 163.59 |
| Grain lb ratio | 3.34 |
| 100 - grain weight (g) | 2.35 |
| Awn length (cm) | 6.40 |
| Germination (%) under flooding (15 cm) | 17.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 102.97 |
| Tiller number | 39.63 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.47 |
| SPAD meter value | 41.51 |
| Tl-Ta ($^0$C) | -1.36 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.08 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 85.26 |
| DT50PE | 68.80 |
| Flag leaf length (cm) | 29.61 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 25.79 |
| Grains per panicle | 263.26 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.02 |
| Awn length (cm) | 3.80 |
| Germination (%) under flooding (15 cm) | 30.00 |

## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 95.79 |
| Tiller number | 26.87 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.61 |
| SPAD meter value | 42.60 |
| Tl-Ta ($^0$C) | -1.57 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.13 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 69.76 |
| DT50PE | 78.3 |
| Flag leaf length (cm) | 35.37 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 23.99 |
| Grains per panicle | 144.83 |
| Grain lb ratio | 2.17 |
| 100 - grain weight (g) | 2.14 |
| Awn length (cm) | 5.30 |
| Germination (%) under flooding (15 cm) | 0.00 |



## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 90.29 |
| Tiller number | 25.77 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.50 |
| SPAD meter value | 39.30 |
| Tl-Ta ($^0$C) | -1.77 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.57 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 86.76 |
| DT50PE | 88.30 |
| Flag leaf length (cm) | 32.74 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 25.79 |
| Grains per panicle | 96.83 |
| Grain lb ratio | 2.17 |
| 100 - grain weight (g) | 2.31 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 7.00 |

## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh.

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 87.99 |
| Tiller number | 24.57 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.32 |
| SPAD meter value | 44.60 |
| Tl-Ta ($^0$C) | -2.08 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 9.57 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.057 |
| DTPE | 78.76 |
| DT50PE | 88.30 |
| Flag leaf length (cm) | 29.84 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 28.54 |
| Grains per panicle | 117.83 |
| Grain lb ratio | 4.84 |
| 100 - grain weight (g) | 1.905 |
| Awn length (cm) | 1.40 |
| Germination (%) under flooding (15 cm) | 10.00 |



## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 85.79 |
| Tiller number | 22.57 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.54 |
| SPAD meter value | 41.50 |
| Tl-Ta ($^0$C) | -2.90 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 14.27 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.08 |
| DTPE | 78.76 |
| DT50PE | 88.30 |
| Flag leaf length (cm) | 34.29 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 22.99 |
| Grains per panicle | 114.49 |
| Grain lb ratio | 2.17 |
| 100 - grain weight (g) | 1.97 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 3.00 |

## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh.

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 75.89 |
| Tiller number | 26.27 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.67 |
| SPAD meter value | 41.80 |
| Tl-Ta ($^0$C) | -2.37 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 11.04 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 60.76 |
| DT50PE | 69.3 |
| Flag leaf length (cm) | 28.09 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 22.89 |
| Grains per panicle | 108.83 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.67 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 17.00 |



## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | purple |
| Collar colour | purple |
| Auricle colour | purple |
| Ligule shape | 2-cleft |
| Plant height (cm) | 85.49 |
| Tiller number | 30.37 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.98 |
| SPAD meter value | 42.70 |
| Tl-Ta ($^0$C) | -2.88 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 13.37 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 88.76 |
| DT50PE | 93.30 |
| Flag leaf length (cm) | 34.54 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 27.69 |
| Grains per panicle | 271.49 |
| Grain lb ratio | 4.34 |
| 100 - grain weight (g) | 2.66 |
| Awn length (cm) | 3.00 |
| Germination (%) under flooding (15 cm) | 17.00 |

**Morphotype collected from Mehgawan village, Jabalpur, Madhya Pradesh.**

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 93.59 |
| Tiller number | 28.87 |
| Transpiration (mMol $H^2O$ $m^{-2}$ $s^{-1}$) | 2.77 |
| SPAD meter value | 37.20 |
| Tl-Ta ($^0C$) | -2.26 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 9.67 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 69.76 |
| DT50PE | 76.3 |
| Flag leaf length (cm) | 33.34 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 27.62 |
| Grains per panicle | 146.83 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.92 |
| Awn length (cm) | 6.90 |
| Germination (%) under flooding (15 cm) | 0.00 |



**Morphotype collected from Mehgawan village, Jabalpur, Madhya Pradesh.**

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 79.49 |
| Tiller number | 32.87 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.44 |
| SPAD meter value | 39.50 |
| Tl-Ta ($^0C$) | -2.6 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 9.07 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.057 |
| DTPE | 88.76 |
| DT50PE | 93.30 |
| Flag leaf length (cm) | 32.47 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 23.36 |
| Grains per panicle | 142.49 |
| Grain lb ratio | 1.84 |
| 100 - grain weight (g) | 2.47 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 17.00 |

## Morphotype collected from Mehgawan village, Jabalpur, Madhya Pradesh.

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 88.99 |
| Tiller number | 30.27 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.81 |
| SPAD meter value | 45.20 |
| Tl-Ta ($^0$C) | -2.20 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 13.07 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.067 |
| DTPE | 55.76 |
| DT50PE | 63.30 |
| Flag leaf length (cm) | 23.00 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 21.76 |
| Grains per panicle | 81.83 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.69 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 10.00 |



## Morphotype collected from Barahat Village, Bhind, Gwalior, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 69.49 |
| Tiller number | 52.07 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.67 |
| SPAD meter value | 42.20 |
| Tl-Ta ($^0$C) | -2.18 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 11.97 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.07 |
| DTPE | 88.76 |
| DT50PE | 93.30 |
| Flag leaf length (cm) | 29.94 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 17.86 |
| Grains per panicle | 134.16 |
| Grain lb ratio | 2.17 |
| 100 - grain weight (g) | 1.80 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 3.00 |

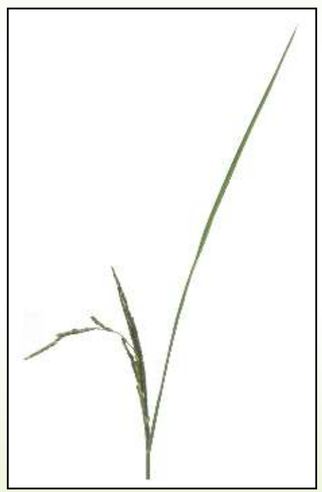
## Morphotype collected from Rithwara village, Muraina, Gwalior, Madhya Pradesh

| | |
|---|---|
| Culm colour | pink at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 118.19 |
| Tiller number | 24.17 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.57 |
| SPAD meter value | 42.10 |
| Tl-Ta ($^0$C) | -2.45 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 14.71 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.07 |
| DTPE | 55.76 |
| DT50PE | 76.30 |
| Flag leaf length (cm) | 38.29 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 27.46 |
| Grains per panicle | 268.49 |
| Grain lb ratio | 2.84 |
| 100 - grain weight (g) | 2.50 |
| Awn length (cm) | 2.80 |
| Germination (%) under flooding (15 cm) | 7.00 |



## Morphotype collected from Malanpur village, Bhind, Gwalior, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 112.49 |
| Tiller number | 44.27 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.86 |
| SPAD meter value | 39.00 |
| Tl-Ta ($^0$C) | -2.20 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 10.27 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 85.76 |
| DT50PE | 88.30 |
| Flag leaf length (cm) | 38.31 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 23.69 |
| Grains per panicle | 231.49 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.62 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 3.00 |



## Morphotype collected from Bhitarwar village, Gwalior, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 98.09 |
| Tiller number | 26.87 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 4.15 |
| SPAD meter value | 44.40 |
| Tl-Ta ($^0$C) | -3.16 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 15.77 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.08 |
| DTPE | 88.76 |
| DT50PE | 93.30 |
| Flag leaf length (cm) | 45.06 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 28.82 |
| Grains per panicle | 98.49 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.42 |
| Awn length (cm) | 4.90 |
| Germination (%) under flooding (15 cm) | 0.00 |



## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 103.78 |
| Tiller number | 48.08 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.87 |
| SPAD meter value | 41.49 |
| Tl-Ta ($^0$C) | -2.24 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 16.89 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 54.26 |
| DT50PE | 62.80 |
| Flag leaf length (cm) | 33.20 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 25.15 |
| Grains per panicle | 97.00 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.10 |
| Awn length (cm) | 4.70 |
| Germination (%) under flooding (15 cm) | 7.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 94.00 |
| Tiller number | 39.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.52 |
| SPAD meter value | 36.90 |
| Tl-Ta ($^0$C) | -1.28 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.25 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.056 |
| DTPE | 65.00 |
| DT50PE | 76.00 |
| Flag leaf length (cm) | 24.57 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 24.98 |
| Grains per panicle | 175.00 |
| Grain lb ratio | 5.02 |
| 100 - grain weight (g) | 2.58 |
| Awn length (cm) | 4.70 |
| Germination (%) under flooding (15 cm) | 33.00 |



## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 84.00 |
| Tiller number | 28.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.91 |
| SPAD meter value | 40.70 |
| Tl-Ta ($^0$C) | -1.72 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 10.77 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 64.00 |
| DT50PE | 70.00 |
| Flag leaf length (cm) | 28.84 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 26.26 |
| Grains per panicle | 154.00 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (g) | 2.15 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 6.70 |

## Morphotype collected from Mehgawan village,Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 83.29 |
| Tiller no | 46.27 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.96 |
| SPAD meter value | 41.40 |
| Tl-Ta ($^0$C) | -2.06 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 11.37 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.068 |
| DTPE | 69.77 |
| DT50PE | 76.30 |
| Flag leaf length (cm) | 32.89 |
| Flag leaf attitude | erect |
| Panicle length (cm) | 23.53 |
| Grains per panicle | 156.50 |
| Grain lb ratio | 2.51 |
| 100 - grain weight (gm) | 2.70 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 10.00 |



## Morphotype collected from Gwalior in Madhya Pradesh

| | |
|---|---|
| Culm colour | Pink at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 119.9 |
| Tiller number | 25.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.45 |
| SPAD meter value | 35.50 |
| Tl-Ta ($^0$C) | -2.67 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 14.37 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.07 |
| DTPE | 77.00 |
| DT50PE | 81.00 |
| Flag leaf length (cm) | 42.60 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 24.99 |
| Grains per panicle | 171.40 |
| Grain lb ratio | 2.84 |
| 100 - grain weight (g) | 2.52 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 17.00 |

## Morphotype collected from DWR, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 75.88 |
| Tiller number | 67.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.11 |
| SPAD meter value | 41.59 |
| Tl-Ta ($^0C$) | -2.43 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 16.59 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.07 |
| DTPE | 68.00 |
| DT50PE | 88.00 |
| Flag leaf length (cm) | 26.27 |
| Flag leaf attitude | Semi-erect |
| Panicle length (cm) | 20.61 |
| Grains per panicle | 87.00 |
| Grain lb ratio | 2.34 |
| 100 - grain weight (g) | 1.88 |
| Awn length (cm) | 5.50 |
| Germination (%) under flooding (15 cm) | 13.00 |



## Morphotype collected from Panagar village, Jabalpur, Madhya Pradesh

| | |
|---|---|
| Culm colour | Purple at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 116.28 |
| Tiller number | 35.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.41 |
| SPAD meter value | 36.89 |
| Tl-Ta ($^0C$) | -2.71 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 11.59 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.07 |
| DTPE | 79.00 |
| DT50PE | 81.00 |
| Flag leaf length (cm) | 36.34 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 21.95 |
| Grains per panicle | 84.00 |
| Grain lb ratio | 2.67 |
| 100 - grain weight (g) | 2.73 |
| Awn length (cm) | 5.00 |
| Germination (%) under flooding (15 cm) | 3.00 |

## Morphotype collected from Chandauli, Uttar Pradesh

| | |
|---|---|
| Culm colour | purple |
| Collar colour | light purple |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 85.25 |
| Tiller number | 36.01 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.09 |
| SPAD meter value | 35.29 |
| Tl-Ta ($^0$C) | -2.59 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 8.56 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.055 |
| DTPE | 92.97 |
| DT50PE | 97.9 |
| Flag leaf length (cm) | 35.15 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 24.53 |
| Grains per panicle | 252.20 |
| Grain lb ratio | 2.46 |
| 100 - grain weight (g) | 1.64 |
| Awn length (cm) | 0.00 |
| Germination (%) under flooding (15 cm) | 23.00 |



## Morphotype collected from Katra, Kanpur, Uttar Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 126.25 |
| Tiller number | 42.01 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.82 |
| SPAD meter value | 32.29 |
| Tl-Ta ($^0$C) | -2.20 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 11.84 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.065 |
| DTPE | 80.97 |
| DT50PE | 87.90 |
| Flag leaf length (cm) | 51.17 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 28.49 |
| Grains per panicle | 145.19 |
| Grain lb ratio | 2.80 |
| 100 - grain weight (g) | 2.29 |
| Awn length (cm) | 3.40 |
| Germination (%) under flooding (15 cm) | 20.00 |

## Morphotype collected from Faizabad, Uttar Pradesh

| | |
|---|---|
| Culm colour | Purple at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 77.24 |
| Tiller number | 50.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 3.24 |
| SPAD meter value | 33.28 |
| Tl-Ta ($^0$C) | -2.55 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 7.50 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.06 |
| DTPE | 85.00 |
| DT50PE | 88.00 |
| Flag leaf length (cm) | 29.40 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 26.36 |
| Grains per panicle | 99.00 |
| Grain lb ratio | 2.79 |
| 100 - grain weight (g) | 2.31 |
| Awn length (cm) | 4.80 |
| Germination (%) under flooding (15 cm) | 10.00 |



## Morphotype collected from Ballia, Uttar Pradesh

| | |
|---|---|
| Culm colour | green |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 101.24 |
| Tiller number | 38.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 2.84 |
| SPAD meter value | 34.28 |
| Tl-Ta ($^0$C) | -2.46 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 9.10 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.05 |
| DTPE | 86.00 |
| DT50PE | 88.00 |
| Flag leaf length (cm) | 33.11 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 23.67 |
| Grains per panicle | 172.2 |
| Grain lb ratio | 2.79 |
| 100 - grain weight (g) | 1.88 |
| Awn length (cm) | 3.00 |
| Germination (%) under flooding (15 cm) | 10.00 |

**Morphotype collected from Kanpur, Uttar Pradesh**

| | |
|---|---|
| Culm colour | Purple at base |
| Collar colour | white |
| Auricle colour | white |
| Ligule shape | 2-cleft |
| Plant height (cm) | 122.25 |
| Tiller number | 33.00 |
| Transpiration (mMol $H_2O$ $m^{-2}$ $s^{-1}$) | 4.43 |
| SPAD meter value | 36.28 |
| Tl-Ta ($^0C$) | -2.57 |
| Photosynthetic rate (µmole $CO_2$ $m^{-2}$ leaf area $s^{-1}$) | 13.18 |
| Conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | 0.08 |
| DTPE | 88.00 |
| DT50PE | 93.00 |
| Flag leaf length (cm) | 43.97 |
| Flag leaf attitude | Erect |
| Panicle length (cm) | 25.96 |
| Grains per panicle | 244.53 |
| Grain lb ratio | 2.46 |
| 100 - grain weight (g) | 2.42 |
| Awn length (cm) | 3.80 |
| Germination(%) under flooding (15 cm) | 33.30 |



# 4. *Research accomplishments*

- One hundred and one weedy rice morphotypes have been maintained at the Directorate as pure lines.
- Studies on morphological, physiological and phenological parameters reveal that Indian weedy rice is not necessarily taller than cultivated rice, dwarf morphotypes are also available.
- Diversity in panicles have been recorded in weedy rice morphotypes.

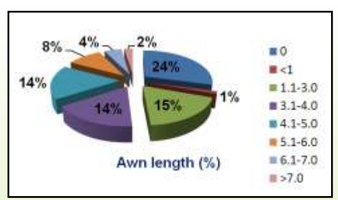
Panicle diversity

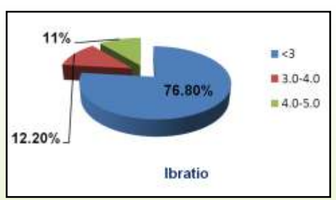


- Diversity analysis based on 17 functional traits reveals that difference in duration (days) from panicle emergence to heading is the most variable trait and awn length is the least variable trait.
- It also reveals that Indian weedy rice has phenotypic and seed mimicry with cultivated rice. Chronological mimicry is absent as weedy rice panicles emerge and mature asynchronously and earlier than cultivated rice.
- Indian weedy rice groups up neither based on agro climatic zones nor geographic regions.
- Diversity analysis based on molecular fingerprinting validates Indian weedy rice to be a hybrid of cultivated and wild rices. It also validates occurrence of independently originated morphotypes i.e. that cluster up with neither cultivated rice nor wild rice.

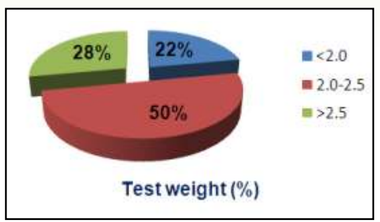
**Early maturity of weedy rice**

- Majority of the weedy rice seeds are awned. Amongst 82 morphotypes studied, 76% had awns though varying in length.
- Majority of morphotypes (76.8%) had grain length - breadth ratio below 3.0 while only 1% had it between 4 - 5.



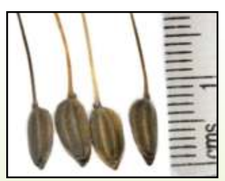



- Hundred seed weight was broadly demarcated into a range of 2.-2.5 wherein 50% morphotypes fell. The remaining 50% had a 100 seed weight <2.0 (22%) and >2.5 (28%).



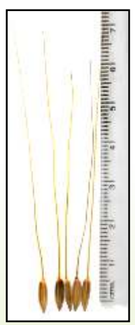

- Weedy rice from India have different hull colour- wheatish, brown and blackish.

Wheatish hull



Blackish hull

Brownish hull



Wheatish hull with awns



- Weedy rice from Central India have a red-brown pericarp, but some also have a white pericarp.
- Indian weedy rice has ability to germinate under stringent anaerobic conditions. This germination ability decreases with increasing seed burial depths and increasing standing water heights.
- Elevated atmospheric $CO_2$ levels significantly affect dry weight of shoot and root, root volume, plant fresh weight, total leaf area, tiller number and SPAD of cultivated rice and weedy rice.
- GxE Interaction studies reveal significant effects of enhanced $CO_2$ levels on root volume and dry weight of root in weedy rice morphotypes.
- Elevated temperature (T) and carbon dioxide (C) delayed panicle maturity in weedy rice morphotype evaluated.
- Dormancy studies of Indian weedy rice reveal significant variations amongst morphotypes from Jharkhand, Bihar, Kerala, Madhya Pradesh, West Bengal, Uttar Pradesh and Chhattisgarh. Some of the morphotypes reveal dormancy even after six months of sowing.

Germinating weedy rice under anaerobic conditions

Delayed maturity in panicles

Weedy rice infested crop

Purple coloured 'Shyamla' variety of cultivated rice

- Use of purple colored rice cultivars e.g. Nagkesar, Shyamla (as there are different in canopy coloured) at higher seed rates in weedy rice infested fields is an option to manage the menace.
- Different cultural methods evaluated for their ability to reduce weedy rice infestations reveal stale seed bed to be the most effective method.
- Another option is adoption of the cropping system rice - wheat - greengram during *kharif-rabi-zaid* as a line sown crop, wherever possible, to manage weedy rice. This will allow application of herbicides to mange weedy rice in a standing crop of greengram as herbicides will not affect the crop.



# 5. *Suggested reading*


***Articles:***

- Burgos NR, Norman RJ, Gealy DR and Black N. 2006. Competitive N uptake between rice and weedy rice. *Field Crop Research* 99: 96-105.
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- Varshney JG and Tiwari JP. 2008. Studies on weedy rice infestation and assessment of its impact on rice production. *Indian Journal of Weed Science* 40 (3 & 4):115-123.

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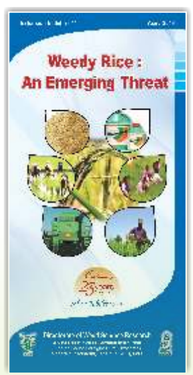
- Rathore Meenal, Singh Raghwendra and Kumar Bhumesh. 2015. Germination of Indian weedy rice under anaerobic conditions and varying seed burial depths In: Proceedings volume III of 25th APWSS Conference on 'Weed science for sustainable agriculture, environment and biodiversity' held at PJTSAU, Hyderabad during 13-16 October, 2015. P577
- Rathore Meenal, Singh Raghwendra, Kumar Bhumesh and Ghosh Dibakar. 2014. Germination of weedy rice under anaerobic conditions In: Biennial Conference of ISWS on 'Emerging Challenges in Weed management' held at, ICAR-DWR, Jabalpur (MP) India during 15-17 February, 2014.
- Mishra Abhishek, Tripathi Niraj, Kumar Bhumesh and Rathore Meenal. 2014. Assessment of molecular diversity of weedy rice using SSR markers In: National Seminar on technologies for Sustainable Production through climate resilient agriculture. 8-9 August. JNKVV, Jabalpur (MP) India.
- Rathore Meenal, Tripathi Niraj, Kumar Bhumesh and Singh Raghwendra. 2014. Variable response of weedy rice to elevated $CO_2$ increases threat to sustainable rice production In: Conference on Biotechnology for Sustainable agriculture. 8-9 September, JNKVV, Jabalpur (MP) India.
- Abraham CT, Jose Nimmy and Rathore Meenal. 2012. Current status of weedy rice in India and strategies for its management. In: Biennial Conference of Indian Society of Weed Science on “Weed threat to Agriculture, Biodiversity and Environment” April 19-20, Kerala Agricultural University, Thrissur, Kerala, India.

## Extension bulletins:

- Rathore Meenal and Singh P.K. 2014. Weedy rice: an emerging threat (Extension bulletin No 41) DWSR, Jabalpur.6 p.
- Rathore Meenal, Singh Raghwendra, Kumar Bhumesh, Ghosh Dibakar and Singh P.K. 2014. Kharpatvarik dhan : ek ubhartee samasya", (Extension bulletin No 43) DWSR, Jabalpur.6 p.




## Abbreviations

| | | |
|---|---|---|
| AICRP-WM | - | All India Coordinated Research Project on Weed Management |
| cm | - | centimetre |
| $CO_2$ | - | Carbon dioxide |
| DAS | - | Days after sowing |
| DSR | - | Direct Seeded Rice |
| DTPE | - | Days to panicle emergence |
| DT50PE | - | Days to 50% panicle emergence |
| DWR | - | Directorate of Weed Research |
| g | - | gram |
| GxE | - | Genotype x Environment |
| ICAR | - | Indian Council of Agriculture Research |
| m | - | metre |
| mMol | - | milliMol |
| s | - | second |
| Ta | - | air temperature |
| Tl | - | leaf surface temperature |
| USA | - | United States of America |
| $^0C$ | - | degree celcius |

## *About the authors*

**Dr. Meenal Rathore,** Sr. Scientist, Plant Biotechnology
**Specializations:**
Molecular diversity analysis, weed biology, weed dynamics under the regime of climate change.

**Dr. Raghwendra Singh,** Sr. Scientist, Agronomy
**Specializations:**
Integrated weed management, weed dynamics under the regime of climate change.

**Dr. Bhumesh Kumar,** Sr. Scientist, Plant Physiology
**Specializations:**
Weed dynamics and management under the regime of climate change, herbicide resistance and bio-prospection of weed species


भाकृअनुप - खरपतवार अनुसंधान निदेशालय
जबलपुर - 482004 (म.प्र.)

**ICAR - Directorate of Weed Research**
**Jabalpur - 482 004 (M.P.)**

**फोन / Phones: +91-761-2353001, 2353101, 2353138, 2353934, फैक्स / Fax: +91-761-2353129**
**ई-मेल / E-mail: dirdwsr@icar.org.in बेबसाइट / Website: http://www.dwr.org.in**