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**OVERVIEW**

Rice is an important food as well as cash crop of Pakistan. It occupies about 11% of total cultivated area in Pakistan. Rice is planted on about 7.03 million acres and produces about 6.90 million metric tons of milled rice. Pakistan is the 4$^{th}$ largest rice exporting country in the world after India, Vietnam and Thailand. About 0.676 million metric tons Basmati rice is exported to the Middle East countries, Europe and America, whereas, 3.045 million metric tons coarse rice is exported to different countries of Asia and Africa. During 2014- 15, Pakistan earned US$ 1.85 billion foreign exchange from the export of rice.

The Punjab is the biggest rice producer province of the country. In the province, during 2014-15, the total area under rice crop was 4.640 million acres and production was 3.648 million tones. Generally, the Punjab contributes 52% to the national production while provinces of Sindh, Baluchistan and KPK contribute 38%, 8% and 2%, respectively.

Two promising lines of basmati rice viz., PK 8892 and RRI 7 have been developed. Both lines yields 6.00 and 6.1 t/ ha with more than 7.60mm and 8.11mm average grain length and 15.1 and 17.5mm cooking quality, respectively.

## I. RICE BREEDING

**Promising lines with their salient characteristics**

❖ ***RRI 7***

This basmati line (Fig. 1) yields 6.1 t/ ha, short stature and early maturing with more than 8.11mm average grain length (AGL). The cooking quality (CGL) of this line is very good (17.5mm).

Fig. 1: RRI 7

❖ ***PK 8892-2-4-1-3-1***

This basmati line yields 6.0 t/ ha with more than 7.60mm AGL (Fig. 2). The cooking quality of this line is very good (15.1mm).

Fig. 2: PK 8892-2-4-1-3-1

❖ ***PK 8685-5-1-1-1-1***

This basmati line yields 5.9 t/ ha with more than 7.8mm AGL (Fig. 3). The cooking quality of this line is good (13.7mm).

Fig. 3: PK 8685-5-1-1-1-1

❖ ***PK 8431-2-1-2-4***

It is a high yielding basmati line having yield potential of 6.5 t/ha with more than 7.5mm AGL (Fig. 4). Cooking quality of this line is good (13.7mm). Due to its physicochemical properties; it is suitable for making white as well as parboiling rice.


Fig. 4: PK 8431-2-1-2-4

❖ ***KSK 462***

It is high yielding coarse grain line (Fig. 5) having yield of more than 8.00 t/ha. It's average grain length is 6.49mm with good cooking quality.

Fig. 5: KSK 462

- ❖ ***KSK 464***

A high yielding coarse grain line having yield of more than 8.0 t/ha (Fig. 6). Its average grain length is 7.03mm with good cooking quality.


Fig. 6: KSK 464

**National uniform rice yield trial**

In fine grain group, PK 8685-5-1-1-1-1 and RRI 7 out yielded the check varieties at four locations throughout Pakistan by producing 3.85 and 3.76 t/ha while the check varieties (Basmati 515 and Super Basmati) produced 3.58 and 3.54 t/ha, respectively.

**Regional adaptability yield trial**

In fine grain group, six lines were tested including Basmati 515 as check variety.

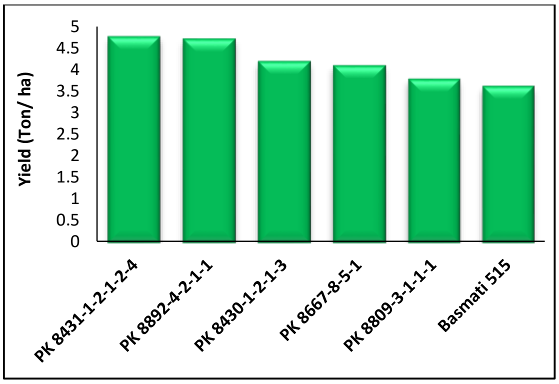


Fig. 7: Yield comparison of fine grain lines

Five lines (Fig. 7) viz., 8431-1-2-1-2-4, 8892-4-2-1-1, PK 8430-1-2-1-3, PK 8667-8-5-1 and PK 8809-3-1-1-1 out yielded the check variety and gave yield of 4.73, 4.68, 4.16, 4.06 and 3.75 t/ha, respectively as compared to check variety- Basmati 515 (3.59 t/ha).

In coarse grain group, six lines were tested including the check variety KSK 133 (Fig. 8). Five lines viz., KSK 466, KSK 462, KSK 474, KSK 463 and PK 8649 out yielded the check variety by producing paddy yield of 4.84, 4.82, 4.79, 4.77 and 4.59 t/ ha, respectively followed by check variety KSK 133 (4.58 t/ ha).

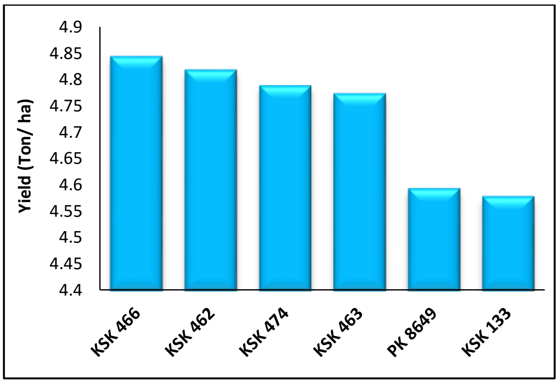


Fig. 8: Yield comparison of coarse grain lines

**Fine grain yield trial**

Eighteen newly selected uniform lines along with a check were evaluated in yield trial in RCBD. Four lines viz., PK 9435-4-1-1 (4.39 t/ha), PK 9301-5-2-1-2 (4.06 t/ha), PK 9606-1-1-1-1 (4.05 t/ha and PK 9531-6-3-1-1 (4.01

t/ha) out yielded the check variety Basmati 515 (4.00 t/ha).

**Coarse grain yield trial**

Five lines viz., PK 9259-4-1-1-1 (7.23 t/ha), KSK 488 (6.82 t/ha), KSK 482 (6.52 t/ha), KSK 486 (6.50 t/ha), KSK 487 (6.36 t/ha) out yielded the check variety KSK 133 (6.32 t/ha).

**Breeding Studies**

***Hybridization***

To combat different problems like pest insects/ diseases, salinity, drought and to improve grain quality and yield of basmati rice, 408 crosses were attempted and 345 successful crosses were harvested for further evaluation.

**Detail of successful crosses**

| | | |
|---|---|---|
| ➢ | High Yielding | 75 |
| ➢ | Salt tolerance | 14 |
| ➢ | Genetic diversity | 23 |
| ➢ | Drought | 03 |
| ➢ | Early maturing & Short stature | 38 |
| ➢ | Plant type | 12 |
| ➢ | Flood tolerance | 10 |
| ➢ | Back cross | 03 |
| ➢ | Quality | 78 |
| ➢ | BLB | 63 |
| ➢ | Aerobic | 02 |
| ➢ | Blast | 03 |
| ➢ | Hopper | 02 |
| ➢ | Aroma | 07 |
| ➢ | Plant type | 12 |

***Development of BLB resistant basmati varieties/ lines***

In $F_7$, 24 lines and 10 uniform lines (having single or combination of genes like *Xa4, xa5, Xa7, xa13, Xa21*) and in $F_6$, 31 lines were studied and 22 progeny lines (having single or combination of genes like *Xa4, xa5, Xa7, xa13, Xa21*) were harvested. Most of IRBB lines have BLB resistance genes like *Xa4, xa5, Xa7, xa13* and *Xa21*. The lines IRBB 13, 21, 54, 57, 58, 64, 65 and 66 showed better resistance in local conditions.

***Development of rice hybrids***

Twelve local hybrids were tested in non-replicated yield trials. Five hybrids out yielded the check variety KSK 133.

**Seed Production**

Pre basic seed of Basmati (668 Kg), coarse grain varieties (421 Kg) and 698 Kg of fine grain non- aromatic varieties (PS-2 and PK 386) were produced during 2014-15.

## II. AGRONOMY

### Effect of transplanting dates on the rice yield

The study was aimed to find out the optimum period of transplanting for fine and coarse grain lines/ varieties to harvest maximum paddy yield of quality rice. An experiment was laid out in RCBD (factorial) with standard crop management practices. Significantly the highest yield was achieved with PK 8431-1-21-2-4 (5.53 t/ha) when transplanted on 14th July (Fig. 9).

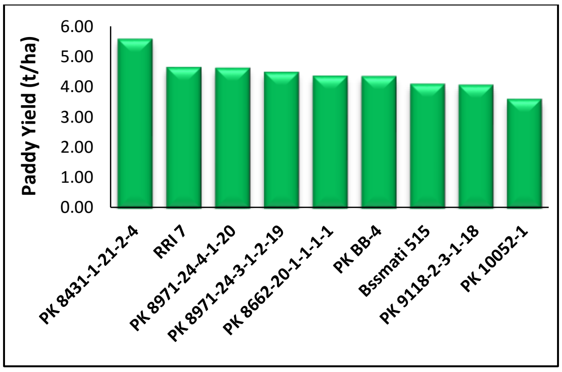


Fig. 9: Effect of transplanting dates (14 July) on paddy yield of fine grain lines/ varieties (LSD 0.54)

In case of coarse lines/ varieties, highest yield (5.83 t/ha) was recorded in case of KSK 474 when transplanted on 27th May (Fig. 10).

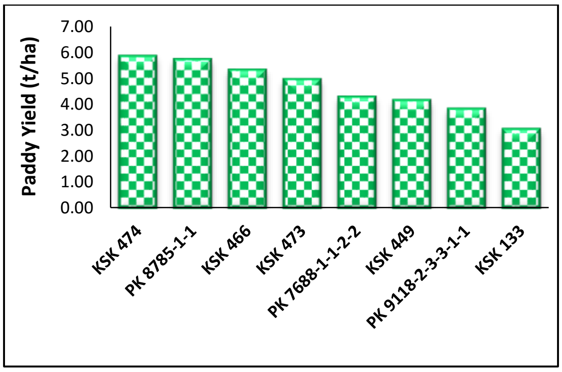


Fig. 10: Effect of transplanting date (27 May) on paddy yield of coarse grain lines/varieties (LSD 0.56)

### Optimizing seed invigoration techniques to enhance emergence of direct seeded rice

A lab experiment was laid out in CRD to explore the appropriate seed invigoration techniques to reduce the emergence time and improve stand establishment of direct seeded rice. The results (Fig. 11) revealed that the minimum mean emergence time (MET) was recorded in "on-farm priming 24 h" (4.63 days).

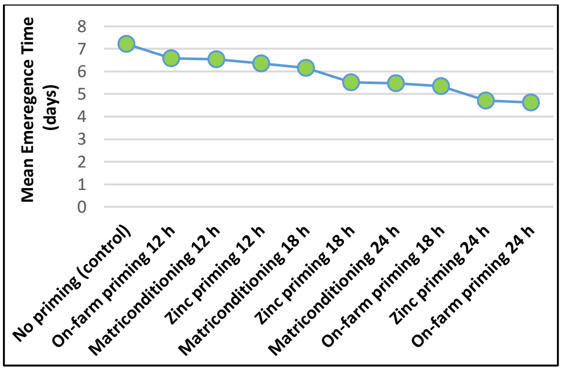


Fig. 11: Effect of different seed invigoration techniques on MET of fine grain rice (LSD 0.889)

### Effect of tillage systems on rice crop growth and productivity in rice-wheat cropping system

To find out an appropriate tillage-residue (TR) system for productivity enhancement of rice-wheat cropping system through resource conservation, an experiment was laid in RCBD with split plot arrangement. Maximum paddy (3.81 t/ha) was achieved in transplanted rice with partial burning of wheat residue (Fig.12).

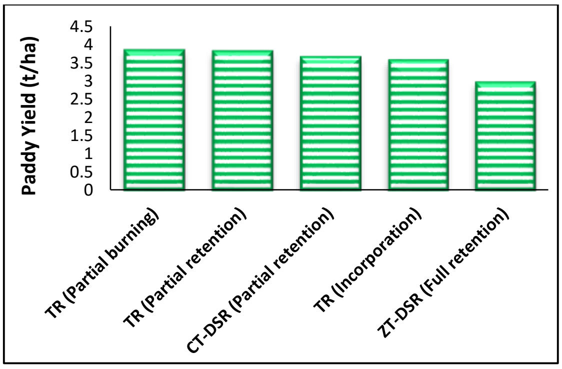


Fig. 12: Effect of different tillage-residue systems on paddy yield of fine grain rice (LSD 0.115)

Fig. 13: Wheat residue management in direct seeded rice

**Effect of different planting methods on agro-physiological characteristics and economics of cultivation of rice crop**

The study was designed in RCBD to explore an appropriate planting method to attain higher paddy yield on sustainable basis. The data showed that the maximum paddy yield (4.23 t/ ha) was achieved with DSR-broadcast (Fig. 14).

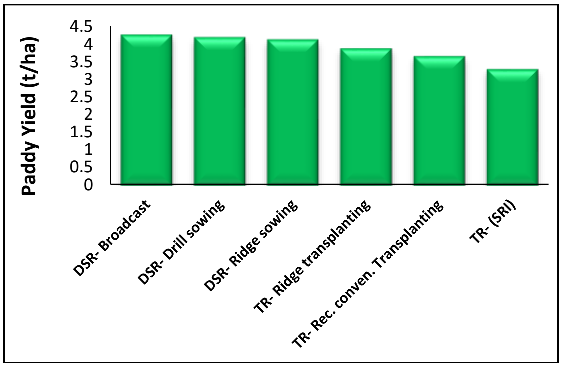


Fig. 14: Effect of different planting methods on paddy yield of fine grain rice (LSD 0.294)

Fig. 15: Ridge planting in direct seeded rice

## III. SOIL CHEMISTRY

**Screening of lines/ varieties against salinity in nutrient culture solution**

Trial was conducted to select salt tolerant local rice lines/varieties. The nursery of 41 fine and 14 coarse grain rice lines/ varieties were sown on raised beds. Thirty five days old seedlings were transplanted on thermo pore sheets (Fig. 16) placed in tubs containing nutrient culture solution (Yoshida solution).

Fig. 16: Rice lines/varieties transplanted on thermo pore sheet

The salinity levels such as 5.0, 7.5 and 10.0 ds/m electrical conductivity (EC) of the nutrient culture solution were maintained by adding mixture of salts of NaCl, $Na_2SO_4$, $CaCl_2$ and $MgSO_4$. After six weeks, the observations on salt tolerance were recorded.

The results revealed that 11 fine grain rice lines/ varieties viz; PK 9748-16-2-1, PK 9831-16-2, RRI 4, PK 8431-6-1-1-1-1, PK 8809-3-1-1-1, PK 9736-3-2-1,PK 9736-12-1-1, PK 9533-9-6-1-1, PK 9533-9-6-3-1, PK 9194-54-1-1-2-2 and PK 10052-1 were found moderately resistant at 5.0 and 7.5 ds/m. However, PK 8685-5-1-1-1-1, Shaheen Basmati, Basmati 385 and PK 8431-1-2-1-2-3 were found moderately resistant only at 5.0 ds/m (Fig. 17).

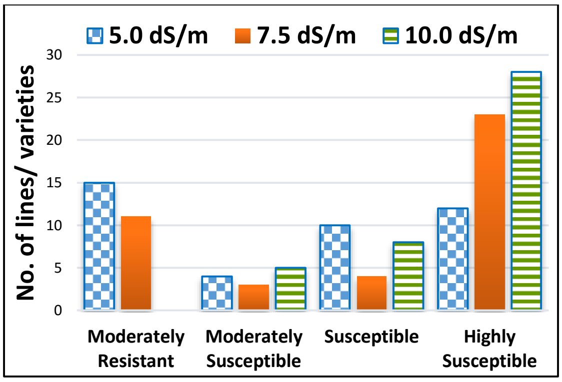


Fig. 17: Response of fine grain rice lines/ varieties against salinity

The results (Fig. 18) showed that five coarse grain rice lines/ varieties viz; PK 7688-1-1-2-2, PK 8649-5-1-1-2, PK 9118-2-3-3-1-1-9, KSK 481 and KSK 468 were found moderately resistant at EC of 5.0 and 7.5 dS/ m. However, KSK 459, KSK 471, NIAB IR-9, KSK 133, KSK 434 and KS 282 were found moderately resistant only at 5 dS/ m.

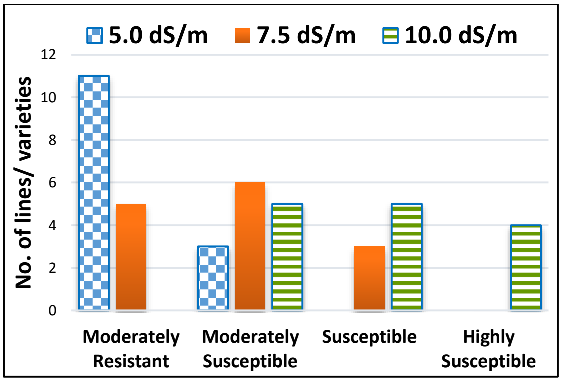


Fig. 18: Response of coarse grain rice lines/ varieties against salinity

## Bio-fortification of rice varieties with zinc and iron

To assess the response of some fine and coarse grain rice varieties to the application of Zinc (Zn) and Iron (Fe) for bio-fortification of rice grains, both fine and coarse grain rice varieties were strengthened with Zn and Fe. The study was carried out with the collaboration of Rapid Soil Fertility Survey and Soil Testing Institute, Thokar Niaz Baig, Lahore. The experiment was laid out in RCBD with three replications.

Rice leaves' analysis showed that percent increase in Zn and Fe concentration (ppm) was highest in Super Basmati (76 and 77%, respectively). Similar trend was also observed in grains of Super Basmati with highest concentration of Zn (42%) and Fe (30%).

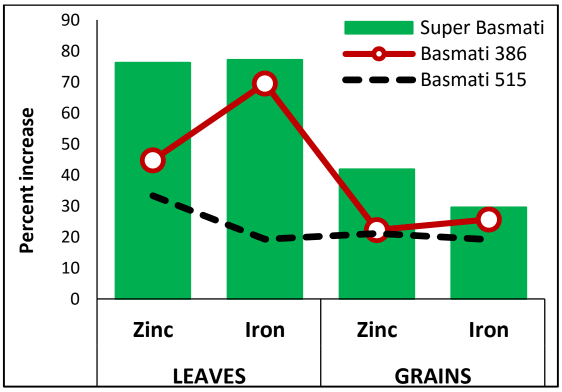


Fig. 19: Bio-fortification of zinc and iron in leaves and grains of fine rice

In case of coarse varieties (Fig. 20), rice grains' analysis reflected that percent increase in Zn and Fe concentration (ppm) was highest in KSK 434 (37%) and (89%), respectively). Similar trend was also observed in grains of KSK 434 with highest concentration of Zn (21%) and Fe (23%).

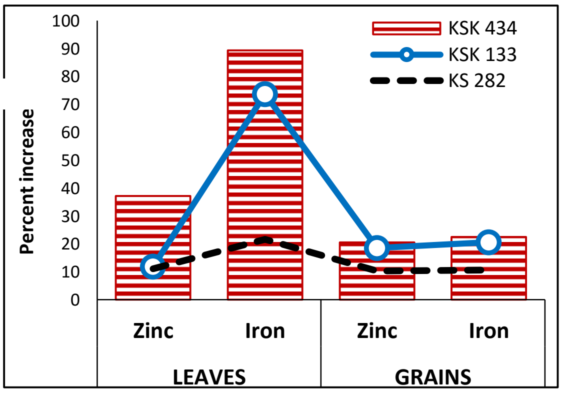


Fig. 20: Bio-fortification of zinc and iron in leaves and grains of coarse rice

**Evaluation of different models of fertilizers for yield prediction of rice**

This study was planned to verify various models for rice yield prediction at Rice Research institute, Kala Shah Kaku with the collaboration of Soil Chemistry Section, ISCES, AARI, Faisalabad. For this purpose five different fertilizer treatments i.e., $T_1$ Control (0-0-0, NPK), $T_2$ Farmer practice (90-0-0, NPK), $T_3$ Departmental recommendation (150-90-60, NPK), $T_4$ University model (165-84-0, NPK) and $T_5$ FFC model (143-35-50 NPK) were tested for yield prediction. For University and FFC models, fertilizer rates were calculated after basal analysis of soils and fixing the target yield of 6 t/ ha. The experiment was laid out in RCBD with three replications.

Maximum paddy yield (4.51 t/ha) was obtained from $T_3$ (Fig. 21) where fertilizer was applied according to the departmental recommendation which is statistically higher than $T_1$ (2.15 t/ha) where no fertilizer was applied and $T_2$ having paddy yield of 3.32 t/ha and at par with $T_4$ and $T_5$ having paddy yields of 4.21 and 4.34 t/ha, respectively.

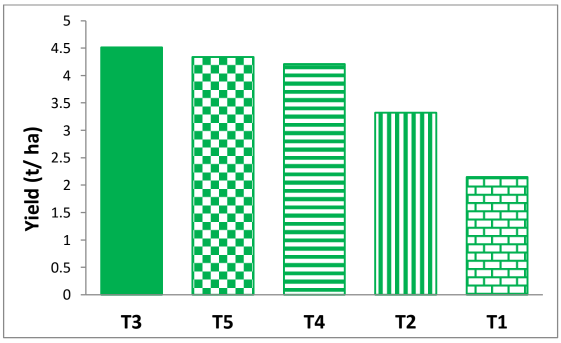


Fig. 21: Effect of different fertilizer models on paddy yield (LSD 0.519)

## IV. ENTOMOLOGY

**Screening of pesticides for the effective control of different rice pest under field conditions**

To observe the efficacy of different pesticides for the effective control of rice pests along with standard treatments were tested for their effectiveness against target pests on Basmati 515 using standard agronomic practices under field conditions in RCBD layout, replicated thrice. Percent effectiveness of pesticides (Fig. 22-25) showed that all the pesticides effectively control the target pest/ insect than untreated check.

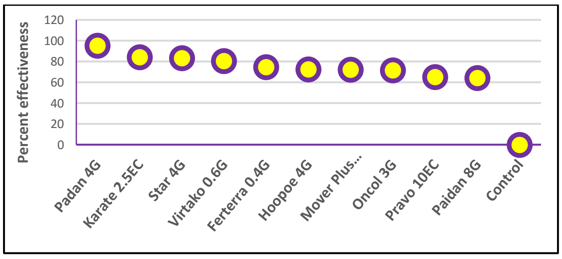


Fig. 22: Post- treatment percent effectiveness of insecticides against rice leaffolder with respect to control (LSD 30.996)

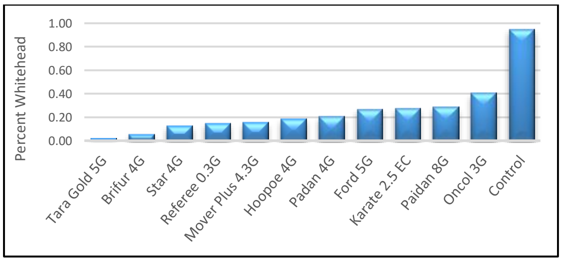


Fig. 23: Post- treatment infestation (whitehead) level of rice stem borers (LSD 0.3489)

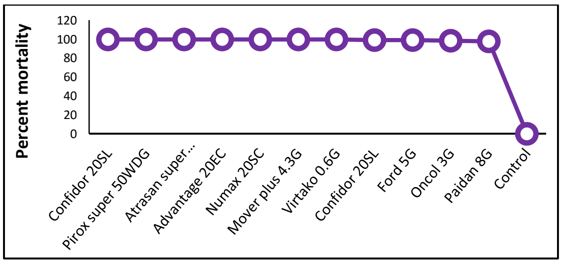


Fig. 24: Post- treatment percent mortality after a week of treatment application with respect to control of rice planthoppers (LSD 1.2892)

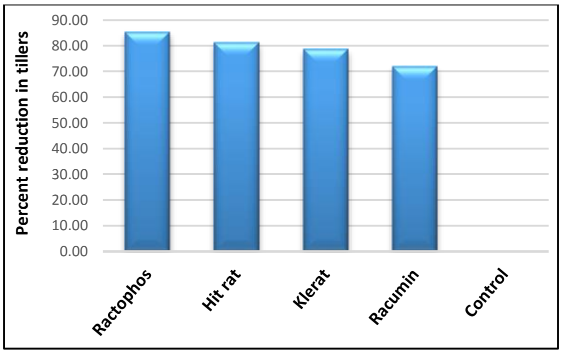


Fig. 25: Post- treatment percent reduction in tiller damage by using rodenticides against rats in rice crop

**Screening of breeding material for resistance against rice leaffolder (*Cnaphalocrocis medinalis*) under field conditions**

Forty two fine and fifteen coarse grain rice lines/ varieties of local origin were tested and analyzed for their respective response against leaffolder by using Standard Evaluation System (SES) for Rice, 2002 developed by the IRRI, Philippine. Keeping in view the percentage infestation of rice leaffolder (Fig. 26) only three fine lines (BLB 1, BLB 4 and RRI 6) behaved as moderately resistant.

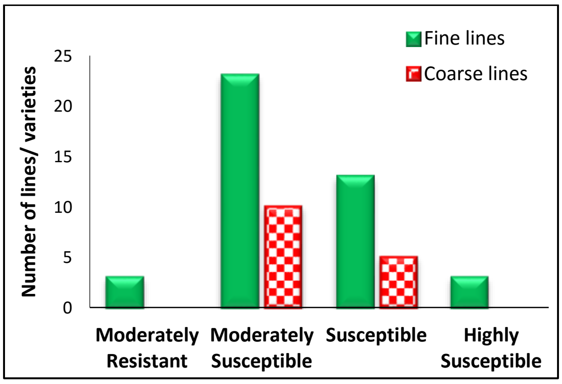


Fig. 26: Response of lines/ varieties against leaffolder

## V. PLANT PATHOLOGY

**Screening of rice lines/ varieties against rice blast (*Pyricularia oryzae*)**

Fifty five lines/varieties were screened for their resistance against rice blast for further use in the breeding programme. The results indicate that six lines/ varieties were found moderately resistant against blast (Fig. 27).

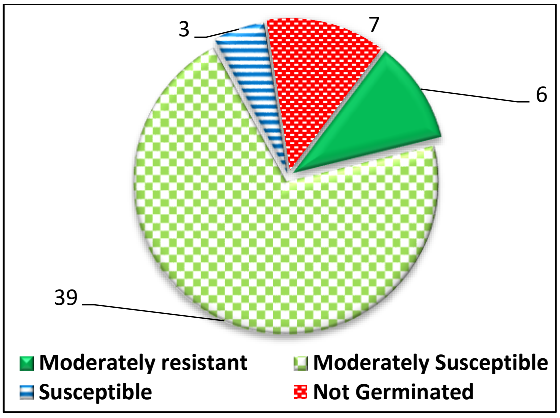


Fig. 27: Response of lines/ varieties against rice blast

**Screening of rice lines/ varieties against bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) disease**

Fifty four lines/ varieties were screened for their resistance against bacterial leaf blight to find out resistant sources, against the disease. Assessment of the tested lines/ varieties was done following the SES (IRRI, 2002). According to the results, 23 lines/ varieties were found moderately resistant against the disease (Fig. 28).

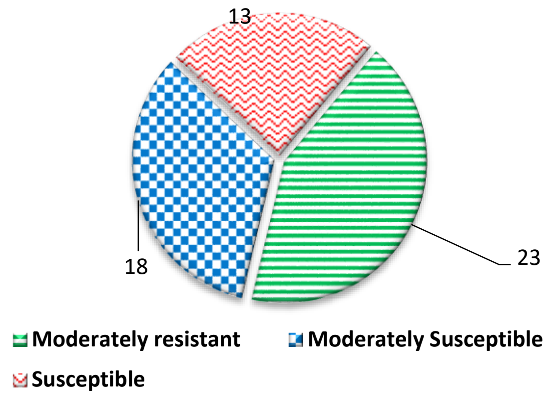


Fig. 28: Response of lines/ varieties against bacterial leaf blight

**Screening of genetic stock against stem rot (*Sclerotium oryzae*) disease**

Fifty five lines/ varieties were screened against stem rot to find out resistant source, against the disease. Disease incidence data were recorded at maturity and the varieties were assessed following the SES for Rice (IRRI, 2002). Twenty three lines/ varieties were found moderately resistant against the disease (Fig. 29).

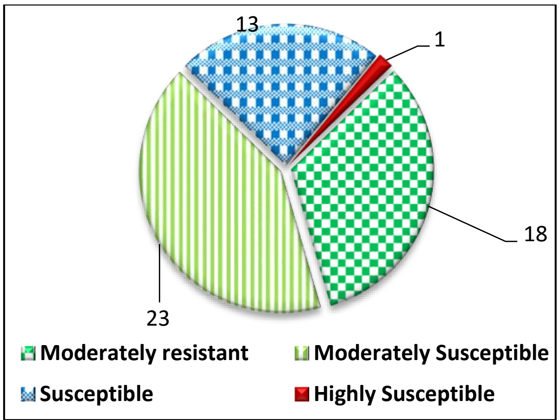


Fig. 29: Response of lines/ varieties against rice stem rot

**Efficacy of different fungicides for the control of blast (*Pyricularia oryzae*) disease**

Six fungicides were tested for their effectiveness against paddy blast in RCBD layout with four replications on Basmati C-622. Test fungicides were sprayed at late booting stage and four days after panicle emergence. According to the results (Fig. 30) all the fungicides resulted in lower disease incidence as compared to control (83.05%). Significantly, lowest disease incidence (6.93%) was recorded in the plot where Castle 50WP was applied.

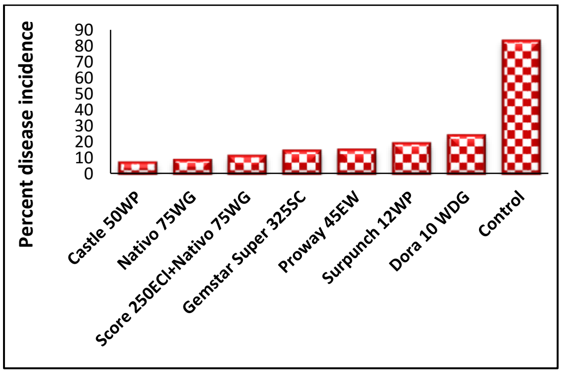


Fig. 30: Efficacy of different fungicides for the control of blast (LSD 2.966)

**Effect of different chemicals on bacterial leaf blight (*Xanthomonas oryzae* pv *oryzae*)**

Seven chemicals were tested against bacterial leaf blight (BLB) in RCBD layout with four replications using Basmati 2000. Data on BLB disease incidence were recorded 21 days after inoculation. Results revealed that all the chemicals resulted in significantly lower disease incidence (Fig. 31). The lowest disease percentage was recorded in Gemstar Super 325SC (7.33%) as compared to untreated control (85.68%).

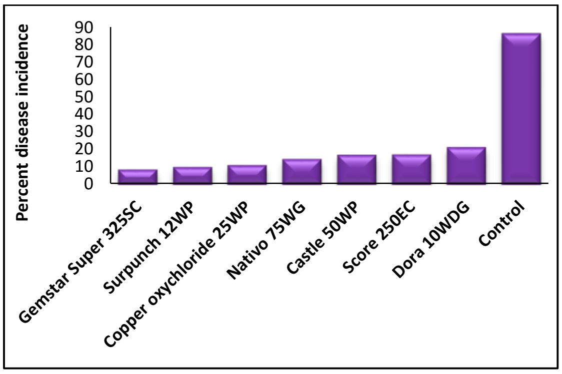


Fig. 31: Efficacy of different chemicals for the control of BLB (LSD 3.828)

## Efficacy of different fungicides for the control of brown leaf spot of rice (*Helminthosporium oryzae*)

Seven fungicides were tested for their effectiveness against brown leaf spot of rice in RCBD lay out with three replications on Basmati 2000. Data on brown leaf spot disease incidence were recorded from booting to flowering stage. According to the results (Fig. 32), Sulfax Gold 80WDG gave the best results with the lowest disease incidence (9.75%) as compared to control (81.25%).

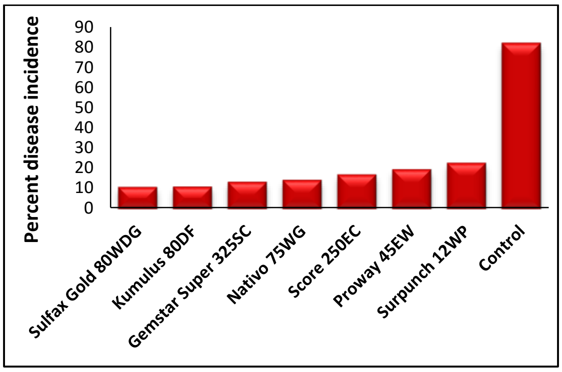


Fig. 32: Efficacy of different fungicides for the control of BLS (LSD 3.626)

# VI. RICE TECHNOLOGY

## Effect of transplanting date on the quality characteristics of different fine grain rice lines

Maximum total milled rice-TMR was recorded at transplanting date of 14$^{th}$ July (71.3%). Maximum head rice recovery- HR (59.2%) was recorded at transplanting date of 5$^{th}$ August (Fig. 33) followed by 14$^{th}$ July (54.4%). This reflects that fine grain lines performed better in terms of milling recovery when transplanted on August 05 than July 14.

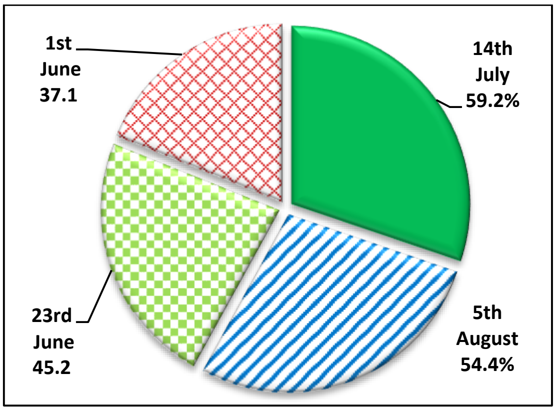


Fig. 33: Rice recovery on the basis of date of transplanting

Maximum cooked grain length- CGL (15.9mm) was recorded for transplanting date of 5$^{th}$ August (Fig. 34) followed by transplanting date of 14$^{th}$ July 2014 (15.1mm) with 6.1% bursting (Fig. 35).

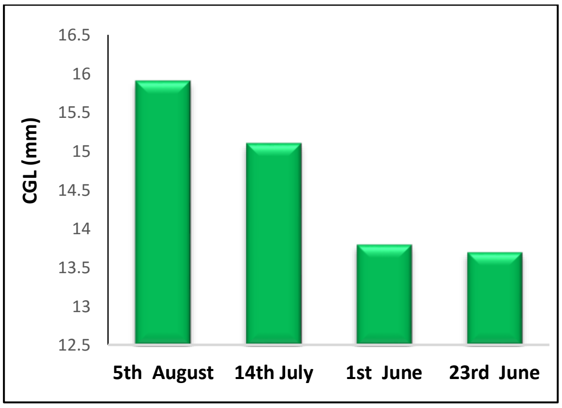


Fig. 34: CGL on the basis of date of transplanting

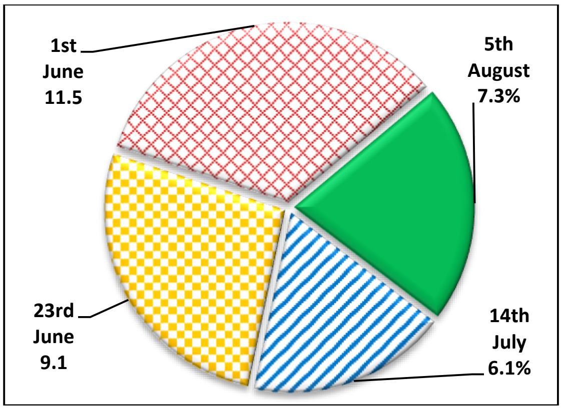


Fig. 35: Bursting percentage on the basis of date of transplanting

**Regional Adaptability Trial**

In Regional Adaptability Trial of fine rice, maximum TMR (72.3%) was recorded at Faisalabad followed by Kala Shah Kaku (71.9%).

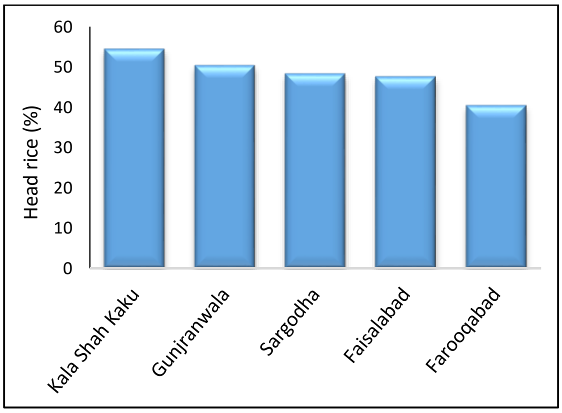


Fig. 36: Head rice recovery in regional adaptability trial

Maximum HR (54.4%) was recorded at Kala Shah Kaku (Fig. 36) followed by Gujranwala (50.5%). It was concluded that maximum head rice recovery of fine grain lines was observed at Kala Shah Kaku followed by Gujranwala.

Maximum CGL (14.6mm) was observed at Kala Shah Kaku (Fig. 37) followed by Sargodha (14.0mm). Minimum bursting upon cooking (4.7%) was recorded at Kala Shah Kaku and Gujranwala followed by Faisalabad (5.6%).

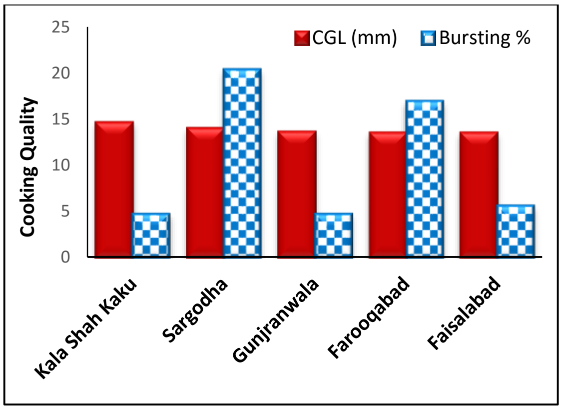


Fig. 37: CGL of regional adaptability trial

It was concluded that CGL was better at Sargodha, but bursting upon cooking was too high. However, with respect to cooking quality, best result was observed at the location of Kala Shah Kaku followed by Gujranwala.

## VII. PUBLICATIONS

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## IX. METROLOGICAL DATA