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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 7.00 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 0.503 million metric tons Basmati rice is exported to the Middle East countries, Europe and America, whereas, 3.759 million metric tons coarse rice is exported to different countries of Asia and Africa. During 2015- 16, Pakistan earned US$ 1.86 billion foreign exchange from the export of rice.

The Punjab is the biggest rice producer province of the country. In the province, during 2015-16, the total area under rice crop was 4.399 million acres and production was 3.502 million tones. Generally, the Punjab contributes 52% to the national production while provinces of Sindh, Baluchistan and KPK contribute 38%, 8% and 2%, respectively.

Spot examination of three early maturing fine grain promising lines (basmati) viz., PK 8431-1-2-1-2-4 (Chenab Basmati), PK 8685-5-1-1-1-1 (Punjab Basmati) and RRI 7 (Kissan Basmati) was made during the year under report.

## A. *RICE RESEARCH INSTITUTE, KALA SHAH KAKU*

### I. RICE BREEDING

**Promising lines with their salient characteristics**

***PK 8431-1-2-1-2-4***

This advance line was planted for spot examination at the institute. It has been tested in varietal yield trials during 2011- 15 (Fig. 1). On an average of 36 yield trials including station and regional trials, it yielded 4.42 t/ha against 3.59 t/ha (23% yield advantage) of Super Basmati and 3.93 t/ha (13% yield advantage) of Basmati 515. It is an early maturity (1 week), stiff stem and lodging resistant. Average grain length (7.61mm) is better than Super Basmati (7.44mm) and Basmati 515 (7.56mm). The proposed name of this line is Chenab Basmati).

Fig. 1: Field evaluation and cooking quality of PK 8431-1-2-1-2-4

***PK 8685-5-1-1-1-1***

This advance line (Punjab Basmati) has been tested in varietal yield trials during 2011- 14 (Fig. 2). On an average of 40 yield trials including station and regional trials, it yielded 4.30 t/ha which is 15% and 7% higher than Super Basmati (3.75t/ha) and Basmati 515 (4.03 t/ha), respectively. It is an early maturing (100 vs 114 days), short statured (107 vs 121cm (Super Basmati) and 132 (Basmati 515) and lodging resistant variety. Grain length and head rice recovery are better than Super Basmati and Basmati 515.

Fig. 2: Field evaluation and cooking quality of PK 8685-5-1-1-1-1

***RRI 7***

This candidate line with proposed name Kissan Basmati was tested in varietal yield trial from 2012- 15 (Fig 3). It is high yielding, early maturing), short stature and extra-long grain (8.12mm) rice variety. This line also suitable for parboiled and steam rice.

Fig. 3: Field evaluation and cooking quality of RRI 7

On an average of 35 yield trials including station and regional trials, it yielded 3.72 t/ha i.e., 9% increase over check varieties (Super Basmati and PS 2). The quality characteristics are better than Super Basmati 515 and at par with PS 2.

***PK 8892***

This Basmati line (Fig. 4) yields 5.0 t/ ha with more than 7.9mm AGL. The cooking quality of this line is good (14.2mm).

Fig. 4: PK 8892

***PK BB 15-01***

This is a high yielding basmati line with BLB resistant gene (*Xa4*) *h*aving yield potential of 6.44 t/ha, early maturing and extra-long grain with AGL 8.1mm. Cooking quality of this line is good (15.3mm).

***KSK 476***

It is high yielding coarse grain line (Fig. 5) having average yield of more than 6.60 t/ha. This line is early maturing (95 days), short statured (99cm), disease and insect resistant with good cooking quality.

Fig. 5: KSK 476

**National uniform rice yield trial**

In fine grain group, RRI 3, RRI 7 and PK 9408-8-1-2-2 out yielded check variety (PS 2) at nine locations throughout Pakistan by producing 3.56, 3.26 and 3.10 t/ha while the check variety produced 2.99 t/ha on an average basis (Fig. 6).

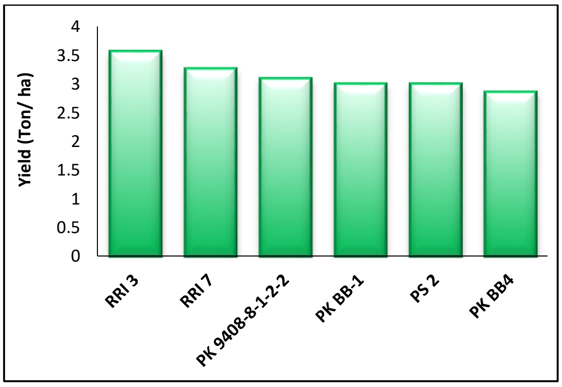


Fig. 6: Mean yield of Fine grain lines

In coarse grain group, KSK 466 out yielded check variety (KSK 133) at eight locations throughout Pakistan by producing 5.17 t/ha while the check variety produced 4.90 t/ha on average basis (Fig. 7).

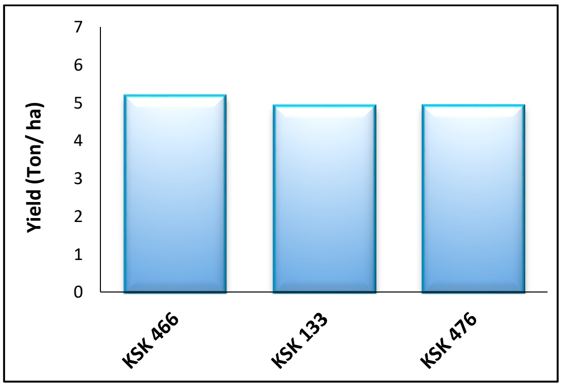


Fig. 7: Mean yield of coarse lines

**Fine grain yield trials**

Thirty-four newly selected uniform lines along with two check varieties were evaluated in yield trial in RCBD layout. Five lines viz., PK PB-8 (5.23 t/ha), PK 10324-1 (5.19 t/ha), PK 9301-5-2-1-2 (4.96 t/ha), PK 10029-13-2-1 (4.90 t/ha) and PK 9831 (4.79 t/ha) out yielded the check variety PS 2 (4.36 t/ha) and Basmati 515 (4.41 t/ha).

**Coarse grain yield trials**

Three coarse grain lines viz., KSK 497 (6.25 t/ha), KSK 496 (6.12 t/ha) and KSK 495 (6.10 t/ha) out-yielded the check variety KSK 434 (6.05 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, 205 crosses were attempted and 135 successful crosses were harvested for further evaluation.

**Detail of successful crosses**

| | |
|---|---|
| High Yielding | 20 |
| Salt Tolerance | 05 |
| Genetic Diversity | 10 |
| Drought | 03 |
| Early Maturity & Short Stature | 10 |
| Plant Type | 10 |
| Submergence Tolerance | 10 |
| Quality | 30 |
| Bacterial Leaf Blight (BLB) | 20 |
| Aerobic | 02 |
| Blast | 03 |
| Hopper | 02 |
| Aroma | 07 |
| Back cross | 03 |

### *Development of BLB resistant Basmati varieties/ lines*

Ten uniform advance lines were studied at three different locations (KSK, Hafizabad & Gujranwala). Out of which six uniform lines were selected. Thirty one (31) IRBB donor lines were studied having single or combination of BLB resistant genes like *Xa4, xa5, Xa7, xa13, Xa21*. In $F_2$, 55 populations were studied. Out of which 47 single panicle selection were done. Similarly, the progenies of 13 crosses were studied in $F_3$ and eight single panicle selection were made for further study in subsequent generations.

### *Marker Assisted Breeding*

DNA fingerprinting of BLB resistant *Xa4, xa5, Xa7 and Xa21* genes was done for Marker assisted selection (MAS). Molecular screening for presence/ absence of BLB resistant genes in the existing rice genotypes/ varieties of the crossing block was done. Most of the lines carry 1 or 2 genes. Only one line has *Xa21* gene. Following is the banding pattern showing BLB genes status.

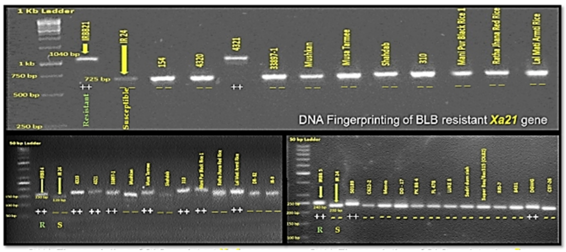


Fig. 8: DNA Fingerprinting of BLB resistant, *Xa4, xa5* and *Xa21* genes

### *Submergence tolerance screening studies*

An experiment was conducted using 115 rice genotypes having Sub1 genes and six local cultivars/ released varieties in Pakistan in order to confirm their effectiveness under submergence condition (Fig. 9). All these genotypes were evaluated in a natural water pond that allows maintenance of water depth of 150 cm for a period of 15 days. The molecular screening was also conducted in Marker Assisted Selection (MAS) lab of Rice Research Institute, Kala Shah Kaku. All the local approved varieties of Pakistan showed zero tolerance level as indicated by the lowest Tolerance Index (TI) values. Among exotic lines eighteen lines showed more than 0.8 TI value indicating highest level of submergence tolerance, Nineteen lines showed TI value from 0.7- 0.9 indicating average level of Tolerance while the rest of the lines showed below 0.7 TI value.


Fig. 9: Submergence tolerance screening

***Development of rice hybrids***

For the development of hybrid parental lines forty eight test crosses were studied. Eight maintainers and eight restorers were identified. All the maintainers were backcrossed with the recurrent parent for their conversion into CMS lines. Among them one back cross in the Basmati back ground is in $BC_5$ and next year will be declared as new CMS line in Basmati back ground (Fig, 10).
Six kilogram seed of CMS line IR58025A and 5Kg seed of IR75596A was produced for its maintenance and the production of rice hybrids.

Eight local test hybrids were tested in non-replicated yield trials. All hybrids out yielded the check variety KSK 133. Fourteen kilogram of local test hybrid LH-118 was produced on trial basis

Fig. 10: Hybrid seed production

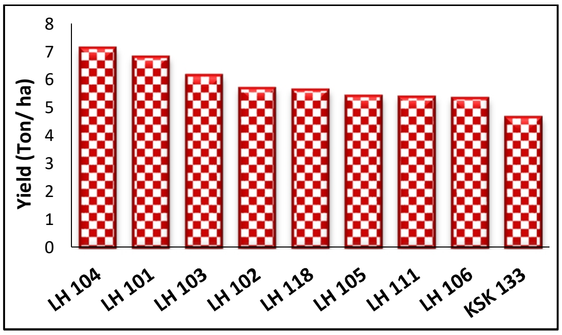


Fig. 11: Yield comparison of local hybrids

## II. AGRONOMY

### Integrated weed management in direct seeded rice

The experiment was conducted to explore the integrated weed management for effective control of anxious weeds i.e., *Leptochloa chinensis* (*Kallar Grass*) and *Dactyloctenium aegyptium* (*Madhana Grass*) in dry-seeded rice (DSR) through modified rice drill (Fig. 12). Among all the treatments, the excellent weed control (79.85%) was achieved where pendimethalin was applied as pre-emergence followed by phenoxaprop-p-ethyl + bispyribac sodium at 23 days after sowing (Fig. 13) with highest yield (4.19 t/ha). The lowest weed control was observed in plots treated with bispyribac sodium + bensulfuraon and in treatment of 'one stale bed technique + spray of Bispyribac sodium.


Fig. 12: Modified seed drill for DSR

Fig. 13: Weed control in DSR

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

The study was designed in split plot design to assess the response of promising coarse grain rice varieties to foliar application of zinc and iron for bio fortification of rice grains. The maximum yield 5.55 and 5.45 t/ ha was obtained when foliar application of 0.1% zinc (Zn) solution and 0.2 % iron (Fe) solution was applied at milking and dough stages in KSK 434 and KS 282, respectively. Maximum Zn contents (26.8 mg/ Kg) in grain was found in KS 282 while maximum iron contents in grain were observed in KSK 434 (16.3 mg/ Kg) as shown in Fig. 14.

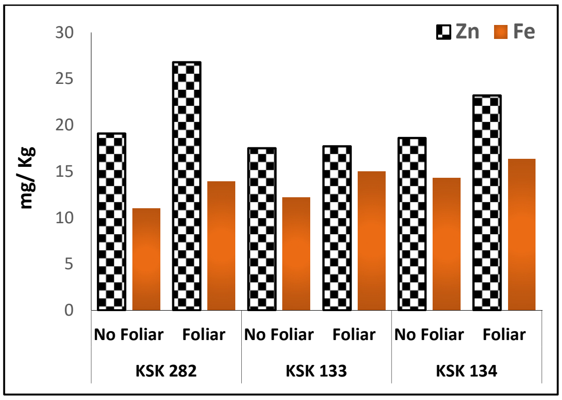


Fig. 14: Zn and Fe contents in coarse grain rice varieties

### 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 yield was achieved in transplanted rice with partial retention of wheat residue which is at par with transplanted rice with partial burning and incorporation (4.06 and 3.97 t/ha), respectively (Fig. 15).

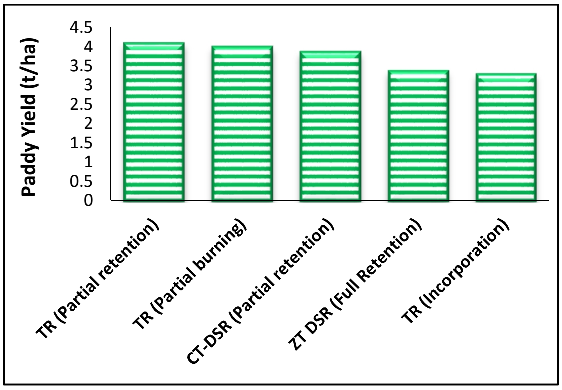


Fig. 15: Effect of different tillage-residue system on paddy yield of fine grain rice

## 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 average yield (4.93 t/ha) was achieved with PK 8892-4-1-3-1 (Fig. 16).

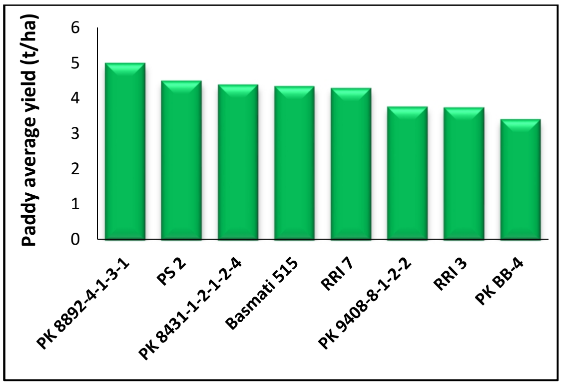


Fig. 16: Effect of transplanting dates (14 July) on paddy yield of fine grain lines/ varieties

In case of coarse lines/ varieties, the highest yield (6.68 t/ha) was recorded in case of KSK 473 when transplanted on 27th May and the maximum average yield (5.50 t/ha) was also recorded in case of KSK 473 (Fig. 17) and it was at par with KSK 466 (5.49 t/ha).

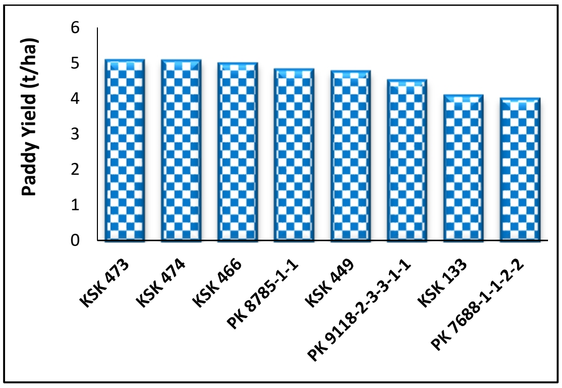


Fig. 17: Effect of transplanting date on paddy yield of coarse grain lines/varieties

## Provincial coordinated yield trial for newly evolved fine and coarse grain rice varieties/ lines

The trial was conducted to find out the performance of newly evolved basmati and coarse lines in four different ecological zones (Gujranwala, Faisalabad, Farooqabad and KSK). The new promising line KSK 474 is out yielded (5.61t/ha) than the check variety KSK 434 (5.02 t/ha).

# 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 34 fine and 19 coarse grain rice lines/ varieties were sown on raised beds.

Fig. 18: Transplantation of seedlings on thermo pore sheets

Thirty five days old seedlings were transplanted on thermo pore sheets (Fig. 18) placed in tubs containing nutrient culture solution (Yoshida solution).

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 nine fine grain rice lines/ varieties viz; PK 9748-16-2-1, PK 9831-16-2, RRI 4, PK 9736-3-2-1 PK 9533-9-6-1-1 PK 9533-9-6-3-1, PK 9194-54-1-1-2-2 and PK 9531-6-3-1-1, and were found moderately resistant at 5.0 and 7.5 ds/m. However, RRI 7, Shaheen Basmati, Basmati 385 and PK 8431-1-2-1-2-3 were found moderately resistant only at 5.0 ds/m (Fig. 19).

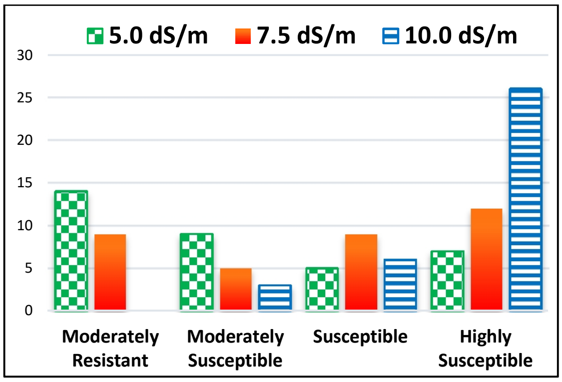


Fig. 19: Response of fine grain rice lines/ varieties against salinity

The results (Fig. 20) showed that three coarse grain rice lines/ varieties viz; KSK 482, KSK 483 and PK 9921-12-1 were found moderately resistant at EC of 5.0 and 7.5 dS/ m. However, KSK 462, PK 9832-4-1, NIAB IR-9, KSK 133, PK 9847-10-1, KSK 434 and KS 282 were found moderately resistant only at 5 dS/ m.

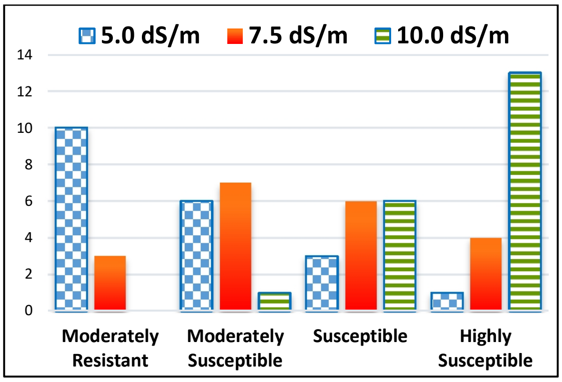


Fig. 20: Response of fine grain rice lines/ varieties against salinity

## IV. ENTOMOLOGY

### Screening of pesticides for the effective control of different rice pests 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. Percent effectiveness of pesticides (Fig. 21-23) showed that all the pesticides effectively control the target pest/ insect than untreated check.

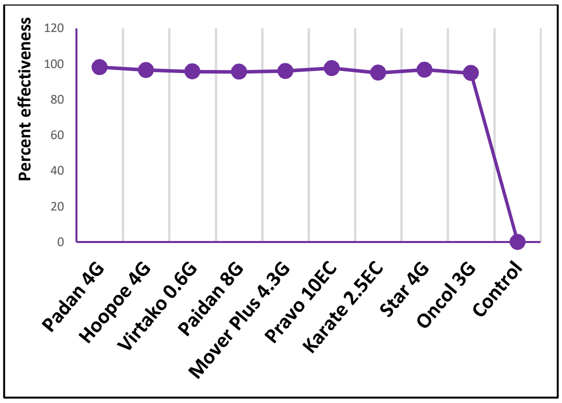


Fig. 21: Post- treatment percent effectiveness of insecticides against rice leaffolder with respect to control

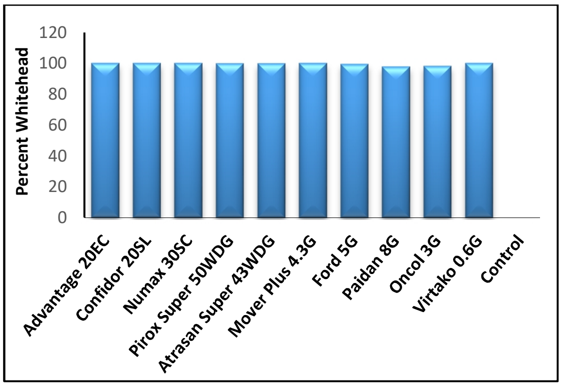


Fig. 22: Post- treatment percent mortality after a week of treatment application with respect to control of rice planthoppers

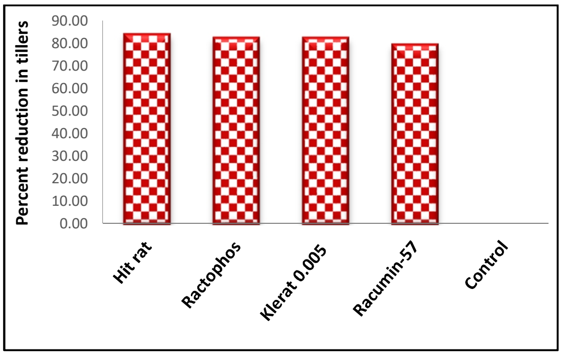


Fig. 23: Post- treatment percent reduction in tiller damage by using rodenticides against rats in rice crop

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

Thirty five fine and twenty 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. 24) only three fine grain lines (PK BB 1, Shaheen Basmati, PK 9533-9-6-1-1 and PK BB 4) and two coarse grain lines (KSK 463 and KSK 482) behaved as moderately resistant.

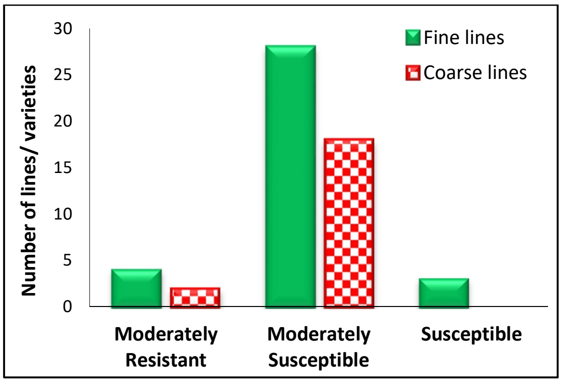


Fig. 24: Response of lines/ varieties against leaffolder

## V. RICE TECHNOLOGY

**Studied on physiochemical characteristics of rice generation lines**

Maximum Cooked Grain Length (CGL) 18.0mm was shown by lines 50147 and 60112 followed by line 60171 with 17.5mm CGL. Maximum Elongation Ratio (E/R) of 2.123 was also shown by line 50147 followed by lines 60112, 60334 and 60171 with 2.103, 2.089 and 2.064 elongation ratio, respectively (Fig. 25).

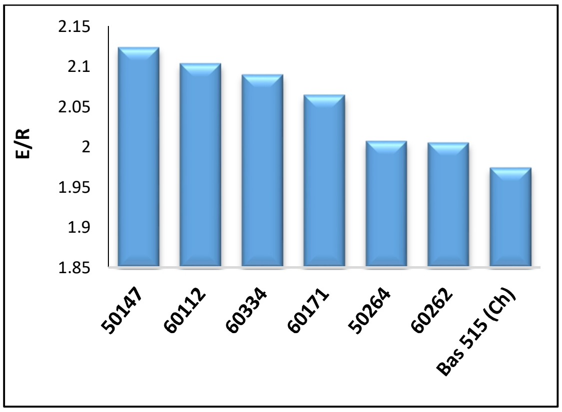


Fig. 25: Elongation Ratio (E/R) of generations

Overall, lines 50147, 60112, 60334 and 60171 performed well in terms of cooking quality by exceeding standard check (Basmati 515 (Fig. 26-27).

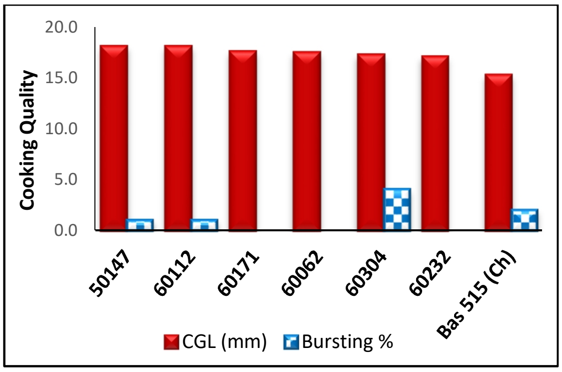


Fig. 26: Cooking Quality of Generation lines

Fig. 27: Cooking quality pictures of generation lines

**Studied on aroma compounds by gas chromatography technique**

In this experiment, selected aromatic compounds in Basmati rice varieties were quantified using Gas Chromatograph machine. Main aroma compound 2-acetyl-1-pyrroline (2AP) was quantified along with two other compounds viz. Decanal and Vanillin.

All Basmati samples were kept at room temperature for one week before run in GC to attain the same moisture level and were then freshly milled just before analysis. The chromatogram data showed (Fig. 28) that maximum concentration of 2AP of 0.97ppm was observed for Basmati 370 followed by Super Basmati with 0.95ppm concentration of 2AP. Basmati 515 showed a concentration of 0.60ppm of 2AP. The Gas chromatogram data showed that maximum concentration was found in Basmati 370 (0.97ppm).

The concentration of Decanal ranged from 0.36ppm to 1.18ppm. Maximum concentration of Decanal of 1.18ppm was observed in Basmati 370 followed by 0.77ppm in Basmati 515 and minimum 0.36ppm in Super Basmati. The concentration of Vanillin was highly variable from 2.17ppm to 4.24ppm. Maximum concentration was found in Basmati 515 with 4.24ppm concentration. Minimum concentration of 2.17ppm was noted in Chenab Basmati followed by Basmati 385 with 2.53 ppm concentration of vanillin.

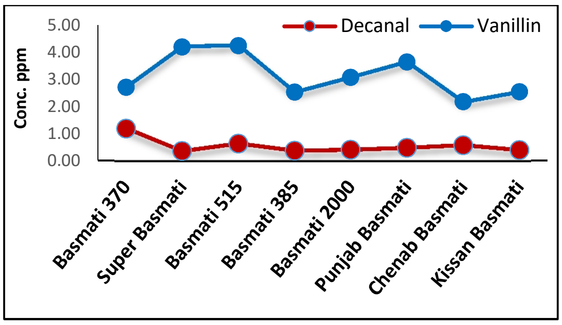


Fig. 28 Concentration of Decanal & Vanillin in Basmati varieties

## VI. AGRICULTURAL ENGINEERING

An experiment was conducted to compare yield and water productivity of rice (*Oryza sativa* L.) hybrids/ varieties in response to transplanting dates (Fig. 29). Comparing the average yields of both hybrids with KSK 133 at three transplanting dates, lowest paddy yield was obtained at transplanting date of 1st July while the yield was again reduced when further delayed to 31st July. However, the date of transplanting showed a significant interaction with the genotypes. Average paddy yield at 31st July treatment declined significantly compared to 16th July. Compared to other two dates, 16th July gave highest yield (Fig. 30).

Fig. 29: Field transplantation

Hybrid Swift produced highest paddy yield (3501 kg/ ha) followed by INH10008 (2873 kg/ ha) and KSK 133 (2539 kg/ ha) under water stress treatment. For early transplanting (1st July), hybrid INH10008 gave highest yield (3458 kg/ ha), followed by Swift (3178 kg/ ha) and KSK 133 (982 kg/ ha). Similarly, in second (16th July) and third (31st transplanting dates, Swift hybrid was the best yielder with average yield of 3803 and 3153 kg/ ha respectively (Fig. 30).

It was concluded that the water productivity was increased with the shifting of transplanting date towards shorter water demand period and shorter duration varieties (Fig. 31).

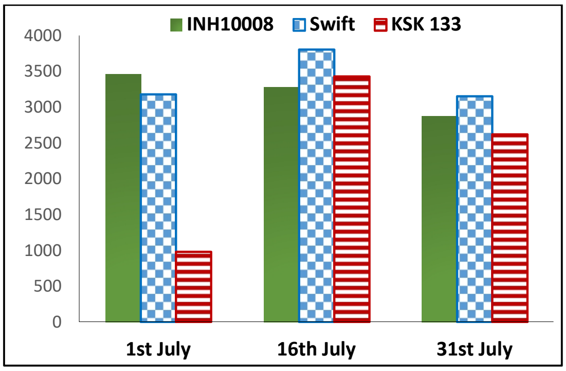


Fig. 30: Average yield performances of three genotypes at all the three transplanting dates

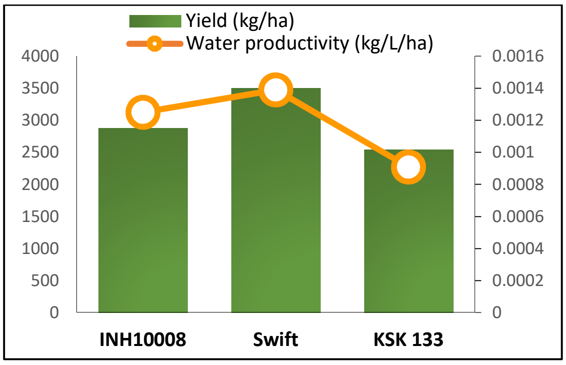


Fig. 31: Pair-wise comparison of mean yield and mean water productivity of hybrids and KSK 133 (check)

## B. *RICE RESEARCH STATION, BAHWALNAGER*

## I. RICE BREEDING

### Fine grain yield trial

In fine grain group (Fig. 32), PK 8749, PK 8662 and PK 8431 out yielded check variety (Basmati 515) by producing 6.8, 6.3 and 6.0 t/ha as compared to check variety (5.5 t/ha).

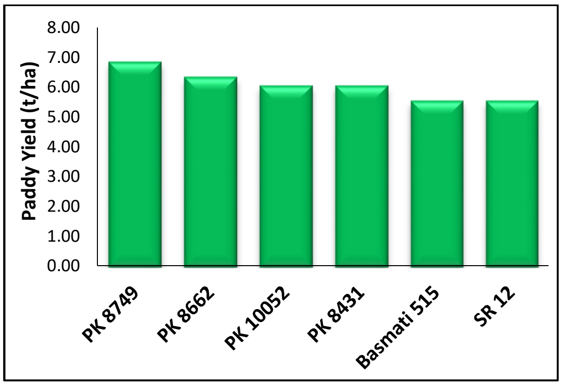


Fig. 32: Mean yield comparison of fine grain strains

### Extra long grain yield trial

In extra long grain group (Fig. 33), PGR 1/03/83B and PGR 1/03/83c out yielded check variety (PS 2) by producing 5.0 and 4.5 t/ha while the check variety produced 3.7 t/ha only.

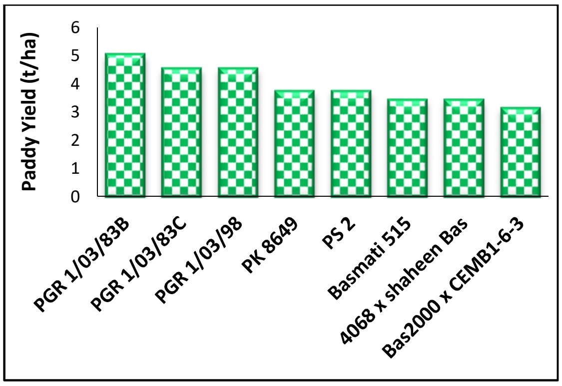


Fig. 33: Mean yield comparison of extra long grain strains.

### Coarse grain yield trial

In coarse grain group (Fig. 34), KSK 463 and KSK 462 out yielded check variety (KSK 133) by producing 7.3 and 6.4 t/ ha while the check variety produced 3.8t/ ha.

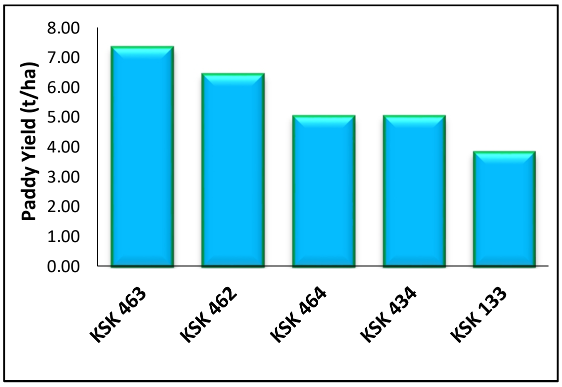


Fig. 34: Mean yield comparison of coarse grain strains

## Breeding Studies

### *Hybridization*

To combat different problems like diseases and to improve grain quality and yield of Basmati rice, 34 crosses were attempted and 12 successful crosses were harvested for further evaluation.

### Detail of successful crosses

| | |
|---|---|
| High Yielding | 04 |
| Early maturity& Short Stature | 02 |
| Quality | 01 |
| Bacterial Leaf Blight (BLB) | 03 |
| Blast | 02 |

## II. AGRONOMY

### Screening of herbicides for the effective control of different rice weeds

Five different herbicides were sprayed on rice variety PS 2 to check their efficacy against notorious weeds. The treatment application of Butachlor + Winsta gave efficient weed control (Fig. 35) and yield (Fig. 36).

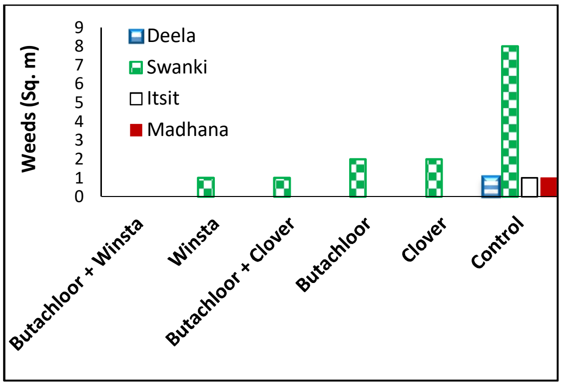


Fig. 35: Effectiveness of weedicides (No. of weeds/ sq. meter)

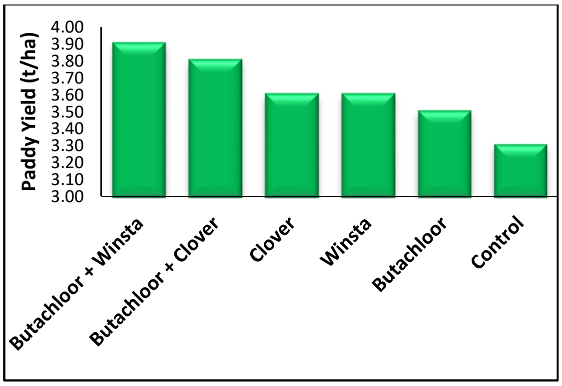


Fig. 36: Paddy yield comparison of different weedicide sprays

## III. PLANT PATHOLOGY

**Screening of fungicides for the effective control of rice blast**

Seven different fungicides were sprayed on rice variety Basmati 515 to check their efficacy against rice blast disease. The treatment application of Amistar top gave efficient blast disease control (Fig. 37) and yield (Fig. 38).

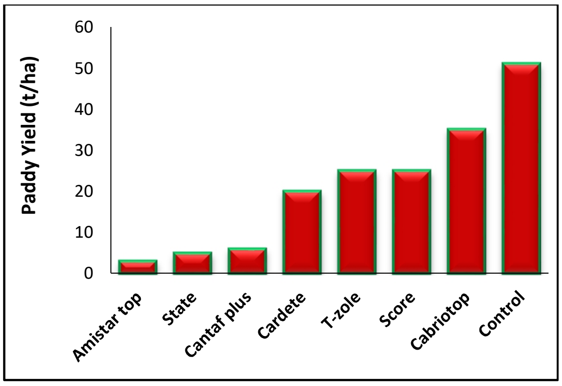


Fig. 37: Percentage of rice blast disease incidence

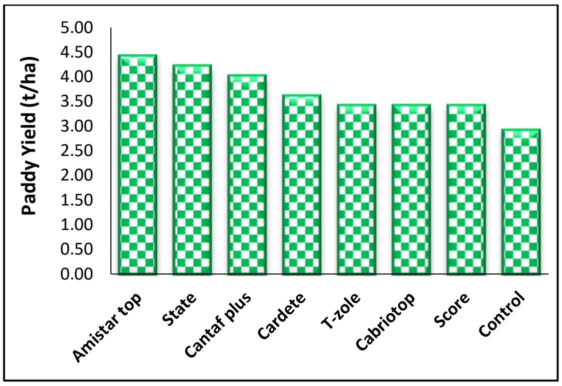


Fig. 38: Paddy yield comparison of different weedicide sprays

## C. *PUBLICATIONS*

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12. Bibi, T., S. Rauf, H. S. B. Mustafa, T. Mahmood and S. Din. Selection of stable mustard (*Brassica juncea* L.) genotypes through genotype × environment interaction and stability analysis suitable for Punjab, Pakistan. J. Agric. Basic Sci., 1 (1):
13. Bibi, T., S. Rauf, T. Mahmood, Z. Haider and S. Din. 2016. Genetic variability and heritability studies in relation to seed yield and its component traits in mustard (*Brassica juncea* L.). Acad. J. Agric. Res; 4(8): 478- 482.
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28. Akhter, M., A. M. Sabir and M. U. Saleem, 2015. *Dhaan ki Jadeed kasht.* RRI, KSK (In press).

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