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OVERVIEW

Rice is the second most important food and cash crop of Pakistan. According to the Economic Survey of Pakistan (2017-18), it accounts for 3.1 percent in the value addition in agriculture and 0.7 percent of GDP. The area under rice increased by 6.4 percent from 2.74 million to 2.89 million hectares in 2016-17. Similarly the rice production increased by 8.7 percent from 6.85 million to historically high level of 7.44 million tones). Rice area increased due to higher domestic prices and availability of inputs on subsidized rates, good advisory services and rising demand in international market, which made rice cultivation attractive for growers.

The production of rice reached historically high level of 7.44 million tons against the production of 6.85 million tones and recorded an increase of 8.7 percent over production of last year. Both these factors helped Pakistan post a 28 percent increase in rice export. According to data from the Rice Exporters Association of Pakistan (REAP), it sent out about 4.106 million tones for $2.04 billion in 2018, as compared to 3.44 million tones for $1.61 billion in 2017. This showed a significant growth of 27.7 percent in terms of value and 17 percent in terms of quantity. During, 2017-18, about 520,759 metric tons of basmati rice for US$ 540 million and about 3.58 million metric tons of non-basmati for US$ 1497 million was exported.

Punjab leads the national production scale with a contribution of 53 percent followed by Sindh, Baluchistan and Khyber Pakhtunkhwa (which has many local coarse varieties for hills and plains) with 26, 12 and 9 percent, respectively. In Punjab, the area under rice crop increased by 5% with 4.754 million acres as compared to previous year. Similarly, there was 5.5% increase in basmati area (3.69 million acres). The production of rice is 3.992 million tons during the year 2018-19.

The Expert Sub Committee conducted the spot examination for four promising fine grain lines during 2018-19. PKPB 8 is early maturing, extra- long grain, stiff stem with yield potential 7500 kg/ha. PKBB 15-116 possessed BLB resistant genes with yield potential of 6500 kg/ha. PK 8892-4-1-3-1 that is high yielding, early maturing, stiff stem and extra-long grain basmati rice with yield potential of 6500 kg/ha. RRI 3 is high yielding, early maturing, stiff stem, and extra-long grain basmati rice with yield potential of 6700 kg/ha, suitable for parboiled and steam rice.

A. RICE RESEARCH INSTITUTE, KALA SHAH KAKU

I. RICE BREEDING

Promising advance rice lines and their significant features

- **PKPB8 (extra-long grain for parboiled rice)**

PKPB8 is an extra-long (>8 mm), early maturing, short stature and fine grain advance rice line that is under candidature for approval as high yielding rice line very suitable for parboiling and steam rice (Fig. 1). It has been tested in various yield trials from 2015 to 2017 including trials such as station yield trails, regional and national (NURYT) adaptability yield trials. It is an early maturing line with maturity duration of 110 days. It also yielded 4.88 t/ha against 4.40 t/ha showing 11 % yield advantage over check variety i.e. PK 1121 Aromatic. Its average grain length (8.20 mm) is better than that of PK 1121 Aromatic (8.10 mm). The cooking quality (CGL).of this line is very good having cooked grain length of 17.2mm.

Fig. 1: PKPB 8

- **PKBB15-116 (BLB resistant and high yielding)**

PKBB15-116 is an advance Basmati rice line (Fig. 2) that carries Bacterial leaf blight (BLB) resistant genes (*xa5, Xa7 & Xa21*). It is earlier (2 weeks earlier) and higher yielding than existing Super Basmati. It was planted for spot examination at the institute for approval as cultivar. It has been tested in thirty-two varietal yield trials during 2014-17 including station, regional and national (NURYT) trials. In NURYTs 2016 and 2017, it yielded 3.52 t/ha (20% yield advantage) against 2.93 t/ha of Basmati 515. Its average grain length and cooking quality is at par with Super Basmati.

Fig. 2: PKBB 15-116

- **PK8892-4-1-3-1 (Basmati & better quality)**

PK8892-4-1-3-1 is advanced basmati rice line (Fig 3) with superior grain and cooking qualities compared with other Basmati varieties. It is short duration and high yielding. It was planted for spot examination at the institute and has been tested in varietal yield trials including station, regional and national (NURYT) trials during 2009-12 and 2016-17. It yielded 3.56 t/ha against 3.18 and 3.34 t/ha of Super Basmati and Basmati 515, with 10% and 14% increase over standard check varieties, respectively. It is an early maturity, stiff stem, extra-long grain and excellent cooking quality rice variety. Average grain length (7.58mm) is better than Super Basmati (7.42mm) and Basmati 515 (7.50mm) with 15.4mm cooking quality.

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

❖ **RRI 3 (extra-long grain for parboiled rice)**

RRI3 is an advance extra-long (>8mm) fine grain line (Fig. 4) that has been tested in varietal yield trials during 2012 to 2016 including station yield trials, regional and national (NUYT) adaptability yield trials over a number of locations to test their performances. RRI 3 gave 13%, 18% and 7% higher paddy yield than commercial variety Super Basmati, Basmati 515 and PK 1121 Aromatic, respectively. In physico-chemical tests conducted at Rice Research Institute, Kala Shah Kaku, AGL (8.13 mm) and CGL (17.3 mm) are better than Super Basmati and PK 1121 Aromatic. It is suitable both for parboiled and steam rice.

Fig. 4: RRI 3

FINE GRAIN RICE YIELD TRIALS

The fine grain yield trial comprised of forty-six selected uniform lines along with two checks i.e. Super Basmati and Basmati 515. Out of total, twenty three lines performed significantly ($p<0.05$) better than check varieties (Fig. 5) i.e., Basmati 515 (4.31 t/ha) and Super Basmati (4.77 t/ha).

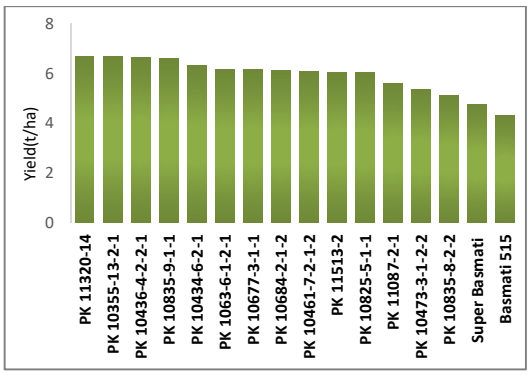

Fig. 5: Mean yield of fine grain promising lines in FGYT-2018

Coarse Grain Yield Trial

To check the relative performance of coarse advance rice line, coarse grain rice yield trial (CGRYT) was conducted (Fig. 6). In this trial, thirty seven selected uniform lines along with two check varieties were evaluated in coarse grain yield trials. Highest yield attained (7.94 t/ha) in case of KSK 514 out of fourteen lines who out yielded the check varieties viz., KSK 133 (6.92 t/ha) and KSK 434 (6.67 t/ha). Some of the lines also showed better grain quality and other agronomic traits as compared with existing coarse varieties.

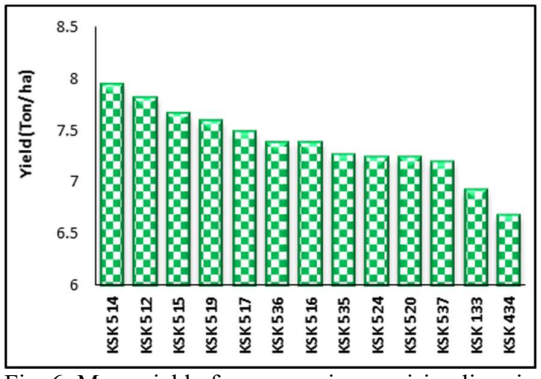

Fig. 6: Mean yield of coarse grain promising lines in CGRYT -2018

BREEDING STUDIES

Hybridization

To develop climatic smart rice varieties with biotic (insect pest and diseases), and abiotic stresses (salinity, submergence, heat and drought) tolerant varieties, 200 parental lines were planted in hybridization program. Three hundred and forty six crosses were attained and successfully harvested for further evaluation in subsequent generations. Number of crosses achieved for each target traits including biotic and abiotic stress tolerance, yield and quality enhancement, are depicted in Table 1.

Table 1: Detail of successful crosses

Breeding objective	No. of crosses
Bacterial leaf blight (BLB)	30
High yielding	95
Flood tolerance	30
Quality	30
Early maturity & Short stature	15
Extra-long grain	15
Salt tolerance	25
Drought	10
Genetic diversity	15
Planthopper	15
Back cross	10
Aroma	05
Plant type	05
Blast	01
Nutrition enhancement	45

Variety test through SSR markers

Polymorphic survey of fifteen approved rice varieties and fourteen advanced lines through SSR markers were accomplished. SSR markers were used and evaluated to discriminate particular genotype from the others. SSR markers RM212 and RM 282 showed polymorphism to differentiate these lines as depicted by different band size achieved on Gel (Fig. 7).

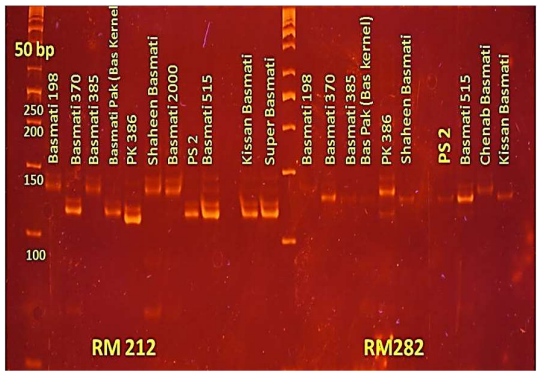

Fig. 7: Variety test of different genotypes through SSR markers

Marker Assisted Selection Breeding

DNA testing of rice genotypes for incorporation of BLB resistant genes (*Xa4, xa5, xa13* and *Xa21*) through Marker Assisted Selection (MAS) approach. BLB resistant genes specific markers are used to screen the genotypes carrying the BLB resistant genes. Similarly, BLB genes status were also determined in 89 lines from Source Nursery (Fig. 8).

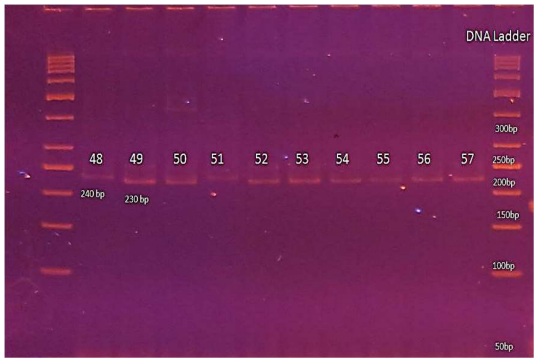

Fig. 8: Banding patterns showing the presence and absence of xa5 gene in BLB Filial generation amplified 240 bp and 230 bp size fragments, respectively.

For salinity tolerant gene (*Saltol*) status, 15 Rice genotypes were screened through ten SSR markers (RM8094, RM10748, RM10720, RM3412, RM493, RM8115, RM1287, RM10773, RM140, RM10793) and nine

samples were screened through RM10748 (Fig. 10).

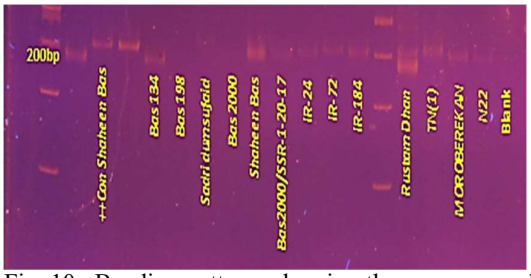

Fig. 10: Banding patterns showing the presence and absence of *Saltol* gene in rice lines

For Bio-fortification of advance rice lies with iron and zinc, nearly sixty (60) rice genotypes were screened for Fe and Zn contents through four SSR markers (Fe-RM319, RM444, Zn-RM152, Fe+Zn-RM7414). The figure below, depicts the polymorphism of genes for iron and zinc contents in rice germplasm (Fig.12).

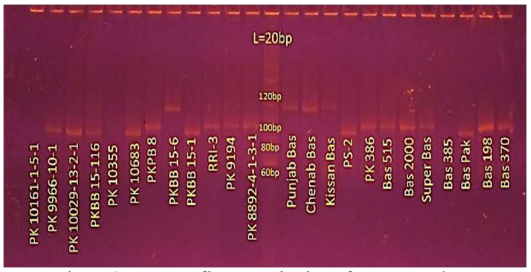

Fig. 12: DNA fingerprinting for Fe and Zn.

For waxy character, 50 rice genotypes were screened through PCR-CTPP with SNP typing primers for rice Wx In 1 (GF, TR, GR, TF) and 10 rice genotypes were screened through SSR marker RM314 and 50 rice genotypes were screened against Aroma gene using Multiplex PCR (Fig.13).

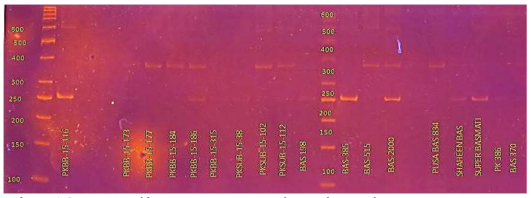

Fig. 13: Banding patterns showing the presence and absence of Aroma gene in rice germplasm amplified 257 bp and 350 bp size fragments, respectively.

Screening for flood tolerance in rice

To screen advance rice lines for flood/ submergence tolerance, an experiment was conducted using one hundred and eighteen advance rice genotypes and fourteen local approved varieties to evaluate under submergence/ flooded conditions. These genotypes were submerged in artificial pond for 15 days under submergence of 1.5 meter. All the local approved varieties showed zero tolerance Index (TI) and six rice lines (IR 102885-29-98-6, PK 386, PK 8892, Chenab Basmati, PKPB8 and Kissan Basmati) showed tolerant response under flood stress with ≥ 0.9 TI value indicating highest level of submergence tolerance. Moderately tolerance behavior of six lines showed TI value from 0.7-0.9.

SEED PRODUCTION

To maintain purity and genetic integrity of approved rice varieties, pre-basic seed of fine (3929 Kg) and coarse grain varieties (1289 Kg) was produced.

HYBRID RICE

Rice hybridization in basmati hybrid development programme

Basmati hybrid development and parental lines multiplication is being achieved for hybrid rice availability on sustainable basis. In hybridization program one hundred and eight test crosses were studied for the development of hybrid parental lines and new hybrids (Fig. 14-15). In testcross nursery, twenty five maintainers and twenty three restorers were identified. Twenty five maintainers with desired traits were backcrossed with the

recurrent parent for the development of new CMS lines.

Fig.14. Pollination

Fig 15: Hybrid rice selections

In development of hybrid rice combination 25 restorers were observed/ studied. Newly developed CMS lines in Basmati background (KSK1601A and KSK 1701A) have been utilized in new cross combinations. In backcross nursery 25 backcrosses were attempted for the development of new CMS lines, six backcrosses are in BC_5 which all are uniform in morphological traits as well as sterility are near to development of new CMS lines. In test cross nursery 25 testcrosses were again identified sterile under microscope and backcrossed for parental line development.

Fig. 16: Supplementary pollination by bamboo stick method in seed multiplication on small scale

The produced quantity of hybrid rice seed (multiplication of identified hybrids) was ten kg seed of CMS line KSK1317A and five Kg seed of KSK1301A, one kg of KSK1601A and KSK1316A each for its maintenance and seed production. (Fig 17).

For testing in NUYRT, seed of 45Kg (KSK111H), 24 kg (KSK118H), 4Kg (KSK144H) and 12 kg (KSK145H) was produced in hybrid rice seed production. Similarly, as per MOU between Sayban group and RRI, KSK under public private partnership, hybrid seed of HR-14 was successfully produced on one acre. The seed quantity of 936kg was sold out to Sayban group. The average calculated yield of produced yield of hybrid rice was 2.2t/ha (Fig 18).

Fig. 17: Hybrid rice seed production

In non-replicated yield trial total 20 local test hybrids (Non-Basmati and Basmati) were tested at the institute (Fig. 17). Ten different hybrids in basmati background were out yielded the check Basmati 385 (4.0 t/ha) the yield ranged from 4.2 to 9.5 t/ha and four rice hybrids in Coarse background were out yielded the Check KSK 133 (6.5 t/ha) yield ranged from 7 to 10 t/ha.

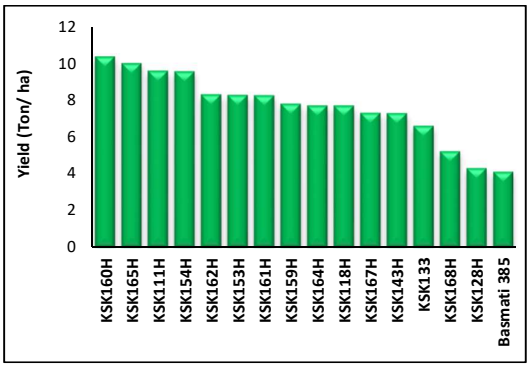

Fig. 17: Yield comparison of local test hybrids

II. AGRONOMY

Effect of time of nitrogen application on efficacy of different post-emergence herbicides in dry seeded rice systems

To find out the the effect of time of nitrogen on the efficacy of post-emergence herbicides and to study the most suitable herbicide(s) to control noxious weeds of rice i.e., *Leptochloa chinensis* (Kallar grass), *Eragrostis japonica* (Bansi grass) and *Dactyloctenium aegyptium* (Madhana grass) in dry-seeded rice (Fig. 1) this experiment was conducted.

The treatment Pendimethalin + Erazer (Fenoxaprop-p-ethyl + Ethoxyxulfuron + Isoxadifen-ethyl) where no nitrogen was applied before post application was observed excellent in terms of weed control (95.9%) and paddy yield (5.50 t/ha). It was followed by the treatment having application of same weedicides but where nitrogen was applied before post application with 93.5% weed control with 5.21 t/ ha paddy yield.

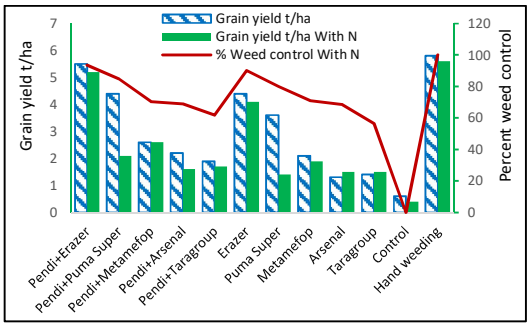

Fig. 1: Effect of different post-emergence herbicides on percent weed control and grain yield of basmati rice

Screening of pre-emergence herbicides to control weeds in transplanted rice

A field experiment was conducted to find out the most effective pre-emergence herbicides to control weeds in transplanted rice. Four pre-emergence herbicides namely Council Active (Triafamone 10% + Ethoxysulfuron methyle 20%), Kelion 50 WG (Orthoxysulfomuron), Topstar 80WG (Oxadyragel), A new chemical (Oxaziclomefone 1% EC) and Machete 60 EC (Butachlor) were compared for their performance. Application of these herbicides was made with shaker bottle after four days of transplanting (Fig. 2).

Fig. 2: Herbicide application with shaker bottle

It was found that among all the treatments (Table 1), maximum weed control of 95.40% alongwith the highest paddy yield of 5.88 t/ha

was achieved with the application of Oxaziclomefone 1% EC. However, the plots where no herbicide was applied expressed the lowest paddy yield (3.17 t/ha).

Table 1: Effect of herbicide application as pre-emergence on percent weed control and paddy yield

Treatments	Percent weed control	Paddy Yield (t/ha)
Oxaziclomefone	95.40	5.88
Topstar	94.51	4.90
Council Active	94.33	5.36
Machete	79.65	4.52
Kelion	76.64	4.69
Control	-	3.17
LSD	-	0.703

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

Field experiment was conducted to evaluate the effect of foliar application of zinc and iron on grain contents of promising coarse grain rice varieties for bio-fortification of rice grains aimed at improving nutritional value of rice grain. The results showed a significant increase in the zinc and iron contents of grains in KSK 434 and KSK 133. However, KSK 434 gave a better response than that of KSK 133 (Fig. 3). Thus, maximum values for Zn (34.64 mg/ Kg) and iron (17.5 mg/ Kg) contents in grains were recorded in case of KSK 434.

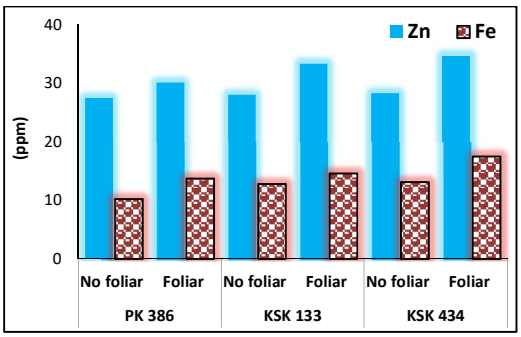

Fig. 3: Zn and Fe contents in coarse grain rice varieties

Effect of residue management and planting techniques on productivity of rice-wheat cropping system

Filed trial was conducted to find out appropriate tillage-residue (TR) system and residue management techniques for to enhance productivity of rice-wheat cropping system through resource conservation. Experiment was laid in RCBD with split plot arrangement.

The highest paddy yield (3.98 t/ha) was achieved (Table 2) in DSR-ZT (partial retention) followed by 3.82 t/ha recorded in case of TR-ZT (partial retention), whilst the minimum yield (3.09 t/ha) was observed in case of TR-CT (incorporation) however it remained at par with that of TR-CT (burning).

Table 2: Effect of different tillage-residue systems on paddy yield of fine grain rice

Treatments	Yield (t/ha)		
	Wheat	Paddy	Average
TR – CT (partial burning)	2.95	3.21	3.08
TR – CT (incorporation)	3.11	3.09	3.10
DSR – ZT (partial retention)	4.56	3.98	4.27
TR – ZT (partial retention)	3.31	3.82	3.57
DSR(ZT) - ZT (full retention)	4.22	3.11	3.66
LSD	0.511	0.539	

Effect of transplanting dates of fine and coarse grain lines/ varieties on yield

Transplanting of rice nursery at optimum time plays a vital role to get maximum crop yield with better grain quality. A field experiment was laid out in RCBD having split plot

arrangement to find out optimum period of transplanting for fine and coarse grain lines/ varieties. It was found that among all the varieties/ lines significantly highest average paddy yield of fine grain rice (4.27 t/ha) was achieved with Chenab Basmati that was statistically at par with the new promising line PK 9444-8-1-2 which gave paddy yield of 4.20 t/ha. It was further noticed that PK 9444-8-1-2 expressed its maximum paddy yield (4.97 t/ha) when transplanted on July 14 (Fig. 4).

As far as the coarse lines/ varieties are concerned, the highest paddy yield of 6.55 and 5.79 t/ha was expressed by KSK 505 and KSK 133, respectively, when transplanted on 27th May (Fig. 5).

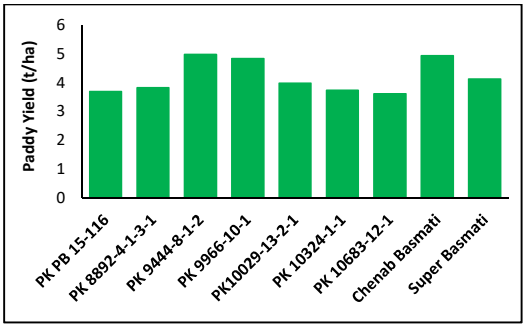

Fig. 4: Effect of transplanting dates (July 14) on paddy yield of fine grain lines/ varieties

Moreover, the highest average yield of all the varieties/lines of all transplanted dates was also recorded in case of KSK 505 and KSK 133, respectively (6.04 and 5.50 t/ha).

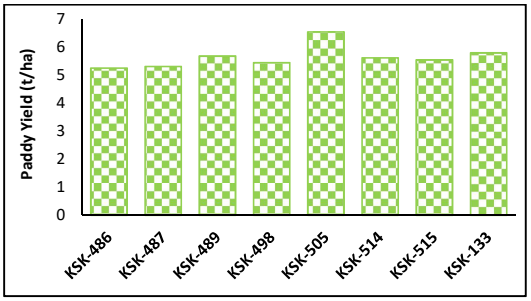

Fig. 5: Effect of transplanting date (May 27) on paddy yield of coarse grain lines/varieties

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

On five different ecological zones viz. Gujranwala, Faisalabad, Sheikhupura, Sargodha, Bahawalnagar and Kala Shah Kaku, an experiment was conducted to compare the field performance of newly evolved basmati and coarse lines/ varieties.

The data showed that at all locations among fine lines (Table 3), Chenab basmati secured the top position with average yield of 5.71 t/ha that was followed by the promising line PK 10324-1-1 which produced 4.36 tons paddy per hectare.

Table 3: Performance of newly evolved basmati lines (t/ha) in different ecological zones

Lines/ Varieties	Gujranwala	Sheikhupura	Faisalabad	Sargodha	Kala Shah Kaku	Bahawalnagar	Average
PK PB 15-116	4.69	4.66	4.66	2.40	4.33	2.82	3.93
PK 8892-4-1-3-1	5.14	4.46	5.02	2.60	5.00	2.63	4.14
PK 9444-8-1-2	3.54	3.59	3.26	2.10	3.65	2.18	3.05
PK 9966-10-1	3.45	5.01	3.29	2.16	3.45	2.72	3.35
PK10029-13-2-1	4.53	4.03	4.38	2.62	3.65	2.84	3.68
PK 10324-1-1	6.24	4.19	6.05	3.50	3.39	2.81	4.36
PK 10683-12-1	4.46	4.68	4.12	3.32	3.33	2.03	3.66
Chenab Basmati	7.02	4.90	6.71	3.72	7.42	4.48	5.71
Super Basmati	5.38	4.47	5.55	2.56	3.6	2.94	4.08

Table 4: Performance of newly evolved coarse lines in different ecological zone (t/ha)

Lines/ Varieties	Gujranwala	Sheikhupura	Faisalabad	Sargodha	Kala shah Kaku	Bahawalnagar	Average
KSK 486	3.23	5.41	4.07	3.83	3.67	2.62	3.92
KSK 487	3.72	5.99	4.00	3.17	3.68	2.57	3.88
KSK 489	3.47	6.16	6.98	3.45	5.45	2.65	4.69
KSK 498	3.62	5.62	6.80	3.34	6.24	2.93	4.99
KSK 505	4.26	5.57	5.83	4.19	5.50	4.66	5.00
KSK 514	2.62	6.25	5.73	3.15	5.29	4.38	4.96
KSK 515	4.05	5.09	5.24	3.02	4.87	3.74	4.39
KSK 133	4.23	5.64	7.96	3.63	3.96	3.93	5.02

In case of coarse grain rice, KSK 133 out yielded all varieties at all locations with average yield of 5.02t/ha which was followed by promising line KSK 505 (5.0 t/ha).

III. PLANT PATHOLOGY

Screening of fungicides for the control of rice blast

Seven different fungicides were tested (Fig. 1) on rice variety Basmati C-622 to check their efficacy against rice blast disease. The Amistar Top 325 SC treatment (Fig. 2) gave efficient blast disease control with least percent disease incidence (11.6%) and yield (4.8 t/ha) as compared to rest of the treatments.

Fig 1: Application of fungicides spray in different treatments

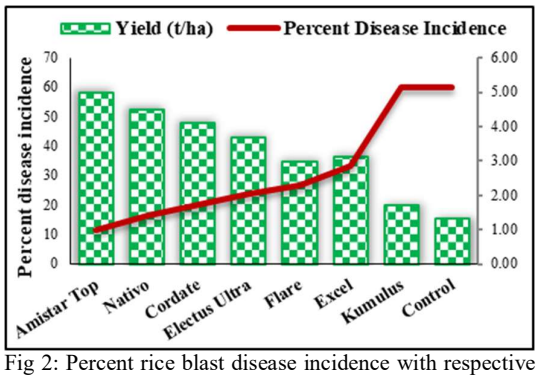

Fig 2: Percent rice blast disease incidence with respective paddy yield

Screening of spray chemicals for the effective control of bacterial leaf blight

Eight different chemicals were applied on rice variety Basmati 515 to check their efficacy against bacterial leaf blight disease (BLB). The treatment application of EV Cin 0.33% (Fig. 3) gave effective disease control with least percent BLB incidence (5%) and yield (5.04 t/ha) as compared to other treatments.

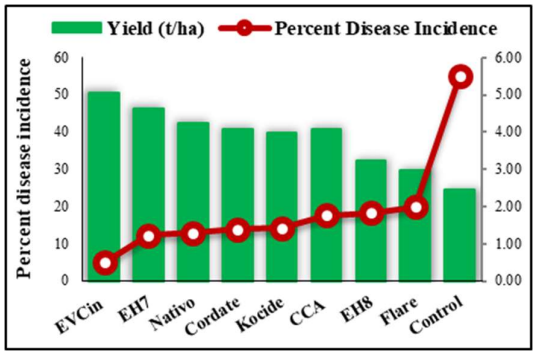

Fig 3: Bacterial leaf blight incidence percentage with respective paddy yield

Screening of spray fungicides for the effective control of brown leaf spot

Seven different fungicides were sprayed on Super Basmati to check their efficacy against brown leaf spot (BLS) disease. The treatment application of Amistar Top 325SC (Fig. 4) gave efficient disease control with least percent BLS incidence (6.60%) and yield (4.64 t/ha) with respect to other treatments.

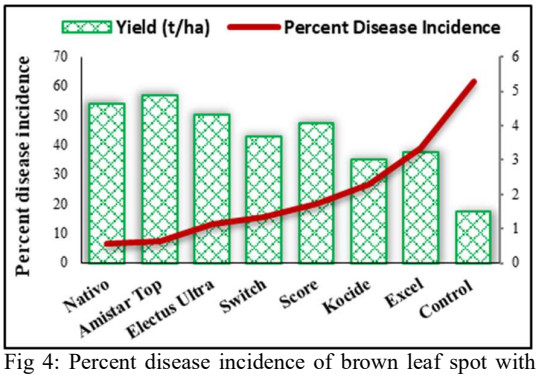

Fig 4: Percent disease incidence of brown leaf spot with comparative paddy yield

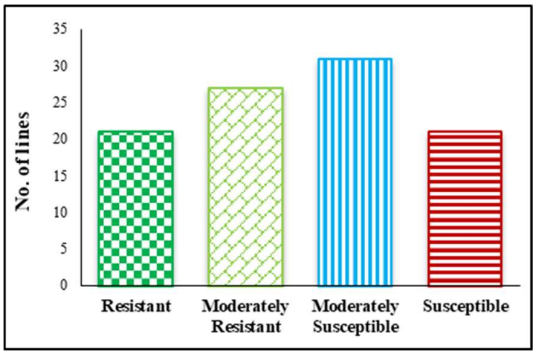

Fig. 6: Response of lines/ varieties against BLB

Screening of breeding material for resistance against bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) under field conditions

One hundred rice lines/ varieties of local and exotic origin were tested and analyzed for their respective response against bacterial leaf blight (BLB) by using Standard Evaluation System (SES) for Rice, 2013 developed by the IRRI, Philippine. Keeping in view the percentage disease infection of bacterial leaf blight (Fig. 5) twenty-one lines/ varieties behaved as resistant, twenty seven as moderately resistant, thirty one as moderately susceptible and twenty one as susceptible (Fig. 6).

Fig 5: Inoculation by leaf clipping method

Screening of breeding material for resistance against brown leaf spot (*Bipolaris oryzae*) under field conditions

One hundred rice lines/ varieties of local and exotic origin were tested (Fig 7).and analyzed for their respective response against brown leaf spot (BLS) by using Standard Evaluation System (SES) for Rice, 2013 developed by the IRRI, Philippine. Keeping in view the percentage disease infection of brown leaf spot (Fig 8).

Fig 7: Nursery of lines/varieties for screening against BLS

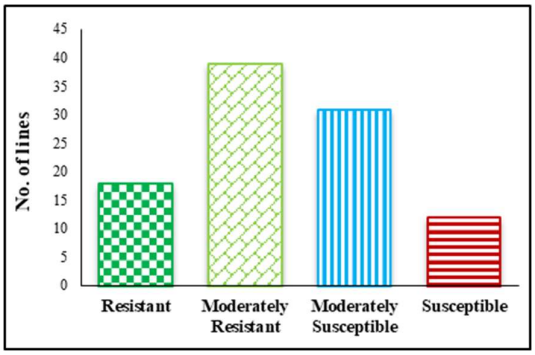

Fig 8: Response of lines/ varieties against BLS

IV. ENTOMOLOGY

Monitoring of planthoppers on alternate hosts in rice ecosystem

Field surveys were carried out throughout the year on different plants/ weeds to monitor planthoppers (Whitebacked planthoppers-WBPH and brown planthopper- BPH) on alternate hosts by net sweepings.

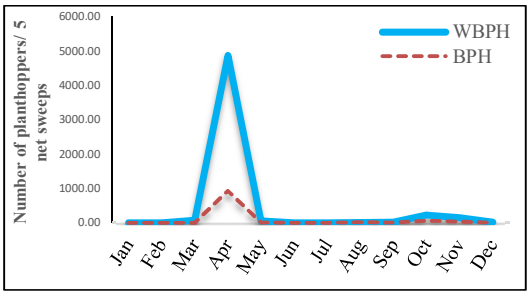

Fig. 1: Temporal assemblage (number) of planthoppers on alternate hosts

Highest population of both WBPH and BPH was recorded in April (Fig. 1) on barseem. WBPH was recorded from Barseem, Sunflower, Maina, Khabbal grass, Ghora grass, Narru, Maize, Sorghum and Swank. In addition to above, BPH was also recorded from Spinach.

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

Fifty-five fine and eleven 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, 2013 developed by the IRRI, Philippine. Keeping in view the percentage infestation of rice leaffolder (Fig. 2) eleven fine grain lines (PK 10684-2-1-2, PK 10680-5-1-1, PK 10681-4-1-1, PK 10680-3-3-2, PK 10684-2-4-1, PK 10678-2-1-1. PKBB15-288, PKPB 8, F3-44, PK 10436-4-2-2-1, PK 10941-9-1-2-1, PK 10684-6-1-1, PK 10681-1-3-2, PK 9966-10-1, PK 10749-18-1-1, PK 10963-29-1-1, PK 10306-15-5, PK 10355-13-2-1 and PK 10683-12-1) and three coarse grain lines (KSK 476, KSK 480 and KSK 133) behaved as moderately resistant (Fig. 3).

Fig. 2: Scratching of green matter of leaf by leaffolder

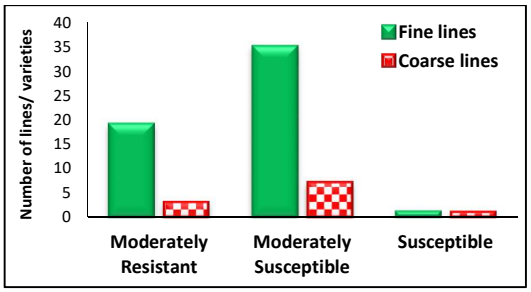

Fig. 3: Response of lines/ varieties against leaffolder

Screening of insecticides for the effective control of rice leaffolder (*Cnaphalocrocis medinalis*) under field conditions

To observe the efficacy of different insecticides for the effective control of rice leaffolder along with standard treatment was tested for their effectiveness against target pests on Basmati 515 using standard agronomic practices under field conditions.

Percent effectiveness of insecticides (Fig. 4 18) showed that all the pesticides effectively controlled the target pest than untreated check with 64% survival percentage of biocontrol agents by Fipryte as compared to standard insecticide, however, it was maximum in untreated check (126.26%).

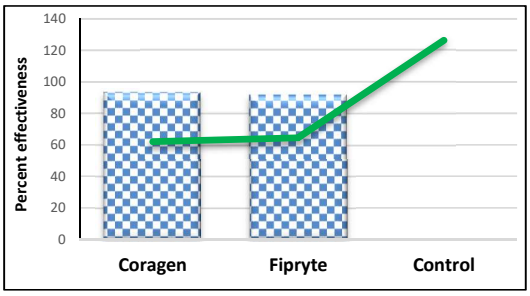

Fig.4:Post-treatment percent effectiveness of insecticides against rice leaffolder and survival percentage of bio control agents

V. RICE TECHNOLOGY

Studied on physiochemical characteristics of fine grain national uniform yield trials

Maximum Total Milled Rice (TMR) of 72.0% was recorded in FR-13 followed by FR-14 with 71.0% TMR (Fig.1). Maximum Head Rice recovery (HR) of 55.5% was recorded for line FR-19 followed by line FR-13 with 55.0% HR. Maximum Average Grain Length (AGL) of 10.06 mm was shown by line FR-12 followed by Line FR-48 with 9.12 mm AGL. Maximum cooked grain length (CGL) of 19.5 mm was recorded for line FR-12 followed by line FR-23 with 16.8 mm CGL.

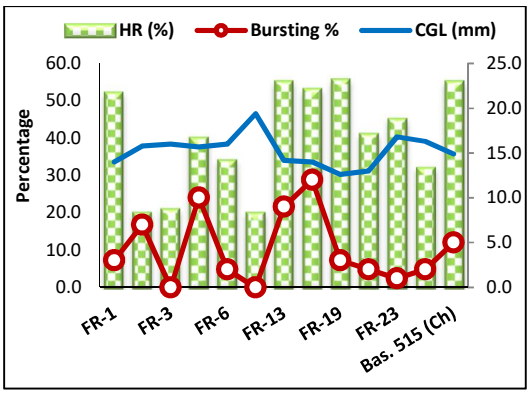

Fig. 1: Milling recovery and cooking quality of NUYT fine grain trial

Maximum elongation ratio of 1.94 was exhibited by the Line FR-12 followed by line FR-23 with 1.85 elongation ratio. Overall, with respect to milling recovery, lines FR-14, FR-13 and FR-19 performed. As for cooking quality, lines FR-12 and FR-23 performed exceptionally well.

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

Maximum Total Milled Recovery (TMR) of 69.0% was recorded on 15th July 2018 followed by date of 3rd June 2018 with 67.6% TMR (Fig. 2). Maximum Head Rice recovery of 44.0% was recorded on 15th July 2018 followed by the date of 5th August 2018 with 37.5% HR. With respect to varieties/lines, maximum TMR 69.3 % was observed for line PK 10029 followed by line PK 8892 with 68.5% TMR. Maximum HR of 51.5 % was recorded for line PK 8892 followed by line PK BB-15-116 with 48.5% HR. In all, best milling recoveries were observed on transplanting date of 15th July 2018 followed by 3rd June 2018. Lines PK 8892, PK 10029 and PK BB-15-116 performed well in milling recovery.

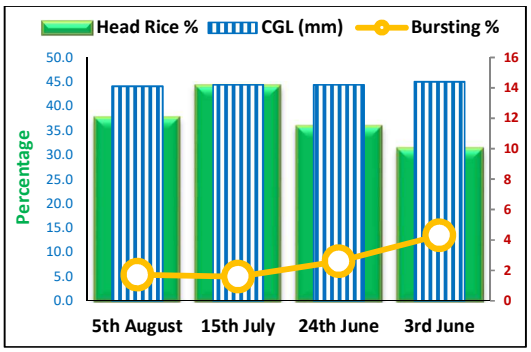

Fig. 2: Head rice recovery, bursting percentage and CGL of fine transplanting trial

Maximum cooked grain length (CGL) of 14.4 mm was recorded for the date of 3rd June 2018 followed by date of 15th July 2018 with 14.2 mm CGL. Minimum bursting of 1.6 % was

observed on 15th July 2018 followed by date of 5th August 2018 with 1.7 % bursting. With respect to lines, maximum CGL of 16.1 mm was recorded for line PK 9444 followed by line PK 9966 with 15.3 mm CGL. Minimum bursting of 0.7 % was recorded for line PK 10324 followed by lines PK BB-15-116 with 1.0 % bursting. Overall, best cooking quality was observed on transplanting date of 15th July 2018 followed by 5th August 2018. Lines PK 8892, PK BB-15-116 and PK 10029 performed well in terms of cooking quality.

Regional adaptability trial of fine grain rice

Maximum TMR of 76.9% was recorded at Gujranwala (GRW) followed by Faisalabad (FSD) with 75.4% TMR (Fig. 3). Maximum Head Rice recovery (HR) of 53.3% was recorded at Faisalabad followed by Gujranwala with 52.1% HR. With respect to individual line, best Head Rice recovery of 52.8% was exhibited by Line PK 8892 followed by line PK BB-15-116 with 50.3% HR.

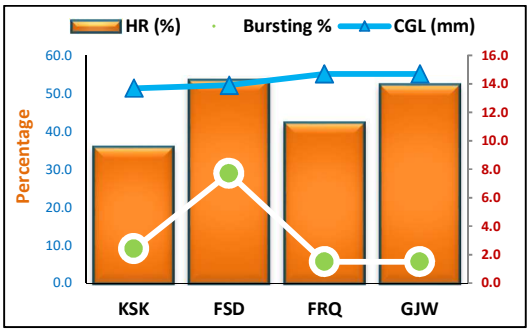

Fig. 3: Head rice recovery, bursting percentage and CGL of regional adaptability trial of fine rice

Overall, best milling recoveries were observed at Faisalabad and Gujranwala. Lines PK 8892 and PK BB-15-116 showed good milling recovery results.

In cooking quality, Maximum CGL of 14.7 mm was observed at Gujranwala and Farooqabad (FRQ) followed by Faisalabad with 13.9 mm CGL. With respect to individual lines, maximum CGL of 15.5 mm was exhibited by line PK 9444 followed by line PK 9966 with 15.2 mm CGL. On account of Average Grain Length (AGL), maximum AGL of 8.25 mm was observed at Faisalabad followed by 8.20 mm AGL observed at Gujranwala. In all with respect to cooking quality, best locations were Gujranwala and Farooqabad followed by Faisalabad. In terms of individual lines, PK 9444 and PK 9966 performed well.

VI. AGRICULTURAL ENGINEERING

Influence of seed rate on grain yield and quality parameters in dry seeded rice (DSR)

The experiment was carried out to evaluate the yield, milling recovery and cooking quality parameters of PK 1121 Aromatic, cultivated by DSR technology with five different seed rates (14, 12, 10, 08, 06 kg/acre). Inclined plate seed drill was used for this purpose. All the treatments were arranged in RCBD replicated thrice.

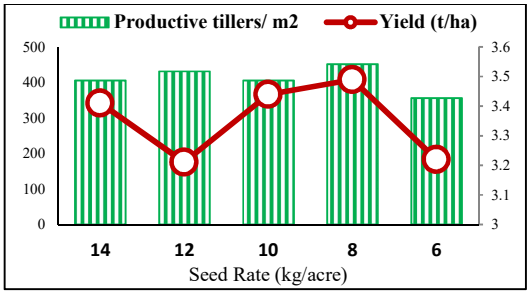

Fig. 1: Effect of seed rate on productive tillers and yield

The results revealed that none of the seed rates significantly affect the no. of productive tillers/m^2 and yield, and interaction among the different seed rates of paddy yield and productive tillers remain insignificant (Fig. 1). Regarding milling parameters; head rice and broken were significantly affected by the seeding rates and good milling recovery (highest % of head rice with lowest % of broken) was obtained with the seed rate 6 kg/acre. In quality; Cooked Grain Length (CGL) was not affected by different seed rates (Fig. 2) but it was observed that bursting of the rice grain after cooking was significantly affected by the different seed rates and the lowest bursting 3.7% followed by 4.0 % was observed in 6 and 8 kg/acre seed rates respectively.

From the results after 1st year of experiment, it can be concluded that good milling recovery and cooking quality with no yield penalty was achieved when rice was cultivated with 6-8 kg/acre seed rate under dry seeded rice technology.

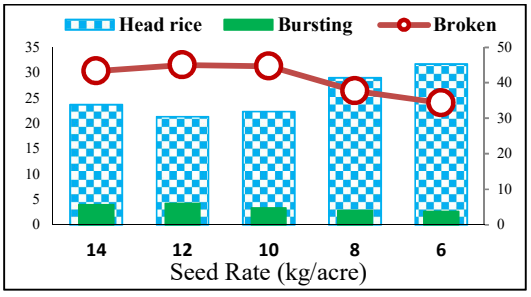

Fig. 2: Effect of seed rate on quality parameters (%)

B. RICE RESEARCH STATION, BAHWALNAGER

I. RICE BREEDING

Fine grain yield trial

Five strains and one check variety were tested in this trial. The data (Fig. 1) reveals that four strains performed better than the check variety. The strains PK 8431 (6.12 t/ha), PK 8662 (5.67 t/ha), PK 10052 (5.03 t/ha) and PK 8749 (4.72 t/ha) gave higher yields as compared to check variety Basmati 515 with paddy yield of 4.08 t/ha. However, the strain SR 12 produced lowest yield of 3.41 t/ha in this trial.

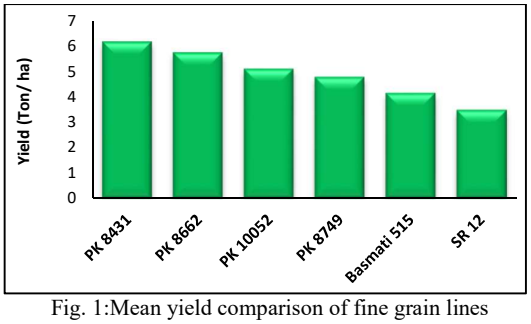

Fig. 1:Mean yield comparison of fine grain lines

Extra-long grain yield trial

Four strains with two checks (Kissan Basmati and PK 1121 Aromatic) were tested for paddy yield performance in extra-long grain yield trial. The paddy yield data (Fig. 2) shows that performance of three strains was superior to both of the check varieties. The paddy yield of PBR 2 was 5.83 t/ha, while paddy yield of PBR 1 and PBR 3 was 5.77 and 4.78 t/ha, respectively as compared to paddy yield of check variety Kissan Basmati (4.65 t/ha).

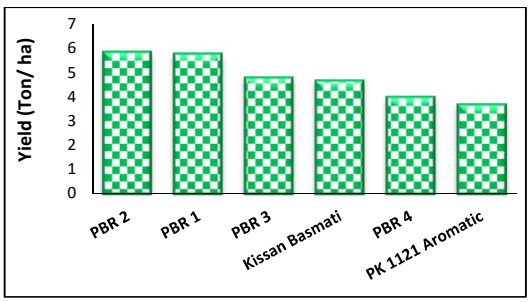

Fig. 2: Mean yield comparison of extra-long grain lines.

Coarse grain yield trial

Four strains with two checks were tested for paddy yield performance in coarse grain yield trial. The two checks KSK-434 and KSK-133 gave paddy yield of 6.25 t/ha and 6.06 t/ha respectively. Two strains i.e. KSK-464 and KSK-462 performed better by giving higher paddy yields as compared to check varieties. KSK-464 produced yield of 6.41 t/ha while KSK-462 produced 6.28 t/ha (Fig. 3).

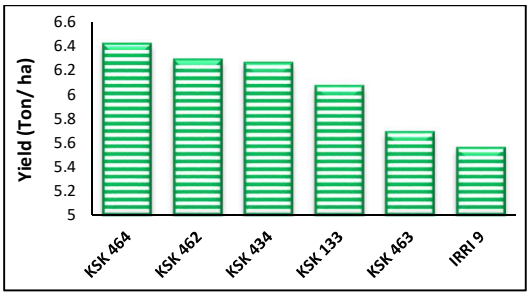

Fig. 3: Mean yield comparison of coarse grain strains

Screening for drought tolerance

Twenty three lines were screened for drought tolerance under field conditions. Five lines showed moderate tolerance to drought conditions. Among these five moderately drought tolerant lines (Fig. 4), IR 95786-9-2-1-2 produced the highest paddy yield (5.71 t/ha) followed by IR13L345 (5.42 t/ha).

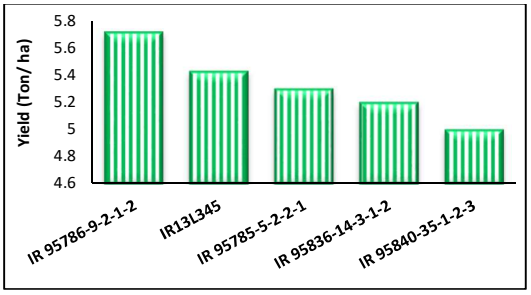

Fig. 4: Mean yield comparison of moderately drought tolerant lines.

Screening for heat tolerance

Twenty-three lines were screened for drought tolerance under field conditions. Six lines showed moderate tolerance to heat conditions. Among these six moderately heat tolerant lines, IR108594-50produced the highest paddy yield of 6.94 t/ha followed by IR93338 with 6.65 t/ha (Fig. 5).

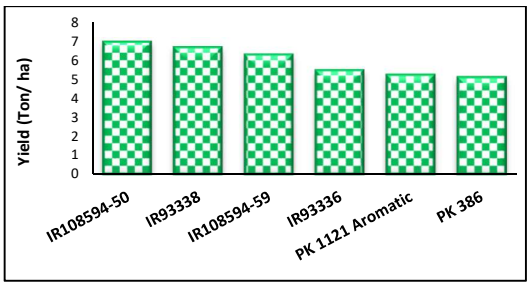

Fig. 5: Mean yield comparison of moderately heat tolerant lines.

BREEDING STUDIES

Hybridization

The objective of hybridization was to create new genetic combinations for yield, grain length, drought tolerance, blast resistance, heat tolerance, grain quality and earliness. In the year 2018-19, total 86 crosses were endeavored and 40 fruitful crosses were collected for further evaluation.

Detail of successful crosses

Breeding objective	No. of crosses
Yield	15
Grain length	12
Drought tolerance	04
Blast resistance	03
Earliness	03
Grain quality	02
Heat tolerance	01

II. AGRONOMY

Screening of herbicides for the effective control of different rice weeds

This trial was conducted to test the effectiveness of different herbicides for weed control in rice. Five treatments consist of either

single herbicide or combination of two herbicides while 6th treatment was control. These herbicides were sprayed on Kissan Basmati to evaluate maximum weed control and highest paddy yield. The data (Fig. 6) indicates that the combination of Butachlor + Winsta produced highest paddy yield (5.83 t/ha) while giving highest weeds control (02 weeds/ sq m). The data also reflects that maximum weed infestation was observed in control (18 weeds/ sq m).

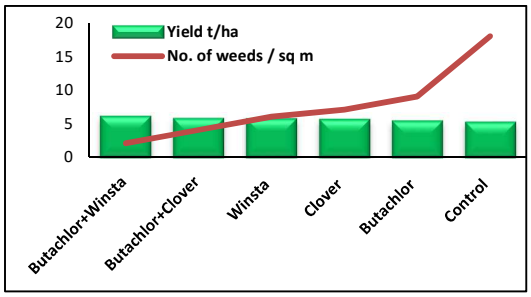

Fig. 6: Effectiveness of weedicides with respective yield comparison

Demonstration of direct seeding rice technology

Six strains were tested for paddy yield in direct seeded rice technology trial. The data (Fig. 7) shows that maximum paddy yield was produced by Chenab Basmati (5 t/ha). The check variety PK 1121 Aromatic produced 4.9 t/ha paddy yield. The yield performance of all other four strains was inferior as compared to check variety.

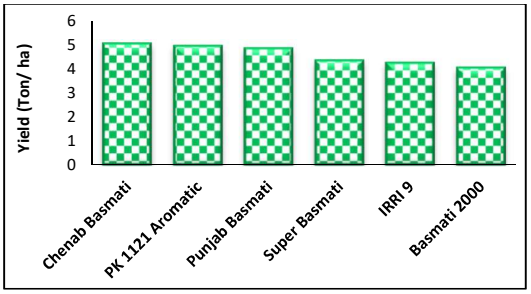

Fig. 7: Mean yield comparison of DSR lines

III. PLANT PROTECTION

Screening of fungicides for the effective control of rice blast

This experiment was conducted to test the effectiveness of seven different fungicides for control of rice blast disease on Kissan Basmati. The data (Fig. 8) indicates that Evito produced the highest paddy yield (5.41 t/ha) with minimum disease incidence (1.8%) followed by Contaf Plus with paddy yield of 5.23 t/ha and disease incidence of 3.4%.

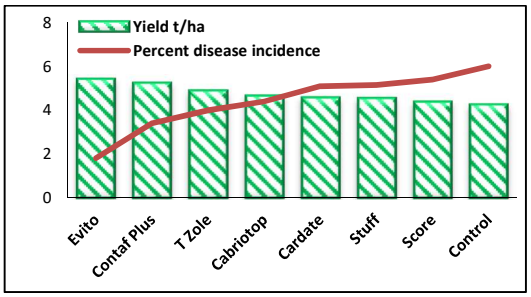

Fig. 8: Effectiveness of fungicides with respective yield comparison

Efficacy of different chemicals for the control of bacterial leaf blight disease

The objective of the experiment was to find the most effective chemical for control of bacterial leaf blight disease on rice variety Kissan Basmati. The results (Fig. 9) indicated that Flare as most effective in control of BLB and showed only 1.3% disease attack while producing maximum yield of 4.4 t/ha followed by Cupride and Kasumin as compared to un-treated check.

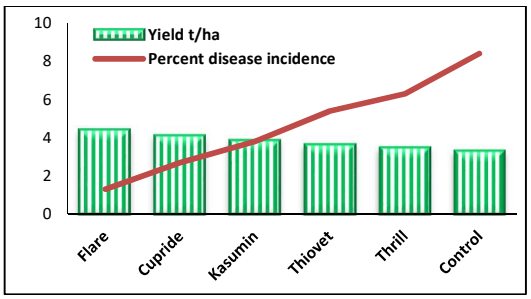

Fig. 9: Effectiveness of bactericide chemicals with respective yield comparison

Screening for Blast resistance in lines/ varieties

Fifteen lines were screened for blast resistance under field conditions and six lines showed moderate resistance to rice blast disease (Fig. 10). Among these six moderately blast resistant lines, KSK 515 produced the highest paddy yield (6.04 t/ha) followed by KSK 434 (5.86 t/ha).

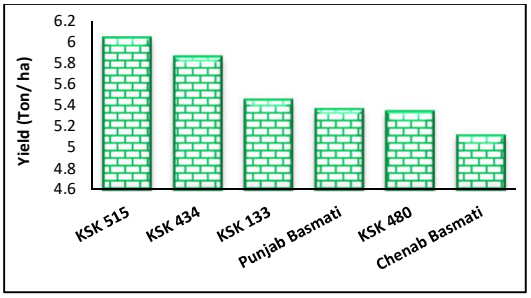

Fig. 10: Mean yield comparison of moderately blast resistance lines.

Efficacy of different insecticides for the control of stem borer under field conditions

Five different insecticides alongwith a control were used to test their effectiveness for control of stem borer in Kissan Basmati. The data (Fig. 11) reflected that Padan gave the best results with maximum insect control (1.3% attack) while giving highest paddy yield (5.28 t/ha) followed by Virtako (5.05 t/ha) and 2.4% insect attack as compared to control.

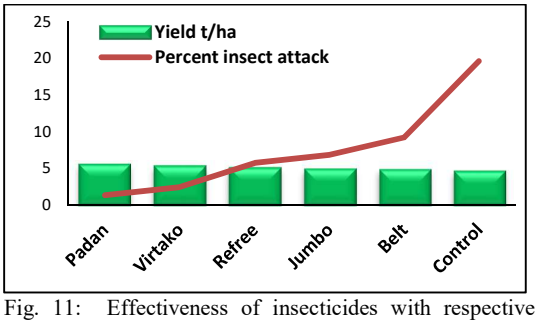

Fig. 11: Effectiveness of insecticides with respective yield comparison

IV. SOIL SCIENCE

Effect of different potassium doses on the yield and yield components of Kissan Basmati under Bahawalnagar agro ecological conditions

The experiment consists of six treatments with different potash levels to find out the quantity of potash application for maximum paddy yield. The results (Fig. 12) showed that potash application @ 90 kg/ha produced the highest paddy yield of 5.56 t/ha followed by potash application @ 80 kg/ha producing 5.42 t/ha yield.

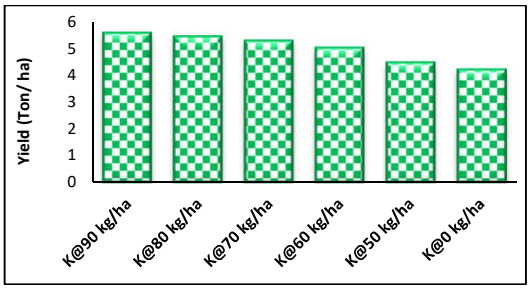

Fig. 12: Paddy yield comparison of different Potash fertilizer treatments.

Effect of different levels of boron fertilizer on yield and yield components of PK1121 Aromatic under Bahawalnagar agro ecological conditions

The data (Fig. 13) indicates that the treatment (1.5 % Boron) produced the highest paddy yield (4.48 t/ha) as compared to control (0% Boron) with 4.0 t/ ha.

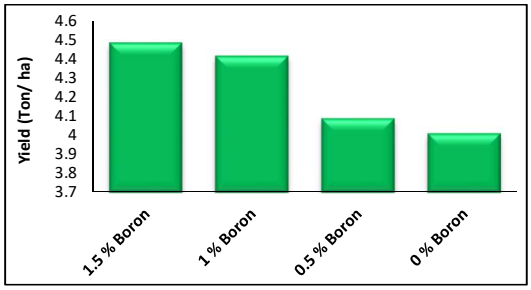

Fig. 13: Paddy yield comparison of different Boron treatments.

Performance of Rice varieties under salinity stress

The data (Fig. 14) indicates that the variety Chenab basmati produced the highest paddy yield (4.57 t/ha) followed by Punjab Basmati (4.36 t/ ha).

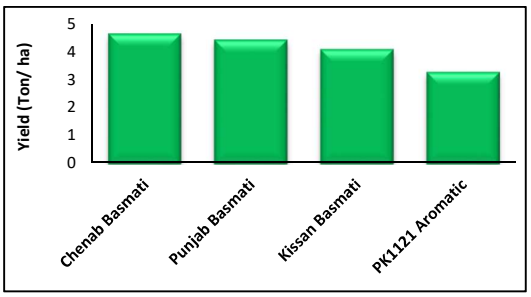

Fig. 14: Paddy yield comparison of different rice varieties under salinity stress.

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II. Book

1. Akhter, M., M. U Saleem, A. M. Sabir and M. Aurangzeb¸ 2018. *Dhaan ki munafah baksh kasht* (Urdu). ISBN 978-969-7582-00-6, RRI, KSK and Doaba Foundation, Pak. P: 94.

III. Urdu Articles

1. Akhter, M., T. H. Awan, M. U. Saleem, H. Qudsia, A. M. Sabir and M. Ali, 2018. *Dhaan ki bazria beij braheyrast kasht*. RRI, KSK, Pak. P: 1-16.
2. Javed, M. S., and H. Qudsia, 2018. *Dhaan ki eham bimariyan aur marboot tareeqa e insdad*. Rice Research Institute, Kala Shah Kaku.
3. Javed, M. S., M. Akhter and A. M. Sabir, 2018. *Dhaan ki ahm beemarian aur tadaruk*. *Zarat nama,* 57 (16): 8-10.
4. Sabir, A. M., Z. U. Shah and M. Akhter and 2018. *Dhaan key tailey ka merboot tareeqa insdaad. Zarat nama,* 57 (18): 8.
5. Sabir, A. M., Z. U. Shah, M. Rizwan, B. Atta, 2018. *Dhaan key ahm zarer rasan keiron ka merbout tareeqa insdaad.* RRI, KSK, Punjab, Pak.
6. Saleem, M, U., M. Akhter and A. M. Sabir, 2018. *Dhaan ki bardasht key doran Ehtiatein. Zirat Nama,* 57 (19): 14- 16.

Radio Talks:

Three Radio talks on May 8th, August 31st, 2018, 30th April, 2019

TV Talk:

Three TV talks on 11th July, 4th September, 2018 and 27th May, 2019

National/ International Trainings/ Workshops

❖ ***National Trainings***

1. Rice Breeders Training Workshop on 28th Aug, 2018 by ADB at and RRI,KSK.
2. Hybrid rice technology in Pakistan from 25th Sep to 15th Oct, 2018 at Islamabad
3. Improving Personal Effectiveness on 15 - 17th Oct, 2018 at Ministry of Federal Education and Professional Trainings, Islamabad.
4. Managing Employees Performance through Motivation at Workplace on 22-24th Oct, 2018 at Pakistan Manpower Institute, Islamabad.
5. Monitoring & Evaluation on 30th October, 2018 at AARI, Faisalabad.
6. Information Technology Skills on 12-16th Nov, 2018 ay MPDD, Lahore
7. Communication Skills on 03-07th December, 2018 at MPDD, Lahore
8. Implementation of procurement Management Information System (PMIS) on 12-13th December, 2018 at RAEDC, Vehari.
9. Training Workshop on the Statistical and Econometric Analysis for Punjab Food Outlook (PFO) on 20th-21st February, 2019 at International Food Policy Research Institute (IFPRI).
10. Training on Statistical Analysis on 24-26 April, 2019 at AARI, Faisalabad.
11. Hands on training workshopon CRISPR/ Cas9 Genome Editing Technology on 29 April at CEMB

❖ ***International Trainings***

1. Hybrid Rice Promotion for Pakistan on 08 - 28 July, 2018 at Yuan Longping High-tech Agriculture Co. Ltd. Changsha, China.
2. Hybrid Rice Promotion for Pakistan on 08 - 28 July, 2018 at Yuan Longping High-tech Agriculture Co. Ltd. Changsha, China.
3. 21st Australasian Weeds Conference on 09-12 Sep, 2018 from Sydney, Australia.

❖ ***Workshops***

1. ADB-PARB workshop in University of Agriculture, Faisalabad. December 2018.

IV. Conferences/ Seminars/ Meetings/ Exhibitions

❖ ***Conferences***

1. Akhter, M., M. Sabar, T. Latif, and Z. Haider, 2019. Current status and developments in basmati rice production and research in Pakistan- A Review: Proceedings of International Conference: International Rice Congress (IRC), Singapore.
2. Atta, B., M. Rizwan, A. M. Sabir, Z. U. Shah and M. D. Gogi, 2019. Incidence and Abundance of canola aphids and their associated predators on canola *var.* Faisal canola. Intl. Entomol. Cong., 8-10 April UAF, Pak., pp:138.
3. Atta, B., M. Rizwan, A. M. Sabir, Z. U. Shah, and M. D. Gogi, 2019. Effect of rice leaffolder morphology on the folding and spinning behaviour of rice leaffolder, *Cnaphalocrocis medinalis* Guenee (Lepidoptera: Pyralidae). Intl. Entomol. Cong., 8-10 April UAF, Pak., pp: 94.

4. Atta, B., M. Rizwan, A. M. Sabir, Z. U. Shah, M. D. Gogi and M. J. Nisar, 2019. Investigations on the effects of crude aqueous plant extracts on the potential predators, *Coccinella undecipuctata* L., and *Coccinella septempunctata* L. (Coleoptra: Coccinellidae). Intl. Entomol. Cong., 8-10 April UAF, Pak., p:101-102.
5. Awan T. H., M. U. Saleem, S. Iqbal, and M. Akhtar, 2018. Herbicide Options for Cost-effective Management of Complex Weed Flora in Mechanized Dry-Seeded Basmati Rice of Punjab, Pakistan. 5th International Rice Congress (IRC) at the Marina Bay Sands, on 15-17 October 2018, in Singapore.
6. Awan, T. H., and B. S. Chauhan, 2018. Performance of Intercom for predicting rice-barnyard grass interference in dry seeded rice systems". 21st Australasian Weeds Conference (AWC), 9-12 September, Australia.
7. Awan, T. H., S. Ahmad, and B. S. Chauhan, 2018. Weed-Competitive Ability of Hybrid and Inbred Rice Cultivars in Managing *Ischaemum rugosum* in Dry-Seeded Rice Systems. Paper presented at the international hybrid rice symposium (IHRS) 2018, 27-28 February & 1 March, Yogyakarta, Indonesia.
8. Qudsia, H., A. Bibi, A. Riaz, Z. Haider, M. Akhter and M. Sabar, 2018. Genotypic and Environment Interaction Analysis of rice NILs and local germplasm having Bacterial Leaf Blight resistance genes against local isolates of *Xanthomonas Oryza* at different agro-ecological zones. Proceedings of international conference: International Rice Congress (IRC), Singapore.
9. Rizwan, M., B. Atta, A. M. Sabir, Z. U. Shah, U. B. Khalid and Q. Ali, 2019. Efficacy of different storage materials for management of stored product insect pests *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), Sitophilus granaries (Curculionidae: Coleoptera) and Sitophilus oryzae (Curculionidae: Coleoptera) for wheat under farm storage conditions. Intl. Entomol. Congr., 8-10 April UAF, Pak., pp: 144.
10. Sabir, A. M., Z. U. Shah, M. Rizwan, B. Atta, M. Sabar, A. Qadir and M. Asghar, 2019. Scenario of pest insects of rice ecosystem in the Punjab. Intl. Entomol. Cong., 8-10 April UAF, Pak., National Speaker, pp: 2.
11. Sabir, A. M., Z. U. Shah, M. Sabar, M. Rizwan, B. Atta, A. Qadir and M. Asghar, 2019. Rice planthoppers: Potential threat to the sustainable rice production in the Punjab, Pakistan. 39th Pakistan Congress of Zoology. Islamia College University, Peshawar, Pak., March 4- 6. Abstr. ENT-90, pp: 229.
12. Saleem, M. U., N. Iqbal, T. H. Awan, S. Iqbal, and M. Akhtar. 2018. Reduced Water Use and Labor Cost and Increased Productivity of Direct Seeded Basmati Rice in Punjab, Pakistan. 5th International Rice Congress (IRC) at the Marina Bay Sands, on 15-17 October 2018, in Singapore.
13. Shah, Z. U., M. Rizwan, B. Atta, A. M. Sabir and Q. Ali, 2019. Rice planthoppers:

Problem in Pakistan. Intl. Entomol. Cong., 8-10 April UAF, Pak., p:163- 164.

❖ ***Seminars***

1. Seminar on Developing Safe Horticultural Value Chain for Exports. 21st-22nd January 2019. Convention Center Auditorium, Expo Center, Lahore.
2. Participated in seminar organized in Pakistan Horti Expo 2019 held in Expo Center, Lahore.

❖ ***Meetings***

Rice R&D Board meetings, Rice Working Group meeting, meetings with REAP etc.

❖ ***Exhibitions***

1. Pakistan Horti Expo, 2019 on 21-22 January, 2019 at Expo Centre, Lahore organized by Punjab Agri. Department

2. Kissan Mela on 27th March organized by Kissan World, Lahore.

3. Rice Exhibition in connection of "Dhaan Convention" on 10th April at Marian Hotel, Gujranwala arranged by Galaxy Rice.

4. Agri Expo, 2019 on 22-23 June, 2019 by the Agriculture Department.

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RUNNING PROJECTS

1. **Provision of lab and field equipment for Development of Basmati Rice Hybrid Resistant to Bacterial Leaf Blight, Flood and Salinity in Punjab**

   Objectives

   - To develop Basmati rice hybrids resistant to bacterial leaf blight, flood and salinity in Punjab.
   - To develop basmati hybrid rice seed production technology.
   - To enhance per hectare yield of basmati rice in Punjab.

Duration:

60 months (2015-16 to 2019-20)

Total Cost:

Rs. 44.010 Million

2. **Nutritional enhancement of crops, fruits, vegetables and their products under climate change scenario**

   Objectives

   - Rice germplasm screening to identify donors for iron and zinc contents.
   - Development of cultivars with enriched level of iron and zinc suitable for Direct Seeded Rice (DSR).
   - Bio-fortification of rice grain through foliar and soil application of iron and zinc.
   - Differential sowing for climate change impact on nutrients uptake
   - Human resource development- training of young rice scientists.

Duration:

60 months (2017-18 to 2021-22)

Date of commencement:

November, 2017

Total Cost:

Rs. 349.8 Million

For Rice Component

Rs. 24.876 million

SEED PRODUCTION
RRI, KSK

#	Name of variety	Seed Produced (Kgs)
1.	Super Basmati	10673
2.	Basmati 515	11697
3.	PK 1121 Aromatic	1060
4.	Kissan Basmati	4130
5.	Punjab Basmati	4558
6.	Chenab Basmati	8174
7.	KSK 133	2360
8.	KSK 434	856
9.	KS 282	817
10.	PK 386	2750
	TOTAL	**47075**

RICE RESEARCH STATION
BAHAWALNAGAR

#	Name of Variety	Seed Produced (Kgs)
1	Punjab Basmati	800
2	PK 1121 Aromatic	1200
3	Kissan Basmati	1600
4	IRRI-9	480

ANY OTHER SIGNIFICANT ACTIVITY

- Under Public Private Partnership (PPP) 923 Kg of Hybrid Rice Seed was produced as per ToRs under MoU. Seed yield of 2.5 tons per hectare was achieved.
- Eleven master trainings "Training of Trainers (ToT) regarding modern production technology and integrated pests management in Rice" were conducted attended by 453 participants from agri department.
- To stop stubble burning and smog reduction a possible solution for wheat planting (36 acres) was carried out successfully in the standing stubbles of rice crop with Zero Tillage Happy Seeder for demonstration purpose.
- Imparted eight trainings on “rice varietal identification, cooking and phyto-sanitation” to 41 participants from rice industry and amateurs.

D. METROLOGICAL DATA

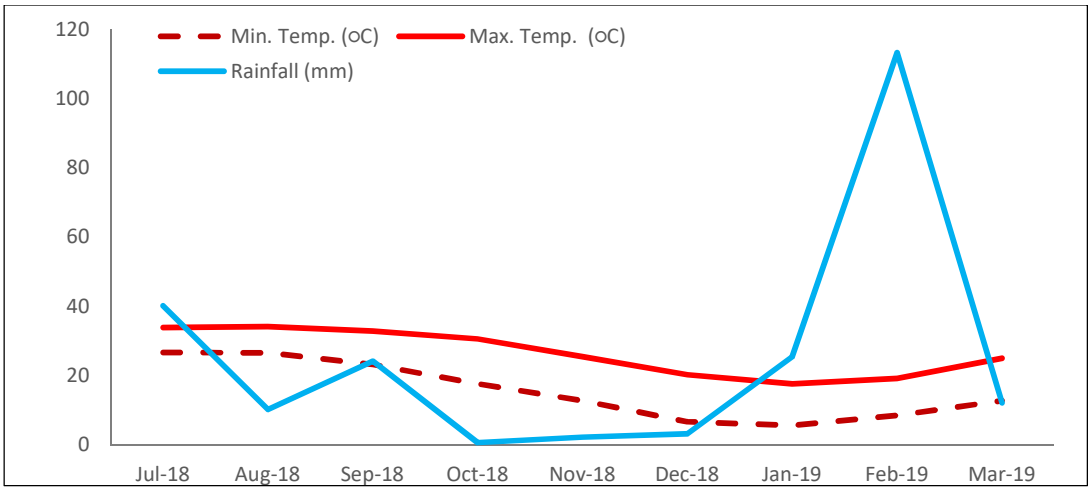

Fig.: Metrological data of Kala Shah Kaku