International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 52, 2016, pp.-2453-2458.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

REVIVAL OF ENDANGERED HIGH VALUED MOUNTAIN RICES OF KASHMIR HIMALAYAS THROUGH GENETIC PURIFICATION AND *IN-SITU* CONSERVATION

NAJEEB S.[1], PARRAY G.A.[1], SHIKARI A.B.[2], BHAT Z.A.[5], BHAT ANWAR M.[4], IQBAL M. ASIF[1], BHAT S.J.[7*], SHAH A.H.[4], MANZAR ABU[6], AHANGAR M.A.[1] AND WANI A SHAFIQ[3]

[1]Mountain Research Centre for Field Crops, Khudwani, Anantnag, Kashmir , 192102, India
[2]Division of Genetics and Plant Breeding, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
[3]Directorate of Research, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
[4]Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
[5]Division of Plant pathology, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
[6]Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
[7]Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Srinagar, Jammu & Kashmir, 191121, India
*Corresponding Author: Email- javaidahmad44@yahoo.com

Received: April 22, 2016; Revised: August 29, 2016; Accepted: August 30, 2016; Published: October 30, 2016

Abstract- A number of rice landraces mostly of japonica background are known from Kashmir valley (India) for their unique quality features particularly aroma with desirable taste and texture of the cooked rice, besides, being early maturing and highly cold tolerant. An initiative for sustainable revival of high valued aromatic landraces namely, *MushkBudgi* and *Kamad* was undertaken in 2007 and during the exploration, 240 and 110 samples, respectively, were collected from the niche areas of these landraces (1900-2100 m amsl). In both cases broad spectrum variability was obtained for most of the morpho-agronomic traits and *MushkBudgi-11* and *Kamad-7* were identified better among the lot. An integrated disease and nutrient management modules were developed during 2010 and 2011 and demonstrated during 2012 and 2013. The year 2014 proved as a success story and the first harvest of these rices were sold in the local market eight times the price of normal rices.

Keywords- Indigenous rice landraces, genetic purification, *in-situ* conservation, up-scaling, marketing.

Citation: Najeeb S., et al., (2016) Revival of Endangered High Valued Mountain Rices of Kashmir Himalayas through Genetic Purification and *In-situ* Conservation. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 52, pp.-2453-2458.

Academic Editor / Reviewer: Dhingra Madhu

Introduction

Landraces have evolved over past centuries under natural and human selection and have accumulated the useful allelic diversity. These are highly adapted to the regions and have special uses [1]. Traditional crop varieties or landraces are valued by plant breeders and farmers because of diversity (a heterogeneous population), rarity (embodying unique traits) and adaptability (exhibiting wide ecological and socio-cultural adaptation) [2]. More than 100 landraces of rice have been documented from Kashmir valley suited to different agro-ecological niches and possessed with combined adaptive traits for the temperate climate. These landraces mostly belong to short grained *japonica* types and are known for their unique quality features particularly aroma with desirable taste and texture of the cooked rice, besides, being early maturing and highly cold tolerant. Some aromatic rice like *MushkBudgi, Kamad, Nun Bouel* etc. enjoy huge demand in local markets due to high consumer preference, particularly during matrimonial occasions and festivals. The farmers on an average sell the polished rice of these types for Rs. 100-150 per kilogram. Participatory rural appraisal carried out before the revival programme identified blast disease, non uniformity of the produce, inadequate quality seed production and its dissemination to such ecologies and poor yield potential as the factors limiting the cultivation of such specialized rices. During past few decades, increase in share of high yielding varieties and shrinkage in the area of local varieties have been reported in India [3] and throughout the world [4]. Further, little attention has been given to the potential use of the existing landrace variability in production systems to provide direct benefits to local communities [5]. The realization of importance of genetic variability in rice improvement and awareness of consequences of genetic erosion has lead to increased initiatives at global level for conservation of rice germplasm. Learning a lesson at global level, an initiative for revival of *Mushkbudgi* and *Kamad* was undertaken with the main objectives of genetic purification together with optimisation of nitrogen input and blast disease management and finally their popularization and adoption through participatory mode and market intervention.

MaterialsandMethods

Survey was conducted during the year 2007 from three districts, Anantnag, Budgam and Bandipora of Kahmir Valley known to be niche areas of cultivation of *MushkBudgi* and *Kamad*. During the exploration, 240 and 110 samples, respectively of *MushkBudgi* and *Kamad* were collected. These samples were estimated for aroma after cooking in the Quality Laboratory of MRCFC, Khudwani by a panel of different persons including researchers. The aroma was scored after cooking on 0-3 scale (0 meaning no aroma, 1 = low, 2 = moderate and 3 = high aroma). In kharif 2008, the selected samples were grown in augmented block

design along with two controls *viz.* Jhelum and Shalimar Rice-1 (popular varieties). Each sample was planted in 3 rows of 3 m length with row to row and plant to plant crop geometry of 20 and 15 cm, respectively. To purify the samples, single seedling/ hill was transplanted to facilitate selection and the observations were recorded on plant height (PH) in cm, panicle length (PL) in cm, grains/panicle (GP), spikelet fertility % (SF), number of effective tillers/ plant (NT) and grain yield per plant (GY) in grams calculated as mean on 20 tagged plants while as, for days to 50% flowering (DF) it was recorded on plot basis. The selected lines of both *MushkBudgi* and *Kamad* were also screened against the blast disease adopting uniform blast nursery (UBN) pattern. The test lines were scored based on leaf and neck blast severity following standard evaluation System of IRRI (SES scale). In the year 2009, selected lines of *MushkBudgi* and *Kamad* were evaluated to validate the performance and data was recorded on 20 tagged plants.

A field experiment comprising of three graded levels of FYM (5, 10 and 15 t ha-1) and four levels of nitrogen (0, 40, 80, 100 kg ha-1) was laid out in RBD design with three replications at Mountain Research Centre for Field Crops, Khudwani during 2010 and 2011 on test variety *Kamad* to find out the optimum dose of organic manure and nitrogen with minimum incidence of blast disease severity. On-farm research trials (OFT's) for the management of blast disease were designed and conducted in farmer's participatory mode at eight locations in the niche area during 2011 and repeated in 2012. The experiment consisted of two treatments *viz.*, farmers practice (no seed and seedling treatment, dense planting, high dose of nitrogenous fertilizer, one fungicidal spray after disease appearance and second as recommended IDM practice for blast disease management(seed and seedling treatment with Tricyclazole 65 WP @ 0.06%, spacing of 15x15 cm, fertilizer dose of 60:30:20 (N:P:K), three alternate sprays of Tricyclazole 65 WP @ 0.06%, Hexaconazole 5 EC @ 0.05%, Carbendazin 50 WP + Mancozeb 75 WP (@ 0.2 % at maximum tillering, panicle emergence and flowering stage). Observations were recorded on leaf blast incidence, leaf blast severity and neck blast incidence. Further, the pure seed multiplication through space planting of two enhanced lines was undertaken in the *kharif* 2011, at Mountain Research Centre for Field Crops, Khudwani. Baby trial evaluation system at 15 locations on an area of 100 m^2 was used to assess the improved version against the farmer's version.

Results

A. Identification of authentic lines from farmers claimed *MushkBudgi* and *Kamad* and their purification:

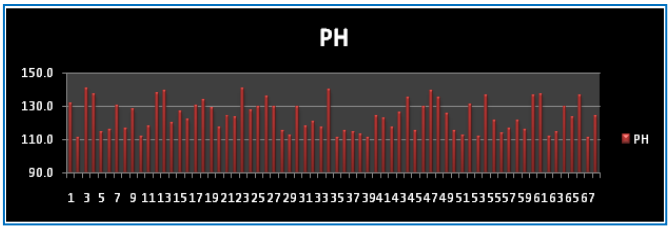
Cooking analysis revealed that 68 samples of *MushkBudgi* (28.3 %) and 24 samples of *Kamad* (21.8 %) were aromatic and rest were possessing low to no aroma and were not used for the study and significant mean squares for all morpho-agronomic traits were observed as revealed by analysis of variance [Table-1] and [Table-2]. This favoured the scope for further improvement through selection. No selection response was expected for panicle length in *MushkBudgi* and plant height in *Kamad* due to non-significant component of variety mean squares for such traits. Wide spectrum variability was observed for other agro-morphological traits in both *MushkBudgi* and *Kamad* [Fig-1a] and [Fig-1b]. In *MushkBudgi* lot, range of 110.5-140.5cm was recorded for plant height, 13-20.8 cm for panicle length, 8.3-20.6 for effective tillers/plant, while as, spikelet fertility ranged from 45.4-85.9 %, number of grains per panicle from 112.2-180.6 and grain yield per plant from 12.64-26.0g. Range of variability in *Kamad* was recorded as 111-130 cm (plant height), 13.0 – 20.8 cm (panicle length), 10.3-22.9(effective tillers/ plant), 45.4-85.9 % (spikelet fertility), 117.7-172.8 (grains per panicle) and 9.0-18.5g (grain yield per plant). All the test entries showed susceptible reaction to both leaf and neck blast with disease score ranging from 7-9 on SES scale. Rank summation index (RSI) was calculated for all the traits across 68 sampled lines of *MushkBudgi* [Table-3]. Accordingly, top three lines of *MushkiBudgi* were identified based on high rank summation index. These lines were, MB-12 (RSI=278), MB-30 (RSI=259) and MB-68(RSI=245). Similarly, KD-10 and KD-12 were identified having highest rank sum scores of 99.5 and 114, respectively [Table-4].

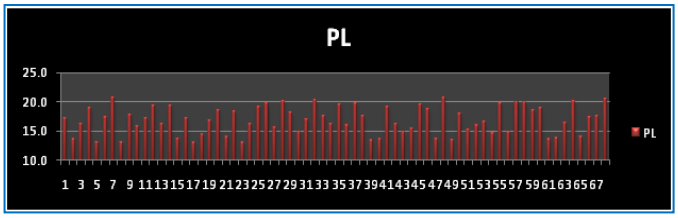
Table-1 *Analysis of Variance for agronomical traits in landrace MushkBudgi*

Source of Variation	d.f	Plant height	Panicle length	No. of tillers/plant	Grains/panicle	Spikelet fertility	Grain yield
		Mean squares					
Entry	68	133.95**	13.22**	14.41**	666.96**	318.50**	21.03**
Variety	67	88.05**	5.64	13.18**	535.86*	134.84**	17.45*
Check	1	2116.88**	167.48**	9.54**	1261.50**	1633.50**	204.52**
Check x Variety	1	958.15**	340.29**	72.88**	7522.26**	10672.30**	35.59
MSE	3	2.53	1.04	0.90	96.44	4.44	6.06
CD (Checks)		2.80	1.80	1.18	1.68	17.31	3.72
CD (Vars)		8.41	5.40	3.50	5.03	51.94	11.15
CD (Vars x Checks)		6.78	4.35	2.26	4.05	41.88	8.99
CV (%)		1.29	6.05	5.34	6.77	6.78	3.23

Table-2 *Analysis of Variance for agronomical traits in landrace Kamad*

Source of Variation	d.f	Plant height	Panicle length	No. of tillers/plant	Spikelet fertility	Grains/panicle	Grain yield
		Mean squares					
Entry	23	145.87**	36.21**	28.95**	260.98**	717.65**	51.41**
Variety	22	35.27	21.50**	13.20**	36.44	240.18**	24.62**
Check	1	1768.17**	96.00**	6.83**	1536.00**	1320.17**	244.48**
Check x Variety	1	665.06**	227.52**	339.52**	3403.91**	9184.08**	344.79**
MSE	3	29.56	0.44	0.34	7.78	23.56	0.65
CD (Checks)		9.58	1.18	1.02	4.92	8.56	1.42
CD (Vars)		28.75	3.53	3.07	14.75	25.67	4.27
CD (Var x Check)		23.18	2.84	2.48	11.89	20.70	3.44
CV (%)		4.49	3.62	3.05	3.30	3.44	2.65





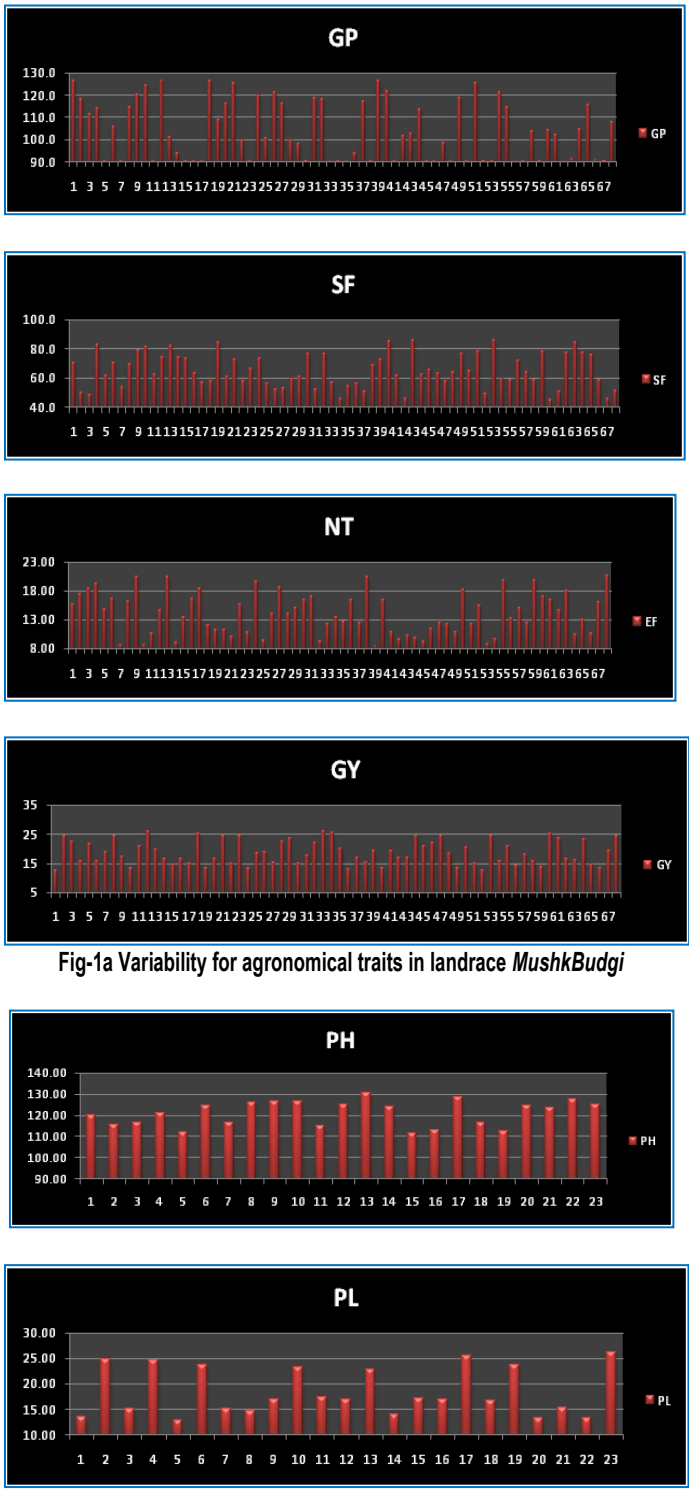


Fig-1a Variability for agronomical traits in landrace *MushkBudgi*

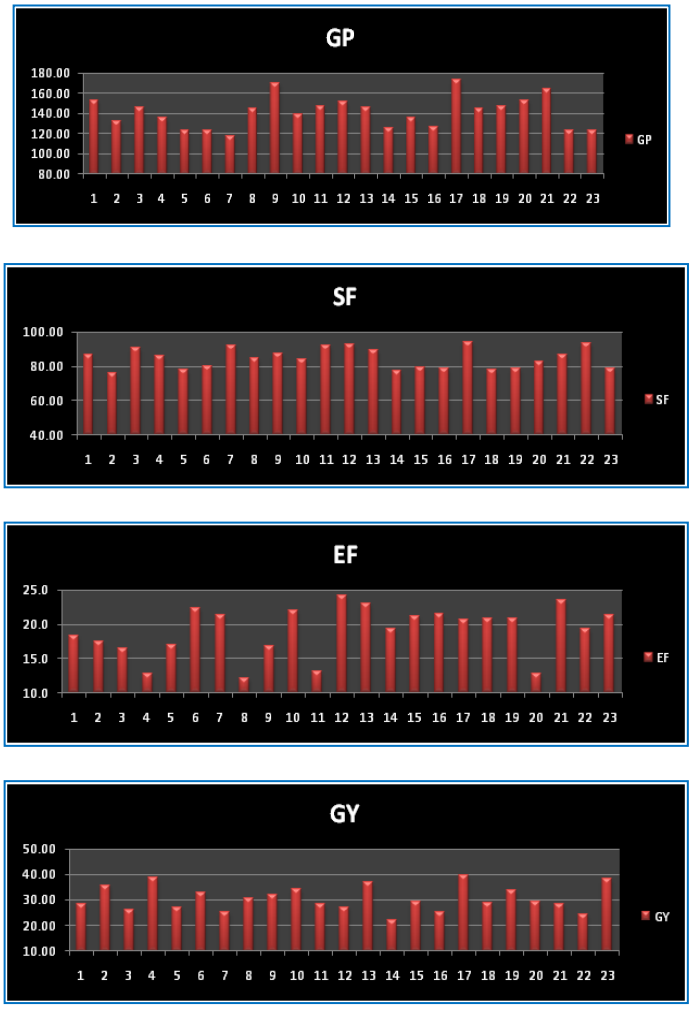


Fig-1b Variability for agronomical traits in landrace *Kamad*

To revalidate the efficiency of selection and improvement over the base population, the seed of 20 plants of five identified promising lines, three of *MushkBudgi* and two of *Kamad* harvested separately during 2008, were evaluated for all the six agronomic traits. The selected lines showed a reduction in plant height by 4.04 and 13.14% in *MushkBudgi* and *Kamad,* respectively. Similarly, the selected lines showed an improvement of 25.26 and 14.27 %, respectively, over base population of *MushkBudgi* and *Kamad*, respectively with respect to panicle length (longer panicle). Likewise, improvement was observed over base population of *MushkBudgi* and *Kamad* with more number of grains/panicle (23.13% and 22.64%), higher spikelet fertility (38.71 and 27.8 %) and more effective tillers per plant (13.1 % and 6.13%) [Fig-2a] and [Fig-2b]. Finally Mushk Budgi-11 and *Kamad*-7 showed high aroma (3), thus promoted for further study.

Table-3 *Ranking of the identified aromatic MushkBudgi samples for various economic traits.*

Line No	Effective tillers per plant	Panicle length	Grains per panicle	Spikelet fertility (%)	Grain Yield	Rank summation index	Rank
MB 12	38	55	66	51	68	278	68
MB 30	66	43	58	60	32	259	67
MB 64	61	50	46	63	23	243	65
MB 68	68	66	42	10	59	245	66

MB=*Mushk-Budgi;* High rank value means highly desirable

Table-4 *Ranking of the identified aromatic Kamad samples for various economic traits*.

Line No	Effective tillers per plant	Panicle length (cm)	Grains per panicle	Spikelet fertility (%)	Grain Yield	Rank Summation Index	Rank
KD 10	22	22	14	23	22	103	23
KD 12	23	20	23	12	23	101	22

KD= *Kamad* **;** High rank value means highly desirable

The results of management experiment revealed that grain yield was significantly enhanced upto 10tha-1 FYM application [Table-5]. The yield quadratic response to FYM and N levels is depicted in [Fig-3]. Regression analyses on the basis of the pooled yield data revealed that beyond 10 t FYM ha-1 the grain yield plateaued and there was decrease in the grain yield with a nitrogen application of more than 60 kg N ha-1. The mean grain yield averaged over FYM levels got significantly increased upto 60 kg N ha-1 in both the years. The treatment combination 60kg N ha-1 + 15 t FYM ha-1 gave highest grain yield during the second year of experimentation but the same was at par with 60 kg N/ha +10 t FYM ha-1.

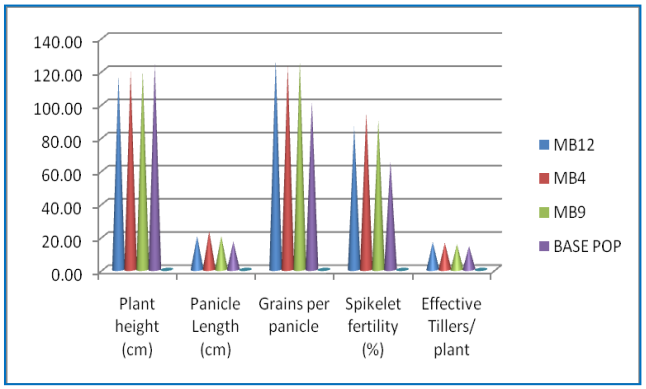


Fig-2a Response to selection in *MushkBudgi* base population

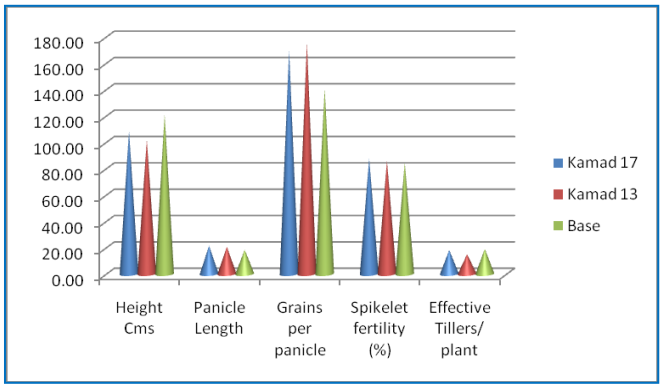


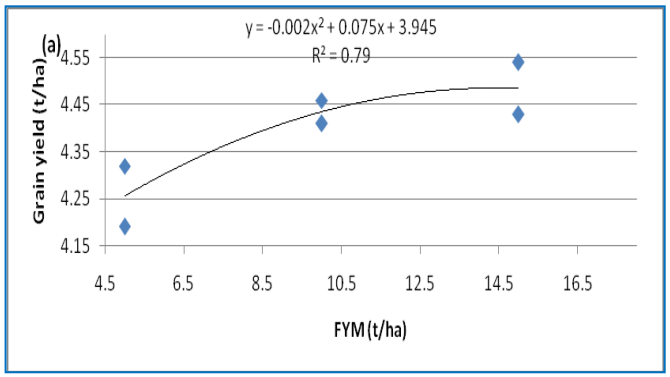
Fig-2b Response to selection in *Kamad* base population

Table-5 *Agronomy Effect of FYM and nitrogen levels on grain and straw yield (t/ha) of aromatic rice Kamad*

FYM (t/ha)	5		10		15		Mean	
	2012	2013	2012	2013	2012	2013	2012	2013
N (kg ha^{-1})								
0	3.58	3.74	4.27	4.41	4.66	4.82	**4.17**	**4.32**
40	4.13	4.31	4.66	4.82	5.04	5.21	**4.61**	**4.78**
60	4.62	4.78	4.97	5.14	5.08	5.25	**4.89**	**5.06**
80	4.84	5.05	4.54	4.46	4.23	4.18	**4.54**	**4.56**
100	3.78	3.74	3.54	3.45	3.13	3.24	**3.48**	**3.48**
Mean	**4.19**	**4.32**	**4.40**	**4.46**	**4.43**	**4.54**		
C.D (FYM levels)	0.17	0.19						
C.D (N levels)	0.23	0.25						
C.D (FYMXN)	0.40	0.44						

B. On-farm conservation/in-situ conservation and utilization through farmer's participation:

During 2011, field evaluation of promising lines of *Mushk-Budgi* and *Kamad* through farmer's participatory mode revealed that they were superior as assessed by the farmers (data not shown). Similarly, the results of On Farm Trials with IDM practices for management of blast disease revealed that the disease got managed to an extent of 70.2% and 79.8% with respect to leaf blast incidence and severity, whereas neck blast incidence was controlled to an extent of 87.6% over farmer practised methods [Table-6].



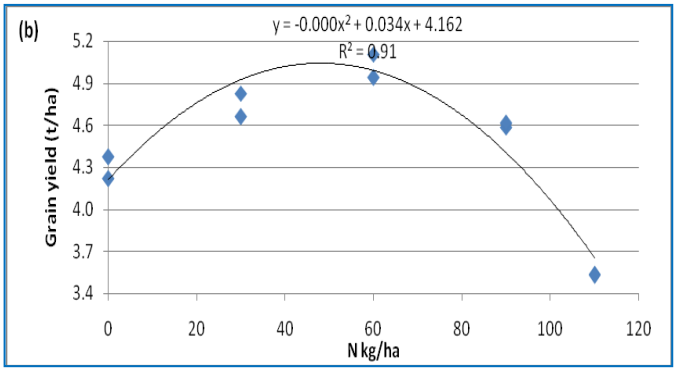


Fig-3 Relationship between grain yield and FYM levels (a) and nitrogen levels (b)

C. Physico-chemical and cooking quality analysis of purified versions of *Mushk-Budgi* and *Kamad:*

MushkBudgi possesses awned straw coloured grains with milled rice length of 5.16 mm and length breadth ratio of 1.89 and was categorized into short bold (SES-IRRI, 1996). Kernel length after cooking was recorded at 6.85 mm with elongation ratio of 1.33, typical feature of non-basmati rices and with amylose content of 14%. *Kamad* was characterized with slightly greater length after and before cooking and was classified as medium bold and had relatively higher amylose content (18%).

D. Pure seed production and up scaling (2012 onwards) and promotion through marketing and trade involvement:

During 2013 season, 1.0 and 2.5 ha land was planted under pure *Mushk Budgi* and *Kamad* respectively, and 40 and 50q seed, was produced. In the year 2013, 60 ha land in 5 villages was encompassed under these purified aromatic lines and 2600 q seed was produced. In 2014 different traders, entrepreneurs and millers were invited for intervening in the trade of these commodities in order to create sure marketing facility to the producers even at their threshing floor.

Discussions

The revival of the aromatic rice cultivation resulted in on-farm conservation of valued mountain rices of Kashmir Himalayas which had reached to the verge of extinction. Plant breeders feel little importance of the farmers conserved material [5] and conserve them in national seed banks. There is a growing global recognition of the importance of traditional varieties, both as components of sustainable production systems and as sources of genetic variation for modern plant breeding [6 & 4]. [7] Collected 32 samples from last remnants of rice landraces of Kashmir valley.

Variability in quality of *Mushk Budgi* and *Kamad* is the main concern of consumers and market entrepreneurs in marketing of these traditionally popular varieties. The non existence of pure form in local markets and low production has necessitated undertaking the measures to safeguard these valuable trade commodities. Very

low uniformity has been observed by workers while assessing the farmer's varieties and landraces for their commercial utilization [8 & 9]. Similar was the case with *Jethobudho* an aromatic rice landrace of the Pokhara valley of Nepal [8, 9 & 10]. Initiatives taken to bring uniformity in quality of *MushkBudgi* and *Kamad* while effecting the *in-situ* conservation and utilization in the niche areas were painstaking as it took seven years in development and successful cultivation of genetically enhanced lines of *Mushk Budgi* and *Kamad.* [11 & 9] identified lines with high public value. [12 & 13] have demonstrated that the value of local cold tolerant rice varieties can be improved by selection of preferred traits from the heterogeneous population.

Table-6 *Impact of Integrated Disease Management module (IDM) for blast disease management of Mushk Budgi (Mean data over the years 2011 and 2012)*

Treatment	Village	No. of Location*	Leaf Blast Incidence (%)	Per cent Control Over Farmer's Practice	Leaf Blast Severity (%)	Per cent Control Over Farmer's Practice	Neck Blast Incidence (%)	Per cent Control Over Farmer's Practice
Farmers check*	Sagam	2	50.3	69.6	17.6	81.2	8.3	87.9
	Tangpawa	2	42.5	68.7	14.0	78.5	6.4	90.6
	Danwetpora	2	53.3	71.8	19.6	81.6	7.3	86.3
	Khalhar	2	48.6	69.9	14.5	77.2	7.3	86.3
		8	**48.7**	**70.2**	**16.4**	**79.8**	**7.3**	**87.6**
IDM followed plots	Sagam	2	15.3	-	3.3	-	1.0	-
	Tangpawa	2	13.3	-	3.0	-	0.6	-
	Danwetpora	2	15.0	-	3.6	-	1.0	-
	Khahar	2	14.6	-	3.3	-	1.0	-
		8	**14.5**	**-**	**3.3**	**-**	**0.9**	**-**
			P<0.05		**P<0.05**		**P<0.05**	

Plot size at each location was 500 m^2

The recent movement in participatory and decentralized plant breeding over the last decade has shown that improving varietal performance in low input systems can help improve local livelihoods [14 & 15]. In the present study evaluation was done under farmer's field conditions and farmer's assessment and scoring helped to identify the lines for final multiplication. [16 & 17] verified the effectiveness of the IDM module at target locations through On-Farm Trial of Integrated Management of rice blast disease and obtained sufficient control of the disease along with enhanced yield as against farmer's practice.

To raise the morale and interest of *MushkBudgi* and *Kamad* growers, SKUAST-Kashmir invited market entrepreneurs, millers, traders and local dealers for smooth lining of marketing channels and the price tag of branded *MushkBudgi* and *Kamad* were fixed at Indian rupees 200 and 180 per Kg respectively, which is 7-8 times the price of normal rices. Since these rices cook slightly sticky possibly because of low amylose content, however is considered as the desirable trait under hill agriculture of Kashmir [18]. Conservation through market promotion is one of the most attractive options for involving farming communities into on-farm management of agro biodiversity. Market network is already established for few popular landraces of Nepal (e.g. *Panhele*, *Jethobudho*) [10].

Conclusion

The study clearly shows the importance of landraces and their economic and future value to the community and highlights the disproportionate attention they have received. It is important to understand that not all landraces can be conserved on farms and therefore promotion of potential landraces in the market offer better choices to the consumers and expanding market network can possibly help to maintain the rice crop diversity for sustainable socioeconomic development.

Author Contributions

S. Najeeb, G. A. Parray, A. B. Shikari, Asif M. Iqbal (Plant Breeders): Plant Breeders who purified the land races through panicle to row evaluations and produced the nucleus seed of purified versions of the two landraces.

M. Anwar Bhat and A. H. Shah (Agronomists): the agronomists devised the successful production module of the two varieties by manipulating the agronomic practices

Z.A. Bhat, M.A.Ahangar (Plant Pathologists) and Abu Manzar (Entomologist): They designed the protection module for successful cultivation of the varieties

S. J. A. Bhat: As SRF worked in the farmer's field for popularization of the varieties.

Shafiq A Wani: Director Research was the leader of the revival programme of elite landraces of insitu conservation for livelihood security of the farmers.

It is certified that the work presented in the manuscript is novel of its kind where the deliverable is quite discernable and has got much commercial orientation within the span of just three years of its successful cultivation in the niche areas. Further, neither this article nor any component of the programme has not been published or presented anyway before.

Acknowledgement

I would like to acknowledge to custodian farmers of these valued rices, and State Department of Agriculture for playing the pivotal role in promoting mass cultivation of these rices in niche areas. The project was fully supported by the State Agriculture University (SKUAST of Kashmir), J&K, India.

Conflict of Interest: All the authors are quite satisfied and have no conflict on the publication of this article in your esteemed journal.

References

[1] Bhat R.S. and Gowda M. V. C. (2004) *Plant Genetic Resources Newsletter,* 140, 42–47.

[2] Gauchan D., Smale M., Maxted N. and Cole M. (2006) Managing rice biodiversity on-farms: the choices of farmers and breeders in Nepal. CABI Publishing, Wallingford, UK, 162–176.

[3] Rana R.B., Garforth C. and Sthapit B. R. (2008) *Plant Genet Resource Characterisation Utilization*, 28, 1–14.

[4] FAO (2010) United Nations, Food and Agriculture Organization (FAO), Rome, Italy.

[5] Sthapit B. R. and Rao V. R. (2009) *Acta Horticulture,* 806, 669–676.

[6] Gepts P. (2006) *Crop Science,* 46,2278–2292.

[7] Sultan S.M. and Subba Rao, K.V. (2013) *International Journal of Conservation,* 4, 467-476.

[8] Barry M.B., Pham J.L., Courtois B., Billot C and Ahmadi A. (2007) *Genetic Resource Crop Evolution*, 54, 1675–1690.

[9] Gyawali S., Sthapit B.R., Bhandari B., Bajaracharya J., Shrestha P. K. and Jarvis D. I. (2010) *Euphytica,* 176, 59-78.

[10] Rijal D.K., Sherchand K K., Sthapit B.R., Pandey Y.R., Adhikari N and Kadayat K.B. (1998) NP Working Paper 1/98.NARC/LI-BIRD, Nepal and IPGRI, Rome, Italy.

[11] Smale M., Bellon M. R., Jarvis D. and Sthapit B. (2004) *Genetic Resource*

Crop Evolution, 51,121–135.
[12] Sthapit B.R., Joshi K.D. and Witcombe J.R. (1996) *Experimental Agriculture*, 32, 479–496.
[13] Witcombe J.R., Joshi A., Joshi K.D. and Sthapit B. R. (1996) *Experimental Agriculture*, 32,445–460.
[14] Ceccarelli S., Grando S., Tutwiler R., Baha J., Martini A.M., Salahieh H., Goodchild A. and Michael M. (2000) *Euphytica,* 111, 91–104.
[15] Dawson J.C., Murphy K.M. and Jones S.S. (2008) *Euphytica,* 160,143–154.
[16] Mubarak T., Zargar M. A and Bhat. Z. A. (2012) *Journal of Krishi Vigyan*, 1, 27-30.
[17] Mubarak T., Bhat Z. A., Zargar M.A. and Wani A. A. (2013) *Crop Research* 45, 29-32.
[18] Shikari A. B., Syed Zameer Hussain, G. A. Parray, A. G. Rather and Shafiq A. Wani (2008) *Crop Improvement,* 35, 109-114.