

**Farmers participatory varietal selection in japonica rice  
(*Oryza sativa* L.) through mother trial evaluation system  
in Kashmir valley**

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(2012-A-917-M)



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**Sher-e-Kashmir University of Agricultural Sciences &  
Technology of Kashmir**

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**Thesis**

Submitted to

**The Faculty of Postgraduate Studies  
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Technology of Kashmir  
in partial fulfilment of requirement for the award of the degree of**

**Master of Science in Agriculture  
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**2014**



**to my**  
*Beloved Parents*



**Sher-e-Kashmir**  
**University of Agricultural Sciences & Technology of Kashmir**  
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**Srinagar– 190 025**  
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**Certificate – I**

This is to certify that the thesis entitled, “**Farmers participatory varietal selection in japonica rice (*Oryza sativa* L.) through mother trial evaluation system in Kashmir valley**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Genetics & Plant Breeding)**, to the **Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Mohammad Rafiq Sheikh (Regd. No. 2012-A-917-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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mother trial evaluation system in  
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### **ABSTRACT**

Rice is the world's most important food crop and a primary source of food for half of the world's population. It occupies an important position in the economy of state of Jammu and Kashmir state with a productivity of around 2 t ha<sup>-1</sup>. The productivity level is higher in the plains of Kashmir valley while as, the position appears to be quite grim just 1-1.5 t ha<sup>-1</sup> under high altitude (2000-2300 m amsl) irrigated agro ecosystem. Although a few varieties have been bred for such agroecology but the results have not been found promising. In the backdrop of these facts participatory plant breeding approach was used in the present study entitled. “Farmers participatory varietal selection in japonica rice (*Oryza sativa* L.) through mother trial evaluation system in Kashmir valley” to identify the most appropriate genotypes on the basis of preference of the farmers and determine their tastes and aspiration for the new varieties to be bred in future in consultation with farmers. Hence, The study was undertaken during *kharif* 2013 in two districts viz., Anantnag (33-34 °E latitude 74-75 °N Longitude) and Pulwama (33.87 °E Latitude 74.89 °N Longitude). In each district two locations were selected for laying out the mother trials, besides two grandmother trials at Mountain Crop

Research Station, Larnoo and KVK, Pombay in RBD design with two replication. Ten *japonica* genotypes including popular variety (K-332) and farmer's variety as check genotypes served the experimental material.

Participatory Rural Appraisal (PRA) was conducted before laying out the research trials and revealed that rice ranks first under high altitude irrigated agro ecologies of Kashmir valley and mono-cropping is usually in vogue and canal system fed by melting snow is the main source of irrigation water. Among major production constraints, low yielding varieties, blast (*rye*) and cold were considered important and farmer saved seed is the main source of seed to raise the new crop. The demand for the farmers for the variety to have should possess high tillering, tall stature, more grains per panicle, medium bold seed, high biomass, early maturing, medium threshing, white grain color and with aroma.

Participatory Varietal Selection (PVS) was done just one week before harvest of the crop to evaluate the varieties by Focal Group Discussion (FGD). The most preferred genotype that is the lowest cumulative rank was recorded on GSL-11 with mean preference rank of (1.4) and SKUA-402 identified as second best (1.6) and followed by SKUA-524 (2.6). The genotype that received maximum number of negative votes was K-08-63 (7.4). Farmers who grow the trial and the neighbours of those farmers, expressed a consistent large and highly significant preference for GSL-11, SKUA-402 and SKUA-524 compared with the K 332 (popular variety) and the farmers variety. Farmer's variety was the least preferred variety and was at par with the test genotype K-08-63. Also genotypes GSL-11 SKUA-402 and SKUA-524 were statistically found at par in terms of rank summation index and mean preference ranking and significantly different with the genotypes K-08-73, K-08-69, SKUA-506, GSL-61 and K-332 which among themselves could be categorized as one group. K-08-63 was least preferred and was at par with the farmer's variety.

Further all the test genotypes were evaluated for stability performance across six locations using Eberhart and Russell model. Analysis of variance showed significant difference in the genotypes at the locations for all the traits. Mean squares due to environment + (genotype x environment) were significant for most of the traits except panicle length and 100 seed weight depicted the distinct nature of environment and genotype x environment interaction on phenotypic expression. Similarly total genotype x environment was found significant except panicle length and 100 seed weight. Genotype x environment (linear) interaction component showed non-significance only for 100 seed weight while as, for all other traits it showed high significance indicating location (environment) had a marked influence on the expression among the genotypes and behaviour of the genotypes could be predicted over environment more precisely. Mean square due to environment (linear) component was found to be non-significant for 100-seed weight, for all the other characters the component was found highly significant except panicle length. Pooled deviation for all the traits except 100-grain weight was found significant suggested that the performance of

different genotypes fluctuated significantly from their respective linear path of response to environments. On the basis of stability parameters SKUA-402 and GSL-11 were identified as the most stable genotypes across all locations on the basis of high mean performance and non-significant estimates of  $b_i$  and  $S^2d_i$  from unit and zero respectively and latter showed sensitivity to better environments for biological yield on the basis of significant  $b_i$  estimates. Similarly these genotypes were identified as consistent for early flowering for all the locations. Further GSL-11 and K-332 genotypes were identified as most stable for plant height and number of panicle plant<sup>-1</sup> respectively and SKUA-524 was identified as the consistent genotype for seeds panicle<sup>-1</sup>.

**Key words:** *Japonica rice*, PRA, PVS, Stability and Eberhart and Russell.

Signature of Student

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Dated: \_\_\_\_\_

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*“In the name of Allah the most beneficent, the most merciful”*

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**Mohammad Rafiq Sheikh**

**Place : Shalimar, Srinagar**

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# CONTENTS

<b>Chapter</b>	<b>Particulars</b>	<b>Page No.</b>
1.	INTRODUCTION	1-5
2.	REVIEW OF LITERATURE	6-19
2.1	Participatory Rural Appraisal (PRA)	6
2.2	Participatory Varietal Selection	8
2.3	Genotype x Location (G x L) interaction and Stability Studies	14
3.	MATERIALS AND METHODS	20-27
3.1	Experimental material used	20
3.2	Village selection	21
3.3	Collaboration with other Departments/Stations/Agencies	21
3.4	Participatory Rural Appraisal	21
3.5	Laying of Grand-mother (On Station) and Mother Trials (On Farm)	21
3.6	Data collection	22
3.7	Statistical analysis of data	24
3.8	Stability analysis	24
4.	EXPERIMENTAL FINDINGS	28-61
4.1	Understanding farmers' perceptions and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA)	28

4.2	Calculation of preferential scoring of different genotypes	47
4.3	Estimation of Stability parameters and identification of suitable genotypes	51
5.	DISCUSSION	62-76
5.1	Understanding farmer's perception and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA)	62
5.2	Determine preferential scoring of test genotypes on farmers field through farmer selection criteria	65
5.3	Analyze Genotype x Location (G x L) interaction and Stability Studies by Eberhart and Russell model	68
6.	SUMMARY AND CONCLUSION	77-80
	LITERATURE CITED	i-xiii

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## LIST OF TABLES

<b>Table No.</b>	<b>Particulars</b>	<b>Page No.</b>
1.	Participatory Rural Appraisal (PRA) at 16 locations for understanding farmers' perceptions and preferences about high altitude rice varieties	30
1.1.	Participatory Rural Appraisal (PRA) at sixteen locations for understanding farmers' perceptions and preferences about high altitude rice varieties (production constraints)	34
1.2.	Participatory Rural Appraisal (PRA) at sixteen locations for understanding farmers' perceptions and preferences about high altitude rice varieties (varietal specifications)	39
2.	Farmers preference ranking (scoring) of different test varieties of rice in mother trails at five locations	48
3.	Cumulative/average ranks of genotype over five locations	50
4.	Analysis of variance for different morphological, maturity, yield and yield component traits in selected rice genotypes across 6 environments	52
5.	Analysis of variance for stability of different traits in selected rice genotypes across 6 environments	54
6.	Stability parameters for days to 50 per cent flowering and days to maturity in selected rice genotypes evaluated across 6 random environments	55
7.	Stability parameters for Plant height and Number of panicles plant <sup>-1</sup> in selected rice genotypes evaluated across 6 random environments	57
8.	Stability parameters for panicle length and seeds panicle <sup>-1</sup> in selected rice genotypes evaluated across 6 random environments	59
9.	Stability parameters for biological yield plot <sup>-1</sup> and grain yield plot <sup>-1</sup> in selected rice genotypes evaluated across 6 random environments	61

## Chapter – 1

### INTRODUCTION

Rice is the world's most important food crop and a primary source of food for more than half of world's population. More than 90 per cent of world's rice is grown and consumed in Asia where 60 per cent of earth's people live. Rice accounts for 35-75 per cent of calories consumed by more than 3 billion Asians. It is planted to about 154 m ha annually or on about 11 per cent of the world's cultivated land. The world's capacity to sustain favorable food production and population balance has again come under spotlight in view of continued population growth and drastic slowdown in growth of cereal production. In India during 2011-2012, 104 m tons of rice was produced from an area of 43.97 m ha with productivity level of 2.2 t ha<sup>-1</sup> (Anonymous, 2012a). The picture appears to be very grim when compared with other countries such as China (4.2 t ha<sup>-1</sup>), Japan (4.3 t ha<sup>-1</sup>), South Africa (4.6 t ha<sup>-1</sup>), Egypt (6.5 t ha<sup>-1</sup>) and Australia 5.5 t ha<sup>-1</sup> (Anonymous, 2008). To meet the demand of increasing population the present production level needs to be increased up to 115-120 m tons of milled rice by the year 2020. The increase in production has to be achieved in the backdrop of declining resource base such as land, water and labor and other inputs without adversely affecting the quality of environment and above all to raise the production in the marginal environments where the productivity is still dismal. This indeed is a herculean task.

Rice occupies an important position in the economy of state of Jammu and Kashmir state and grown on an area of 0.243 m ha with a production of 0.512 m tons and productivity of around 2 t ha<sup>-1</sup> (Anonymous, 2012b). Rice being the staple food and the most important crop in Kashmir and occupies 55 per cent (0.141 m ha<sup>-1</sup>) of the total rice area of the state. The productivity level is relatively higher in Kashmir (2.5 t ha<sup>-1</sup>) as compared to Jammu Division (1.7 t ha<sup>-1</sup>). Rice is grown at an altitude range of 1350-2300 m amsl in Kashmir valley. The crop is frequently challenged by various biotic and abiotic stresses more particularly by

low temperature throughout the growing season. Other challenges to rice production in the valley comprise shrinking land resources due to urbanization, industrialization, demographic pressures and water shortage. According to one of the estimate the total rice requirement of the state would be 1.75 million tons by 2020 as against the current production of 0.57 million tons. This huge increase in demand for rice will have to be met from less land and water without affecting the resource base adversely. In the fact of limited scope for horizontal growth due to aforementioned reasons the vertical growth seems to be a viable option.

Rice area in Kashmir can be broadly categorized into two distinct zones; plain or valley basin areas (1350-1800 m altitude) that enjoys relatively better and favorable growing conditions in terms of water, edaphic and climatic factors. Early maturing rice varieties of sub species *indica* form the predominant group in this area. The growing period is limited to 140-150 days. The improved varieties released for general cultivation have increased the efficiency of rice production in this region to an appreciable extent. Whereas, mountain agro ecology (high altitude region) situated between 2000 to 2300 m amsl in foot hills, constitute 12-15 per cent of total rice cultivated area of the valley. The region is characterized by short growing seasons, low atmospheric temperature, cold irrigation water and insufficient solar radiation. The rice varieties cultivated in this area belong to such species *japonica* group. Although a good varietal profile has been developed and recommended for low to mid altitude zones of valley, whileas under higher belts varietal group is much more restricted and limited to the cultivation of few varieties such as *K-332*, *Kohsar* and a few landraces.

Despite the fact that rice being the only ray of hope for sustainable source of farm income and livelihood and food grain security, the high altitude rice crop has not received much attention from breeders, farmers and policy makers alike due to inherently narrow genetic profile, relegation to harsh environment, lack of major technological breakthrough and lack of encouraging policy support from the government. Although, yields as high as 4-5 t ha<sup>-1</sup> is being harvested in

temperate world, it is as low as 1-1.5 t ha<sup>-1</sup> under high altitude agroecology of Kashmir valley. Only one or two varieties have been developed inspite of the fact that organized research efforts are in progress for the last 40 years. The low adoption of improved cultivars *viz-a-viz* the low seed replacement rate (<2%) resulting in low production and productivity in rice possibly have the following reasons :

- the farmers have not been exposed to acceptable alternatives to their existing varieties/landraces,
- lack of appropriate genetic resources and long history of cultivation under marginal conditions,
- the varieties bred in most favorable environments and from other tropical and subtropical belts, no way thrive under such poor and marginal environmental conditions,
- poor risk bearing capacity of farmer's due to marginal conditions,
- less number of varieties for farmers choices,
- farmers interests not taken into consideration,
- elite varieties developed by considering broad geographical area neglecting the marginal environment and
- the resource poor farmers practicing under high altitude marginal conditions are often bereft of knowledge on the availability of HYVs for their use.

Participatory plant breeding (PPB) has evolved as viable alternative to conventional plant breeding that lays more emphasis on the involvement of different stakeholder's right from deciding the varietal specification, identification of parents through the selection across segregating generations as well as testing and release of product. The greater involvement of farmers and other stakeholders ensures that their perceptions are taken care of in order to speed up the rate of

adoption. Appropriate client orientation mechanism in the form of participatory rural appraisal (PRA) is being done in order to generate basic data for varietal specification and decide stage and levels of participation of farmers. The increased speed of PPB in producing results is one of its major advantages because the speeds at which benefits achieved from an investment in plant breeding significantly affect the rate of return. The faster progress probably doesn't require more resources, because careful targeting of farmers need to restrict the range of germplasm that needs to be advanced to early participatory trials. Further early quality testing also helps reduce the demand on resources.

The rice improvement program for high altitude irrigated ecology of Kashmir has remained less successful, partly because of cold stresses, marginal environments, partly because of the allocation of limited research resources by national and international programs and partly due to failure to use high yielding varieties developed at more favorable environments. Most of the entries from cold tolerant nurseries from International Rice Research Institute (IRRI), Philippines such as International Rice Tolerance Observatory Nursery (IRTON) and International Rice Temperate Observatory Nursery (IRCTN) have failed to make any significant dent when tested at High Altitude Rice Testing Station (Mountain Crop Research Station, Larnoo {2286 m amsl}), hence little use has been made out of them.

To tackle such situation, an alternative approach such as Farmers Participatory Varietal Selection (PVS) is considered to address the problems of the limited varietal choices available to farmers. Traditionally, the development of rice varieties has been the task of breeders, and farmers are merely the recipients of furnished products. Therefore the program to involve farmers will help us to produce farmer acceptable cultivars more effectively. So it is intended that PVS would minimize resources use, produce cultivars that are acceptable to farmers, and increase the genetic diversity of rice in participatory village and also to determine most suitable cultivars that are highly acceptable and above all, to

determine most suitable and consistent cultivars for high altitude irrigated ecology of Kashmir. When participatory techniques are appropriately employed in plant breeding they can have a quick impact besides, producing cost effective and much improved crop varieties. These varieties may be for resource poor farmers in marginal environments, who previously were entirely dependent on landraces (Virk *et al.*, 2003; Witcombe *et al.*, 2003).

Rice (*Oryza sativa*) is grown under diverse agro-ecological conditions. Though more than 1000 rice varieties have been released in India, many of them have been out of cultivation within a few years due to inconsistent performance in diverse environments and only few varieties with stable performance continue to be under cultivation even after 15-20 years of release. Although good number of varieties have been bred by Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir for the entire state of Jammu and Kashmir but only one a few of them are grown by the farmers. In the backdrop of these facts there is a dire need to identify the farmer preferred high yielding and suitable varieties for high altitude irrigated ecosystem of Kashmir valley and at the same line determine their adaptability and consistency across different locations. Hence the present study is undertaken with the following objectives:

- 1) Understanding farmers' perceptions and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA).
- 2) Evaluating advanced, pipeline, pre-released, germplasm and released lines on farmers' fields using farmer's selection indices and criteria through mother trials.
- 3) Analyze Genotype x Location (G x L) interaction to observe a change in magnitude of response across locations.

## Chapter – 2

## REVIEW OF LITERATURE

A Brief account of literature pertaining to different aspects of the present study is described in the present chapter.

Modern crop varieties bred in various national and international breeding programs have been a driving force for agricultural transformation for improving crop productivity, quality and resilience to biotic and abiotic stresses. However, the impacts of these high yielding varieties have invariably been more pronounced in high input areas and have seemingly failed to make any dent in low input marginal farming systems. This is largely due to the inherent bottlenecks of low input farming systems such as low socio-economic profile of farmers, lack of organized seed sector, lack of affordability/accessibility to resources as well as diversity of farming systems. This has resulted in polarized impact of high yielding varieties in high input favourable systems. Participatory plant breeding has mainly evolved in response to the growing need of addressing the problems faced by poor farmers in marginal environments with high stress and low yield potential. The work done in the area of Participatory varietal selection in rice under high altitude is reviewed in light of the available literature, mentioned below:

### **2.1 Participatory Rural Appraisal (PRA)**

Participatory rural appraisal is an exercise aimed at identification of farmer's constraints pertaining to production, consumption and marketing of crops and is thus a kind of market research, to identify farmer's needs to allow cultivars, that are likely to meet their requirements, to be tested and avoid the cultivars that will not be obviously acceptable (Joshi and Witcombe, 1998).

Frio *et al.* (1994) through participatory rural appraisal conducted the regional training courses in gender analysis and its application to farming systems research (FSR) in south and Southeast Asia and aimed to assist scientists in national agricultural resource institutes conduct gender-responsive research. The

experience of the International Rice Research Institute (IRRI) in the area of gender analysis has been found exploratory and, at best, cuts across regional differences in culture and environment to improve social conditions of rice growing farming committee.

Barik *et al.* (1996) presented a study regarding the experiences of participatory research, particularly farmer-led trials, the objective of which was to involve farmers in the decision making at all stages and inculcating their preferences obtained through participatory rural appraisal and the study was also undertaken by the Krishi Vigyan Kendra, a government organization involved in technology transfer, in Salepali, a complex, diverse and risk prone village in Orissa, India during 1992-93 with the aim of understanding the local agricultural system.

Loader and Amartya (1999) advocated that the rapid acceptance of Participatory Rural Appraisal (PRA) approaches to facilitate the understanding of problems among rural people, and the acknowledged priority for such studies to be sensitive to local conditions, has sometimes meant that such approaches have overlooked opportunities for the appropriate application of relevant techniques and an example was presented from Nepal, where conjoint analysis was used to help farmers to assess their rice variety requirements.

Nepali *et al.* (1999) carried out a baseline and need identification survey site at Chambas of Tanahun district representing river basins in western Nepal. The participatory rural appraisal technique was used to establish benchmark information on bio-physical, socioeconomic, institutional and farming constraints, farmers' needs and researchable problems and different ethnic groups were found with diverse food preferences were rice and maize followed by millet were found as commonly consumed food staples and women were involved in all the farming activities except ploughing the land. The needs of the farmers were found high yielding and good taste preferences.

Joshi *et al.* (2001) used Participatory Rural Appraisal technique to establish benchmark information on biophysical, socioeconomic, institutional and farming constraints, as well as farmers' needs and researchable problems. The general problems of the site was found: the lack of irrigation; hailstroms; attacks of red ants in root crops as well as late blight in potato and tomato and white grub in maize, millet and rice; snail attack; labour scarcity during the time of cultivation; blast in rice; animal disease (infertility problem in buffalo and cattle); and scarcity of fodder and forage in summer besides farmers were found demanding high yielding varieties of potato, maize, rice and millet and also the saplings of fodder trees and fruit crops.

Gichangi *et al.* (2012) underlined the need of assessment of farmer's perceptions and stated that understanding of farmer's technology preference criteria are important considerations in technology generation and dissemination process. In most of the cases, technologies fail to be adopted by farmers due to mismatch in preference criteria between technology promoters and end users. Such an appraisal exercise should focus on personal, demographic as well as socio-economic variables, in order to identify farmer's constraints as well as preferred attributes to develop varieties that are likely to be accepted by farmers. Furthermore, PRA can potentially reveal mismatches in the evaluation criteria used by farmers and breeders to evaluate for the same trait.

## **2.2 Participatory Varietal Selection**

Participatory Varietal Selection specifically refers to evaluation of released varieties, pipeline materials, advanced breeding lines, landraces or germplasm accessions on farmers' fields under his management practices. It is essentially a researcher designed and farmer managed trial in which the genotypes targeted for a specific niche are evaluated by farmer using his own selection indices.

Farmers preferences are very imperative and modern cultivars are often rejected by farmers because of traits that have not been considered in the breeding

process (LARC, 1995). Poor adoption and narrow genetic diversity of improved upland varieties become main problem of centralized breeding program for upland rice. Participatory Varietal Selection (PVS) was designed to overcome this problem (Almekinders and Elings, 2001). Even though many improved varieties of upland rice have been released, most farmers still prefer to cultivate traditional varieties. The poor adoption of improved varieties may be due to limited accessibility of the new varieties seeds or poor adaptation of improved varieties to local condition (Joshi and Witcombe, 1995).

Joshi and Witcombe (1996) used Farmer Participatory Varietal Selection (PVS) to identify farmer-acceptable cultivars of rice and chickpea (*Cicer arietinum*). Farmers' requirements in new crop cultivars (varieties) were determined, a search was carried out for released and non-released cultivars that matched these needs, and they were tested in farmer-managed, participatory trials. Farmer-acceptable cultivars were found amongst released material, but not among the recommended material for the area.

Joshi *et al.* (1997) through a participatory varietal selection (PVS) approach, enhance the diversification of rice varieties for the specific needs of farmers and four pre-release and one released chaite (sown in February-March) rice varieties were distributed in 20 villages of the Western Hills of Nepal in 1991. A survey conducted during June 1993 found that varietal diversity increased in all locations and in 80 per cent of the study area at least two new rice varieties were reported where only CH 45 was grown before the distribution. On-farm varietal diversity was further enhanced by farmer-to-farmer dissemination of new rice varieties. All the rice varieties tested were adopted, but the adoption level varied between locations. Of the households surveyed 37% were growing the new rice varieties and a further 57 per cent were aware of those varieties within two years of introduction. The PVS approach provided farmers with the benefits of new genetic materials five to six years in advance of the formal system and with minimum effort.

Bandari *et al.* (1998) Worked at Lumle Agricultural Research Centre (LARC) aimed at developing high yielding varieties for diverse rice growing environments in the mid and high hills (>1000 masl) where low temperature is a major constraint for lower yields and through participatory varietal selection six advanced lines (NR10315-76-2-2-1, NR10315-143-3-2-1, NR10290-21-1-2-1, NR10308-24-1-2-1, NR10320-22-2-3-3 and NR10308-117-2-1-1) were identified as producing satisfactory grain yield under hill conditions, with acceptable plant height and resistance to blast (*Magnaporthe grisea*).

Witcombe *et al.* (1999) used Participatory varietal selection in a development project in western India showed that the rice (*Oryza sativa*) variety Kalinga III was highly preferred by farmers. The spatial diffusion of this variety from three villages (two project and one non-project) was studied. Seed of Kalinga III had spread from the three villages in 1994 to 41 villages by 1996 and is estimated to have reached over 100 widely distributed villages by 1997. A financial analysis revealed the very high internal rates of return that are possible from investment in participatory varietal selection.

Bhandari *et al.* (2000) developed high yielding and farmer preferred rice varieties for irrigated and rainfed ecosystems of the high hills and mid-hills of western Nepal through farmers' participation in varietal selection. In farmers' field trial, the genotypes NR 10285 and NT 10286 were found promising, whereas in participatory varietal selection, genotype NR 10172 was preferred by participating farmers at different locations for its higher grain yield.

Sthapit *et al.* (2000) presented an overview of Nepalese experience with participatory approaches in plant breeding. Examples of innovative participatory approaches were designed to address the needs and problems of marginal farmers in Nepal were detailed.

Witcombe *et al.* (2001) reported that PVS increased on-farm biodiversity within three cropping seasons in a high potential production system in Nepal and

India. Also by participatory varietal selection the local varieties were maintained and improved to tolerate blast pathogen and dreadful maladies of rice as these varieties possess high genetic variability.

Witcombe and Virk (2001) identified new varieties such as Kalinga III and BG-1442 through Participatory Varietal Selection that farmers preferred. Their adoption by farmers increased on-farm varietal biodiversity within the period of the three cropping seasons that were studied.

Courtois *et al.* (2001) evaluated Sets of 15 to 25 varieties both in farmers' fields and on-station in 1997 and 1998 and ranked by both farmers and breeders. The objective was to evaluate the respective effects of participation of farmers in varietal evaluation and decentralization of varietal testing from breeding stations to farmers' fields on varietal ranking. The effect of participation was judged by comparing the rankings attributed by farmers and breeders to a given set of material in a given trial. In about two-thirds of the trials, there was a good agreement between farmer's and breeder's mean rankings.

Witcombe *et al.* (2001) studied On-farm varietal biodiversity in Chitwan and Nawalparasi districts of the Nepal Terai and in Lunawada sub-district, Gujarat, India using the Participatory Varietal Selection (PVS). In both areas, one cultivar dominated, CH 45 in Nepal and GR11 in India. PVS identified new varieties that farmers preferred. Their adoption by farmers increased on-farm varietal biodiversity within the three cropping seasons studied.

Joshi and Witcombe (2002) demonstrated that farmer managed participatory research (FAMPAR) which used formal survey methods, was more useful for diagnosing reasons for adoption or rejection. It was cost effective and farmer to farmer seed dissemination was higher. Usefulness of approach of FAMPAR in offering choice of new varieties or techniques in a rapid and cost effective manner is well documented (Witcombe *et al.*, 1996; Joshi *et al.*, 1997). They reported the approach to be instrumental in clarifying the complexities of

farming systems by identifying the niches for which farmers adopted technologies. When participatory techniques are appropriately employed in plant breeding they can have an impact by quickly and cost effectively producing much improved varieties. These varieties may be for resource poor farmers in marginal environments who previously were entirely dependent on landraces (Virk *et al.*, 2003; Witcombe *et al.*, 2003) or for farmers in more productive environments where they are dependent on very old varieties (Witcombe *et al.*, 2001).

Hawclader *et al.* (2004) conducted participatory varietal selection of boro rice over 2 seasons in 9 villages of Faridpur District, Bangladesh to identify the cultivars/lines preferred by local farmers. The advanced line BR4828-54-4-1-4-9 recorded the highest grain yields of 7.2 and 6.3 t ha<sup>-1</sup> in the first and second year, respectively. The grain yield of this advanced line was 19 per cent higher than that of the farmer's cultivar over 2 seasons. All participating farmers preferred the advanced line over the other entries.

Witcombe *et al.* (2005) reviewed the history and analyzed the participatory techniques used at different stages of the breeding programmes. They reported that rice varieties derived from client oriented breeding programmes were tested in mother and baby trials in Bangladesh. The rapid acceptance of these varieties by farmers illustrate the power of participatory trial system and the process of highly client oriented breeding approach.

Joshi *et al.* (2005) presented results of participatory crop improvement programs in Nepal and Bangladesh. The cultivars from this highly client-oriented breeding programs were widely disseminated in Nepal through a wide network of NGO and GO partners.

Gyawali *et al.* (2005) screened 142 accessions through collaborative selection for quality varieties and few were finally proven to be generally superior for post harvest traits in Pokhara valley of Nepal. When explicit measures are taken

to account for the needs of clients using local preferences and selection, it can produce widely adapted rice varieties (Joshi *et al.*, 2007).

Gyawali *et al.* (2010) developed some enhanced *Jethobudo* an aromatic landrace of rice in Nepal and evaluated them on Farm using Participatory Varietal Selection (PVS) and trained farmers to produce basic seeds. The study of adoption of Improved Sweet potato Varieties in Uganda was quantitatively assessed by Barnabas *et al.* (2012). They showed that how participatory plant breeding (PPB) and participatory varietal selection (PVS) influence farmers' uptake of the improved sweet potato varieties and also determined other factors influencing this adoption.

Paris *et al.* (2008) assessed farmer adoption of rice varieties and new genotypes introduced through participatory varietal selection (PVS) in villages which represent submergence- and drought/submergence-prone villages in eastern Uttar Pradesh, India. They focuses on the involvement of women farmers in participatory research for screening improved varieties for areas which suffer from abiotic stresses.

Manzanilla *et al.* (2011) carried out research regarding farmer's preference through Participatory Varietal Selection regarding sub 1 rice in South East Asia. The preference analysis indicated that farmers prefer rice cultivars that are tolerant of submergence, have early to medium maturity relative to their commonly grown varieties, are resistant to pests and diseases, and are resistant to lodging, among other traits. Also advocated that to enhance adoption, male and female farmers should be involved in the evaluation process.

Subedi *et al.* (2011) carried out participatory varietal selection (PVS) practiced in four villages of Sundar Bazaar, Lamjung, Nepal. Eight genotypes, (IR-55435-5, Ghaiya-2, Bindeshwori, Radha-32, B6149-MR-7, NR-1824-21-1-1, IR55539-2, Radha-4) five each for direct seeded and transplanted rainfed rice, alongwith local checks (Phakhe Jhinuwa and Gokule Mansuli) were grown in

farmers' field in mother and baby trial design. Situation of on farm diversity, farmers' selection criteria, and socio-economic conditions were studied using participatory tools including household survey, farmers' group discussions, farmers' field days and on-farm experimentation. Difference in adoption of cultivars was found connected with difference in selection criteria which was eventually based on socio-economic context of farmers. Consequently, increase in varietal diversity of upland rice is related with diversity in selection criteria and priority linked with difference in socioeconomic conditions. They envisioned important advantage of participatory varietal selection (PVS) is increased adoption of improved cultivars due to speedy uptake by farmers.

Ojehomon *et al.* (2012) showed that Participatory Varietal Selection (PVS) as a means of disseminating NERICA to other parts of the country using extension agents. The findings of their study may be applicable to other similar states and countries.

Yadavendra and Witcombe (2013) showed that Participatory approaches can be used to rapidly and cost-effectively to identify the best existing varieties in a process termed Participatory Varietal Selection (PVS). However, client-oriented breeding (COB) approaches also can produce more readily-adopted varieties as identified by PVS.

### **2.3 Genotype x Location (G x L) interaction and Stability Studies**

The term “stability of genotypes” is central to all types of analyses of G x E interactions especially with reference to plant breeding. Stability has been described in many different ways over the years and there have also been different concepts of stability (Lin *et al.*, 1986).

Researchers use the terms adaptation, phenotypic stability and yield stability in different ways (Becker and Leon, 1988). Stability in common usage connotes consistency in performance that would mean minimum variation among environments for a particular genotype (Chahal and Gosal, 2002). Ramagosa and

Fox (1993) concluded that if a genotype maintains high yield over a wide range of environments, it is referred to as having general or wider adaptation. On the other hand, if this is true only for a limited range of environments, that genotype has specific or narrow adaptation. The variation in genotypic response from one environment to another is an intrinsic part of a genotypic behavior and without its estimation, assessment of a genotype remains incomplete (Westcott, 1987).

Reddy *et al.* (1998) ascertained Genotype X Environment interaction for grain yield in 24 genotypes of lowland rice at five locations in India: Cuttack (Orissa), Masodha (Uttar Pradesh), Patna (Bihar), Raipur (Madhya Pradesh) and Titabar (Assam). On the basis of stability parameters, genotypes RAU79-2-14 and RAU617-59-14-1 were identified as the most stable, with high grain yields over different environments. A selection from Raipur, (IET6286/Bd.83)-29, was identified as a suitable genotype for favourable environments.

Honarnejad and Mohammad-Salehi (1998) determined grain yield in 10 promising rice genotypes at 3 locations in Guilan province, Iran, over a 2-year period and found significant differences between genotypes for grain yield but not between locations or between years. Location  $\times$  year and location  $\times$  year  $\times$  genotype interactions were found significant, but genotype  $\times$  year and genotype X location interactions were non-significant analyses showed high yield and stability for genotypes Sepidrud, Amol 2 and 211.

Abdul-Qayyum *et al.* (2000) studied stability analysis of 6 rice genotypes, tested at 5 locations, indicated significant genetic differences among rice genotypes, while genotype  $\times$  location interaction was non-significant. The regression coefficients ( $b_i$ ) and deviations from regression ( $s^2d_i$ ) found significant for all genotypes except Pak-4554 and Basmati-385. Basmati-385 performed best at all locations with average stability.

Shadakshari *et al.* (2001) evaluated forty long duration genotypes in six random environments. Significant mean squares for days to 50 per cent flowering,

plant height and grain yield plot<sup>-1</sup> were recorded for genotypes, environment + G × E interaction, environment (linear) and G × E (linear). Eight genotypes revealed high mean, non-significant deviation of regression coefficient from unity (bi) and non-significant deviation from regression (S<sup>2</sup>d<sub>i</sub>). The genotypes were suitable for cultivation across the locations.

Narayana and Dushyantha (2003) evaluated twenty genotypes at four locations. Significant variances due to genotypes, environments and G × E interactions were observed. Linear G × E interactions was significant for most of the traits. Several genotypes were found to be highly stable and yielding across the locations.

Munisonnappa *et al.* (2004) studied seven high yielding new rice hybrids in six micro-environments (different dates of sowing). G × E was significant for most of the traits. Variance due to environment (linear variance) was significant for days to 50 per cent flowering, plant height, grain weight and grain yield. Four hybrids showed high stability with high mean and were suitable for planting throughout the season.

Kumar and Shadakshari (2006) conducted stability studies of 18 elite rice genotypes in lowlands for their yield at three different locations (Mudigere, Ponnampet and Sirsi, Karnataka, India) during the kharif season of 2001 and found significant deviation from regression for grain yield in genotypes Intan, IET-14080, Sharavathi, IET-10472, IET-14320 and KHRS-22, IET-16695, KHRS-21 and KHRS-28 showed unit regression and non-significant deviation from regression and Genotypes KHRS-21, KHRS-22 and KHRS-28 were assessed ideally adaptable and stable and recommended for cultivation in hill zone of Karnataka.

Devi *et al.* (2006) evaluated ten promising rice genotypes for stability parameters with respect to grain yield and its components in four environments, i.e. E1 (1 May sowing, under 20x10 cm spacing), E2 (1 May sowing, under 20x20

cm spacing), E3 (1 June sowing, under 20x10 cm sowing), and E4 (1 June sowing, under 20x20 cm sowing) in Manipur, India. The linear components of genotype x environment (G x E) interaction were found significant only for three characters, i.e. plant height at maturity, days to 50% flowering and grain yield plot-1, whereas the non-linear component was significant for all the characters. Among the genotypes, CAUR-2 and KD-2-7-6-2 produced better grain yield. However, on the basis of estimated parameters of stability, the genotypes RCM-9 and KD-2-7-6 was considered better for grain yield for general cultivation in Manipur valley.

Tahir *et al.* (2007) studied Genotype x Environment interaction for paddy yield of rice (*Oryza sativa* L.) by growing eight rice genotypes and mean squares due to genotype x year were found highly significant indicating genetic differences among genotypes for linear response to various environments. The genotypes PK 2557-24-2-1 and PK 3355-5-1-4 were identified of performing well in favourable environment while the variety KS 282 performing better under unfavourable environment. PK 3303-15-1 was found most desirable genotype with  $b_i = 0.92$  and  $S^2d_i = 0.109$  exhibiting comparatively more consistent performance in all the environments.

Sambandon *et al.* (2008) studied Thirty-five genotypes of rice for stability of grain yield and its component traits under four artificially created environmental conditions. The data on various parameters were analyzed for G x E interaction. Pooled analysis of variance revealed that the genotypes had sufficient variability for all the characters studied. G x E interaction was also found significant for most of the traits except hulling per cent. Linear component of G x E was found significant for most of the traits except hulling per cent and head rice recovery. Non-linear component of G x E was found significant for most of the traits except plant height, 1000-grain weight, hulling percentage and milling per cent and based on their performance over environments, genotypes viz., IR 72,

IR 8, HKR 46, HKR 99-60, PR 113, PR 116 and Sarbati were found to be stable for grain yield and its component traits.

Haryanto *et al.* (2008) undertook yield stability studies of aromatic upland genotypes using regression lines proposed by Finlay and Wilkinson and they found some genotypes showing high yield stability and wide adaptability in different locations, and others showed good adaptability to a specific location. The lines having high yield stability and wide adaptability were G10 (405 g m<sup>-2</sup>), G19 (400 g m<sup>-2</sup>), G39 (418 g m<sup>-2</sup>), and G136 (411 g m<sup>-2</sup>), which were considered as candidates of new aromatic upland rice cultivars.

Waghmode and Mehta (2011) evaluated one hundred twenty five rice hybrids along with their 28 parental lines and checks over environments and the stability of genotypes revealed that none of the parents and hybrids were proved to be ideal for better or poor environmental condition for all the characters.

Kadhem and Al-Nedawi (2011) used five of parametric and 11 of nonparametric techniques for analysis of genotype x environment interaction for grain yield of 7 rice genotypes through three locations in two years (2005, and 2006) and according to the values of the stability measures, the genotypes with the highest grain yield in the majority of cases were not the most stable.

Bose *et al* (2012) evaluated twenty-one lowland rice genotypes for their stability parameters with respect to grain yield in a multi-locational trial at five different sites of Eastern India. Pooled analysis of variance reflects existence of genotype x environment interactions and contribution of both linear and non-linear components to genotype x environment interactions. Through stability parameter analysis, it was found that Rayda B3, CR 778 and CR 66 were suitable for all environments. The genotypes Sabita, OR 13 and RGA-4 were suitable for better environments. PSR 12, CR 78, Ambika, OR 87, ST 42, NDR 40 and CR 66 were identified for poor environments.

Mosavi *et al.* (2013) investigated five rice promising genotypes, Danesh, Jahesh, Milad, Partov, Jelodar, and seven rice genotypes parents, Sangtarom, Tarommahali, Dilamani, Noksiyah, Sepidrod, R9, Fajr for grain yield stability of 2010-11 over three locations in North of Iran. The results obtained demonstrated highly significant yield differences among rice genotypes, environment and genotype by environment interaction. Some rice genotypes were adjudged stable when different yield stability parameters were considered.

## Chapter – 3

### MATERIAL AND METHODS

The present investigation entitled “Farmers participatory varietal selection in *japonica* rice (*Oryza sativa* L.) through mother trial evaluation system in Kashmir valley” was conducted during *kharif* 2013 in two districts viz., Anantnag (33-34° E latitude 74-75° N Longitude) and Pulwama (33.87° E Latitude 74.89° N Longitude). In each district two locations were selected to lay out the trials. The experimental material and methodology used during study are detailed below:

#### 3.1 Experimental material used

The cultivars (Genotypes) used in the present study are given below :

#### Brief description of the genotypes evaluated across the locations

Genotypes	Pedigree
<b>Advanced lines</b>	
1) K-08-73	: Kohsar x K332
2) K-08-63	: Koshikari x K-508
3) K-08-69	: K-508 x Koshikari
<b>Pipeline varieties</b>	
4) SKUA-524	: GSL-25
5) SKUA-506	: Larnoo selection-2
<b>Pre released</b>	
6) SKUA-402	: Pureline Selection from International Rice Cold Tolerance Nursery (IRCTN-2008)
<b>Germplasm lines</b>	
7) GSL-61	: V <sub>7</sub> (IVT-I)
8) GSL-11	: V <sub>17</sub> (IVT-I)
<b>Check</b>	
9) K-332	(Popular Variety)
10) Farmers check	

The details of the techniques followed during the course of investigation are as follows:

### **3.2 Village selection**

The present study was undertaken at two villages each in Districts of Anantnag and Pulwama. Two sites each in both the districts were selected in consultation with Krishi Vigyan Kendras (KVK) of concerned districts. One farmer at each site was identified for laying Mother Trial whileas, the Grandmother Trial (On station Trial) will be laid at Mountain Crop Research Station (MCRS), Larnoo (Anantnag) and Krishi Vighyan Kendra (KVK), Pombay.

### **3.3 Collaboration with other Departments/Stations/Agencies**

- i) Mountain Crop Research Station (MCRS), Larnoo
- ii) Mountain Research Centre for Field Crops (MRCFC), Kudwani
- ii) Krishi Vigyan Kendra (KVK), Pombay (Kulgam)
- iii) Krishi Vigyan Kendra (KVK), Malangpora (Pulwama)
- iv) Local Panchayat Representatives

### **3.4 Participatory Rural Appraisal**

Participatory Rural Appraisal will be conducted prior to laying of trials in the selected sites. Fifty households from each site will be surveyed using pre-designed Household Level Questionnaire (HLQ) to identify production constraints as well as the farmers perception about varietal specifications (Annexure – I).

### **3.5 Laying of Grand-mother (On Station) and Mother Trials (On Farm)**

The Grand Mother trail which were laid at experimental farms of MCRS, Larnoo and KVK, Pombay and the experiment material was laid in replicated design including most popular variety and farmer's variety as checks, while as the

Researcher designed farmer-managed trial (Mother Trial) was laid in a similar fashion at each site in the farmer field. Each genotype both at Grand Mother and Mother Trials were represented by three rows of two meter length with inter and intra row spacing of 20 cm and 15 cm respectively.

### **3.6 Data collection**

The data generated from Grand Mother and Mother trials were collected in two ways:

#### **3.6.1 Preference data**

Preference data was gathered by using preferential analysis (PA). A group of farmers were allowed to vote for their preferred genotypes during farm walk day by depositing paper ballots in a bag or envelope in front of each plot. During the farm walk the bag was placed in front of each plot in the trial, and the bag served as ballot box for genotype. Each farmer was given two ballots of different color and were asked to vote for most and least preferred variety as per their own selection and preferential indices. The preferential score was calculated as:

$$PS = \frac{\text{No. of positive votes} - \text{No. of negative votes}}{\text{Total No. of votes}}$$

(De-Boef and Thijssen, 2007)

#### **3.6.2 Quantitative data**

The data for following quantitative traits was recorded from ten competitive plants from each replication for various morphological, agronomical, yield and yield attributing traits to study their relationship with farmer's preferential scoring and stability performance over six random environments. Each selected plant were taken at random from each experimental plot in a replication and tagged for recording bio-metrical observations. Mean value of all characters and median values for days to flowering and days to maturity were worked out. Observations were recorded at the appropriate developmental stages

of the plant growth as per the descriptors for rice formulated by IBPGR-IRRI Advisory Committee (IRRI, 1980). The characters included for the study were:

#### **3.6.2.1 Days to 50% flowering**

Recorded as number of days taken from the seed sowing to the emergence of flowering in 50 per cent plants in each experimental plot.

#### **3.6.2.2 Days taken to maturity**

Recorded as number of days taken from seed sowing to grain ripening (physiological maturity) on whole plant basis.

#### **3.6.2.3 Plant height**

Height of tagged plants was measured in cm as the distance from the ground level to the tip of the tallest panicle excluding awns at maturity as suggested by Gomez (1972).

#### **3.6.2.4 Number of panicles plant<sup>-1</sup>**

Total number of panicles bearing tillers m<sup>-2</sup> were recorded from the middle of the experimental plot by placing a steel square (1m × 1m) around the area.

#### **3.6.2.5 Panicle length (cm)**

Panicle length of the main tiller of each tagged plants in an experimental plots was measured in cm from the panicle base to the tip of the panicle at the dough stage.

#### **3.6.2.6 Number of grains panicle<sup>-1</sup>**

Grains were counted from the panicles of tagged plants in each experimental plot at maturity and the mean worked out.

#### **3.6.2.7 100-grain weight (g)**

From the bulk sample of grains obtained from the panicles of tagged plants, 100 well filled grains were counted and weighted in grams.

### **3.6.2.8 Biological yield plot<sup>-1</sup> (kg)**

At maturity the entire crop from the net plot (0.8 m<sup>2</sup>) was harvested and sun dried for a few days. Weight of the total biomass (straw and grain yield) was recorded before seed threshing and also after cleaning in respect of the seed (filled grains) and rest of straw in Kg.

### **3.6.2.9 Grain yield plot<sup>-1</sup> (kg)**

The grains obtained from the net plot (0.8m<sup>2</sup>) were dried for two to three days, cleaned and then weighed in kg.

### **3.6.2.10 100-grain weight**

From the bulk sample of grains obtained from the panicle of tagged plants 100 well filled grains were counted and weighted in grams.

## **3.7 Statistical analysis of data**

The qualitative data generated through participatory rural appraisal (PRA) was analyzed by using  $\chi^2$ -test. The data generated from replicated Grandmother and Mother Trials was analyzed through ANOVA.

## **3.8 Stability analysis**

### **3.8.1 Analysis of variance for stability**

Linear model of Eberhart and Russell (1966) was followed for analyzing the stability of the ten genotypes across six locations including four farmers by the following model:

$$Y_{ij} = \mu_i + b_i I_j + S^2_{ij}$$

Where,

$Y_{ij}$  = Mean performance of the  $i^{\text{th}}$  genotype ( $i= 1,2,3,\dots,g$ ) in the  $j^{\text{th}}$  environment ( $j= 1,2,3,\dots,n$ ),

$\mu_i$  = Overall mean of the  $i^{\text{th}}$  genotype over all the environments,

$b_i$  = Regression coefficient which measures the response of the  $i$ th genotype to varying environments,

$I_j$  = Environmental index obtained as the mean of all varieties at the  $j$ th environment minus the grand mean, and

$S_{ij}^2$  = Deviation from regression of the  $i$ th genotype in the  $j$ th environment

The environmental index for  $j$ th environment was calculated as:

$$I_j = \left[ \left( \sum_{j=1} Y_{ij} \right) - \left( \sum_{i=1} \sum_{j=1} \frac{Y_{ij}}{gn} \right) \right]$$

Where,  $\sum_{j=1} I_j = 0$

Analysis of variance for stability following Eberhart and Russell model (1966)

Source	d.f.	S.S.	MS
Genotypes	(g-1)	$\left[ \frac{\sum_i Y^2_i}{n} - \frac{Y^2_{...}}{gn} \right]$	MS1
Environment + (Genotype x Environment)	(n-1) + (g-1) (n-1) = g(n-1)	$\left[ \frac{\sum_i \sum_j Y^2_{ij}}{g} - \frac{\sum_i Y^2_i}{n} \right]$	MS2
Environment	(n-1)	$\left[ \frac{\sum_j Y^2_j}{g} - \frac{Y^2_{...}}{gn} \right]$	MS3
Genotype x Environment	(g-1)(n-1)	$\left[ \sum_i \sum_j jY^2_{ij} - \frac{\sum_i iY^2_i}{n} - \frac{\sum_j jY^2_j}{g} \right] + \left[ \frac{Y^2_{...}}{gn} \right]$	MS4
Environment (linear)	1	$\frac{1}{g} \left[ \frac{(\sum_i iY \cdot \sum_j jI_j)^2}{\sum_j jI_j^2} \right]$	MS5
Genotype x Environment (linear)	(g-1)	$\left[ \frac{\sum_i (\sum_j Y_{ij} I_j)^2}{\sum_j jI_j^2} \right] - \text{Env. (linear) S.S.}$	MS6
Pooled deviation	g(n-2)	$\sum_i \sum_j \left[ \sum_j Y^2_{ij} - \frac{Y^2_i}{n} \right] - \frac{(\sum_j Y_{ij})^2}{(\sum_j I_j^2)}$	MST7

Genotype 1	(n-2)	$\left[ \sum_j Y_{ij}^2 - \frac{Y_i^2}{n} \right] - \left( \sum_j Y_{ij} \cdot \sum_j I_j \right)^2 / \sum_j I_j^2$	
Genotype g	(n-2)	$\left[ \sum_j Y_{gj}^2 - \frac{Y_g^2}{n} \right] - \left( \sum_j \sum_{rgi}^2 \right)^2 / \sum_j I_j^2$	
Pooled error	n(r-1)(g-1)	Pooled replication S.S x genotypes S.S over environments=Me	
Total	(gn-1)	$\left[ \sum_i \sum_j Y_{ij}^2 - \frac{Y^2 \dots}{gn} \right]$	

Where,

- g = Number of genotypes,
- n = Number of environments,
- r = Number of replications,
- I = Environmental index,
- $Y_{ij}$  = Basic observations (mean of the  $i^{\text{th}}$  genotypes over replications in  $j^{\text{th}}$  environment), and
- Me = pooled  $\sigma^2_e/r$ .

### 3.8.1.1 Estimation of stability parameters

a) Regression coefficient ( $b_i$ ) =  $\sum_i Y_{ij} I_j / \sum_j I_j^2$

Where,

$\sum_i Y_{ij} I_j$  = The sum of products i.e. sum of the products of environmental index (I) with the corresponding mean (X) of that genotype at each location.

$\sum_j I_j^2$  = Sum of squares (of environmental index)

b) Mean squares deviation ( $S^2_{di}$ ) from linear regression

$$= \frac{\sum_j S^2_{ij}}{n-2} - \frac{S^2_e}{r}$$

Where,

$$\sum_j S^2_{ij} = \left[ \sum_j Y^2_{ij} - \frac{Y \dots}{n} \right] - \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}$$

$S^2_e$  = the estimate of pooled error.

### 3.8.1.2 Test of significance

i) Among the variety means :

$H_0 = g_1 = g_2 = g_3 = \dots = g_n$ , the appropriate test is defined as:

$$F = MS_1/MS_3$$

ii) Among varieties for their regression on the environmental index.

$$H_0 = B_1 = B_2 = B_3 = \dots = B_g$$

$$F = MS_2/MS_3$$

iii) The genetic differences among genotypes for their regression on environmental index was tested by 't' test.

$$t = \frac{b - 0}{S.E. (b)}$$

$$\text{Where, } S.E. (b) = \left[ \frac{\text{pooled deviation MS}}{\sum_j I^2_j} \right]^{\frac{1}{2}}$$

i) For the deviation from regression of each genotype.

$$F = \left[ \sum_j S^2_{ij} / n - 2 \right] / M.S. \text{ Pooled error.}$$

ii) The deviation of  $b_i$  values from unity was tested as :

$$t = \frac{b - 1}{S.E. (b)}, \text{ for } (n-2) \text{ d.f.}$$

Where,

$$S.E. (b_i) = \left[ \sum_j S^2_{ij} / n - 2 / \sum_j I^2_j \right]^{\frac{1}{2}}$$

$n$  = number of environments.

## Chapter – 4

### EXPERIMENTAL FINDINGS

The present investigation entitled “Farmers participatory varietal selection in *japonica* rice (*Oryza sativa* L.) through Mother trial Evaluation System in Kashmir valley” was carried out for evaluation of released varieties, pipeline materials, advanced breeding lines, landraces or germplasm accessions on farmers’ fields under his management practices and produce farmer acceptable cultivars more effectively. The genotypes K-08-73, K-08-63, K-08-69, SKUA-524, SKUA-506, SKUA-402, GSL-61, GSL-11 and K-332 (popular variety) and farmer’s variety as checks were evaluated by farmers to target for a specific niche to target using his own selection indices. Further the genotypes were assessed for the stability across six test locations/environments to character performance to characterize the nature of genotype × location interaction for yield related and other traits. The genotypes were evaluated in a Randomized Complete Block Design (RCBD) with two replications across all six random environments representing mountain agroecology of Kashmir valley situated between 2000 to 2300 m a.m.s.l. Before laying out the trials Participatory Rural Appraisal (PRA) was conducted.

The results obtained, after subjecting the data (qualitative as well as quantitative) to parametric statistical tests, and inferences drawn thereafter, regarding the farmers perception preferential scoring and stability parameters of genotypes are described in the present chapter under the following heads:

- 4.1 Understanding farmers’ perceptions and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA)
- 4.2 Calculation of preferential scoring of different genotypes; and
- 4.3 Estimation of Stability parameters and identification of suitable genotypes.

#### **4.1 Understanding farmers' perceptions and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA)**

PRA was conducted by selecting 50 households from 16 selected sites. The sites were selected from high altitude areas eight each from Districts of Anantnag and Pulwama to identify background information, production constraints as well as the farmers perception about varietal specification of rice crop.

##### **4.1.1 Background Information**

There were 23 easy questions in the questionnaire and the questions were asked in vernacular language and were filled in by the researcher himself after listening to the replies (Table-1).

##### **4.1.1.1 Ranking of rice among *kharif* crops (Ist verses other)**

Household Level Questionnaire (HLQ) conducted during start of 2013 revealed that under high altitude irrigated ecosystem of Kashmir valley, only rice crop is being grown, because of the fact that cent percent farmers replied that they grow rice only.

##### **4.1.1.2 Farming practice (Mono-cropping verse double cropping)**

Mono-cropping is being widely practiced method due to limited number of favorable days available for other crop, however at locations Pastuna, Aripal and Lorgam (Tral) a good number of farmers were practicing double cropping. On an average 77 and 23 per cent farmers were following mono-cropping and double cropping respectively.

##### **4.1.1.3 Irrigated system (Canal verses spring)**

When farmers were asked about the source of irrigation system, it was found that canal system of irrigation is significantly in vogue while as at locations Pastuna, Aripal and Lorgam (Tral), natural springs were also the source of irrigation. The data revealed that canals contribute 82.5 per cent and springs just

**Table 1 : Participatory Rural Appraisal (PRA) at 16 locations for understanding farmers' perceptions and preferences about high altitude rice varieties**

Locations (L)	N	R	Background information						
			Ranking of rice among <i>Kharif</i> crops	Farming practices		Irrigation system		Source of irrigation water	
			1 <sup>st</sup>	Mono crop	Double crop	Canal	Spring	Rivers/ streams	Snow melting
L-1 (Village Pastuna, Tral)	50	36	36 (100)	23 (63.89)	13 (36.11)	0	36 (100)	36 (100)	0
L-2 (Village Aripal, Tral)	50	44	44 (100)	21 (47.73)	23 (52.27)	9 (20.45)	35 (79.55)	31 (70.45)	13 (29.55)
L-3 (Village Lorgam, Tral)	50	41	41 (100)	8 (19.51)	33 (80.49)	0	41 (100)	41 (100)	0
L-4 (Village Narastan, Tral)	50	38	38 (100)	36 (94.74)	2 (5.26)	38 (100)	0	0	38 (100)
L-5 (Village Satoora, Tral)	50	38	38 (100)	36 (94.74)	2 (5.26)	38 (100)	0	0	38 (100)
L-6 (Village Gutru, Tral)	50	43	43 (100)	38 (88.37)	5 (11.63)	43 (100)	0	0	43 (100)
L-7 (Village Zuastan, Tral)	50	40	40 (100)	32 (80.00)	8 (20.00)	40 (100)	0	0	40 (100)
L-8 (Village Lam, Tral)	50	38	38 (100)	32 (84.2)	6 (15.8)	38 (100)	0	0	38 (100)

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Table-1 Contd.....

Locations (L)	N	R	Background information						
			Ranking of rice among Kharif crops	Farming practices		Irrigation system		Source of irrigation water	
			1 <sup>st</sup>	Mono crop	Double crop	Canal	Spring	Rivers/ streams	Snow melting
L-9 (Village Larnu)	50	42	42 (100)	34 (80.95)	8 (19.05)	42 (100)	0	0	42 (100)
L-10 (Village Khretti)	50	41	41 (100)	33 (80.49)	8 (19.51)	41 (100)	0	0	41 (100)
L-11 (Village Desu)	50	38	38 (100)	33 (86.84)	5 (13.16)	38 (100)	0	0	38 (100)
L-12 (Village Bidihard)	50	36	36 (100)	32 (88.89)	4 (11.11)	36 (100)	0	0	36 (100)
L-13 (Village Gohan)	50	43	43 (100)	35 (81.40)	8 (18.60)	43 (100)	0	0	43 (100)
L-14 (Village Vailu)	50	40	40 (100)	32 (80.00)	8 (20)	40 (100)	0	0	40 (100)
L-15 (Village Gadol)	50	42	42 (100)	32 (76.19)	10 (23.81)	42 (100)	0	0	42 (100)
L-16 (Village Walangam)	50	45	45 (100)	37 (82.22)	8 (17.78)	45 (100)	0	0	45 (100)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>			<b>(322.5)</b>	<b>(135.9)</b>		<b>(308.2)</b>			<b>(308.18)</b>

N = Total number of farmers provided with questionnaire; R= Total number of farmers responded

\* $\chi^2$ -tabulated value at 15 df = 25; \*Values within parenthesis are calculated % age data

17 per cent as part of irrigation system. It was also observed that nowhere rain-fed rice are being grown.

#### **4.1.1.4 Source of irrigation water (Snow melting verses rivers/streams)**

Regarding the source of irrigation water, significant number of the selected farmers reported that melting glaciers feed directly the canal system however, at locations Pastuna, Aripal and Lorgam (Tral), farmers replied that natural springs were also the direct source of irrigation water. It was observed that melting glaciers contribute 100% source of irrigation water barring locations Pastuna, Aripal and Lorgam (Tral), were natural springs directly feed their fields.

#### **4.1.2 Production constraints**

##### **4.1.2.1 Major production constraint (Low yielding verses diseases)**

Household Level Questionnaire (HLQ) conducted was composed of few questions regarding the constraints in rice crop production. In this regard farmers were asked whether it was low yielding varieties or diseases as major constraints in rice production. The comparison data revealed that low yielding varieties was found to be a significant factor in limiting rice crop production and diseases rank second as production constraints. The low yielding varieties are the major production constraints and observed data in this regard ranged from 62.5-81.4 per cent with a mean percentage of 71.5 per cent (Table-1.1).

##### **4.1.2.2 Major disease (Blast verses any other)**

Under the heading of major production constraints another questing posed to farmers was regarding the diseases and in this regard blast locally called *rye* was compared with other diseases. When the data of blast verses other diseases was analyzed,  $\chi^2$ -value revealed high significance proving that blast is the big challenge to rice production. Blast is a big impediment to rice production was assessed by 83.9 per cent of the farmers, while as rest was attributed to other diseases and can be deemed as of minor importance (Table-1.1).

#### **4.1.2.3 Biotic stress (Disease verses Insect)**

Similarly the data of biotic stress under which losses due to diseases vs insect pest damage was compared and it revealed that former effect was highly significant, rather the effect of insect damage has not been felt economically important by the high altitude rice growing farmers. In totality 84.75% farmers considered the diseases as more important and a marginal proportion 15.25% felt the gravity of insect and snails and slugs particularly at nursery stage (Table-1.1).

#### **4.1.2.4 Abiotic stress (Cold verses drought)**

Among abiotic challenges cold damage was felt by the significant proportion of the selected farmers and drought spells affecting the rice production was hardly felt by the farmers. The comparison of cold vs drought revealed that former was felt by 77 per cent and later by less than 23 per cent economically important as rice production constraints. Cold stress is a big issue particularly at critical stages of crop growth was assessed by most of the farmers and ranged between 61-91.96 per cent (Table-1.1). Drought was of least occurrence and was felt by less than 40 per cent at location (Lorgam, Tral).

#### **4.1.2.5 Source of seed (Farmer saved seed verses Institution + Farmer to farmer exchange + any other)**

More than half (55.7%) of total farmers use their own saved seed and 23.63 per cent get it through farmer to farmer exchange while as other sources and institute contributing 8.65 and 12.03 per cent. respectively. One important information was that the private market has no role in rice seed supply. The non significance of test of comparison of farmer's seed verses other classes as a group revealed equal contribution of these two seed sources.

#### **4.1.3 Specification of new varieties for the area**

Household Level Questionnaire (HLQ) conducted to design the new varieties and to set breeding objectives, the questionnaire consisted of some

**Table-1.1 : Participatory Rural Appraisal (PRA) at sixteen locations for understanding farmers' perceptions and preferences about high altitude rice varieties**

Locations (L)	Production constraint													
	N	R	Major production constraints		Major disease		Biotic stress		Abiotic stress		Source of seed			
			Low yielding varieties	Diseases	Blast (rye)	Any other	Disease	Insect	Cold	Drought	Farmers saved seed	Institution/ University	Farmer to farmer exchange	Any other
L-1 (Village Pastuna, Tral)	50	36	26 (72.22)	10 (27.78)	27 (75.00)	9 (25.00)	28 (77.78)	8 (22.22)	27 (75.00)	9 (25.00)	19 (52.78)	3 (8.33)	11 (30.56)	3 (8.33)
L-2 (Village Aripal, Tral)	50	44	32 (72.73)	12 (27.27)	35 (79.55)	9 (20.45)	37 (84.09)	7 (15.91)	34 (77.27)	10 (22.73)	25 (56.82)	4 (9.09)	12 (27.27)	3 (6.82)
L-3 (Village Lorgam, Tral)	50	41	32 (78.05)	9 (21.95)	35 (85.37)	7 (17.07)	37 (90.24)	4 (9.76)	25 (60.99)	16 (39.02)	23 (56.10)	2 (4.88)	13 (31.71)	3 (10.53)
L-4 (Village Narastan, Tral)	50	38	27 (71.05)	11 (28.95)	33 (86.84)	5 (13.16)	32 (84.21)	6 (15.79)	28 (73.68)	10 (26.32)	21 (55.26)	3 (7.89)	10 (26.32)	4 (10.53)
L-5 (Village Satoora, Tral)	50	38	27 (72.97)	11 (29.73)	33 (89.19)	5 (13.51)	32 (86.49)	6 (16.22)	28 (75.68)	10 (27.03)	21 (56.76)	3 (7.89)	10 (27.03)	4 (10.81)
L-6 (Village Gutru, Tral)	50	43	35 (81.40)	8 (18.60)	36 (87.50)	7 (16.28)	37 (86.05)	6 (13.95)	32 (74.42)	11 (25.58)	22 (51.16)	7 (16.28)	10 (23.26)	4 (10.53)
L-7 (Village Zuastan, Tral)	50	40	25 (62.50)	15 (37.50)	35 (83.72)	5 (12.50)	34 (85.00)	6 (15.00)	31 (77.50)	9 (22.50)	20 (50.00)	4 (10.00)	11 (27.50)	5 (12.50)
L-8 (Village Lam, Tral)	50	38	26 (68.4)	12 (31.6)	35 (92.10)	3 (7.90)	33 (86.84)	5 (13.16)	32 (84.21)	6 (15.79)	21 (55.26)	6 (15.79)	9 (27.68)	2 (5.26)

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**Table-1.1 Contd....**

Locations (L)	Production Constraint													
	N	R	Major production constraints		Major disease		Biotic stress		Abiotic stress		Source of seed			
			Low yielding varieties	Diseases	Blast (rye)	Any other	Disease	Insect	Cold	Drought	Farmers saved seed	Institution/ University	Farmer to farmer exchange	Any other
L-9 (Village Larnu)	50	42	28 (66.67)	14 (33.33)	35 (83.33)	7 (16.67)	36 (85.71)	6 (14.29)	32 (76.19)	10 (23.81)	23 (54.76)	5 (11.90)	10 (9.52)	4 (9.52)
L-10 (Village Khretti)	50	41	26 (63.41)	15 (36.59)	33 (80.49)	8 (19.51)	37 (90.24)	4 (9.76)	33 (80.49)	8 (19.51)	22 (53.66)	7 (17.07)	8 (19.51)	4 (9.76)
L-11 (Village Desu)	50	38	25 (65.79)	13 (34.21)	33 (86.84)	5 (13.16)	32 (84.21)	6 (15.79)	28 (73.68)	10 (26.32)	21 (55.26)	6 (15.79)	6 (15.79)	5 (13.16)
L-12 (Village Bidihard)	50	36	28 (77.78)	8 (22.22)	33 (91.67)	5 (13.89)	32 (88.89)	4 (11.11)	30 (83.33)	6 (16.67)	22 (61.11)	6 (16.67)	5 (13.89)	3 (8.33)
L-13 (Village Gohan)	50	43	32 (74.42)	11 (25.58)	38 (88.37)	5 (11.63)	36 (83.72)	7 (16.28)	32 (74.42)	11 (25.58)	25 (58.14)	5 (11.63)	10 (23.26)	3 (6.98)
L-14 (Village Vailu)	50	40	26 (65.00)	14 (35.00)	32 (80.00)	8 (20.00)	35 (87.50)	5 (12.50)	31 (77.50)	9 (22.50)	22 (55.00)	5 (12.50)	10 (25.00)	3 (7.50)
L-15 (Village Gadol)	50	42	30 (71.43)	12 (28.57)	33 (78.57)	9 (21.43)	32 (76.19)	10 (23.81)	33 (78.57)	9 (22.50)	25 (59.52)	5 (11.90)	10 (23.81)	2 (4.76)
L-16 (Village Walangam)	50	45	27 (60.00)	18 (40.00)	38 (84.44)	7 (15.56)	37 (82.22)	8 (17.78)	36 (80.00)	9 (21.43)	27 (60.00)	5 (11.10)	9 (20)	4 (8.89)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>			<b>(56.5)</b>		<b>(154.74)</b>		<b>(158.06)</b>		<b>(92.00)</b>		<b>(5.24)</b>			

N= total number of farmers provided with questionnaire; R= Total number of farmers responded

\*X<sup>2</sup>-tabulatedvalue at 15 df= 25; \*Values within parenthesis are calculated %age data

questions to seek preferences regarding plant phenology and grain characteristics and some post harvest traits (Table-1.2).

#### **4.1.3.1 Tillering (High verses Medium)**

Regarding the tillering, most of the farmers preferred high tillering when they were having the option of medium plus low tillering and high tillering was desired by 85.31 per cent of the farmers and only 14.83 per cent farmers liked to have medium tillering. Medium tillering on an average was preferred by less than 18% at any location except at location (Zuastan, Tral) of where medium tillering was desired by 30% and in no way less tillering was opted by any farmers at any location.

#### **4.1.3.2 Plant Stature (Tall verses medium Tall)**

Tall stature was a highly desirable trait against medium tall and semi dwarf possibly because of the demand for good biomass. The mean percentage of liking for tall stature was 79.65 per cent and medium stature was on an average preferred by 20.35 per cent. There was no preference for semi dwarf nature of the plant.

#### **4.1.3.3 Panicle length (Long verses medium)**

There was a highly significant aspiration for long panicle once compared to the medium long panicle. Farmers attributed that long panicle means high yield for them. The mean preferential percentage with respect to long panicle and medium panicle was 90 and 10 per cent, respectively.

#### **4.1.3.4 Grain number per panicle (High>150 verses medium< 120)**

No farmer opted for low grain number (up to 100) and cent percent preferential trait was for high grain numbered varieties (>150 grains/panicle). Farmer added that they are fed up with the varieties in vague under high altitude system and usually bear <100 grains/panicles and attributed this as root cause to low production under the system.

#### **4.1.3.5 Grain type (Long slender verses medium bold)**

Regarding grain type farmers favored medium bold grained varieties as it is socially and ecologically fit under their production system. Short bold grained varieties were highly disliked by the farmers. The mean percentage preference for medium bold grained rice varieties was 73 per cent. There was 43.24 per cent preference for long slender grains at location (Satoora, Tral).

#### **4.1.3.6 Variety fitness to such system (Growth verses biological yield)**

When growth duration was compared to biological yield, the  $\chi^2$ -test showed non-significance implying that both the traits maturity and biomass play equal role to the farmers under such agro-ecosystem.

#### **4.1.3.7 Maturity duration (Early verses medium)**

Early maturing varieties would be the most preferential trait liked by the farmers. The test of significances of early maturity verses medium maturity was highly significant and early maturing trait was preferred by majority the selected farmers (85-94%).

#### **4.1.3.8 Yield (Biomass verses high grain + straw)**

In terms of yield total biomass was compared with grain yield and straw yield and  $\chi^2$ -test revealed non-significance implying equal importance of biomass and grain and straw yield as a group. Average estimate over all locations showed that high biomass was preferred by 46.26 per cent and high grain and high straw yield collectively by 53.74 per cent.

#### **4.1.3.9 Threshability (medium verses easy)**

Medium threshability was preferred by significant number of farmers as revealed by test of significance and 70.02 per cent preferred medium threshing and hard threshing was preferred by none of the farmers.

#### **4.1.3.10 Market related traits (Grain shape and size verses grain color)**

The non significance of  $\chi^2$ -test for the comparative preference of grain size verses grain color (white) revealed equal importance of both the aspects for fetching good price in the market. The mean percentage of preference for grain size and grain color was 45.21 and 54.85 per cent, respectively.

#### **4.1.3.11 Milling (Easiness in milling verses head rice recovery)**

Easy to mill and high recovery of head rice were equally preferred by the farmers as revealed by the non-significance of  $\chi^2$ -testing. The observed values over the locations ranged between 52.63 to 70 per cent in case of easy milling while as, for head rice recovery the preference ranged from 30.0-47.3 per cent and the mean percentage value were 59.3 and 40 per cent respectively.

#### **4.1.3.12 Milled grain color (White verses brown)**

To ascertain the preference for milled grain colour, white was significantly preferred by majority of farmers in comparison to brown and mean percentage preference were 84.5 and 15.4 per cent, respectively. Highest preferential value for brown rice were observed at location Pastuna, Tral (25%) whileas, white colour preference ranged from 75-92.5 per cent.

#### **4.1.3.13 Cooking nature (Cook verses cook dry + cook sticky)**

The perceptions of farmers regarding the nature of cooked rice revealed that significant number of farmers preferred rice variety that cook neither sticky nor dry and desired that it should cook in between (medium) and mean percentage over all locations for this preference was 67.2 per cent against the cook dry plus cook sticky. The non significant number of farmers desired that they like the sticky rice (16.5%).

#### **4.1.3.14 Volume expansion of cooked rice (High verses medium)**

The cooked rice should expand high was preferred by a significant number of farmers in comparison to medium expansion plus low expansion number. The

**Table-1.2 : Participatory Rural Appraisal (PRA) at sixteen locations for understanding farmers' perceptions and preferences about high altitude rice varieties**

Location (L)	Varietal specification								
	Tillering		Plant stature		Panicle length		Grain No. per panicle	Grain type	
	High	Medium	Tall	Medium tall	Long	Medium	High >150	Long slender	Medium bold
L-1 (Village Pastuna, Tral)	34 (94.44)	2 (5.56)	25 (69.44)	11 (30.56)	32 (88.89)	4 (11.11)	36 (100)	9 (25.00)	27 (75.00)
L-2 (Village Aripal, Tral)	34 (84.09)	8 (18.18)	25 (77.27)	10 (22.73)	39 (88.84)	5 (11.36)	36 (100)	13 (29.58)	31 (70.45)
L-3 (Village Lorgam, Tral)	34 (92.68)	3 (7.32)	25 (78.07)	9 (21.95)	39 (95.12)	2 (4.88)	36 (100)	9 (21.95)	32 (78.05)
L-4 (Village Narastan, Tral)	32 (84.21)	6 (15.79)	25 (76.32)	9 (23.68)	36 (94.74)	2 (5.25)	36 (100)	11 (28.95)	27 (71.05)
L-5 (Village Satoora, Tral)	32 (84.49)	6 (16.22)	25 (78.38)	9 (24.32)	36 (97.30)	2 (5.41)	38 (100)	11 (29.73)	27 (72.97)
L-6 (Village Gutru, Tral)	34 (88.37)	5 (11.63)	25 (76.74)	10 (23.26)	36 (93.02)	3 (6.98)	39 (100)	8 (18.60)	35 (81.40)
L-7 (Village Zuastan, Tral)	28 (70.00)	12 (30.00)	25 (95.00)	2 (5.00)	35 (87.50)	5 (12.50)	40 (100)	8 (20)	32 (80)
L-8 (Village Lam, Tral)	34 (86.84)	4 (13.16)	25 (94.74)	2 (5.26)	30 (78.95)	8 (21.05)	38 (100)	6 (15.79)	32 (84.21)

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Table-1.2 Contd.....

Location (L)	Varietal specification								
	Tillering		Plant stature		Panicle length		Grain No. per panicle	Grain type	
	High	Medium	Tall	Medium tall	Long	Medium	High >150	Long slender	Medium bold
L-9 (Village Larnu)	34 (85.71)	6 (14.29)	25 (76.19)	10 (23.81)	38 (90.48)	4 (9.52)	42 (100)	12 (28.57)	30 (71.43)
L-10 (Village Khretti)	34 (82.93)	7 (17.07)	25 (75.61)	10 (24.39)	36 (87.80)	5 (12.20)	41 (100)	10 (24.39)	31 (75.61)
L-11 (Village Desu)	34 (89.47)	4 (10.53)	25 (76.32)	9 (23.65)	34 (89.47)	4 (10.53)	38 (100)	10 (26.32)	28 (73.68)
L-12 (Village Bidihard)	34 (88.89)	2 (11.11)	25 (88.89)	4 (11.11)	31 (86.11)	5 (13.89)	36 (100)	9 (25.00)	27 (75.00)
L-13 (Village Gohan)	34 (83.72)	7 (16.28)	25 (76.74)	10 (23.26)	39 (90.70)	4 (9.30)	41 (100)	15 (34.88)	28 (65.12)
L-14 (Village Vailu)	33 (82.50)	7 (17.50)	25 (77.50)	9 (22.50)	38 (95.15)	2 (4.85)	41 (100)	13 (32.50)	27 (67.50)
L-15 (Village Gadol)	34 (80.95)	8 (19.50)	25 (78.57)	9 (21.43)	37 (88.10)	5 (11.90)	42 (100)	12 (28.57)	30 (71.43)
L-16 (Village Walangam)	37 (82.22)	8 (17.78)	25 (82.22)	8 (17.78)	39 (86.67)	6 (13.33)	45 (100)	13 (28.89)	32 (71.11)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>	<b>(156.25)</b>		<b>(119.5)</b>		<b>(206.1)</b>		<b>(76.2)</b>		

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Table-1.2 Contd.....

Locations (L)	Variety fit to such system		Maturity			Yield	
	Growth duration	Biological/ straw yield	Early	Medium	High grain	High straw	Total biomass
L-1 (Village Pastuna, Tral)	24 (61.90)	16 (38.10)	28 (83.33)	8 (16.67)	12 (33.33)	8 (16.67)	16 (50.00)
L-2 (Village Aripal, Tral)	27 (61.36)	17 (38.64)	36 (81.82)	8 (18.18)	16 (36.36)	12 (27.27)	16 (36.36)
L-3 (Village Lorgam, Tral)	28 (68.29)	13 (31.71)	35 (85.37)	6 (14.63)	14 (34.15)	8 (19.51)	19 (46.34)
L-4 (Village Narastan, Tral)	25 (65.79)	13 (34.21)	35 (92.11)	3 (7.89)	13 (34.21)	7 (18.42)	18 (47.37)
L-5 (Village Satoora, Tral)	25 (65.57)	13 (35.14)	35 (94.59)	3 (8.11)	13 (35.14)	7 (18.92)	18 (48.65)
L-6 (Village Gutru, Tral)	26 (60.47)	17 (39.52)	34 (79.07)	9 (20.93)	16 (37.21)	6 (13.95)	21 (48.84)
L-7 (Village Zuastan, Tral)	26 (65.00)	14 (35.00)	37 (92.500)	3 (7.50)	15 (37.50)	9 (22.50)	16 (40.00)
L-8 (Village Lam, Tral)	29 (76.32)	9 (23.68)	31 (81.58)	7 (18.42)	12 (31.58)	7 (18.42)	19 (50.00)

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Table-1.2 Contd.....

Locations (L)	Variety fit to such system		Maturity			Yield	
	Growth duration	Biological/straw yield	Early	Medium	High grain	High straw	Total biomass
L-9 (Village Larnu)	26 (61.90)	16 (38.10)	35 (83.33)	7 (16.67)	14 (33.33)	7 (16.67)	21 (50.00)
L-10 (Village Khretti)	23 (56.16)	18 (43.90)	37 (90.24)	4 (9.76)	15 (36.59)	9 (21.59)	17 (41.46)
L-11 (Village Desu)	22 (57.89)	16 (42.11)	33 (86.84)	5 (3.16)	12 (31.58)	6 (15.79)	20 (52.63)
L-12 (Village Bidihard)	22 (61.11)	16 (44.44)	32 (88.89)	4 (11.11)	10 (27.78)	7 (19.44)	19 (52.78)
L-13 (Village Gohan)	26 (60.47)	17 (39.53)	38 (88.37)	5 (11.63)	16 (37.21)	8 (18.60)	19 (44.19)
L-14 (Village Vailu)	26 (65.00)	14 (38.00)	35 (87.50)	5 (12.50)	13 (32.50)	11 (27.50)	17 (42.50)
L-15 (Village Gadol)	26 (61.90)	16 (38.10)	35 (83.33)	7 (16.67)	14 (33.33)	7 (16.67)	21 (50.00)
L-16 (Village Walangam)	28 (62.22)	17 (37.78)	37 (82.22)	8 (17.78)	17 (37.78)	7 (15.56)	26 (57.78)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>		<b>(24.8)</b>		<b>(167.3)</b>		<b>(4.87)</b>	

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**Table-1.2 Contd.....**

Locations (L)	Threshability		Market related traits		Miling		Milled grain colour	
	Easy	Medium	Grain shape & size	Grain colour	Easiness in miling	Head rice recovery	White	Brown
L-1 (Village Pastuna, Tral)	12 (33.33)	24 (66.67)	22 (61.11)	14 (38.89)	23 (63.89)	13 (36.11)	27 (75.00)	9 (25.00)
L-2 (Village Aripal, Tral)	13 (29.55)	31 (70.45)	19 (43.18)	25 (56.82)	26 (59.09)	18 (40.91)	37 (84.09)	7 (15.91)
L-3 (Village Lorgam, Tral)	13 (31.71)	28 (68.29)	20 (48.78)	21 (51.22)	26 (63.41)	15 (36.59)	37 (90.24)	4 (9.76)
L-4 (Village Narastan, Tral)	13 (34.21)	25 (65.79)	18 (47.37)	24 (63.16)	20 (52.63)	18 (47.37)	31 (81.58)	7 (18.42)
L-5 (Village Satoora, Tral)	13 (35.14)	25 (67.57)	18 (48.55)	24 (64.86)	20 (54.05)	18 (48.65)	31 (83.78)	7 (18.92)
L-6 (Village Gutru, Tral)	15 (34.88)	28 (65.12)	19 (44.19)	24 (55.81)	26 (60.47)	17 (39.53)	36 (83.72)	7 (16.28)
L-7 (Village Zuastan, Tral)	11 (27.50)	29 (75.50)	16 (40.00)	24 (60.00)	28 (70.00)	12 (30.00)	37 (92.50)	3 (7.50)
L-8 (Village Lam, Tral)	13 (34.21)	25 (65.79)	15 (39.47)	23 (60.53)	23 (60.53)	15 (39.47)	31 (81.58)	7 (18.42)

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Table-1.2 Contd.....

Locations (L)	Threshability		Market related traits		Miling		Milled grain colour	
	Easy	Medium	Grain shape & size	Grain colour	Easiness in miling	Head rice recovery	White	Brown
L-9 (Village Larnu)	12 (28.57)	30 (71.43)	18 (42.86)	24 (57.14)	24 (57.14)	18 (42.86)	37 (88.10)	5 (11.90)
L-10 (Village Khretti)	11 (26.83)	30 (73.17)	18 (43.90)	23 (56.10)	22 (53.66)	19 (46.34)	36 (87.80)	5 (12.20)
L-11 (Village Desu)	10 (26.32)	28 (73.68)	18 (47.37)	20 (52.63)	20 (52.63)	18 (47.37)	33 (86.84)	5 (13.16)
L-12 (Village Bidihard)	10 (27.78)	26 (72.22)	16 (44.44)	20 (55.56)	22 (61.11)	14 (38.89)	33 (91.67)	3 (8.33)
L-13 (Village Gohan)	12 (27.91)	31 (72.09)	20 (46.51)	23 (53.49)	24 (55.81)	19 (44.19)	38 (88.37)	5 (11.63)
L-14 (Village Vailu)	12 (30.00)	28 (70.00)	17 (42.50)	23 (57.50)	22 (55.00)	18 (45.00)	33 (82.50)	7 (17.50)
L-15 (Village Gadol)	12 (28.57)	30 (71.43)	18 (42.86)	22 (52.38)	25 (59.52)	15 (35.71)	32 (76.19)	10 (23.81)
L-16 (Village Walangam)	16 (35.56)	29 (64.44)	19 (42.22)	26 (57.78)	27 (60.00)	18 (40.00)	37 (82.22)	5 (11.11)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>		<b>49.33</b>	<b>5.88</b>		<b>12.3</b>		<b>157.9</b>	

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**Table-1.2 Contd.....**

Locations (L)	Post-harvest traits								
	Cooking Nature			Volume expansion after cooking		Texture of cooked rice		Aroma preference	
	Cook dry	Cook Medium	Cook Sticky	High	Medium	Medium	Soft	Yes	No
L-1 (Village Pastuna, Tral)	5 (13.89)	27 (75.00)	3 (8.33)	28 (77.78)	8 (22.222)	7 (19.44)	29 (80.56)	28 (77.78)	8 (22.22)
L-2 (Village Aripal, Tral)	9 (20.45)	28 (63.64)	7 (15.91)	32 (72.73)	12 (27.27)	10 (22.73)	34 (77.27)	36 (81.82)	8 (18.18)
L-3 (Village Lorgam, Tral)	7 (13.16)	27 (65.85)	7 (17.07)	29 (70.73)	12 (29.73)	9 (21.95)	32 (78.05)	33 (80.49)	8 (19.51)
L-4 (Village Narastan, Tral)	5 (13.16)	27 (71.05)	6 (15.79)	29 (76.32)	9 (23.68)	4 (10.53)	34 (89.47)	31 (81.58)	7 (18.42)
L-5 (Village Satoora, Tral)	5 (13.51)	27 (72.97)	6 (16.22)	29 (78.88)	9 (24.32)	4 (10.81)	34 (91.89)	31 (83.78)	7 (18.92)
L-6 (Village Gutru, Tral)	9 (20.93)	25 (72.97)	9 (20.93)	34 (79.07)	9 (20.93)	7 (16.28)	36 (83.72)	38 (88.37)	5 (11.63)
L-7 (Village Zuastan, Tral)	5 (12.50)	30 (75.00)	5 (12.50)	28 (70.00)	12 (30.00)	12 (30.00)	28 (70.00)	33 (82.50)	7 (17.50)
L-8 (Village Lam, Tral)	6 (15.79)	25 (65.79)	7 (18.42)	31 (81.58)	7 (18.42)	4 (10.53)	34 (89.47)	32 (84.21)	6 (15.79)

**Contd.....**

**Table-1.2 Contd.....**

Locations (L)	Post-harvest traits								
	Cooking Nature			Volume expansion after cooking		Texture of cooked rice		Aroma preference	
	Cook dry	Cook Medium	Cook Sticky	High	Medium	Medium	Soft	Yes	No
L-9 (Village Larnu)	7 (16.67)	28 (66.67)	7 (16.66)	30 (71.43)	12 (28.57)	8 (19.05)	34 (80.95)	35 (83.32)	7 (16.67)
L-10 (Village Khretti)	6 (14.63)	28 (68.29)	7 (17.07)	33 (80.49)	8 (19.51)	7 (17.07)	34 (82.93)	32 (78.05)	9 (21.95)
L-11 (Village Desu)	6 (15.79)	28 (73.68)	4 (10.53)	28 (73.68)	10 (36.32)	4 (10.53)	34 (89.47)	32 (84.21)	6 (15.79)
L-12 (Village Bidihard)	4 (11.11)	26 (72.22)	6 (16.67)	28 (77.78)	8 (22.22)	6 (16.67)	30 (83.33)	33 (91.67)	3 (8.33)
L-13 (Village Gohan)	9 (20.93)	25 (58.14)	9 (20.93)	35 (81.40)	8 (18.6)	10 (23.26)	33 (76.74)	37 (86.04)	6 (13.95)
L-14 (Village Vailu)	7 (17.50)	23 (57.50)	10 (25.00)	29 (72.50)	11 (27.50)	7 (17.50)	33 (82.50)	34 (85.00)	6 (15.00)
L-15 (Village Gadol)	6 (14.29)	27 (64.29)	9 (21.43)	32 (76.19)	10 (23.81)	8 (19.05)	34 (80.95)	37 (88.10)	6 (14.29)
L-16 (Village Walangam)	7 (15.56)	28 (62.22)	7 (15.56)	32 (71.11)	13 (28.89)	9 (20.00)	36 (80.00)	39 (86.67)	6 (13.33)
<b>X<sup>2</sup>-value = (p&lt;0.05)</b>		<b>(39.3)</b>		<b>(85.8)</b>		<b>(135.7)</b>		<b>(149.7)</b>	

preference for high expansion ranged from 70-81.5 per cent whileas, no farmer from any location had a desire for low volume expansion. The mean preference for high volume and medium volume expansion of cooked rice was 76.2 and 23.8 per cent, respectively.

#### **4.1.3.15 Texture of cooked rice (soft verses medium)**

Preference for soft texture of cooked rice was highly significant and ranged from 70-89.47 per cent with a mean preference overall location of 82.05 per cent. Hard texture was highly undesirable and not liked by any farmer at any location; however observed preference (non significant) for medium texture of cooked rice was 18 per cent.

#### **4.1.3.16 Aroma preference (Yes verses No)**

Preference for aroma was highly significant in comparison to no desire for aroma. The mean preference overall locations was 84 per cent and ranged from 7.7 to 91.67 per cent.

### **4.2 Calculation of preferential scoring of different genotypes**

Evaluation of Mother Trials through farmer's preferential ranking was carried out at five locations including all trials laid out in the farmer's fields and one grandmother trial at Larnoo. Just one week before harvest, Focal Group Discussions (FGD) were used to evaluate the varieties. Plot measurements were taken by the researcher but managed by the farmer. There was very good response from the farmers who not only cooperated while laying out the trials in their area but actively participated in preferential ranking of the varieties through voting. The highest response to voting (100%) was recorded at Mountain Crop Research Station, Larnoo (Table-2) where all farmers participated in the voting followed by at village Khratti (89.28%) whileas, at other three locations it was around 80 per cent. At Research Station most preferred variety was SKUA-402(1) and GSL-11(1). The variety that received maximum number of negative votes was K-08-63(10). At village Pastuna (Tral) (Table-2) highest preferential scoring i.e. lowest

**Table-2 : Farmers preference ranking (scoring) of different test varieties of rice in mother trails at five locations**

Genotypes	Pastuna, Tral (n=26, f=20)		Satoora, Tral (n=26, f=16)		Larnoo (n=19, f=15)		Khreti village (n=28, f=25)		Research station (n=13, f=13)	
	Positive votes	Preferential scoring	Positive votes	Preferential scoring	Positive votes	Preferential scoring	Positive votes	Preferential scoring	Positive votes	Preferential scoring
K-08-73	12	0.2	11	0.38	11	0.47	17	0.36	8	0.23
K-08-63	8	-0.2	12	0.50	11	0.47	16	0.28	7	0.08
K-08-69	13	0.3	13	0.63	8	0.07	12	0.16	9	0.38
SKUA-524	15	0.5	14	0.75	13	0.73	20	0.60	10	0.54
SKUA-506	9	-0.1	10	0.25	10	0.00	18	0.44	9	0.38
SKUA-402	17	0.7	13	0.63	14	0.87	22	0.76	12	0.85
GSL-61	14	0.4	11	0.38	12	0.60	15	0.20	7	0.15
GSL-11	18	0.8	15	0.88	13	0.73	21	0.68	12	0.85
K-332	11	0.1	9	0.13	12	0.60	14	0.12	8	0.23
F. check	10	0	8	0.00	7	-0.07	13	0.04	9	0.23

n = Number of farmers assembled

f = Effective number of farmers who participated in preferential scoring

rank value was recorded on GSL-11(1) followed by SKUA-402 (2) and SKUA-524 (3). The lowest preference was recorded for K-08-63 (10). Similarly at village Satoora Tral maximum scoring was recorded for GSL-11 (1) and the minimum for farmer's check (10). The genotypes SKUA-524 (2) was followed by K-08-69 (3) and SKUA-402 (3) as per the desirability assessed by the farmers. At Larnoo village genotype SKUA-402 (1) received maximum number of votes and was followed by SKUA-524 (2), GSL-11 (2) and GSL-61 (4). The maximum number of farmer's votes were recorded for SKUA-402 (1) followed by GSL-11 (2), SKUA-524 (3) and so on at village Khratti, while as maximum number of negative votes were recorded for farmer's check (10). There was significant interaction between varieties and locations as observed from the data of preferential ranking. Most of the variations in ranking between sites are for the lower ranked entries .

Table-3 gives the picture of rank summation preferential data for different test entries as collected from five mother trials and evaluated by 89 farmers including the ones who grow the trials on their farm. Lowest cumulative rank that is the most preferred variety was recorded on GSL-11 with mean preference rank of 1.4 and SKUA-402 identified as second best (1.6) and followed by MST-4 (2.6). Clearly shows that GSL-11, SKUA-402 and SKUA-524 were statistically at par in term of rank summation index and mean preference ranking and significantly different with the test entries K-08-73, K-08-69, SKUA-506, GSL-61 and K-332 which among themselves could be categorized as one group. K-08-63 was least preferred and was at par with the farmer's variety.

The interviews from most of the farmers revealed that the reasons for the preference for a genotype were related to many traits including high biomass (biological yield), grain yield, early maturity, good plant height (100-110 cm) and also were free from diseases.

**Table-3: Cumulative/average ranks of genotype over five locations**

Genotypes	Individual ranks					Cumulative rank	Average of ranks	Pooled preference
	Research Station, Larnoo	Satoora	Larnoo	Khreti	Pastuna			
K-08-73	6	6	6	5	7	30	6.0	1.64
K-08-63	10	5	6	6	10	37	7.4	1.13
K-08-69	5	3	8	8	4	28	5.6	1.50
SKUA-524	3	2	2	3	3	13	2.6	3.12
SKUA-506	9	8	9	4	4	34	6.8	1.03
SKUA-402	2	3	1	1	1	8	1.6	3.81
GSL-61	4	6	4	7	9	30	6.0	1.73
GSL-11	1	1	2	2	1	7	1.4	3.94
K-332	7	9	4	8	7	35	7.0	1.18
F. check	8	10	10	10	4	42	8.4	0.35
		<b>SE</b>				<b>3.95</b>	<b>0.79</b>	<b>0.39</b>
		<b>CD</b>				<b>7.74</b>	<b>1.54</b>	<b>0.76</b>

### 4.3 Estimation of stability

Analysis of variance showed significant difference in the genotypes over the locations for all the traits showing that there was significant variation among all the genotypes as uniformity test of error variance was non-significant, therefore its uniformity was conformed and hence combined analysis of data was conformed (Table-4).

In the present investigation, 10 genotypes including two checks were subjected to pooled analysis of variance. Analysis of variance revealed the existence of significant differences among the genotypes for all the traits studied (Table-5) indicating the presence of genetic variability in the experimental material under investigation. Mean squares due to environment + (genotype  $\times$  environment) were significant for most of the traits except panicle length and 100 seed weight depicted the distinct nature of environment and genotype  $\times$  environment interaction on phenotypic expression. Similarly genotype  $\times$  environment component was found significant except on panicle length and 100 seed weight. Genotype  $\times$  environment (linear) interaction component showed non-significance only for 100 seed weight while as for all other traits it showed high significance indicating location (environment) had a marked influence on the expression of the genotypes and behavior of the genotypes could be predicted over environment more precisely. Mean square due to environment (linear) component was found to be non-significant for 100-seed weight, however for all the other characters the component was observed implied that means of genotypes varied considerably at different locations.

Significant pooled deviation component for all the traits except 100-grain weight suggested that the performance of different genotypes fluctuated significantly from their respective linear path of response to environments. Predominance of linear component of (genotype  $\times$  environment) to non-linear component (pooled deviation) suggested that genotype  $\times$  environment interaction

**Table-4 : Analysis of variance for different morphological, maturity, yield and yield component traits in selected rice genotypes across 6 environments**

Source of variation	d.f.	Days to 50% flowering	Days to Maturity	Plant height	No. of panicles plant <sup>-1</sup>	Panicle length	Seeds panicle <sup>-1</sup>	Biological yield plot <sup>-1</sup>	Grain yield plot <sup>-1</sup>	100-seed weight
Replication	1	0.408	6.075	9.918	0.102	0.31	50.44	153.21	0.001	0.003
Genotypes	59	59.32**	27.34**	110.17**	5.36**	7.01**	492.60**	249.35**	0.82**	0.52**
Error	59	8.696	6.38	1.776	1.531	19.594	19.594	50.06	0.003	0.0003
Bartlett's test for homogeneity of variances		0.4633	1.5035	11.769	4.992	7.235	0.008	7.396	21.28	9.471
C.V.		6.281	4.651	2.238	4.992	5.705	7.917	6.625	10.402	8.516

was predominantly the outcome of linear function of genotype  $\times$  environment and performance can be predicted with great precision across the environments.

#### **4.4 Estimation of stability parameters and identification of stable genotypes (as per Eberhart and Russel's Model)**

In the present study the mean performance coupled with regression coefficient ( $b_i$ ) and variance of deviation from regression ( $S^2d_i$ ) of each genotype represent its stability (Table-5). With these conditions, the experimental material tested over six locations were classified for their adaptability and stability in respect of all the traits except 100 grain weight due to non-significant nature for all components. The component  $b_i$  measures predictability and the component  $S^2d_i$  measures the stability. As per the Eberhart and Russel's model of stability, the component  $b_i$  measures predictability and  $S^2d_i$  stability. Stability of a genotype can be predicted more precisely if  $b_i$  and  $S^2d_i$  value are non-significant, from unit and zero respectively.

##### **4.4.1 Days to 50% flowering**

Results regarding this trait number of days to 50% flowering ranged from 87.83(SKUA-524) to 104.5(Farmer's check) (Table-6). Genotypes GSL-11, SKUA-402, SKUA-524, K-08-69, K-08-73, K-08-63 were found earlier to flower compared to general mean and both the check genotypes were significantly late compared to general mean. All the genotypes recorded linear regression value ( $b_i$ ) around unity and deviation from regression ( $S^2d_i$ ) statistically equal to zero, however latter deviated significantly from zero for genotypes K-08-73, K-08-69, GSL-61 and both the check genotypes. The genotypes with wide stability with respect to early flowering as per the stability parameters are GSL-11 and SKUA-402. The performance of genotype, K-08-73, K-08-69, GSL-61 and the two checks for the trait can not be predicted precisely over range of environments.

**Table-5 : Analysis of variance for stability of different traits in selected rice genotypes across 6 environments**

Source of variation	d.f.	Mean squares								
		Days to 50% flowering	Days to Maturity	Plant height	No. of panicles <sup>-1</sup> plant	Panicle length	Seeds panicle <sup>-1</sup>	biological yield plot <sup>-1</sup>	grain yield plot <sup>-1</sup>	100-seed weight
Genotypes	9	223.97**	121.418**	257.953**	12.657**	19.088**	1390.038**	0.555**	0.037**	18.70**
Environment + (Genotypes × Environment)	50	4.786**	3.851**	26.334**	1.840*	0.704	40.429**	0.028*	0.017*	0.029
Environment	5	1.813**	4.563**	28.408*	1.317**	1.089	62.635**	0.050*	0.011**	0.008
Genotypes × Environment	45	4.897**	3.772**	17.478*	1.725*	0.661	37.961**	0.250**	0.019*	0.310
Environment (linear)	1	11.325**	22.801**	142.026**	1.583**	1.444*	313.194**	0.262**	0.021**	0.420
Genotype × Environment (linear)	9	10.36**	10.882**	42.867*	1.823**	0.204	60.841*	0.019**	0.045*	0.050
Pooled deviation (non linear)	40	3.227**	1.802**	10.017**	0.582**	0.698**	17.328*	0.016**	0.011*	0.024
Pooled error	60	0.908	0.583	0.956	0.75	0.264	0.055	0.108	0.018	0.064

\*Significant at p = 0.05; \*\*Significant at p = 0.01

**Table-6 : Stability parameters for days to 50 per cent flowering and days to maturity in selected rice genotypes evaluated across 6 random environments**

Genotypes	Days to 50% flowering			Days to Maturity		
	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$
K-08-73	90.83	0.89	9.58**	140.75	0.32	4.13**
K-08-63	92.83	2.11	0.52	142.33	2.35	4.96**
K-08-69	90.66	-4.53	1.99*	139.58	-1.11	4.36**
SKUA-524	87.83	-1.16	-0.23	136.75	0.76	1.77*
SKUA-506	95.33	0.21	1.04	143.41	2.02	5.6**
SKUA-402	87.5	2.58	1.18	137.66	0.83	3.61**
GSL-61	94.58	4.21	3.54**	143	0.69	2.92**
GSL-11	86.83	-2.95	1.27	136.58	1.96*	1.34*
K-332 (Popular variety)	102.58	6.11	1.59*	144.66	1.52	7.75**
Farmers check	104.5	2.53	2.71**	146.25	0.87	1.787**
<b>Population mean</b>		<b>93.35</b>			<b>141.1</b>	
<b>SE(m)</b>		<b>0.86</b>			<b>0.9</b>	
<b>SE(<math>b_i</math>)</b>		<b>2.6</b>			<b>0.9</b>	

#### 4.4.2 Days to maturity

The genotype SKUA-524 and SKUA-402 were earlier to mature compared to population mean and both the checks (Table-6). The days to maturity ranged from 136.58 (GSL-11) to 146.25 (Farmer's check). Regression coefficient value around unity was observed for all the genotypes except GSL-11 ( $b_i = 1.96$ ), however deviation from regression was observed significant for all the genotypes. GSL-11 with regression coefficient deviating from unity indicates its sensitivity to environmental and stability parameters  $S^2d_i$  elucidate the inconsistency or unpredictability of genotypes across all test locations/environments.

#### 4.4.3 Plant height

The genotype SKUA-524 (87.8 cm) and K-08-63 (68.0 cm) were identified as taller and dwarf genotypes respectively (Table-7). All the genotypes deviated significantly from farmers check except K-08-63 and SKUA-506. Linear regression coefficients were observed unity and linearity from zero for all the genotypes, however the latter was found non-significant for K-08-73, K-08-69, SKUA-524, GSL-11 and farmers check. The genotype GSL-11 with higher mean compared to grand mean and over both the checks,  $b_i$  value around unity and  $S^2d_i$  statistically equal to zero can be considered as the most stable genotype for the trait across the test six locations.

#### 4.4.4 Number of panicles plant<sup>-1</sup>

Panicle number plant<sup>-1</sup> ranged from 13.91 (SKUA-506) to 18 (K-332). All linear regression coefficients ( $b_i$ ) and deviation from regression ( $S^2d_i$ ) were found non-significant from unit and zero respectively (Table-7). The variety GSL-11 with high mean compared to population mean and farmer's check and both the response ( $b_i$ ) and stability ( $S^2d_i$ ) parameters. GSL-11 can be suggested as the stable genotype across all test locations, as per the Eberhart and Russell (1996).

**Table-7 :** Stability parameters for plant height and number of panicles plant<sup>-1</sup> in selected rice genotypes evaluated across 6 random environments

Genotypes	Plant height (cm)			Number of panicle plant <sup>-1</sup>		
	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$
K-08-73	77.91	0.07	1.46	15.91	0.21	0.93
K-08-63	68.00	-0.35	4.01*	17.91	-2.63	-0.22
K-08-69	75.12	0.20	-0.14	15.25	1.89	0.33
SKUA-524	87.83	1.33	3.74*	14.83	2.00	-0.45
SKUA-506	70.83	2.17	17.43**	13.91	-0.74	0.28
SKUA-402	82.83	4.94	40.12**	16.58	3.26	0.13
GSL-61	82.10	-0.23	7.73**	17.41	2.26	-0.03
GSL-11	85.71	0.74	0.30	17.91	2.58	0.54
K-332 (popular variety)	82.03	2.14	7.34**	18.08	-1.32	-0.52
Farmers check	73.71	-1.00	0.59	15.83	2.47	0.22
<b>Population mean</b>		<b>78.6</b>			<b>16.36</b>	
<b>SE (m)</b>		<b>1.41</b>			<b>0.41</b>	
<b>SE (bi)</b>		<b>0.83</b>			<b>2.34</b>	

#### 4.4.5 Panicles length

All the genotypes were found promising for the longer panicle compared to farmer's check (Table-8). Whereas, the genotypes K-08-73, K-08-63, K-08-69, SKUA-524, SKUA-506 and SKUA-402 were having longer panicle than popular variety. The panicle length ranged from 10.9 cm (Farmer's check) to 15.7 cm (K-08-63). The response variable ( $b_i$ ) was found hovering around unity for most of the genotypes and deviation from regression non-significant with zero for all test genotypes except K-08-69, SKUA-506 and GSL-11. The genotypes K-08-63 with high mean panicle length (15.74 cm),  $c$  and  $S^2d_i$  statistically equal to unity and zero respectively, can be considered as the consistent genotype for the trait.

#### 4.4.6 Seeds panicle<sup>-1</sup>

The most important yield contributing trait ranged from 73.7 (Farmer's check) to 119.6 (SKUA-524) (Table-8). The mean performance of genotypes SKUA-524, SKUA-402, and GSL-11 were found promising compared to best check and remaining genotypes revealed more seeds panicle<sup>-1</sup> compared to farmers check. Only the non-linear component of genotype  $\times$  environment ( $b_i$ ,  $S^2d_i$ ) was significant for GSL-11, K-332 and K-08-63 depicting their inconsistency over environments for the trait. As per the criteria of Eberhart and Russell SKUA-524 with mean seeds panicle<sup>-1</sup> 119.6 and ( $b_i$ ) value around unity and deviation from linearity non-significant with zero can be considered as the widely adapted genotypes over all the test locations.

#### 4.4.7 Biological yield plot<sup>-1</sup>

Biological yield is a preferred trait by the farmers of high altitude of Kashmir and biological yield plot<sup>-1</sup> ranged from 1.36 kg (GSL-61) to 2.28 Kg (K-08-69) (Table-9). All the genotypes except GSL-61 and SKUA-506 showed promising performance over the Farmer's check. Five test genotypes viz. K-08-63, K-08-69, SKUA-524, SKUA-402 and GSL-11 were identified with good biomass compared to the popular variety (K-332). The stability parameters  $b_i$  and

**Table-8 :** Stability parameters for panicle length and seeds panicle<sup>-1</sup> in selected rice genotypes evaluated across 6 random environments

Genotypes	Panicle length (cm)			Seeds panicle <sup>-1</sup>		
	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$
K-08-73	13.3	1.93	0.32	89.75	-0.18	-6.58
K-08-63	15.74	1.27	-0.12	104.91	3.03	29.37**
K-08-69	13.83	0.97	1.44*	96.53	0.55	-4.43
SKUA-524	15.40	1.28	-0.13	119.66	0.53	-4.81
SKUA-506	14.95	-0.21	1.06*	94.05	0.09	-5.73
SKUA-402	11.91	1.16	-0.02	116.83	-0.25	-1.82
GSL-61	11.68	0.92	-0.08	79.58	1.58	8.27
GSL-11	11.86	0.49	1.11	11.26	3.45	122.57**
K-332 (popular variety)	11.5	1.62	0.38	103.78	-0.53	49.41
Farmers check	10.9	0.56	0.36	73.73	1.72	3.39
<b>Population mean</b>		<b>13.11</b>			<b>99.00</b>	
<b>SE(m)</b>		<b>0.37</b>			<b>2.40</b>	
<b>SE(b<sub>i</sub>)</b>		<b>1.13</b>			<b>1.00</b>	

$S^2d_i$  showed non-significance from unity and zero respectively for most of the genotypes. However,  $b_i$  responded significantly from the unity for GSL-11 and K-332 and  $d_i$  deviated significantly from zero for only SKUA-506. This depicts that GSL-11 K-332 which responded positively are grouped as average in stability and could be recommended for good environments. SKUA-402 compared to both the check varieties estimates of linear regression around unity and deviation from regression equal to zero is considered as genotype with consistency over all the test environment for high biomass.

#### **4.4.8 Grain yield plot<sup>-1</sup>**

The genotype SKUA-402 (0.688 kg) recorded highest grain yield plot<sup>-1</sup> and the same was recorded lowest for K-08-73 (0.443 kg) and K-08-63 (0.487) (Table-9). SKUA-402 (0.688 kg) and GSL-11 (0.662 kg) proved promising in comparison to popular variety (K-332). Estimates of  $b_i$  were significantly high and positive for K-08-69 and SKUA-506 sensitivity to environment index (linear) and also depict adaptability to suitable growth areas. Whileas popular check K-332 with  $b_i$  value -15.05 can be recommended for poor environments. The genotypes SKUA-402 and GSL-61 had regression coefficient almost close to unity and similarly showed deviation from linearity closer to zero due to non-significant estimates of  $b_i$  and  $S^2d_i$ . The mean yield for all these genotypes also seemed top ranking; hence are regarded as most stable for the trait over all test locations/environments.

**Table-9 :** Stability parameters for biological yield plot<sup>-1</sup> and grain yield plot<sup>-1</sup> in selected rice genotypes evaluated across 6 random environments

Genotypes	Biological yield			Grain yield		
	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$	Mean ( $\bar{X}$ )	$b_i$	$S^2d_i$
K-08-73	1.81	0.33	-0.01	0.443	1.92	-0.02
K-08-63	2.00	0.45	-0.01	0.487	-5.35	0.00
K-08-69	2.28	0.49	-0.01	0.577	10.35*	-0.01
SKUA-524	2.18	0.13	-0.01	0.565	-10.77	0.01
SKUA-506	1.58	1.14	0.04**	0.497	14.29*	-0.01
SKUA-402	2.03	-0.67	-0.01	0.688	3.20	-0.01
GSL-61	1.36	-0.14	0.00	0.620	6.39	0.00
GSL-11	2.31	4.40*	0.02	0.662	-0.48	0.00
K-332 (popular variety)	1.86	3.18*	0.01	0.611	-15.05*	0.00
Farmers check	1.84	0.69	-0.01	0.537	5.50	-0.01
<b>Population mean</b>		<b>1.92</b>			<b>0.56</b>	
<b>SE(m)</b>		<b>0.05</b>			<b>0.04</b>	
<b>SE(<math>b_i</math>)</b>		<b>0.75</b>			<b>4.58</b>	

## Chapter – 5

### DISCUSSION

In the present investigation 10 *japonica* genotypes including popular variety and farmer's variety (two checks) were evaluated through mother trial evaluation system to identify the most appropriate genotypes on the basis of preferences of the farmers and to find the varietal specification to bred in future in consultation with farmers. There were six Mother trials laid out in the farmers field including two Grandmother trials laid at Mountain Crop Research Station (MCRS), Larnoo and KVK-Pombay. The experiment was laid in Randomized Complete Block Design (RCBD) with two replications. Further stability of the genotypes was established by following Eberhart and Russell model. Before laying out the trials Participatory Rural Appraisal (PRA) was conducted. The experimental results on these aspects in the light of available literature are discussed below under following headings :

#### **5.1 Understanding farmer's perception and preferences about high altitude rice varieties through Participatory Rural Appraisal (PRA)**

Participatory Rural Appraisal (PRA) describes a growing approaches and methods to enable farmers to share, enhance and analyze their knowledge of farming practices and conditions, to plan and to act. PRA has sources in activist participatory research, agroecosystem analysis field research on farming systems, and rapid rural appraisal (RRA). Besides, Participatory Rural Appraisal (PRA) technique is used to establish benchmark information on biophysical, socioeconomic, institutional and farming constraints, as well as farmers' needs, and researchable problems, Joshi *et al.* (2001). In addition plant Participatory Rural Appraisal (PRA) has been employed as an effective tool to get feedback and information regarding the likes and dislikes of end users (farmers) about various traits of rice so as to chalk out the strategy for breeding and evaluating the genotypes at farmers field through Participatory Varietal Selection (PVS) in order to increase the adoption rate of released varieties. Similarly the PRA was

conducted to get feedback from end users (farmers) regarding the preferences and perceptions about rice crop by Frio *et al.* (1994), Barik *et al.* (1996), Joshi and Witcombe (1998), Loader, and Amartya, (1999), Bam *et al.* (2007), Nepali *et al.* (1999), Joshi *et al.* (2001) and Gichangi *et al.* (2012).

In the process of PVS information is obtained on the biotic and abiotic stresses most commonly encountered in the target areas and currently adapted varieties and their important. However without some prior knowledge of the target area, involves the risk of wasting resources and losing credibility with farmers by testing highly unsuitable varieties (Joshi *et al.*, 2002). A successful PRA provides the information needed to specify the characteristic needed in a new variety regarding its physical environment and the existing varietal diversity. Sumberg and Reece (2004) argue that *de facto* Participatory Plant Breeding (PPB) program do not lead to a new product development orientation. For a breeding program, well applied PRA techniques or customer profiling results in better client orientation and makes possible efficient goal setting or product design (Sumberg and Reece, 2004). Successful PRA provides everything that could be included in the full design specification of a new crop variety. Witcombe *et al.* (2005) while high lightening the importance of Participatory Rural Appraisal (PRA) in plant breeding, and focuses on the issue relating to the particular target crop.

In the present investigation the PRA was conducted to get the background information, identify major production constraints and to determine the farmers perception about varietal specification of rice crop under high altitude low production potential system of Kashmir valley. The background information revealed that under high altitude irrigated ecosystem of Kashmir valley, only rice crop is being grown and mono-cropping is being widely practiced method due to limited number of favorable days available for other crop. Also canal system of irrigation fed by melting snow is the main source of irrigation water. Among major production constraints low yielding varieties was identified a significant factor in limiting rice crop production followed by disease particularly blast

locally called *rye*. Cold stress was also identified a big issue to rice crop and posing a big threat particularly at critical stages of crop growth. Further farmers saved seed of traditionally grown rice is the main source of seed to raise the new crop.

Regarding specification of new varieties for low production potential system of Kashmir valley, farmers showed their willingness for the varieties possessing high tillering, tall stature, long panicle, more grain panicle<sup>-1</sup>, medium bold grained bold varieties, high biomass, early maturity and medium threshability. Regarding post harvest traits easy milling, high head rice recovery, high volume expansion of cooked rice, soft texture of cooked rice and preferably with aroma.

The PRA conducted in a systematic manner identify the trait needed in new variety such as duration, pericarp color in rice (Sthapit *et al.*, 1996) and easy threshing in rice (Joshi *et al.*, 2002). Joshi and Witcombe (1996) carried out PRA and got the valid information that there was no adoption of improved cultivars in any crop and improved cultivars available on the market did not meet the farmer's needs such as, long maturing with low straw. The PRA proved to be quick and effective method of identifying and characterizing what the farmers grow and subsequently showed the importance of PRA as first step in choosing which cultivars should be tested with farmers.

House hold level questionnaire were conducted to determine the perception of new varieties for new varieties for chaite and main season in Nepal (Joshi and Witcombe, 2002). Farmers identified varieties and preferred to like those having early maturity, market price, good milling and eating qualities and shape of the grain.

Virk *et al.* (2003) conducted PRA to elicit farmer's needs in new varieties through Focal Group Discussion (FGD) and interviews. PRA showed that Knowledge of the constraints of the target area and the traits the farmer require in

a variety are important for goal setting in a plant breeding program. The information received through PRA showed that coarse grained landraces were grown by the farmers and wanted varieties with early vigor to smoother weeds in the initial stage, early maturing, tall stature, stiff straw and resistance to lodging, tolerance to major pests and diseases, higher grain yield and good cooking quality.

## **5.2 Determine preferential scoring of test genotypes on farmers field through farmer selection criteria**

Client-oriented breeding explicitly takes into account the needs of end users (farmers, processors and consumers) in designing a new variety and then tests without delay the new products from the breeding programme with the target clients in the target environments (Witcombe *et al.*, 2005). A major component of client-oriented breeding is participatory varietal selection (PVS) where farmers test varieties on their own fields with their own levels of inputs and management. PVS identifies new varieties that farmers prefer to grow for the traits they consider important and facilitates their adoption and spread resulting in positive and rapid impacts on food security and income (Joshi and Witcombe, 1996; Witcombe *et al.*, 2001).

Farmers preferences are very imperative and modern cultivars are often rejected by farmers because of traits that have not been considered in the breeding process (LARC, 1995). The poor adoption of improved varieties may be due to limited accessibility of the new varieties seeds or poor adaptation of improved varieties to local condition (Joshi and Witcombe, 1995).

Hence in present investigation ten genotypes including two checks were evaluated in Mother trials through farmer's preferential ranking at five locations laid out in the farmer's fields including all one Grandmother trial at Mountain Crop Research Station, Larnoo. Just one week before harvest, Focal Group Discussions (FGD) were used to evaluate the varieties. At village Pastuna (Tral) highest preferential scoring i.e. lowest rank value was recorded on GSL-11 (1) followed by SKUA-402 (2) and SKUA-524 (3). The lowest preference was

recorded for K-08-63(10). Similarly at village Satoora Tral (Table-3) maximum scoring was recorded for GSL-11 (1) and the minimum for Farmers check (10). At Larnoo Village SKUA-402(1) received maximum number of votes and was followed by SKUA-524 (2), GSL-11(2) and GSL-61 (4). The maximum farmer's votes were recorded for SKUA-402(1) followed by GSL-11(2), SKUA-524 (3) and so on at village Khretti, whileas maximum number of negative votes were recorded for farmer's check(10). At Research Station most preferred variety was SKUA-402 (1) and GSL-11 (1). The variety that received maximum number of negative votes was K-08-63 (10). There was significant interaction between varieties and locations as observed from the data of preferential ranking. Most of the variations in ranking between sites was for the lower ranked entries. The reasons came to be known for the preference were related to many traits including high biomass (biological yield) and grain yield, early maturity, good plant height (100-110 cm) and free from diseases.

Participatory Varietal Selection (PVS) approach has been employed to evaluate, identify and disseminate different genotypes on farmers field as per farmers tastes regarding various traits and their perception and aspirations about varietal specification by Bandari *et al.* (1998), Witcombe *et al.* (1999), Bhandari *et al.* (2000), Sthapit *et al.* (2000), Witcombe *et al.* (2001), Witcombe and Virk (2001), Courtois *et al.* (2001), Joshi and Witcombe (2002), Hawlader *et al.* (2004), Joshi *et al.* (2005), Witcombe *et al.* (2005), Gyawali *et al.* (2010), Singh *et al.* (2006), Witcombe *et al.* (2006), Dorward *et al.* (2007), Paris *et al.* (2008), Singh *et al.* (2008), Moreno *et al.* (2009), Singh *et al.* (2010), Manzanilla *et al.* (2011), Subedi *et al.* (2011), Ojehomon *et al.* (2012), Yadavendra and Witcombe (2013).

Sthapit *et al.* (1996) reported large differences in farmer's preferences among different varietal checks and most preferred were adopted rapidly. The Participatory Plant Breeding (PPB) product Judi 567 and Barke 2001 in spite of its moderate yield potential consistently ranked as the preferred variety in Nepal

because of very good grain quality. Farmer's perception on the maize landraces change was observed by Joshi and Witcombe (2002) where the farmers reported that they would increase the area under M3 or M9, the varieties developed through Participatory Plant Breeding (PPB).

Virk *et al.* (2003) used Focal Group Discussions (FGDs) to evaluate the varieties for grain and straw yield, grain type, grain color through over all ranking. Joshi *et al.* (2007) through client oriented breeding determined farmer's preferences and adoption and showed three varieties Judi 552, Judi 567 and Ashoka 200f in high barind tracts of Bangladesh and in Chaitwan districts of Nepal. Research related to preferences and adoption revealed that that these varieties were preferred even all available alternatives and thus farmer's preferences increased the efficiency of targeting new germplasm lines. New varieties through PPB were of higher utility than existing ones in the study area of Nepal (Witcombe *et al.*, 2001). Farmer's perception confirmed Radha 32 higher yielder. Further farmers did not regard yield as the only charter of importance. They preferred low yielding varieties IR 13155 for early maturity and earliness and slender grain of Kalinga-III. Farmers in Focus Group Discussion (FGD) rejected some high yielding varieties because of one or other flaw.

Further significant interaction between varieties and locations for the preferences ranking was recorded. Most of the variations in ranking between sites was for the lower ranked varieties (Witcombe *et al.*, 2005). Also the research team collected 53 varieties from 12 districts and distributed to farmers, 34 were preferred by the farmers for various grain characteristics (SEARICE, 2001).

Witcombe *et al.* (2005) reviewed the history and analyzed the participatory techniques to rice varieties derived from client oriented breeding programmes through Mother and baby trials system in Bangladesh. The rapid acceptance of these varieties by farmers illustrate the power of participatory trial system. Gyawali *et al.* (2005) screened 142 accessions through collaborative selection for quality varieties and few were finally proven to be generally superior for post

harvest traits in Pokhara valley of Nepal using local preferences and selection (Joshi *et al.*, 2007 and Tiwari *et al.*, 2009) using Mother and Baby trial design, led to release of population 22 in 2002 through preferences by farmers that had previously escaped identification.

In the present investigation, the genotypes SKUA-402 and GSL-11 were identified by the farmers through their perceptions for traits like earliness, tall stature, good biomass and without diseases. These varieties are therefore suggested for these niches after validation of results through multilocations and to confirm the real performance and after revalidation are recommended for last stage of Participatory Plant Breeding (PPB) which participatory seed production for up scaling.

### **5.3 Analyze Genotype x Location (G x L) interaction and Stability Studies by Eberhart and Russell model**

Further to the above exercise the test genotypes were evaluated to identify high yielding stable genotypes that would further be tested for their general and specific adaptation depending on their performance, and could also be used in future breeding programmes. The real estimate of a genotype gets biased if G x E interaction is present and this results when a crop is grown in a single environment. The multi environmental testing allows removing this bias. The knowledge about the extent of fluctuations of yield and yield attributes over environments is very important to identify genotypes which are widely adapted. Yield is a quantitatively inherited character and there is considerable interaction between genotypes and environments. Some of the crop varieties are widely adapted, while as others are not. Multi location testing of genotypes provides an opportunity to the plant breeders to study the adaptability of a genotype to a particular environment and also the stability of the genotype over different environments. The information on genotype × environment interaction is of major importance to the plant breeder in developing an improved stable variety. Main strategy among small-scale subsistence farmers, particularly in marginal areas, is

risk minimization. In these areas, stable yields are the key to the sustainable food supplies.

During the past several decades, one of the most important advances in biometrical genetics has been the investigation, elucidation and understanding of genotype x environment interaction. Even though the importance of genotype-environment interaction was recognized well and these were known to be heritable (Jinks and Mather, 1955). The main efforts made by the researchers were aimed to measure this G x E interaction, which helped to recognize well this interaction. It indicates that genotypes react in different ways if environmental conditions change and is of significance for breeders, official test stations and growers. Estimation of the genotype x environment interaction is an important consideration in plant breeding programs because it otherwise reduces the progress from selection in the target environment (Hill, 1975). Significant G x E interaction results from the change in the magnitude of different environments or changes in relative ranking of the genotypes. Consistent performance of a genotype across different sites and/or years is referred to as stability. For a cultivar to be a commercially successful one, it must perform well across a range of target environments where the cultivar has to be commercially grown. Since the genotype x environment interaction has a masking effect on the phenotype, some breeders have adopted to estimate the magnitude of this interaction so that, the precise estimate of stability could be obtained. In order to minimize this interaction, stratification of environments has also been used effectively. The region for which a breeder is developing improved varieties could often be so subdivided such that the entire environment in the sub-region is nearly homogenous. However, even with this refinement technique the interaction of genotypes with locations in a sub-region and with environments has been encountered at a location over different years and its magnitude has been quite a large (Allard and Bradshaw, 1964).

There is a general agreement among the breeders that average yield alone

may not be sufficient to describe the performance of a certain genotype, since it does not indicate the relative performance as compared to other genotypes over different environments. G x E interaction is a major concern in plant breeding for two main reasons; first, it reduces progress from selection, and second, it makes cultivar recommendation difficult because it is statistically impossible to interpret the main effects (Kang and Gauch, 1996). There is a general agreement among breeders that average yield alone may not be sufficient to estimate the performance of a certain genotype, since it does not indicate the relative performance as compared to other genotypes over different environments. The significant genotype x environment interaction reduces the usefulness of genotypic means for identifying superior cultivars.

The presence of genotype x environment interactions indicates the statistical non-addictiveness of genotypes and environments, which means that differences between genotypes depend on the environment. Existing genotype x environment interactions may, but must not necessarily, lead to different rank orders of genotypes in different environments. The breeder is not interested in knowledge of the numerical amount of G x E interactions *per se*, but is only interested in the existence (or non-existence) of G x E interactions in so far as they lead to different orderings of genotypes in different environments. This concept of G x E interaction is closely related to the concept of selection in plant breeding. The breeder is interested in rank orders of genotypes in different environments and in changes of these rank orders and whether the best genotype in one environment is also the best in other environments, which means that relative characterizations and comparisons of the genotypes are often more important than absolute characterizations and comparisons (Huhn, 1996).

The most desirable property of genotypes for acceptability for commercial cultivation is their stable performance across locations (environments), which also remains the aim of breeders to develop or identify such genotypes that are stable across a range of environments. Environments may be locations or years or

combinations of both. Eberhart and Russel (1966) preferred to measure the environment as deviation of mean of all the varieties at locations from the overall mean and recommended growing of a variety in number of environments representing a full spectrum of possible environmental condition. Partitioning of mean squares due to [environment + (genotype x environment)] interaction into three components namely; environments (linear), genotype x environment (linear) and deviation from regression (pooled deviation over all the genotypes). An ideal genotype is defined as the one possessing high mean performance, with regression coefficient around unity ( $b_i = 1$ ) and deviation from regression ( $S^2d_i$ ) close to zero. The linear regression is regarded as the measure of linear response of a particular genotype to the changing environment. If the regression coefficient ( $b_i$ ) is greater than unity, the genotype is said to be highly sensitive to environmental fluctuations but adapted to high yielding environments. If the regression coefficient ( $b_i$ ) is equal to unity, it indicates the average sensitivity to environmental fluctuations and adaptable to all environments. If the regression coefficient ( $b_i$ ) is less than unity, it indicates less sensitivity to environmental changes and if this is accomplished by a high mean value, then the genotype is said to be better adapted for poor conditions. The non-significant linear ( $b_i$ ) and non-linear ( $S^2d_i$ ) estimates indicate average stability of genotypes across different environments, whereas significant  $b_i$  and non-significant  $S^2d_i$  values indicate stability to specific environments. However the significance of  $S^2d_i$  estimate, irrespective of whether the corresponding  $b_i$  estimate is significant or non-significant would suggest that the behavior of the genotype is unpredictable.

In the present study stability parameters such as mean ( $\bar{X}$ ), regression coefficient ( $b_i$ ) and deviation from regression ( $S^2d_i$ ), as suggested by Eberhart and Russell (1966) were considered to explain and discuss the stability of different genotypes for various characters under consideration.

As per Eberhart and Russell model (1966) analysis of variance revealed the existence of significant differences among the genotypes for all the traits

studied i.e. days to 50% flowering, days to maturity,, plant height (cm), number of panicle plant<sup>-1</sup>, panicle length (cm), number of seeds panicle<sup>-1</sup>, biological yield plot<sup>-1</sup> (kg), grain yield plot<sup>-1</sup> (kg) and 100-seed weight (g) indicating the presence of genetic variability in the experimental material under investigation. Mean squares due to environment + (genotype × environment) were significant for most of the traits except panicle length and 100 seed weight depicted the distinct nature of environment and genotype × environment interaction on phenotypic expression. Similarly total genotype × environment was found significant except the traits of panicle length and 100 seed weight. Genotype × environment (linear) interaction component showed non-significance only for 100 seed weight whileas for all other traits it showed high significance indicating location (environment) had a marked influence on the expression among the genotypes and behavior of the genotypes could be predicted over environment more precisely. Mean square due to environment (linear) component was found to be non-significant for 100-seed weight, for all the other characters the component was observed to be highly significant except panicle length where, it was found significant (at 5% level only) implied that means of genotypes varied considerably at different locations. Result of significant pooled deviation for all the traits except 100-grain weight suggested that the performance of different genotypes fluctuated significantly from their respective linear path of response to environments. Predominance of linear component of genotype × environment to non-linear component (pooled deviation) suggested that genotype × environment interaction was predominantly the outcome of linear function of genotype × environment and performance can be predicted across the environments with great precision.

Significant mean squares have been reported for most the traits in rice genotypes over environments by Ramagosa and Fox (1993), Westcott (1987), Honarnejad and Mohammad-Salehi (1998), Abdul-Qayyum *et al.* (2000), Shadakshari *et al.* (2001), Deshpande *et al.* (2003) and Swamy and Kumar (2003). For genotype x environment interaction, significant mean squares have been

reported by Allard and Bradshah (1964), Reddy *et al.* (1998), Narayana Swamy and Dushyantha Kumar (2003), Munisonnappa *et al.* (2004), Devi *et al.* (2006), Tahir *et al.* (2007), Sambandon *et al.* (2008), Kadhem and Al-Nedawi (2011), Bose *et al.* (2012) and Mosavi *et al.* (2013). Similarly, significant [environments + (genotype x environment)] variances were reported by Sinha *et al.* (1990) and Baktha and Das (2008). In case of environment (linear) significant mean squares were reported by Narendra *et al.* (1998), Honarnejad *et al.* (1998), Deshpande *et al.* (2003), Munisonnappa *et al.* (2004) and Baktha and Das (2008). The variance due to genotype x environment (linear), genotype (G), environments (E) were found significant for various traits by Sinha *et al.* (1990), Vivekanandan and Subramanian (1994), Das and Chowdary (1996), Mishra and Mahapatra (1998), Reddy *et al.* (1998), Bose *et al.* (2004) and Deshpande *et al.* (2003), Haryanto *et al.* (2008), Selvan and Palaniraja (2010), Kadhem and Al-Nedawi (2011), Sellammal and Robin (2013). Similarly significant mean squares for pooled deviation (non-linear) regarding various traits have been reported by Sinha *et al.* (1990), Vivekanandan and Subramanian (1994), Das and Chowdary (1996), Mishra and Mahapatra (1998), Bose *et al.* (2004), Selvan and Palaniraja (2010), Kadhem and Al-Nedawi (2011), Sellammal and Robin (2013).

The failure of a genotype to give the same phenotypic performance when tested under different environments is the reflection of the genotype environment interaction. It was observed by Yates and Cochran (1938) that the magnitude of the genotype x environment interaction in the determination of the phenotypes shown by a number of genetically different lines or varieties raised in a range of different environments could be related to the overall effects of the environments. Also a genotypes showing a constant performance in most of the environments does not respond to improved growing conditions with regard to increase in yield. Therefore, most agronomists, no longer regard this type of stability as desirable, their objective is a variety which could always show the yield expected at a level

in productivity of the respective environments as measured by the average yield of all treatments in that environment i.e., a variety that shows no G x E interaction.

The mean yield of a genotype and the slope of its regression line is used to determine the stability of genotypes over the environments by Finlay and Wilkinson (1963). This method was modified by Eberhart and Russel (1966) who added an extra parameter that measures the deviation from linear regression. The choice of a variety depends on its performance at different location in different years and seasons. Comstock and Moll (1963) suggested that selection would not be effective due to presence of significant genotype x environment interaction. Therefore, breeders should give emphasis on stable performance of a line over a wide range of environment.

The statistical relationship among nine stability parameters were investigated by Lin *et al.* (1986), and classified them into three types, the Type-1 stability  $S^2_i$ , a genotype is considered to be stable provided that the environmental variance is small. Francis and Kennenberg (1978) coefficient of variability belongs to Type-1. Type-2 stability  $\sigma^2_i$  (Shukla, 1972) and  $W_i^2$  (Wricke, 1965), a genotype is considered to be stable if its response to environment is parallel to the mean response of all genotypes in an experiment. Finlay and Wilkinson (1963) regression coefficient ( $b_i$ ) belongs to Type-2 stability. Since the regression analysis uses the mean of all genotypes included in the test as environmental index, it is a stability measure relative to other genotypes. Eberhart and Russel's (1966) residual mean square of deviation from regression ( $S^2d_i$ ) and  $R^2_i$  (Pinthus, 1976) belongs to Type-3 stability.

Based on the principle of stability analysis as per the Eberhart and Russel's model (1966), the sum of squares attributed to environment and G x E interaction is partitioned into three components viz. environmental (linear), genotype x environment (linear) and deviation from regression (pooled deviation over all the genotypes). The quantification of environments differs from that of Finlay and Wilkinson (1963) in the meaning that all varieties at a site of seasons

were regarded by them as 'site mean'. Eberhart and Russel (1966) preferred to measure the environments as deviation of means of all the varieties at a location from the overall mean. They recognized the need for defining environmental index which is independent of the experimental varieties, but is based on experimental factors such as rainfall, temperature or soil fertility. Eberhart and Russel (1966) is a widely used model where regression and deviation from regression are taken for analysing stability of a variety. They recommended growing of varieties in adequate number of environments (covering a full range of possible environmental conditions) so that useful information is available regarding the stability.

In the present investigation, estimation of stability parameters for ten *japonica* rice genotypes including popular variety and farmer's variety as checks were estimated to identify the genotypes most suitable across a range of environments and for suitable environments. For days to 50% flowering GSL-11 and SKUA-402 were identified earlier and the most stable across six test locations whileas for days to maturity SKUA-524 and SKUA-402 were observed to be early maturity, however GSL-11 behaved inconsistent for maturity across the test locations. Similarly for plant height and number of panicle plant<sup>-1</sup> GSL-11 was recognized as stable genotypes. The genotypes K-08-63 and SKUA-524 were reported highly adaptable genotypes across the locations for long panicle and number of seeds panicle<sup>-1+</sup> respectively as per criteria of Eberhart and Russell model (1966) for fulfilling the status of stability. Further the promising genotypes with respect to consistency for biological yield was K-08-63. SKUA-and GSL-61 were found to have wide adaption for grain yield, whileas K-08-69 and SKUA-506 find their position under suitable growth areas. The popular variety K-332 was found suitable for poor environments.

Knight (1970), criticized grounds the stability based on linear regression coefficient and deviation from linearity on physiological grounds but nevertheless, the biometrical model given by Eberhart and Russel (1966) has been highly

successful in predicting genotypic performance over a wide range of environments. Jinks and Mather (1955) observed that above average performance of a genotype is indicative of the fact that the capitalization of additive type of gene action and residual genetic heterozygosity coupled with critical structural variability could confer wider adaptability to the genotypes.

Based on the above discussion, SKUA-402 was identified as most stable across all test locations for yield and other traits, emphasize the importance on revalidation of the results by carrying out the experiment on more number of locations for one more year and then to recommend these varieties with high degree of conviction for such agro-ecologies of Kashmir.

Farmers in the low production potential system are not benefiting long after green revolution and Participatory Varietal Selection (PVS) can solve this problem. Less formal methods of Participatory Varietal Selection (PVS) are most cost effective and can be organized by plant breeders, government extension agencies or NGOs. A major challenge will be the reform of policies so that participatory research can be officially incorporated into varietal testing release and extension systems. More varieties need to formally or informally, released on the basis of participatory data to cater for the diversity of niches found in more productive environments. Such policy changes are vital, because the yield gains from varietal replacement in more productive agricultural environments, although likely to be lower in percentage terms than those found in marginal areas, produce higher absolute gains in yield per area.

## Chapter – 6

### SUMMARY AND CONCLUSION

The present investigation entitled. “Farmers participatory varietal selection in *japonica* rice (*Oryza sativa* L.) through mother trial evaluation system in Kashmir valley” was carried out to identify the most appropriate genotypes on the basis of preference of the farmers on the test varieties and determine their tastes and aspiration for the new varieties to be bred in future in consultation with farmers. The study was undertaken during *kharif* 2013 in two districts viz., Anantnag (33-34° E latitude 74-75° N Longitude) and Pulwama (33.87° E Latitude 74.89° N Longitude). In each district two locations were selected for laying out the Mother trials, besides two Grandmother trials at Mountain Crop Research Station, Larnoo and KVK, Pombay in RCBD design with two replication. Each genotype was represented by three rows of 2m length with row to row and plant to plant spacing of 20 and 15 cm respectively. The experimental material consisted of ten *japonica* genotypes including popular variety (K-332) and farmer’s variety as check genotypes. The observations were recorded on days to 50% heading, days to maturity, plant height (cm), number of panicles plant<sup>-1</sup>, panicle length (cm), number of seeds panicle<sup>-1</sup>, biological yield plot<sup>-1</sup> (kg), grain yield plot<sup>-1</sup> (kg) and 100-seed weight (g). The data was subjected to various statistical and biometrical analysis and the results are summarized in the present chapter.

Participatory Rural Appraisal (PRA) conducted before laying out the research trials revealed that rice crop ranks first under high altitude irrigated agro ecologies of Kashmir valley and mono-cropping is usually in vogue and canal system fed by melting snow is the main source of irrigation water. Among major production constraints, low yielding varieties, blast disease and cold were considered important and farmers saved seed of conventionally grown varieties is the main source of seed to raise the new crop. Further, the farmers would like to demand the variety possessing high tillering, tall stature, more grains per panicle,

medium bold seed, high biomass, early maturity, medium threshability, white grain color and with aroma.

The preferential scoring of test genotypes revealed that most preferred genotype on the basis of lowest cumulative rank was GSL-11 with mean preference rank of (1.4) and SKUA-402 as second best (1.6) followed by SKUA-524 (2.6). The genotype that received maximum number of negative votes was K-08-63 (7.4). Farmers who grow the trial and the neighbors of those farmers, expressed a consistent large and highly significant preference for GSL-11, SKUA-402 and SKUA-524 compared with the K 332 (popular variety) and the farmers variety. Farmer's variety was the least preferred variety and was at par with the test genotype K-08-63. Also genotypes GSL-11, SKUA-402 and SKUA-524 were statistically found at par in term of rank summation index and mean preference ranking and significantly different with the genotypes K-08-73, K-08-69, SKUA-506, GSL-61 and K-332, which among themselves were found statistically at par and could be classified as a separate group. K-08-63 was least preferred and was at par with the farmer's variety.

Analysis of variance revealed the existence of significant differences among the genotypes for all the traits studied indicating the presence of genetic variability in the experimental material under investigation. Mean squares due to environment + (genotype  $\times$  environment) were significant for most of the traits except panicle length and 100 seed weight depicted the distinct nature of environment and genotype  $\times$  environment interaction on phenotypic expression. Similarly total genotype  $\times$  environment was found significant except the panicle length and 100 seed weight. Genotype  $\times$  environment (linear) interaction component showed non-significance only for 100 seed weight whereas, all other traits showed high significance indicating location (environment) had a marked influence on the expression among the genotypes and behavior of the genotypes could be predicted more precisely over environment. Mean square due to environment (linear) component was found to be non-significant for 100-seed

weight, for all the other characters the component was found highly significant except panicle length. Pooled deviation for all the traits except 100-grain weight was found significant suggested that the performance of different genotypes fluctuated significantly from their respective linear path of response to environments. On the basis of stability parameters SKUA-402 and GSL-11 were identified as the most stable genotypes for grain yield across all locations on the basis of high mean performance and non-significant estimates of  $b_i$  and  $S^2d_i$  from unit and zero respectively, however latter genotype showed sensitivity to better environments for biological yield on the basis of significant  $b_i$  estimates. Similarly these genotypes were identified as consistent for early flowering for all the locations. Further GSL-11 and K-332 genotypes were identified as most stable for plant height and number of panicles plant<sup>-1</sup> respectively and SKUA-524 was identified as the consistent genotype for seeds panicle<sup>-1</sup>.

Based on the findings of the present study, the following conclusions could be drawn:

- PRA gave cognizance to breeders to breed for such varieties for high altitude irrigated agro-ecologies particularly for Kashmir valley which should possess high biomass and grain yield together with blast resistance, cold tolerance, medium bold seed, high tillering, tall stature, medium threshing, and white grain color preferably with aroma,
- The most preferred genotypes identified by the Focal Group Discussion through PVS were GSL-11 and SKUA-402. These genotypes need to be evaluated further by Baby Trial evaluation system on big plot size and over many more locations to corroborate the real performance and finally to recommend the varieties for up scaling through Participatory Seed Production under such ecologies.

- Genotypes SKUA-402 and GSL-11 were also identified as most stable based on stability analysis across all the test environments/locations for yield and other desirable traits put emphasis on the role of further evaluation both spatially and temporally so that the recommendation of the said genotypes can be suggested with authenticity.

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**CERTIFICATE**

Certified that all the corrections/amendments as suggested by External Examiner Dr. D.K. Verma, Principal Scientist, IGFRI, Srinagar during Viva-Voce examination held on July 10, 2014 have been incorporated in the manuscript entitled **“Farmers Participatory varietal selection in japonica rice (*Oryza sativa* L.) through mother trial evaluation system in Kashmir valley”** submitted by **Mr. Mohammad Rafiq Sheikh (Regd. No. 2012-A-917-M)**.

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