Variability, Correlation and Path Coefficient Analysis of Rice (Oryza sativa L.)

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ABSTRACT: In the present investigation the experimental material comprised of 8 local germplasm of rice (Oryza sativa L.) representing diversity for yield and yield attributing characters to irrigated condition. All the 8 genotypes were grown in Kharif season of 2015 in RCBD with three replications. Wide range of variation was observed for all the quantitative traits under study indicating enough scope for bringing about improvement in desirable direction for hybridization. This suggests that there is high contribution of positive and negative genes among the genotypes exhibited higher and lower values for these characters. Phenotypic coefficient of variation was highest for grains yield per plant followed by number of fertile grain per panicle, flag leaf length, length breadth ratio and text weight exhibited moderate high phenotypic coefficient. High heritability values were also recorded for test weight, plant height at maturity and vegetative plant height. Estimate of genetic advance was highest for number of grains per panicle, followed by plant height .Genetic advance as percent of mean was, however, highest for no of grains per panicle followed by grain yield per plant. Number of tiller exhibited positive and significant association with test weight, positive and non significant association with length breadth ratio and grain yield/plant. It showed negative and non significant association with vegetative plant height, plant height at maturity, panicle length, number of grains per panicle, fertile grain per panicle. The direction and magnitude of association indicated that the grain yield of rice in irrigated conditions can be improved by selecting germplasms having higher performances for yield attributing traits

Keyword: RCBD, Randomized Complete Block Design

I. INTRODUCTION

Rice (*Oryza sativa* L.), is widely grown in tropical and subtropical regions (Ezuka and Kaku, 2000). All the varieties of rice found in Asia, America and Europe belongs to *Oryza sativa* and varieties found in West Africa belong to *Oryza glaberrima*. *Oryza sativa* is a diploid species having 24 chromosomes. The *sativa* rice species are commonly grouped in to three subspecies namely, *Indica*,, *Japonica* and *Javanica*.

From India, this crop spread to the east, China, Japan, Indonesia, and also to the west, Iran and Mesopotamia. During the middle ages it was introduced in North Africa (Egypt) and in South Europe (Italy and Spain). The cultivation of rice has been known in North America since the 17th century (Vavilov, 1951; Smith, 1969; Singh and Hardas, 1970). Rice is cultivated worldwide over an area of about 153.51 m ha with an annual production of about 614.65 m t and average productivity of 4.00 t ha^{-1}. India has the largest area (44.6 m ha) covering 28.01% of the

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land under rice in the world and ranks second in total production (90.00 m t) next to China (184.25 m t) with an average productivity of 2.02 t ha^{-1}. However, at present China has an area of only 29.30 m ha but productivity as much as 6.3 t ha^{-1} (FAO, 2006). In the year 2010, the top three producers were China (32.7% of world's production), India (26.0%) and Indonesia (10.3%), (FAO, 2010). World trade figures are very different, as only about 5-6% of rice produce is traded internationally. The three largest exporting countries are Thailand (26% of world's exports), Vietnam (15%) and the United State (11%), while the largest three importers are Indonesia (14%), Bangladesh (4%) and Brazil (3%) (International Rice Research Institute: Statistics, 2005).

Approximately 90% of the world's rice is grown in the Asian continent and constitutes a staple food for 2.7 billion people worldwide (Salim *et al*., 2003). Rice is placed on second position in cereal cultivation around the globe and occupies an important position in the economy of India as an export item as well as staple food. In India, it has been grown on 41.85 million hectares and has given a production of 89.13 million tonnes in 2009-10 (Directorate of Economics and Statistics, Department of Agriculture and Corporation). At the current rate of population growth of 1.8%, the rice requirement of the country is estimated to be around 140 million tonnes by 2020. For achieving this production target in the next few decades, it has been advocated that hybrid rice may be of greater hope as it has hypothetical to produce about 20-30% higher yield than the pure line varieties.

In Nepal, total cultivated area is 1486951 ha and production is 5047047 mt (Krishi dairy 2013/2014). Agriculture is an important sector in the Nepalese economy, contributing to about a third of its GDP and engaging about two-thirds of its population (MoAC, 2013).

Rice is the most important staple food crops in Nepal occupying hectares of land producing 5045045 tomes of grains with national productivity of 3.39 t ha^{-1} (ABPSD, 2014). Rice is the major cereal crop of the terai and inner terai occupying 67.87% of total area (ABPSD, 2013) but can be grown throughout all agro-ecological regions from terai plains to the high hills up to 3000 m above sea level (NARC, 2007) including valleys and foothills (Dhital*et al.*, 1995). Agriculture is mostly rain-fed and dominated by subsistence farming systems. Rice production, amounting to about half of the total cereal grains produced in the country, is Nepal's most important crop (Ghimire et al., 2013). Rice is produced mainly in the Terai region and contributes to the livelihood of a majority of farm households in the area. However, growth in production has been low at 1.4 per cent per year over the last two decades. Some 70 per cent of total rice produced is used for home consumption. Yet, for most subsistence farmers, rice production meets only a part of their annual household food requirements (Ghimire et al., 2013). Population growth and the increase in the demand for food, on the one hand, and insufficient growth in farm productivity, on the other, have turned Nepal gradually from a food-exporting country to a food-importing country within a few decades (Pokhrel, 2013).

As a global food rice has large influence on nutrition and food security all over the world and is no way inferior to the wheat and other cereal grains. In Asia alone, more than 2 billion people obtain 60 to 70% of their calories (calorific value 346) intake from rice and rice products. Almost a billion households in Asia, Africa and America depend on rice systems for their main source of employment and livelihood. About four-fifths of the world's rice are produced by the small-scale farmers, and consumed locally. The rice grain contains much carbohydrate (76.7%), fat (1.0%), minerals (calcium 10 mg, phosphorus 190 mg, iron 3.3 mg per 100 g), fiber (0.6%) but rather little protein (about 7.5%) of 100 g of edible portion. The digestibility and assimilation of rice starch and protein is higher (95.5%) than the other cereal grains. Rice water is valuable for medical remedy. The consumption of rice in the developing countries of the hot climate in Asia exceeds 100 kg per person annually, in Latin America 50 to 80 kg, in Africa 40 to 70 kg and in European countries 6 kg.

Rice is therefore, on the frontline in the fight against world hunger and poverty. Rice is also a symbol of both cultural identity and global unity. For all these reasons, **"Rice is life"** and therefore the United Nations General Assembly (UNGA) during its 57th session on 16th December 2002 declared 2004, the International Year of Rice. This dedication of an International Year to rice, a single crop, is unique precedence in the UNGA's history. It

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reflects the fact that rice is not only a fundamental commodity and primary food source for more than half the world's population, but also a focus within a complex rice-based ecosystem that influences issues of global concern such as food security, poverty alleviation, preservation of cultural heritage and sustainable development. Rice plays a fundamental role in Indian agriculture as it is the staple food for more than 70 per cent of the population and the source of livelihood for 120-150 million rural households. It accounts for 43 per cent of food grain production and 55 per cent of the cereal production in the country.

In recent year ,rice production has reached a plateau. In general, the narrow genetic base of semi-dwarf varieties is likely to make them vulnerable to different biotic and abiotic stresses. Therefore, to meet the ever-increasing demand of food grains, for higher production emphasis should be given to the genetic improvement of existing varieties of rice. The major thrust area for such genetic improvement has been known to lay importance on selecting efficient breeding system and identifying desirable parent in hybridization programme. This would depend to large extent on the knowledge of genetic variation and genetic system controlling the yield and yield traits.

The success of any breeding programme depends on the exploitation of existing variability and therefore it is desirable to collect ,evaluate and utilize the available diversity for crop improvement to suit specific need diversity in rice has been well utilized in the efforts to solve the present day food problem. Land races of rice were collected over past several decades to use them as parents for producing the high yielding varieties, disease and pest resistant, well adapted varieties and it resulted in unprecedented rise in rice yield often referred to as 'Green revolution' (Jackson and Haggan, 1993). In India, the revolution in rice production was realized after the introduction of lodging resistant, fertilizer responsive and photo-insensitive semi-dwarf high yielding varieties of rice in mid sixties. The success of any breeding programme depends on the exploitation of existing variability and therefore it is desirable to collect, evaluate and utilize the available diversity for crop improvement to suit specific need with regards to specific ecosystem.

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Genetic improvement mainly depends upon the amount of genetic variability present in the population. In any crop, the germplasm serves as a valuable source of base population and provides scope for wide variability. Information on the nature and degree of genetic diversity would help the plant breeder in choosing the right parents for breeding programme (Vivekanandan and Subramanian, 1993).

Genetic diversity among the parents is very important because a cross involving genetically diverse parents is likely to produce high heterotic effect and also more variability could be expected in segregating generations (Khush, 1974).

Estimates of genotypic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), heritability and genetic advance will play an important role in exploiting future research projection of rice improvement. In rice improvement program, it is the germplasm, which virtually determine the success and nature of end product. The development of superior rice population involved the intelligent use of available genetic variability, both indigenous as well exogenous, to cater the need of various farming situations of rice. The grain yield is the primary targeted for improvement of rice productivity in both favorable and unfavorable environments from its present level.

Heritability and genetic advance are other important selection parameters. The estimates of heritability would be rewarding and helpful to the plant breeder in determining the characters to be considered for the selection. The major function of heritability estimates is to provide information on transmission of characters from the parents to the progeny. Genetic diversity is pre-requisite for any crop improvement programme as it helps in the development of superior recombinants. The crosses between parents with maximum genetic diversity are generally the most responsive for genetic improvement (Arunachalam, 1981). A quantitative estimation of genetic diversity guide the breeder for rapid progress of the breeding programme.

The nature and relationship between yield and its component traits and also among them self seems to provide information which would be of greater value at the time of practicing selection for improved yield. The quantitative traits are generally govern by polygenic control and are considerably influenced by an environment to which the individual is exposed. The knowledge on genotypic and phenotypic correlation among yield components and their relationship with yield is of great importance in selecting the superior genotypes. Identification of the characters that are contributing towards yield, the knowledge regarding relative contribution of individual trait to yield is very important and this can be accomplished by partitioning the correlation coefficient into direct and indirect effects (S,Wright and Dewey & Lu,). Path coefficient analysis helps in determining the direct and indirect causes of association and permits to examine the specific forces acting to produce a given correlation. Path analysis also helps in formulating effective breeding strategies to develop elite genotype.

However, simple correlation studies do not provide adequate information regarding the contribution of each yield component traits toward estimate grain yield.

Therefore, with this backdrop, the present investigation entitle" *IN VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS IN RICE (Oryza sativa L.)*"Was undertaken with the following objectives:

OBJECTIVES:

❖ To estimate variability, heritability and genetic advance in a germplasm line of rice.

❖ To find out the character associations of yield and yield attributing traits by means of simple correlation coefficients..

❖ To assess the direct and indirect contribution of each character on grain yield through path-coefficient analysis.

❖ To assess the influence of Flag leaf width (narrow and broad) on character association and path coefficients.

II. REVIEW OF LITERATURE

The present investigation relates to the study on variability, heritability, genetic advance, correlation and path coefficient analysis in a set of 8 genotype of rice. Relevant literatures on these aspects have been reviewed here under the following heads:

Variability, heritability and genetic advance

Correlation (Character association)

Path-coefficient analysis

Variability, heritability and genetic advance

Information on the genetic parameters such as coefficient of variation, heritability, genetic advance would be helpful to the breeder to evolve suitable cultivars within short time. Some of the significant studies in rice are cited here under.

Bui and Tran (1991) in a study of five yield components in some crosses of rice observed high values of phenotypic and genotypic coefficient of variability for panicle per hill, grain yield per panicle and single plant

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yield. Grain weight had a low broad sense heribility values and low genetic advance, indicating non- additive gene action

Chaubey and Singh (1994) studied genetic variability in a set of 20 rice varieties and observed high heritability coupled with high genetic advance for effective tiller per plant, grain yield per plant, and 1000-grain weight.

Roy, Panwar and Sarma (1995) observed moderate genotype and phenotypic coefficient of variation for traits like plant height, panicle length, days to 50% flowering in collection of 99 rice genotypes.

Sawant and pati (1995) found high values of GCV, heritability and genetic advance for traits like grains per panicle, plant height, grain yield per plant and 1000-grain weight in a study of 75 germplasm of rice.

Singh and chaudhary (1996) studied genetic variability, heritability and genetic advance for 12 characters in F1 F2 and their parents of some rice varieties and found that he values of PVC were higher than GCV for all the characters. Estimate of GCV and PVC was high for biological yield followed by number of panicle per plant, number of grains per panicle, grain yield per plant, 1000-grain weight and harvest index. Heritability and genetic advance were found to be higher in plant height and numbers of grains per panicle.

Kumar et al. (1998) studied on 34 cold tolerant rice genotype, reported that genotype coefficient of variation together with heritability genetic advance was observed for plant height, total tillers per hill, flag leaf area, panicle length, spikelet fertility, 1000-grain weight and grain yield.

Balan, Muthiah and Boopathi (1999) evaluated 28 genotype parameters. They reported that high heritability estimates were combined with genetic advance for grain yield. They also observed moderate genetic advance for days to 50% flowering and plant height.

Tripathy, Sinha and Bhanderkar (1999) in a study of 20 local scanted rice varieties reported that plant height and panicle length exhibited high genotypic and phenotypic coefficient of variation. High genetic coefficient of variation, heritability and genetic advance were observed for grain yield per plant.

Chauban et al (2000) evaluated 383 associations of upland rice for quality traits which displayed low variability (CV %) for hulling, milling recovery, volume expression, amylase content, and kernel length and kernel linear expansion. Alkali value exhibited the highest variability (CV 32%) followed by rice recovery (21.5%). Variation for kernel length and shape (L/B ratio) and water uptake were moderate (CV 10-18%).

Monalisa and Sasmal (2000) reported gain thickness and embryo weight has high heritability, genetic advance, whereas kernel length, grain yield and endosperm weight exhibited higher heritability with moderate GCV and genetic advance. Kernel length and thickness were strongly associated with grain yield per plant.

Yadav (2000) in a study of genetic variability in rice observed appreciable amount of genotypic coefficient of variation, heritability and genetic advance for total grains per panicle, fertile grains per panicle and grain yield per plant.

Significant genetic variability for all the character studied except for number of tillers per plant and panicle length was noted by **Ali, Jafri, Khan, Mahamod and Butt(2000).** Heritability was observed maximum for plant height followed by 100 seed weight, number of tillers per plant, spikelets density and panicle length. However, genetic advance was observed highest for number of tillers per plant followed by plant height and spikelet density.

Verma, Sigh, Dwivedi and Singh (2000) studied genetic variability, heritability and genetic advance in 49 rice genotypes for sixteen traits. High to moderate genotypic variance coupled with high heritability and genetic advance were observed for the plant height, days to flowering and 100-grain weight suggesting the preponderance of additive gene action in the inheritance of these attributes.

Sarma, Bhuyan and Chaudhury(2000) in a study of 55 rice genotypes observed highest phenotypic as well as genotypic variability for grains per panicle followed by grain yield per plant and effective panicles per plant. Heritability in broad sense was highest for effective panicle per plant followed by grains per panicle and grain yield per plant. Grains per panicle also exhibited highest genetic advance as percent of mean followed by effective panicle per plant and grain yield per plant.

Bharadwaj et al. (2001) evaluated of rice genotypes for 9 quantitative characters, i.e. plan height, days to 50% flowering, number of ear bearing tiller per plant, panicle length, number of spikelet per panicle, number of filled grain per panicle, 100-grain weight, L/B ratio, and grain yield per plant. The analysis of variance indicated significance difference among the genotype for all the characters studied. Multivariate analysis indicated that all the 9 characters showed diversity for the genetic divergence among the genotype. Kernel (L/B) ratio contribute maximum towards the genetic divergence, followed by 100-grain weight and grain yield per plant accounting to 87% of total diversity.

Pandey and Awasthi (2002) in an experiment with 21 aromatic varieties of rice reported that high genetic variability existed for most of the yield contributing traits.

Mahto, Yadav and Mohan (2003) evaluated twenty six early maturing upland rice genotypes for genetic variation. The genotypic coefficient of variation ranged from 5.36 for panicle length to 24.83 for grain yield. The difference between PCV and GCV was minimum for 1000-grain weight (0.12) and days to 50% flowering (0.13). Estimates of heritability in broad sense were high for 1000-grain weight (98.30) and days to flowering (97.33). The number of grains per panicle and panicle length showed a wide difference between PCV and GCV.

Akter, Iftekharuddaula, Bashar, Kabir and Sarkar (2004) studied the genetic variability in the irrigated nine hybrid rice hybrid rice varieties. All the characters studied by them showed significant variation. The higher GCV's were found in case of flag leaf area followed by panicle per sq. meter, 1000-grain weight and spikelet per panicle. High heritability was observed for all the tested characters except grains per panicle. High heritability with high genetic advance as percentage of mean was found for panicle per square meter, flag leaf area and 1000 grain weight.

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In the study of quantitative and qualitative traits of thirty-six rice genotypes, **Sourosh, Mesbah, Hossainzadeh and Bozorgipour (2004)** observed the significant differences among genotypes for all traits. The PCV was greater than GCV for all traits. The PCV was greater than GCV for all the traits although difference for most of all them were small. The highest phenotypic and genotypic coefficients of variation were observed for gel consistency, leaf area, leaf width and number of panicle per plant. The highest estimate of heritability was for plant height and lowest for panicle weight.

Krishna, Kavita and Pushpalata (2010) studied on 97 rice accessions with three check varieties and reported that highest magnitudes of phenotypic and genotypic coefficient of variation were found for number of unfilled spikelets per plant, number of total spikelets per plant respectively. High estimates of heritability coupled with high genetic advance was found for number of total spikelets per plan and number of fil with three check varieties and reported that highest magnitudes of phenotypic and genotypic coefficient of variation were found for number of unfilled spikelets per plant, number of total spikelets per plant respectively. High estimates of heritability coupled with high genetic advance was found for number of total spikelets per plan and number of filled spikelets per plant, indicating that they can be effectively improved through selection.

Character association:

Study of character association helps the breeder in choosing selection criteria for grain yield in parental lines, such that selection will be effective in isolating the plants with desired combination of characters. Phenotypic correlation is the correlation of observed values of variable and subjected to the changes in the environment. It measures the environment deviation together with non-additive gene action. Knowledge of association between different characters is highly essential for planning a sound breeding programme. The available literature on correlation studies in rice has been reviewed as under.

Marasis (1980) observed significant positive correlation of characters like plant height, panicle length, number of spikelets per plant and 100-grain weight with yield. The genotypic correlation between the numbers of fertile tillers per plant and yield was negative.

Suare et al. (1984) while analyzing for yield and its components in upland rice, observed a significant and positive correlation with 100- grain weight (0.72) and filled grain per panicle.

Shamsudddin (1986) studied on 53 ectopically diverse varieties of rice reported positive and significant genotypic correlation of grain yield per plant with 1000- grain weight and volume, rachilla number per panicle and panicle length.

Chen et al. (1987) reported, through their study on 13 *Japonica* rice varieties (with varying panicle size), that panicle weight exhibited positive correlation with stem thickness, thickness of neck of panicle and unit stem weight, but not with plant height. Panicle weight was also found to be positively correlation with leaf area only in variety with small flag leaf and second leaves.

Yadava et al (1988) found positive correlation among grain yield, leaf area index and dry matter accumulation at 85 days after transplanting during full trial with 14.

De and Suriya Rao (1988) reported non- significant and negative association of yield per plant to kernel length and kernel breadth.

Bai et al. (1992) studied correlation of yield and yield components in medium duration rice cultivars in kernel and observed that grain yield per plant was positively correlated with number of productive tillers per plant, plant height, panicle length and number of grain per panicle at genotypic and phenotypic levels. They further reported that flag leaf area and panicle exertion were positively correlated with yield only at genotypic level. The genotypic correlations were found to be greater than phenotypic ones.

Chakraborty and Hazaarika (1994) studied the magnitude and direction of association between grain yield and its components in rice and reported a significant positive correlation of grain yield per plant with plant height, panicle length, and panicle weight, number of panicles per plant and kernel breadth at genotypic level.

Roy et al. (1995) in their correlation study for 11 characters in 99 rice genotype, revealed non-significant and negative association of 1000-grain weight with grain yield.

Marekar and Siddiqui (1996) reported positive and significant correlation between yield per plot and plant height, length of panicle, days to maturity, 1000-grain weight, length of grain and L/B ratio in 73 rice varieties.

Ganesan et al. (1997) observed significant and positive correlations of days to panicle emergence, plant height, panicle number per plant, length of panicle, grains per panicle, 100-grain weight, kernel length, kernel breadth and grain shape with grain yield per plant in 11 parental lines of rice comprising four early maturing (105-115 days), parents (ADT36, ASD16,CO37 and IR 50) and extra early maturing (85-95 days) parents (Heera, Kalyani II, Sattari, AS18696, AS 98011 and CO41).

Reddy, De and Suriya Rao (1997) reported negative and significant association of plant height with kernel length and kernel breadth. Yield per plant showed positive but non-significant association with kernel length and kernel breath. Kernel length had a negative and non significant association with kernel breadth.

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Reddy, De, and Suria Rao (1997) reported negative significant association of plant height with kernel breadth. Yield per plant showed positive but non-significant association with kernel length and kernel breath. Yield per plant showed positive but non-significant association with kernel length and kernel length and kernel breadth. Kernel length had a negative and non-significant association with kernel breadth.

Selvarani and Rangasamy (1998) studied yield and yield components in population of rice reports that phenotypic correlation coefficient exhibits significant and positive correlation of grain yield with days to flowering, leaf and index, number of productive correlation of grain yield with days to flowering, leaf area index, number of productive tillers, dry matter production and harvest index.

Valarmathi and Leenakumary (1998) studied character association involving 20 genotypes of rice and found that grain yield was significantly correlated with the productive tillers per plant, panicle length and filled grain per panicle length and filled grains per panicle. Productive tiller have shown significant correlation with total tillers while panicle length showed signification correlation with field grains per panicle. Plant height was found to be non-significantly associated with grain yield. Non-significant and negative association of 100-grain weight with grain yield was also reported by **samonte Wilson and Mc clung (1998)** from the result obtained in an experiment involving 15 genotypes of rise.

Balan et al.(1999) in their study of correlation between yield and some associated characters in 28 rise genotyped reported positive and significant association of number of panicles per sq. meter with grain following by days to 50% flowering. Grain yield and plant height showed non-significant association and they suggested that both the characters inherited independently.

In a study involving 10 hybrids and two varieties of rice **shivani and sree Rama Reddy (2000)** found significant and positive association of plant height with panicle length and number of grains per panicle. They also reported significant and positive association for panicle length with grains per panicle.

Janardhanam, Nadarajan and Jebaraj (2001) in a study with eight parental cultivars and 16 hybrids estimated the correlation between yield and yield components. They observed that grains per panicle was the only character which was directly and positively associated with grain yield per plant.

Shanthi and Singh (2001) in and experiment involving 17 rice mutants of Mahsuri rice studied six quantitative characters and their correlation. Yield per plant was significantly and positively associated with the number of grains per panicle. Plant height was positively and significantly associated with the number of grains per panicle and grain yield per plant at both genotypic and phenotypic levels.

Babu, Netaji, Philip and Rangasamy (2002) in an association study for eight quantitative characters with 33 genotypes of rice reported that the plant height and productive tillers per plant were the principle characters responsible for single plant yield.

Mohammad Saif, Hafeez Ahmed and Mohammad Baber (2002) with an experiment on 14 different quality rice genotypes have found significant correlation for panicle length with number of grains per panicle.

Surek and Beser (2003) studied the association among the yield components involving 80 breeding line. The results revealed that grain yield had significant and positive correlation with its component characters like number of filled grains per panicle expressed significant negative association with 1000 grain weight.

Xu Zhenjin et al. (2004) reported that chalkiness and plant height are significantly and positive correlated with amylase content and 1000-grain weight. Amylase content gelatinization showed significant positive correlation with 1000-grain weight.

Madhavilatha et. al. (2005) evaluated 44 elite genotypes to study the association between grains and yield components. They reported that the yield was positively associated with days to 50% flowering, plant height, number of effective tillers per plant, panicle length, numbers of grains per panicle, harvest index and 1000-graims weight.

Swain and Reddy (2006) conducted a study by using rainfed lowland rice and reported that the number of panicle per plant and single panicle weight were positively correlated with grain yield under normal planting. Whereas, under delayed planting, only number of panicle per plant showed significant positive association with grain yield. They suggested that, for improving grain yield in rainfed lowland rice, selection should largely depend on single panicle weight under normal planting and on number of panicles per plant under delayed planting condition.

Manna et al. (2006) conducted an experiment by using 20 lowland rice cultivars. Their studied revealed that grain yield per plant was positively and significantly associated with effective tillers per plant, panicle weight, spikelets and high density grains per panicle.

Correlation studies by **Eradasappa, Nadarajan, Ganapathy, Shanthala and Satish (2007)** in rice reported positive and significant association of plant height and productive tillers per plant with grain yield per plant.

Karad and Pol (2008) observed in their study with rice genotypes that the grain yield had positive correlation with almost all the characters expect 1000 grain weight at both phenotypic and genotypic levels. They found that genotypic correlation estimates were higher than phenotypic correlation with grain yield per plot.

Kole and Hasib (2008) conducted a investigation to determine interrelationships among yield and yield contributing characters in scented rice. Grain yield per plant had positive and significant correlation with plant height, flag leaf length and panicle weight at both genotypic and phenotypic levels, while days to flower and panicle number per plant showed significant and negative correlation with grain yield at both genotypic and phenotypic levels.

Chandra and Reddy et al. (2009) studies correlation in rice correlation in rice revealed that genotypic correlation coefficients for most of the characters under study. Character association analysis revealed significantly positive association of grain yield per plant with number of productive tillers per plant, 1000-grian weight, panicle length and number of grains per panicle.

Nandan, Sweta and Singh (2010) studies correlation on thirty three rice genotypes, and found strong positive association of yield with days to 50% flowering, plant height, number of grains per panicle, number of spikelets per panicle and spikelet fertility.

Pankaj, Pandey and Dhirendra (2010) studied correlation using 48 genotypes of rice for grain yield, its components and quality characters and found that grain yield exhibited significant positive correlation with grains per panicle, spikelets per panicle and effective tillers per plant at maturity at both phenotypic and genotypic levels. Total tillers per plant had correlation with grain yield per plant at phenotypic level only. Significant negative genotypic correlation with days to 50% flowering and days to maturity revealed that early maturing genotypes yielded high under Palampur condition.

Path-coefficient analysis

Path coefficient analysis, a statistical device developed by Wright (1934) helps in partitioning of the correlation coefficient into direct and indirect effects of independent variable on dependant variable. As grain yield is a complex character influenced by several factors, selection based on simple correlation without taking into consideration the components characters is not effective. Hence, path analysis is of much importance in any plant breeding programme. Correlation in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters.

The finding of rice workers on relative contribution of different characters to grain yield are being cited here under:

Dash (1992) reported maximum direct effect of panicle weight on yield per plant which was followed by days to flowering and tiller number in his study of character association and path analysis in rice. He indicated that panicle weight too showed a highly significant association with grain yield per plant.

Sawant (1995) stidied character association and path-coefficient analysis in rice and compiled the information on yield correlation based on data derived from 6 yield components in F2 plants of two crosses. In his finding path analysis revealed highest positive and direct effect of productive tillers per plant on grain yield, followed by filled grains per panicle.

Deosarkar and Nerker (1996) made studies on yield and yield contributing characters and iron chlorosis mean index, path analysis, which indicated that panicle length, number of effective tillers per plant and straw yield per plant had the greatest direct effect on grain yield per plant. Iron chlorosis exhibited the largest direct effect on grain yield per plant and large indirect effect via straw yield per plant.

path-coefficient analysis study in rice by **Sarawgi, Rastogi, and Soni (1997)** revealed that direct selection for number of fertile spikelets per panicle and harvest index would likely be effective for increasing grain yield per plant, hundred grain weight, grain breadth, grain length and grain thickness would increase harvest index.

Balan et al. (1999) employed path-coefficient analysis with a set of 28 rice genotypes and reported that number of panicles per sq. meter exerted high positive direct effects in grain yield. They also found that days to 50% flowering exerted a high positive indirect effect on grain yield through number of panicles per sq. meter.

Janardhanam et al. (2001) conducted a field experiment with eight parental cultivar and sixteen hybrids. Study of path-coefficient analysis by them revealed that plant height, spilelets per panicle and grains per panicle had high direct effects on single plant yield. They found the major yield contributing characters based on indirect and direct effects, were plant height, spikelets per panicle and grains per panicle.

Bala (2001) conducted a study with 42 saline and alkaline tolerant rice genotypes and observed that grain yield per sq. meter and panicle length recorded positive and significant correlation and positive direct effect with plot yield.

Babu et al. (2002) thought the path-coefficient analysis for eight quantitative characters in rice utilizing 33 genotype reported that plant height had highest positive direct effect on single plant yield via positive indirect effect of panicle length, number of grains per panicle and spikelet fertility, they suggested that the selection based on these characters would be efficient.

Path-coefficient analysis by **Surek and Beser (2003)** in 80 breeding lines of rice and their 10 parents revealed that their biological yield and harvest index had the highest positive direct effect on grain yield. In addition, the yield components had positive and direct effect on grain yield. They suggested that the improvement in the grain yield will be efficient if the selection is based on biological yield, harvest index, number of productive tillers per sq. meter and number of filled grains per panicle under temperate condition.

Maheto et al. (2003) studied 26 early maturing upland rice genotypes for path-coefficient analysis, which showed that the number of branches per panicle had the highest (0.42) positive direct effect on grain yield followed by number of filled grains per panicle (0.41), number of panicles per plant (0.15) and days to 50% flowering (0.007). 1000-grain weight and plant height had a negative correlation with grain yield but had a positive direct effect on grain yield.

Akter et al. (2004) studied the path-coefficient for grain and its component trait in nine hybrid rice genotypes and observed the maximum contribution of the larger flag leaf to gain yield followed by harvest index, grain per panicle and days to maturity through higher direct effect. Grains per panicle, panicle length, plant height, days to maturity, spikelets per panicle and panicle per hill had positive but indirect effect on grain yield through flag leaf area.

ISSN 2229-5518

Satyanarayana et al. (2005) through path-coefficient analysis in 66 elite restores line of rice reported that panicle length and spikelet fertility exerted maximum direct effect on grain yield. High indirect effects of the different yield, indicating the need for emphasis on spikelet fertility on grain yield, indicating the need for emphasis on spikelet fertility during selection for yield improvement in restorer lines of rice.

Muthuswamy and kumar(2006) studied path analysis among 22 draught resistant cultivar of rice and reported cultivar of rice and reported that panicle length, root volume and plant height had high positive direct effect on yield. Under such conditions they suggested that simultaneous selection based on plant height and panicle length will improve the yield in drought resistant cultivars.

Manna et al. (2006) recorded high positive direct effects were coupled with significant positive association of effective tillers per plant & high density grains per panicle with grain yield per plant in plant in their study with 20 lowland rice cultivars.

Eradasappa et al. (2007) in their Studies on path analysis suggested that selection based on the productive tiller per plants filled grain per panicle would be more useful for improvement of grain yield in hybrid rice, because of their high and positive direct effect on grain yield.

Habib et al. (2007) studied the path analysis on seven hybrid rice genotypes and reported that 1000-grain weight had the highest positive direct effect on grain yield. The highest positive indirect positive indirect effect on grain yield was recorded by panicle per plant days to maturity through 1000-grain weight.

Panwar, Dhaka, and Vinod Kumar (2007) carried out path analysis in 22 rice genotypes and observed that the grain yield panicle, days to 50% flowering, number of effective tillers per plant had the highest positive direct effect on grain yield. They suggested that, greater emphasis should be given for selection for these characters.

Karad and Pol (2008) working with rice, reported that the length of panicle had highest positive direct effect on grain yield whereas, the characters plant height, number of immature panicles and 1000-grain weight had the negative direct effect via indirect effect on grain yield per plot. They concluded that, length of panicle, total number of panicles, number of tillers per plant and number of mature panicles per sq. meter can be considered as the most reliable yield indicator in rice.

Kole, Chakraborty and Bhat (2008) working with rice reported that panicle number had the highest positive direct effect followed by grain number, test weight, plant height, days to flower and straw weight. The overall results indicated that selection favoring higher panicle number per plant, test weight and straw weight and medium plant height with a reasonable balance for moderate grain number would help to achieve higher grain yield in this population of aromatic rice.

Saravana and Sabesan (2009) studied path coefficient analysis on 46 genotype of rice for 14 traits. The analysis revealed that grain breadth, grain L/B ratio and the total number of tillers per plant had the highest direct effect on grain yield per plant, suggesting that the improvement in grain yield could be efficient if the selection is based on these component traits.

Jayasudha and Sharma (2010) studied on forty seven rice genotype including thirty three hybrids and fourteen parents and their path coefficient analysis revealed that productive tillers per plant had the highest positive direct effect on grain yield followed by harvest index, spikelet fertility (%), pollen fertility (%) and plant height.

Makwana and Jadeja et al. (2010) studied the path analysis with grain yield as dependent variable, which indicated high direct effect for plant height, grain length and head rice recovery; while the indirect effect were predominant for panicle length, test weight and grain breadth. The path analysis for quality components with kernel length after cooking, showed high direct effects of kernel length and kernel elongation ratio; whereas selection for kernel L/B ratio, water uptake, alkali score (gelatinizing temperature) and cooking time can indirectly improve the cooking quality.

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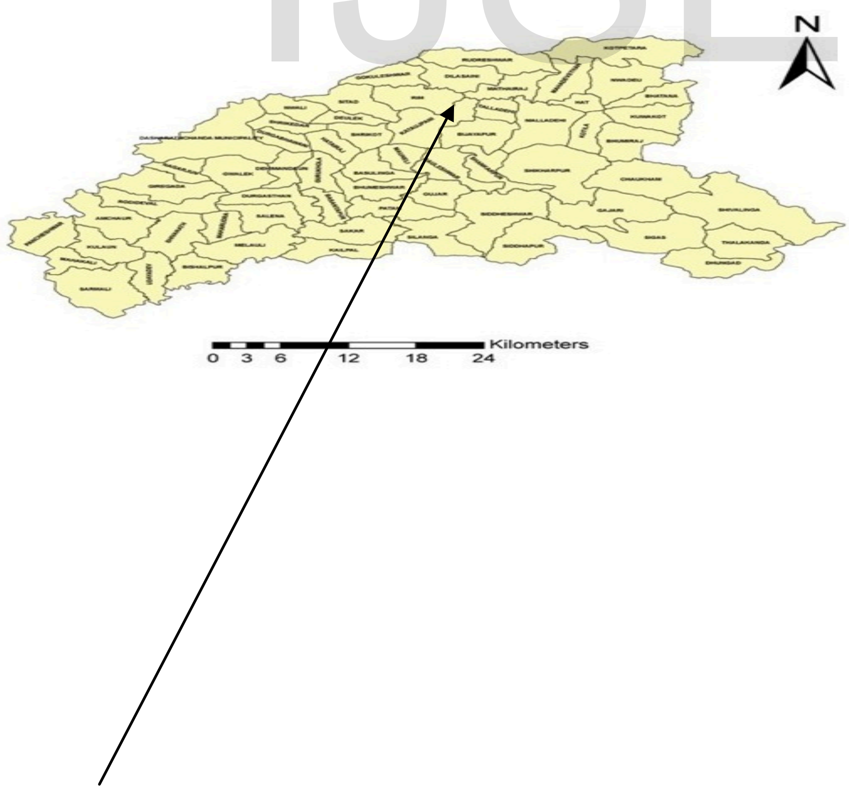
Wattoo and Khan et al. (2010) studies on 30 rice genotype, and their path analysis revealed that days to maturity had the highest direct effect (0.751) on grain yield per plant. In addition, the yield components had positive direct effect on grain yield except the days to heading (-0.834). The order of yield components was the number of productive tillers per plant, flag leaf area and 1000 grain weight.

II. MATERIALS AND METHODS

The present investigation was carried out during *Kharif (*2015-16) at Agricultural Research Farm, Agricultural and Animal Sciences College Gokuleshwor, Baitadi, which is situated at $25^{o}18'$ North latitude and $83^{o}03'$ East longitude and at altitude of 811 m from sea level. The soil of the experimental plot was fertile, Sandy loam. Details of the meteorological records during the period of experimentation are presented in the Appendix XII and XIII.



ISSN 2229-5518

Figure no 1: Google Maps of Research Site.

Experimental material

In the present investigation the experimental material comprised of 8 Local germplasm of rice (*Oryza sativa* L.) representing diversity for yield and yield attributing characters to irrigated condition. It was provided to me by Assistant Professor Ganga Ram Kohar , Department Of Genetics and Plant Breeding, Institute of Agricultural and Animal Sciences Paklihawa Campus, Tribhuvan University. The genotypes received from local farmer in the present study have been named as line numbers Li...Ln and their respective designation provided by farmer have presented in table -1.

TABLE NO 1

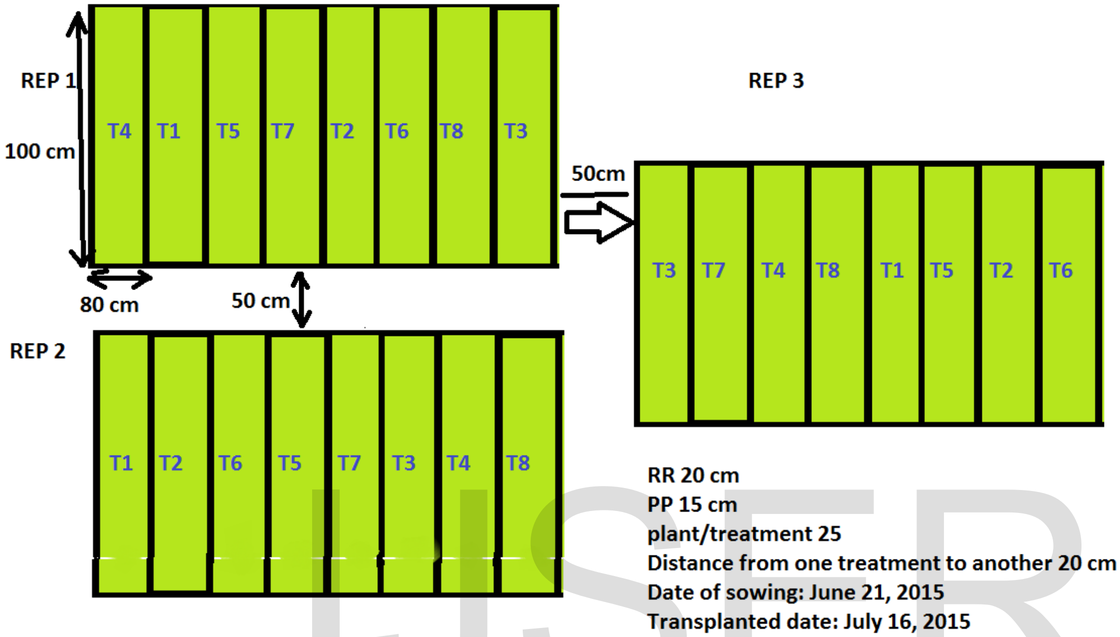
s. no.	Line number	Designation from farmer

ISSN 2229-5518

1	Line-1	Mansuli
2	Line-2	Pakistani
3	Line-3	Chiure
4	Line-4	Jhini Bashmati
5	Line-5	Kaljadha
6	Line-6	Jhini
7	Line-7	Shyam Zero
8	Line-8	Bikashe

Experimental method and layout

All the 8 genotypes were grown in *Kharif season* of 2015. The crop was sown under the irrigated upland condition on16th July, 2015. Eight genotypes were grown in Randomized Complete Block Design with three replications. Each plot consists of 80cm length and 100 cm breadth where row to row distance is 20 cm and plant to plant distance is 15 cm i.e (20 ×15 cm). The distance between two plots is 20 cm and distance between two replications is 50 cm. The fertilizers were applied at the rate of 100 kg N, 30 kg P2O5 and 30 kg K2O per hectare.



Observations

Five plants were randomly selected from each entry in each replication and their means were used for the statistical analyses. The plants were selected from the middle of the rows to learning border plant. Observations were recorded on grain yield and 10 yield attributing traits, the details of which are presented in table

Observations Record

Table 3.2: Details of yield and yield attributes recorded.

S.N.	Traits	Abbreviation	Description
1.	Number of tiller per plant	DF	Number of panicle bearing tiller counted and recorded.
2.	Vegetative plant height (cm)	VPH	Height of the plant from the ground to the tip of the tallest panicle at maturity excluding awns.
3.	Number of effective tillers per plant	TN	Number of panicle bearing tiller counted and recorded.
4.	Panicle length (cm)	PL	Measured from panicle collar to the tip of the panicle at maturity.
5.	Number of grains per panicle	G/p	Number of spikelets in the longest panicle.

ISSN 2229-5518

6.	Number of fertile grains per panicle	G/p	Number of well filled spikelets in the longest panicle.
7.	Grain length / breadth ratio	L/B	Length of the grain divided by breadth of the grain
8.	Test weight (g)	GW	. Weight of 250 grains taken on electronic balance and multiplied by 4 to obtain 1000-grains weight.
9.	Grain yield per plant (g)	GY/P	Weight of total filled grains per plant.

Analysis of variance

The mean of five plants for 10 different characters of each entry in each replication was used for the detailed statistical analysis. The data recorded on 10 quantitative traits and mentioned earlier were subjected to the analysis of variance, following Panse and Sukhatme (1995) and measure of mean, variance and genetic parameters were estimated as detailed below:

Source	df	SS	MSS	F value (Calculated)
Replication	r-1	SSr	$\frac{SSr}{(r-1)} = MSR$	
Treatment	t-1	SSt	$\frac{SSt}{(t-1)} = MST$	$\frac{MST}{MSE}$
Error	(r-1) (t-1)	SSe	$\frac{SSe}{(r-1)(t-1)} = MSE$	
Total	(rt-1)	TSS		

Where,

r = number of replications

t = number of treatments

df = degree of freedom

SSr = replication sum of square

SSt = treatment sum of square

SSe = error sum of square

TSS = Total sum of square

MST = treatment mean sum of square

MSR = replication mean sum of square

MSE = error mean sum of square

The significance of difference among the treatments was tested by comparing the calculated ‘F’ value with table value of ‘F’ at 5 and 1 percent level of significance at (t-1) and (r-1) (t-1) degrees of freedoms.

ISSN 2229-5518
Variability parameters such as Mean, range, standard error, coefficient of variation (CV), heritability and genetic advance were estimated for the different characters as follows:

Mean

The mean value of each character was determined by summing up all the observations and dividing them by corresponding number of observations.

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{N}$$

Where,

$\overline{X}$ = mean,

$\sum_{i=1}^{N} X_i$ = Sum of all observations

N = Number of observations

Range

The lowest and highest values for each character were taken as the range.

Standard error of difference between two means [S.E.d.(M)]

S.E.d.(M) was calculated with the help of error mean square from ANOVA table.

$$S.E.d.(M) = \sqrt{\frac{2M.S.E.}{r}}$$

ISSN 2229-5518

Where,

r = Number of replications

MSE = Mean sum of square due to error

Phenotypic and Genotypic Variances

Phenotypic and Genotypic coefficients of variation were calculated by the method suggested by Burton and Devane (1953):

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\text{Phenotypic Standard Deviation}}{\text{General Mean}} \times 100$$

$$= \frac{\sigma_p}{\bar{\bar{X}}} \times 100$$

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\text{Genotypic Standard Deviation}}{\text{General Mean}} \times 100$$

$$= \frac{\sigma_g}{\bar{\bar{X}}} \times 100$$

Heritability

It was calculated by the formula given by Allard (1960) which is as below:

$$H = \frac{\sigma_g^2}{\sigma_p^2}$$

Where,

H = Heritability in broad sense

$$\sigma^2_g = \text{Genotypic variance} = \frac{\text{MST - MSE}}{r}$$

$$\sigma^2_p = \text{Phenotypic variance} = \sigma^2_g + \sigma^2_e \quad \text{(MSE)}$$

Genetic Advance (Expected)

The genetic advance, i.e., expected genetic gain resulting from selecting five percent superior plants was estimated by the following formula suggested by Allard (1960):

$$\text{Genetic Advance (Expected)} = H \times \sqrt{\sigma_p^2} \times k$$

Where,

H = Heritability coefficient

$\sqrt{\sigma_p^2}$ = Phenotypic standard deviation

K = Selection differential in standard units which is 2.06 at 5% selection intensity.

Genetic advance as percentage of mean was calculated by the following formula:

$$\text{Genetic Advance as Percentage of Mean} = \left(\frac{GA}{\overline{X}}\right) \times 100$$

Where,

GA = Expected genetic advance

$\overline{X}$ = General mean of the character in the population

Correlation coefficient:

The simple phenotypic correlation coefficients among pairs of characters were calculated according to the formula suggested by Searle (1961).

$$r(X_1X_2) = \frac{\text{Cov}(X_1X_2)}{\sqrt{V(X_1) \cdot V(X_2)}}$$

Where,

X_1 = Character 1

X_2 = Character 2

ISSN 2229-5518

$r(X_1X_2)$ is the correlation between characters X_1 and X_2

Cov X_1X_2 is the covariance between X_1 and X_2

$V(X_1)$ is the variance of X_1

$V(X_2)$ is the variance of X_2

In the estimation of phenotypic correlation coefficients, phenotypic covariance and variance are considered for calculation.

To test the significance of correlation coefficients, the estimated values were compared with the table value (statistical table by Fisher and Yates, 1963) at n-2 degrees of freedom (where n denotes the number of genotypes tested) at 5% and 1% level of significance, respectively.

Path-coefficient analysis

Path-coefficient analysis was done to partition the total correlation into direct and indirect effects due to the dependent variable. S. Wright (1934) suggested this analysis and it was further elaborated by Dewey and Lu (1959).

Path-coefficient is the ratio of standard deviation of the effect due to a given cause to the total standard deviation of the effect, i.e., if grain yield per plant (Y) is the function of the causal factor X_1, then path co-efficient for the path from causal factor X_1 to the effect Y is $\sigma X_1 / \sigma Y$.

In other words, it is a standardized partial regression coefficient, which individually provides a measure of direct effect of the causal factor or independent variables on the dependent variable. These permit partitioning of the correlation between the causal factor and the effect of variable into components of direct and indirect effects and this makes the association of causal factor with the effect of variable more clear.

Here, grain yield per plant (Y) was taken as effect of the other characters like days to 80% maturity, total number of tillers per plant, plant height, 1000-grain weight and chlorophyll content.

The path-coefficients were obtained by solving a set of simultaneous equations of the form:

$$r_{X_1Y} = P_{X_1Y} + r_{X_1X_2}P_{X_2Y} + r_{X_1X_3}P_{X_3Y} + ... + r_{X_1X_6}P_{X_5Y}$$

$$r_{X_2Y} = r_{X_2X_1}P_{X_1Y} + P_{X_2Y} + r_{X_2X_3}P_{X_3Y} + ... + r_{X_2X_6}P_{X_5Y}$$

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$$r_{X_5Y} = r_{X_5X_1}P_{X_1Y} + r_{X_5X_2}P_{X_2Y} + r_{X_5X_3}P_{X_3Y} + ... + r_{X_5Y}$$

Where,

r_{X_1Y} to r_{X_5Y} denotes coefficient of correlation between independent characters X_1 to Y_5 and dependant character Y.

$r_{X_1X_2}$ to $r_{X_4X_5}$ denotes coefficient of correlation between all possible combinations of independent characters.

P_{X_1Y} to P_{X_5Y} denotes direct effects of character X_1 to X_5 on Y.

The solutions for path-coefficients, direct and indirect effects of the causal factor were calculated as per the values of right hand side of equation.

Indirect effect : = $r_{ij} . P_{ij}$

i = 1……n

j = 1…..n

and P_{ij} = P_{1Y}, P_{2Y}, P_{3Y} ….. P_{ny}.

The residual factor (P_{RY}) i.e. the variation in yield unaccounted for causal effects under consideration or the path values for residual effect was calculated as follows:

Residual factor (P_{RY}) = $\sqrt{1 - R^2}$ Where, $\left(R^2\right) = \sum_{i=1}^{5} P_{X_1Y} r_{X_5Y}$

$$= \sqrt{1 - \left(P_{1Y} r_{1Y} + P_{2Y} r_{2Y} + ... + P_{iY} r_{iY}\right)}$$

Where,

P_{RY} = Residual effect

P_{iY} = Direct effect of X_i on Y

r_{iY} = Correlation coefficient of X_i and Y.

ISSN 2229-5518

R^2 is the coefficient of determination and is the amount of variation in yield and that can be accounted for the yield component trait. Path-coefficient at phenotypic level was calculated using phenotypic correlation coefficient.

III. RESULTS AND DISCUSSION

Results and discussion in the present study have been presented under the Experiment -I

Experiment-I: It comprised of study on variability parameter, correlation and path analysis in Kharif season of 2015 among 8 germplasm lines of rice.

Experiment-I: In Kharif 2015, a set of 8 germplasm of rice genotypes was assessed for variability, heritability, genetic advance, correlation and path-coefficients. The results obtained are presented under the following heads:

- Analysis of variance
- Variability, heritability and genetic advance
- Character association
- Path-coefficient analysis

Analysis of variance

The analysis of variance for 10 quantitative traits including grain yield and its related traits in the present set of 8 rice genotypes is presented in Table 1. It is evident from the analysis of variance that the treatment (genotype) differences were highly significant for all the traits under study. This suggested that there is an inherent genetic difference among the genotypes. Significant variability for various traits in a different set of germplasm were also reported by many rice workers in their experimental material (Shobha Rani et al., 2001; Pandey and Awasthi, 2002; Akter et al., 2004 and Singh et al., 2007). Significant differences for characters in the present set of germplasm suggest a positive scope of improvement through simple selection.

ISSN 2229-5518

Table 1. Analysis of variance (ANOVA) for 10 characters in 8 germplasm lines of rice

Source	Df	Tillers/plant	Vegetative plant height	plant height at maturity	Flag leaf length	Grains /panicle	Fertile Grains /panicle	Length breadth ratio	Test weight	Grain yield/plant
Replication	2	0.254480	11.120000	66.795010	12.301250	6.106670	197.855000	0.381547	1.166667	17.758710
Treatment	7	0.0034 **	0.0011 **	0.0003 ***	0.0335 *	0.0000 ***	0.0001 ***	0.0021 **	0.0002 ***	0.0142 *
Error	7	0.236622	13.941901	76.105478	43.103628	303.963802	287.645545	0.142022	4.500000	24.970739

(1) **Variability , heritability and genetic advance**

The *per se* performance (mean) of genotypes for all the 10 quantitative traits have been presented in Appendix-I. The estimates of range, mean, phenotypic coefficient or variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance are presented in Table 2.

Wide range of variation was observed for all the quantitative traits under study indicating enough scope for bringing about improvement in desirable direction. Genotypes which recorded lowest and highest values for different traits are as follows:

Range and mean

The upper limit of range for various characters under study was exhibited by different genotypes. However, genotypes which recorded highest values for more than one character were line 1, line 4 and line 8. The highest flag leaf length (49.50 cm) and panicle length (29.60 cm) were recorded in line 1. In line 4 the highest values of vegetative plant height (80.56 cm), plant height at maturity (144.73), number of grains per panicle (193.06) and number of filled grains per panicle (170.66) were recorded. Similarly, line 8 produced the highest number of tillers per plant, length breadth ration and grain yield (g/plant) and the values for these attributes were 10.26, 3.90 and 30.69, respectively. On other hand genotypes which recorded lowest values for more than one characters were line 2, line 3, line 4 and line 6. The lowest vegetative plant height (61.60 cm), plant height at maturity (102.40 cm), flag leaf length (28.16 cm) was recorded in line 2. In line 3 the lowest values of number of grains per panicle (75.80), number of fertile grains per panicle (67.73), length breadth ratio (2.11) and grain yield per plant (13.65 g) were recorded. Line 4 produced the lowest number of tillers per plant (8.46); test weight (20.00) and the lowest values of panicle length (22.20) and test weight (20.00 g) were recorded in line 6.

A wide rang was observed for grain yield per plant, number of grains per panicle, number of grains per panicle and number of tillers per plant compared to other characters. This suggests that there is high contribution of positive and negative genes among the genotypes exhibited higher and lower values for these characters. The cross among distant genotypes may be expected to exhibit high heterosis through desirable segregation in later generation of hybridization.

Genotypes which recorded lowest and highest mean performance for various characters under study are listed here below.

Traits	**Genotype with lowest value**	**Genotype with highest value**
Number of tillers per plant	Line4	line 8
Vegetative Plant height (cm)	line 2	line 4
Plant height at maturity	line 2	line 4
Flag leaf length	line 2	line 1
No of grains per panicle	line 3	line 4
No of fertile grains per panicle	line 3	line4
Panicle length	line 3	line 1

Grain length/breadth ratio	line 3	line 8
Text weight	line 4	line 3
Total yield per plant	line 3	line 8

Phenotypic and Genotypic Coefficient of Variation

A perusal of the data in Table 3 reveals considerable variation for all traits under study with a wide range of phenotypic as well as genotypic coefficient of variation. In general, as could normally be expected, the values of phenotypic variance were higher than those of genotypic variance for all the traits. The relative magnitudes of the phenotypic as well as genotypic variances between the traits were compared based on the phenotypic and genotypic coefficient of variation.

Phenotypic coefficient of variation was highest for grains yield per plant followed by number of fertile grain per panicle, flag leaf length, length breadth ratio and text weight exhibited moderate high phenotypic coefficient. Lowest magnitude of phenotypic coefficient of variation was exhibited panicle length. All other traits exhibited considerable values of phenotypic coefficient of variation. The results are in accordance with the findings of other researchers (Bai and Tran, 1991; Chaubey and Singh, 1994; Panwar and Sarma, 1995).

Genotypic coefficient of variation was also high for fertile grain per panicle followed by grain per panicle, grains yield per plant and length breadth ratio. Similarly lower magnitude of coefficient of variation was exhibited by panicle length and number of tiller. The differences between the values of PCV and GCV were small for almost all the traits indicating less influence of environment in expression of these traits. This difference was comparatively smallest in case of Plant height at maturity, panicle length and test weight. Coefficient of variation with high heritability and genetic advance as percent mean was observed for grains/panicle, fertile grain per panicle which indicates additive gene action and good scope for selection followed by text weight and grain yield per plant. Kumar et al. (1998) also suggested that high GCV along with heritability and genetic advance gave better picture for selection of the parents. Similar results were also reported by Tripathy et al. (1999), Yadav (2000) and Patra et al. (2006).

Heritability

Estimates of heritability for the 10 traits under study are presented in Table 3. Broad sense heritability estimate was highest for no of grains per panicle followed by fertile grain and **Plant** height at maturity. High heritability values were also recorded for test weight, plant height at maturity and vegetative plant height. Lowest heritability was for flag leaf length. The heritability was ranged from 80.5%to 41.3%. The estimates for different characters indicated that variation observed in these characters is primarily due to genetic causes and very less by environmental effects. Similar results were reported by Saravanan &Senthil (1997) for days to 50% flowering, plant height and test weight (Ali et al., 2000).

Genetic advance

Estimate of genetic advance was highest for number of grains per panicle, followed by plant height. Lowest genetic advance was observed for grain L/B ratio .Genetic advance as percent of mean was, however, highest for no of grains per panicle followed by grain yield per plant. Considerably high magnitude of genetic advance as percent of mean was also observed for no of grain per panicle followed by plant height and number of tiller .Low magnitude of genetic advance as percent of mean was observed for L/B ratio and panicle length. High heritability coupled with high genetic advance as percent mean was observed for number of grains per panicle and grain yield per plant which indicate the control of additive gene of action and a greater scope of selection for these two traits. Similar result was observed by Sabesan et al. (2009) for grain yield per plant, test weight and number of effective.

High heritability and high genetic advance may be attributed to additive gene action. Khan (1990) suggested that high heritability and high genetic advance may be due to mainly additive gene action and under the circumstance advocated simple plant selection for genetic for genetic improvement.

A high estimate of both phenotype and genotypic coefficient of variation was observed for grain yield per plant indicating their importance in selection for improving the yield. Similarly, Anjaneyulu, Reddy (2010), Mahto,Yadav &Mohan (2009), Singh, Kumar & Machhavi Latha (2007) studied on 50 germplasm lines of rice and reported high PCV and GCV values for number of grains per panicle, and grain yield per plant.

ISSN 2229-5518

Table 2. Variability parameter for 10 quantitative traits in8 genotypes of Rice on 2015

Traits	Tillers/plant	Vegetative plant height (cm)	Plant height at maturity (cm)	Flag leaf length (cm)	Grains /panicle	Fertile Grains /panicle	Panicle Length (cm)	Length breadth ratio	Test weight (g)	Grain yield/plant (g)
Range	8.46-10.26	61.60-80.56	102.40-144.73	28.16-49.50	75.80-193.06	67.73-170.66	1.25-1.23	22.00-26.90	20.00-30.66	13.65-30.69
Mean	9.15	69.22	127.95	37.55	149.09	128.77	23.91	3.062	22.91	24.30
SEM (±)	0.236	13.941	76.105	43.103	303.963	287.645	0.142	4.500	24.970	24.970
PCV (%)	8.39	9.31	12.98	22.82	26.49	27.70	7.68	20.19	18.25	28.89
GCV (%)	6.49	7.59	11.05	14.67	23.77	24.37	6.13	16.01	15.73	20.29
Heritability (%)	0.59	0.66	0.72	0.41	0.80	0.77	0.63	0.62	0.74	0.49
Genetic advance (K=2.06)	1.21	11.31	31.78	9.35	83.96	72.91	3.08	1.02	8.20	9.14

Genetic advance(% of mean)	13.28	16.35	24.84	24.90	56.31	56.62	12.90	33.51	35.80	37.64

2. Character Association

The simple correlation coefficients (phenotypic) between yield and its related characters were estimated and the results are presented in Table 3. The observations on phenotypic correlation coefficients are described here under.

Number of tiller exhibited positive and significant association with test weight, positive and non significant association with length breadth ratio and grain yield/plant. It showed negative and non significant association with vegetative plant height, plant height at maturity, panicle length, number of grains per panicle, fertile grain per panicle. Similar observation in rice has been reported by Ray and Srivastava (1994), Ganesan et al. (1997), Marker & Siddiqui (1996).

Vegetative plant height showed the positive significant association with plant height at maturity positive and non significant association with panicle length, number of grains per panicle, fertile grain per panicle, length breadth ratio. All other association of plant height with most of other characters were non significant. Test weight shows negative and non significant. Similar results were also reported by Chaudhary and Das et al. (1992), Shivani & Reddy et al. (2002).

Plant height at maturity had positive and significant correlation with flag leaf length, number of grain per plant, fertile grain per plant and length breadth ratio. It had negative and significant association with test weight .Rest of the association of panicle length and grain yield per plant were non significant. The results were reported by Surek and Beser (2003), Nandan, Sweta & Singh (2010) suggested days to 50% flowering and number of grains per panicle.

Flag leaf length showed positive and significant correlation with number of grain per panicle, panicle length, fertile grain per panicle and test weight and rest of two show non significant.

No of grain per panicle showed positive and significant correlation with fertile grain per panicle and Length breadth and non significant correlation with panicle length and grain yield per plant except negative and significant association with test weight. Number of grain per panicle had non significant association with rest of the characters. Biswas et al. (1992) reported significant association of number of grains per panicle with other characters.

Fertile grain per panicle showed positive and significant correlation with L/B ratio, panicle length and grain yield per plant.

Panicle length exhibited non positive and significant correlation with L/B ratio and grain yield per plant while negative and non significant association with test weight.

L/B ratio showed positive and non significant correlation with test weight and grain yield per plant but while other character had negative and significant correlation. Test weight had no positive and significant correlation with grain yield per plant.

Karad & Pol (2008) observed that the grain yield had positive correlation with almost all the character at phenotypic level. The grain yield per plant had a non significant association with plant height and panicle length at phenotypic level. Similar type of non significant of the traits except effective tiller per plant with grain yield per plant was reported by Reddy et al. (1997) and Balan et al. (1997). The grain yield per plant had negative non significant association with number of effective tiller per plant, L/B ratio. Similar types of results were reported by Nandan et al. (2010) for character like panicle length, test weight, and panicle length.

The result on correlation study suggested that the character like number of grains per panicle and number of effective tiller which had positive association with yield may be taken in to account in rice breeding program for yield improved in the present set of rice germplasm. Among other yield component traits no of grains per panicle and test weight can be improved by selecting for either character since they exhibited positive association.

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Table 3. Estimation of phenotypic correlation coefficient between yield and it component character from 8 germplasm of rice 2015

S. N.	Character	Tillers/plant	Vegetative plant height	Plant height at maturity	Flag leaf length	Grains /panicle	Fertile Grains /panicle	Panicle length	Length breadth ratio	Test weight	Grain yield /plant
1	**Tillers/plant**		-0.2068	-0.2068	-0.3930	-0.3773	-0.3563	-0.0935	0.0298	0.4406 *	0.2063
2	**Vegetative plant height**			0.5885 **	0.3276	0.2883	0.2898	0.1887	0.3159	-0.2648	0.0200
3	**Plant height at maturity**				0.7740 ***	0.5321 **	0.4714 *	0.3435	0.4050 *	-0.7005 ***	0.3004

4	**Flag leaf length**	0.5273 **	0.4579 *	0.5416 **	0.2019	0.5576 **	0.2049
5	**Grains /panicle**		0.9833 ***	0.3254	0.6602 ***	-0.7340 ***	0.7301
6	**Fertile Grains /penicle**			0.2675	0.6111 **	-0.6904 ***	0.7099
7	**Penicle lenght**				0.3043	-0.2828	0.2164
8	**Length breadth ratio**					0.2164	0.6970

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9	**Test weight**	- 0.405 7

(2) Path-coefficient analysis

The correlation coefficient between grain yield per plant and its six main component characters *viz.* number of tiller, vegetative plant height, plant height at maturity, panicle length, length flag, leaf number of grains per panicle, fertile grains per panicle, length breadth ratio, test weight were partitioned into their corresponding direct and indirect effects through path-coefficient analysis. The estimates of the path-coefficient for the different attributes on the grain yield are presented in table 4. The cause and effect relationship is diagrammatically represented in figure 1. The traits namely days to 50% flowering, number of effective tillers per plants, panicle length, number of grains/panicle, test weight exhibited direct positive effect on grain yield of varying magnitude. The character wise indirect contributions are discussed below. These finding were in agreement with the findings of Akter et al. (2004) for days to maturity, Reuben and Katuli (1998) for panicle length, Girolkar et al. (2008) and Shanthala et al. (2004) for test weight on grain yield per plant. The traits like plant height and total number of tillers per plant exhibited direct negative effect on grain yield. These finding were in agreement with the earlier report of Amrithadevathinam (1983) and Shavini and Reddy (2000).

Number of tiller

The direct effect of days to number of tiller was positive with high magnitude. Its indirect effects through grain yield and test weight were positive and high but the magnitude was low with length breadth ratio. It had negative and high effects with plant height at maturity, grains/panicle and fertile grains/panicle while the negative and low effects were found with number of tillers/plant.

Vegetative plant height

The direct effect of vegetative plant height was positive with high magnitude. Its indirect effects through test weights and grain yield were positive and low. It had negative and high effects with length breadth ratio, flag leaf length and plant height at maturity while the negative and low effects were found with number of grains/panicle, flag leaf length and panicle length.

Plant height at maturity

The direct effect of plant height at maturity was positive with high magnitude. Its indirect effects through vegetative plant height, flag leaf length, grains/panicle, fertile grains/panicle, panicle length and length breadth ratio were positive and high. It had negative and high effects with number of tillers/plant and test weight.

Flag leaf length

The direct effect of flag leaf length was negative with high magnitude. Its indirect effects through number of tillers/plant, test weight and grain yield were positive and high. It had negative and high effects with plant height at maturity, grains/panicle and panicle length while the negative and low effects were found with vegetative plant height and length breadth ratio.

Number of grains/panicle

The direct effect of number of grains/panicle was positive with high magnitude. Its indirect effects through fertile grains/panicle, length breadth ratio, grain yield per plant, panicle length, flag leaf length and vegetative plant and plant height at maturity were positive and high. It had negative and high effects with number of tillers/plant and test weight.

Fertile grains/panicle

The direct effect of fertile grains/panicle was negative with high magnitude. Its indirect effects through grain yield were positive and high. It had positive and low effects with panicle length, fertile grains/panicle, flag leaf length, grains/panicle, plant height at maturity, vegetative plant height and number of tillers/plant while the negative and low effects were found with test weight.

Panicle length

The direct effect of panicle length was positive with low magnitude. Its indirect effects through grain yield were positive and high. It had positive and low effects with length breadth ratio, fertile grains/panicle, vegetative plant height and plant height at maturity while the negative and low effects were found with test weight and number of tillers/plant.

Length breadth ratio

The direct effect of length breadth ratio was positive and medium. Its indirect effects through grain yield were positive and high. It had positive and low effects with panicle length, fertile grains/panicle, grains/panicle, flag leaf length, plant height at maturity, vegetative plant height and number of tillers/plant while the negative and low effects were found with test weight.

Test weight

The direct effect of test weight was positive and medium. Its indirect effects through number of tillers/plant were positive and high. It had negative and high effects were found with grain yield per plant, length breadth ratio, flag leaf length, fertile grains/panicle and plant height at maturity while the negative and low effects with test weight.

Table 4. Path coefficient in terms of direct and indirect effects of 10 component traits on grain yield /plant 8 germplasm of rice 2015

N	Character	**Tillers/plant**	**Vegetative plant height**	**Plant height at maturity**	**Flag leaf length**	**Grains /penicle**	**Fertile Grains /penicle**	**Panicle lenght**	**Length breadth ratio**	**Test weight**	**Grain yield /plant**
	Tillers/plant	**0.4157**	-0.0860	-0.1361	-0.1634	-0.1568	-0.1481	-0.0389	0.0124	0.1831	0.2063
	Vegetative plant height	0.0679	**-0.3285**	-0.1933	-0.1076	-0.0947	-0.0952	-0.0620	-0.1038	0.0870	0.0200
	Plant height at	-0.1542	0.2771	**0.4709**	0.3645	0.2506	0.2220	0.1618	0.1907	-0.3298	0.3004

maturity										
Flag leaf lenght	0.1187	-0.0989	-0.2337	**-0.3020**	-0.1592	-0.1383	-0.1635	-0.0610	0.1684	0.2049
Grains /penicle	-0.5067	0.3872	0.7146	0.7081	**1.3430**	1.3205	0.4370	0.8867	-0.9858	0.7301
Fertile Grains /penicle	0.1090	-0.0886	-0.1442	-0.1400	-0.3007	**-0.3058**	-0.0818	-0.1869	0.2111	0.7099
Penicle length	-0.0016	0.0032	0.0059	0.0093	0.0056	0.0046	**0.0171**	0.0052	-0.0048	0.2164
Length breadth	0.0044	0.0466	0.0597	0.0298	0.0974	0.0901	0.0449	**0.1475**	-0.0823	0.6970

ratio										
Test weight	0.1531	-0.0920	-0.2433	-0.1937	-0.2550	-0.2399	-0.0982	-0.1939	**0.3474**	-0.4057

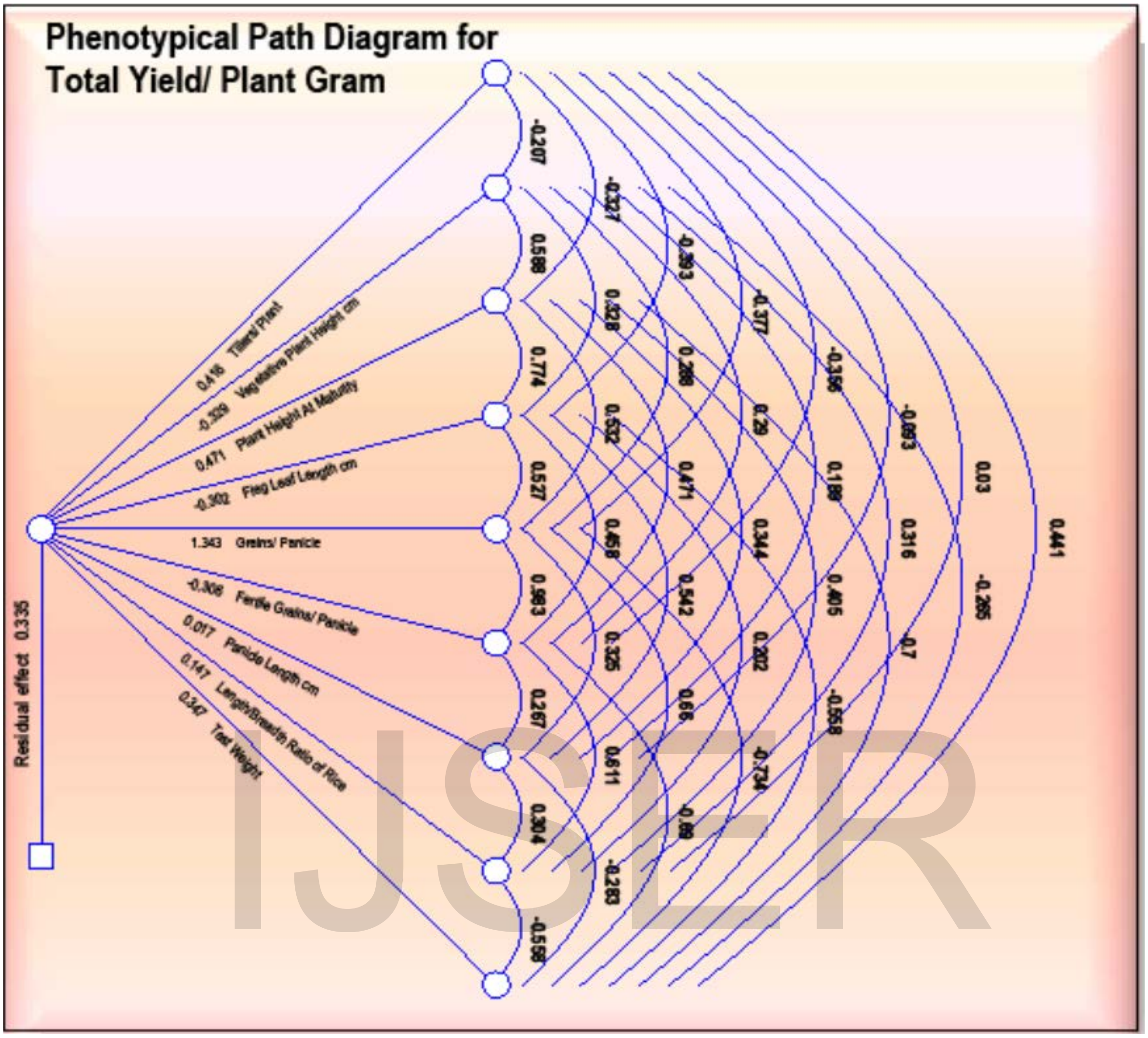

Fig. 1. Path diagram

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2166
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IV. SUMMARY AND CONCLUSION

The present investigation entitled "*variability, correlation and path coefficient analyses in rice (Oryza sativa L.)*", was conducted during the Kharif season of 2015 with the broad objective of identifying potential genotypes based on their genetic distances for utilization in crossing programs to develop suitable varieties. The results obtained during the investigation are presented as under:

- A wide rang was observed for grain yield per plant, number of grain per panicle and number of effective tillers per plant compared to other characters.
- No of grain /panicle exhibited higher value of GCV, accompanied by high heritability and genetic advance as per cent of mean, which indicates additive gene action.
- The highest estimate of phenotypic coefficient of variation was observed for number of grains per panicle followed by grain yield per plant and no of effective tiller
- Genotypic coefficient of variation was highest for test weight followed by grain yield per plant and grains per panicle.
- A high estimate of both phenotypic and genotypic coefficient of variation was observed for grain yield per plant.
- Highest value of broad sense heritability was obtained for test weight followed by grain breadth.
- Number of tillers per plant, no of grains per panicle showed strong positive and significant association with grain yield per plant to phenotypic levels.

- The grain yield per plant had a positive and significant association with no of effective tiller at phenotypic level.
- Panicle length, no of grains per panicle, effective tiller and test weight exhibited positive direct effect on grain yield.
- The traits like number of effective tillers per plant had positive and significant association while no of grains per panicle, panicle length and test weight had resulting into a considerable positive and non significant association with grain yield.
- In case of grains per panicle, the indirect effect via other traits on grain yield were very small (negligible)

Based on the aforementioned results it can be concluded that selection for the characters which were widely varied among genotypes would be more effective to bring simultaneous improvement for yield and yield components of rice. The path analysis suggested that grains per panicle and filled grains per panicle were main contributors towards association with grain yield. Therefore, selection based on these two traits under irrigated conditions for improvement in grain yield seems to be effective.

The direction and magnitude of association indicated that the grain yield of rice in irrigated conditions can be improved by selecting germplasms having higher performances for yield attributing traits. The results on correlation study in the present set of germplasms suggested that the characters like effective tillers per plant, no of grains per panicle may be taken in to account in rice breeding programs for yield improvement under irrigated conditions.

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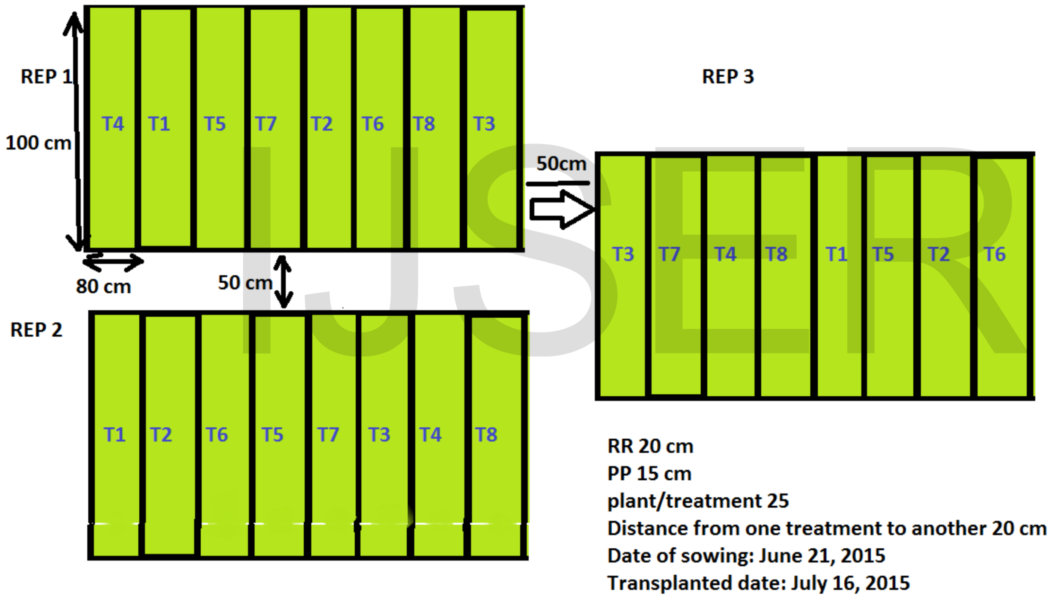
VI. APPINDICES

Appendix 1: Details of plant materials(genotypes) used in research

Appendix 2 : Layout of research plot



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