“Screening of Stable Wheat Genotypes for Morpho-Physiological and Quality Attributes under different Environments”

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By

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2015

CERTIFICATE - I

This is to certify that the thesis entitled **"Screening of Stable Wheat Genotypes for Morpho-Physiological and Quality Attributes under different Environments"** submitted in partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY in AGRICULTURE** (**PLANT BREEDING AND GENETICS)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mrs. MONIKA SINGH** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

All the assistance and help received during the course of the investigation has been acknowledged by her.

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Chairman of the Advisory Committee

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The matter embodied in the thesis has not been submitted for the award of any other degree / diploma. Due credit has been made to all the assistance and help.

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Place

Date (**MONIKA SINGH**)

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LIST OF ABBREVIATIONS

%	:	Percentage
±	:	Plus or minus
$\sqrt{\ }$	:	Square root
√	:	Right
Σ	:	Summation
&	:	and
^{0}C	:	Celsius
CTD	:	Canopy thermometer depression
CD	:	Coefficient of dispersion
CC	:	Chlorophyll content
cm	:	centimeter
ml	:	milliliter
g/l	:	gram per liter
et al.,	:	And others
g	:	Gram
Gk	:	Greek
i.e.	:	That is
G X E	:	Genotype and environment interaction
E1	:	Environment First (timely sown 1st year)
E2	:	Environment Second (late sown 1st year)
E3	:	Environment Third (very late sown 1st year)
E4	:	Environment Fourtht (timely sown 2nd year)
E5	:	Environment fifth (late sown 2nd year)
E6	:	Environment sixth (very late sown 2nd year)

Env	:	Environment
Lin.	:	linear
Min.	:	Minimum
Max	:	Maximum
MSW	:	Meteorological Standard Week
No.	:	Number
RWC	:	Ralative water contain
SD	:	Standard Deviation
SE	:	Standard Error
viz;	:	Namely
via	:	by a
vs	:	Versus
Var.	:	Variance
wt.	:	Weight
$\bar{X}$	:	Mean
R^2	:	coefficient of determination
βi	:	Regression coefficient
S^2di	:	Deviation from regression
SDS	:	Sedimentation value
$\hat{Y}$	:	Yield per plant (intercept)

INTRODUCTION

Globally, wheat is the leading source for human food, having second position after rice in terms of total production tonnages and number one food grain consumed directly by human beings. It is estimated that more than 35 per cent of the world population depends on wheat [Borlaug, 1968, Johnson et al. 1978]. It has been considered as the “versatile cereal food” also described as the “Stuff of life” or “king of cereals” for centuries. Continues to retain this pride of place with its roots ramifying into the depths of human culture, has an evolutionary history parallel with the history of human civilization itself. Even today, it occupies primary position among all the cereal crops due to its feeding boon to mankind. As wide adaptation to diverse agro-ecological conditions, storability, and its complex chemical composition, are main attributes that have made wheat the most widely used cereal not only in agriculture but also in food processing industries. Wheat also holds its importance in global trading, occurs world-wide, and is now more dynamic than ever. Wheat was a key factor enabling the emergence of city-based societies at the start of civilization because it was one of the first crops that could be easily cultivated on a large scale, and had the additional advantage of yielding a harvest that provides long-term storage of food.

Wheat is the dominant crop in temperate countries, which is favorably adapted to cool and dry environment. The major production is concentrated between 30^0 and 60^0 N and 27^0 and 40^0 S latitudes [Nuttenson, 1955). In India, it is mostly grown in plains, in the northern hilly region of Himalayas and Nilgiries & Palani hills of southern India. At globe, India ranked second in wheat production with a level of 80.7 million tones that is approximate 12% of the global wheat production (Singh et al. 2012). India cultivates three species of wheat *viz.,* dicoccum, (*Triticum dicoccum* (Schrank) (schulb), macaroni (*Triticum durum* def.) and bread (*Triticum aestivism* L.). Globally, *aestivum* wheat is most important species which covers 90 per cent of the area. *Durum* is the second most popular

species, which covers about 9 per cent of the total acreage. The *T*. *diccoum* and *T*. *monococcum* cover less than the one per cent of the total area.

Wheat compares well with other cereals in nutritive value with a good nutritional profile of 12.1 per cent protein, 1.8 per cent lipids, 1.8 per cent ash, 2.0 per cent reducing sugars, 6.7 per cent pentose, 59.2 per cent starch, 70 per cent total carbohydrates and provides 314K cal/100g of food. It is also a good source of minerals and vitamins *viz*., calcium (37 mg/100g), iron (4.1 mg/100g), thiamine (0.45mg/100g), riboflavin (0.13mg/100g) and nicotinic acid (5.4mg/100mg) (Lorenz and Kulp, 1991) as it supplied more nutrients. Wheat grain is a staple food used to make flour, as it contains a high amount of gluten and the protein that provides the elasticity necessary for excellent leavened, flat and steamed breads. Hard wheat is high in protein (10-17%) and yields a flour rich in gluten, making it particularly suitable for yeast. Low-protein (6 to 10%) softer type yields flour lower in gluten and therefore, better suited for tender baked products, such as biscuits, pastries and cakes. Wheat, although high in gluten, is not suitable for baking, but suitable for semolina, the basis for excellent pasta, such as spaghetti and macaroni preparation. It is also used for fermentation for production beer, alcoholic beverages or bio-fuel.

Present and predicted shifts in the composition and trading figures of the wheat export market, are strongly associated to economical and social (agricultural reforms, rural-urban population balance, labor force composition, food habits) changes occurring in mainly developing and emerging countries; the urban population shows an steady increase, so is the demand for convenience and novel food products. The wheat processing industry is becoming more efficient and versatile, and therefore requires more specific quality characteristics to produce distinct flour and food types. Wheat grades and classes have to be developed for further refined, to market wheat with specific and, above all, more uniform quality attributes.

Therefore in order to maintain wheat production in agreement with growing population and consumers' demands, wheat-producing countries

need to become more efficient in developing wheat cultivars possessing high productivity as well as specific quality attributes. On the other hand, there are nutritional and health issues associated with the food consumption of wheat. In the first case, the still large use of wheat as the main source of nutrients, particularly by the rural populations of South Asia regions, makes it necessary to enhance (naturally or artificially) the nutritional value of wheat-based foods consumed by the more vulnerable (rural and urban-poor) part of the population. In India, it is one of the major cereal crop on which food security rests for serving the ever increasing population of the nation. Since 2000, India has struggled to match the record production figure and thus faces a critical challenge in maintaining food security for its growing population. The current major challenges facing future wheat production in India are increasing heat stress, dwindling water supplies for irrigation etc (Joshi et al. 2007). Damage caused by temperature extremes and drought could be minimized or eliminated by framing strategy to develop thermo tolerance genotypes during early growth period and heat stress tolerance genotypes during grain filling stages. There is continuous increase in demand of wheat grain to feed the increasing population of about 109 million tonnes of wheat is to be needed to feed its projected population of 1.4 billion by 2020 AD.

Madhya Pradesh is the third largest producer state of wheat with 16.10 million tonnes from the 5.40 million hectares area (Anonymous, 2013). Wheat cultivation in Madhya Pradesh is characterized by the prevalence of high temperatures during the crop growth period. This is mainly due to the fact that large area of wheat (70 %) is grown under rainfed conditions and only a small part of the growing period experiences the cool climate. Very often the crop is exposed to terminal heat stress causing potential yield loss. However, to fulfill the task of meeting the increasing demand of wheat and changing circumstances there is an urgent need to breed the high yielding wheat genotypes tolerant to high temperature and low moisture stress coupled with good quality and suitable under semi irrigation.

Prevalence of such a high temperature stress during the latter crop growth stages affects the quality of produce, which will lead to reduction in

premium market and industrial price. Plant breeders are engaged in crop improvement programms which often desire to develop genotypes, adapted to wide range of environments along with optimum nutritive value.

The current investigation was carried out to determine the potential and promising wheat genotypes with stable yield performance along with quality index under different agro climatic conditions. Furthermore, selection based on only yield is misleading. Thus, for effective selection, information on nature and magnitude of variation in population, association of character with yield and among themselves and the extent of environmental influence on the expression of these characters are necessary (Yagdi 2009; Tsegaye et al. 2012). Variability in the base population is essential for any successful breeding progamme. Quantum of genetic variability and the extent to which heritable and non-heritable variation are related to the characters determine the extent of genetics amelioration.

The task of breeder is to screen out genotypes planted at different interval enables the selection of those genotypes which are suitable for wider range of planting. Information on phenotypic stability is useful for the selection of crop varieties as well as for breeding programs.

The phenotypic performance of a genotype is not necessarily the same under diverse agro climatic conditions (Ali et al. 2003). Same genotypes may perform well in certain environment, but, fail in several others. Genotype-environment interaction is extremely important in the development and evolution of plant varieties because they reduce the genotypic-stability values under diverse environments (Herbert et al. 1995). Hence a study of genotypic-environment interaction can lead to successful evolution of wheat cultivars for stability in yield performance across environments.

Partitioning of phenotypic and genotypic variation, environmental variation, idea of heritability, multiple regression analysis, association between traits and path coefficient analysis is an essential feature of breeding programme.

Keeping in this view the aforesaid problems and prospects, the present investigation has been planned under different environments with the following objectives:-

Objectives:

- To estimate genetic parameters for yield and quality attributes.
- To find out association among traits under study.
- To estimate direct and indirect effect of yield and quality attributing traits on seed yield.
- To estimate importance of characters through multiple regression analysis.
- To identify potential and stable wheat genotypes suitable for different environments.

REVIEW OF LITERATURE

A thorough understanding of genetic diversity, extent of variation, genetic architecture of plant and heritability of characters among the genotypes, stable performance in different environments would help in developing sound plant improvement program. A brief review of available information on the above aspects in wheat is presented in this section under the following headings.

2.1. Genetic variability

2.2. Heritability, Genetic advance

2.3. Correlation coefficient analysis

2.4. Path coefficient analysis

2.5. Multiple regression analysis

2.6 Stability analysis

2.1 Genetic variability

The presence of genetic variability is a pre requisite in any breeding programme for the improvement of any crop plant. The phenotypic variability expressed by a genotype or a group of genotypes in any species can be partitioned into genotypic and phenotypic components. The genotypic component being the heritable part of the total variability, it's magnitude on yield and its component characters influences the selection strategies to be adopted by the breeders. A comprehensive character wise review on phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) in relation with their morpho-physiological and quality traits under different environments is presented as following:

Ghimiray and Sarkar (2000) revealed that the phenotypic coefficient of variation were higher than genotypic coefficient of variation for all the characters studied except plant height.

Pochaba and Wegrzyn (2000) recorded highest variability and coefficient of variation for grain weight per spike and lowest for number of days to heading and maturity.

Sairam et al. (2000) conducted an experiment with three wheat genotypes C 306, HD 2285 and HD 2329 that differentially susceptible to water and temperature stress induced by manipulating dates of sowing. Increase in temperature by late sowing significantly decreased leaf water content (RWC) in all the genotypes at 8 and 23 d after anthesis. Temperature tolerant genotypes C 306 followed by HD 2285 were superior to HD 2329 in maintaining high RWC content under high temperature (late sowing) at the two stages.

Shukla et al. (2000) studied 25 cross combination of bread wheat and observed high genotypic coefficient of variation for grain yield per plant, 1000 grain weight and harvest index.

Abo-Worda et al. (2001) studied the genotypes Zna 3, Omrabi 5, Karifla and Sohag 3 and reported the earliest heading dates among them. However, Bcrch 1 recorded the highest grain yield/fed (18.42 ard/fed). In this study across the locations heading date showed the highest genotypic and phenotypic variances and heritability whereas, grain yield had the highest coefficients of genotypic and phenotypic variation.

Singh et al. (2001) observed maximum variation for grains per spike, followed by plant height, days to maturity, days to flowering and number of spikes per plant.

Pawar et al. (2002) studied the genetic variability and heritability for yield and yield components in 50 wheat cultivars and observed high genetic variability for number of days to 50% flowering, plant height, number of productive tillers per plant, length of spike, number of spikelets, grains per ear, 1000-grain weight and grain yield. Also, they recorded highest genotypic and phenotypic coefficient of variation for plant height.

Hamada (2003) reported high value of genotypic genetic coefficient of variation (GCV), for spike length in the three crosses and for number of spikes per plant in the second and third crosses. Moderate GCV values were obtained for grain yield per plant, number of kernels per spike and 1000-kernel weight in the three crosses and plant height in the first cross.

Kumar et al. (2003) evaluated twenty four wheat cultivars for yield and yield components. They reported wide range of variation for plant height, number of grains per ear and 1000-grain weight. The estimates of GCV and PCV were low for number of days to heading and number of days to maturity. The remaining traits recorded moderate PCV and GCV estimates.

Phadnawis et al. (2003) studied the genotypic and phenotypic coefficients of variation and reported high GCV for grain yield per plot, weight of grains per ear, 1000- grain weight and number of ears per plant.

Kumar and Mishra (2004) evaluated thirty diverse wheat cultivars for genetic variation. The highest genotypic coefficient of variation was observed for number of tillers per plant and kernel yield.

Mohammad et al. (2004) studied analysis of variance for traits *viz.,* days to 50% heading, height of main tiller, spike length and total dry weight and showed that these traits varied significantly but not superior to yield per se.

Mondal et al. (2004) evaluated bread wheat cultivars under rainfed condition and reported significant difference among these traits number of effective tillers per sq. m., number of grains per ear, 1000-grain weight and grain yield per plot.

Renu et al. (2004) reported days to heading was significantly high in early sown conditions than late sown conditions.

Sharma et al. (2004) observed that short duration genotypes show low heat susceptibility as compared to the long duration genotypes.

Mahboob et al. (2005) showed reduction in following traits *viz*., plant height, days to heading, days to maturity, spikelets per spike, grains per spike and grain yield, as a result of difference in sowing dates.

Singh et al. (2005) reported that early maturing genotypes have the ability to possess greater grain weight and longer grain formation period thereby having the ability to tolerate heat stress as compared to long duration genotypes.

Malik (2005) evaluated 210 genotypes of bread wheat including indigenous and exotic collection for analysis of variance and observed significance for characters like number of tillers per plant, ear length, 100-grain weight, biological yield, grain yield and harvest index. High phenotypic coefficient of variation was reported for number of tillers per plant, grain yield, biological yield and harvest index.

Cheema et al. (2006) observed genetic variability for number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight and grain yield per plant under rainfed conditions.

Menshawy (2007) reported small difference between phenotypic and genotypic variance for days to heading that indicated a greater effect of genetic variance within the total phenotypic variance.

Khan et al. (2007) revealed high to moderate genetic variability for grain yield, 1000-grain weight, grains per spike, and plant height in both normal and stress conditions, while moderate genetic variability were recorded for days to anthesis in heat stress.

Kaur et al. (2008) studied 150 advanced breeding lines of bread and durum wheat along with 3 control cultivars to estimate the genetic variability for different characters. The maximum range of variability in percentage was observed for tillers per meter, followed by grain yield, sedimentation value, biological yield, number of spikelet per ear, number of grains per ear, 1000-

grain weight, ear length, plant height, harvest index, protein content, days to heading and days to maturity. High phenotypic coefficient of variation was reported for grain yield, number of tillers per meter and number of grains per ear.

Ali et al. (2008) evaluated seventy local and exotic wheat genotypes for variability analysis, for the traits *viz*., plant height, number of productive tillers per plant, number of spikelets per spike, spike length, number of grains per spike, fertility %, 1000 grain weight and yield per plant. Significant genotypic differences were observed for all the traits studied, indicating considerable amount of variation among genotypes for each character. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for yield per plant, number of productive tillers per plant and number of grains per spike.

Koppel and Ingver (2008) evaluated fifteen wheat varieties for yield and quality traits of spring and winter wheat. Spring wheat had higher protein, gluten content and volume weight. According to variance analyses, the value of yield and 1000 kernel weight were determined by the wheat type (spring or winter) but other characteristics were more affected by the weather conditions of a particular year. The effect of the weather conditions for the year was greater for yield, 1000 kernel weight, protein and gluten content for the both types of wheat. For falling number the influence of the year was greater than that of the variety of spring wheat and the influence was revised for winter wheat. Volume weight depended more on the weather for spring wheat and on the variety for winter wheat.

Pireivatlou and Yazdansepas (2008) evaluated yield and yield components of 24 advanced bread wheat genotypes to pre- and post-anthesis drought stress conditions. They reported genotypes produced significantly lower spikes no. per sq m, seeds no. per spike and grain yield under pre-anthesis than in post-anthesis drought stress conditions. However, an average of 1,000 kernel weight of genotypes under pre-anthesis was higher than under non-stress and post-anthesis drought stress conditions.

Bisht and Gahalain (2009) observed high phenotypic coefficient of variation for almost all the characters except for days to 75% spike emergence, plant height, days to maturity and number of spikelets/spike.

Chandra et al. (2009) observed that high variability among the genotypes existed for all the characters in both the years except for days to ear emergence and days to maturity in the first and second years respectively.

Maniee et al. (2009) recorded high genotypic and phenotypic coefficients of variations for number of tiller (NT) and spike length (SL) based on 12 advanced durum wheat genotypes along with the two local checks.

Manal (2009) evaluated four lines of wheat under irrigated as well as drought stress conditions and found that mean for plant height, spike length, number of spikes per plant, number of grains per spike, 50% heading date and 1000 grain-weight revealed highly significant differences among genotypes and crosses under both sowing conditions.

Tripathi et al. (2009) reported higher genotypic and phenotypic coefficients of variation for harvest index, biological yield per plant, number of productive tillers per plant, test weight and grain yield per plant.

Gholamin et al. (2010 a) studied analysis of variance showed significant differences between the traits *viz*., plant height, total number of tillers, fertile tillers, peduncle length, length of main spike, spike original weight, number of seeds per spike main spike, grain weight and total dry weight.

Khayatnezhad et al. (2010) studied performance of 25 genotypes of durum wheat genotypes for analysis of variance and showed significant differences between the traits *viz*., height, main spike length, grain weight and grain yield.

Kotal et al. (2010) reported high significant genetic variability for traits like plant height, number of effective tillers per plant, panicle length number of spikelet per panicle, number of grains per panicle, 1000 grain weight, days to flowering, days to maturity, harvest index and grain yield per plant. Also numbers of effective tillers per plant and grain yield per plant were characterized by high GCV and would be effective for selection.

Riaz et al. (2010) observed considerable amount of variation among genotypes for each character under normal and late planting conditions. The maximum reduction was noticed in grain yield (53.75%), while tillers per m^{-2} showed less reduction (15.38%) under late planting conditions. These characters were observed to be have high genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) for grain filling duration, grains per spike, 1000-grain weight and grain yield per plot.

Zecevic et al. (2010) noticed variability and components of variance for number of grains per spike and grain weight per spike in 10 winter wheat varieties from different selection centers. The average coefficient of variation for number of grains per spike was 17.4%, and for grain weight per spike was 21.4%. The lowest variability for number of grains per spike and grain weight per spike was established in Sterna variety (V=13.0%; 16.2%, respectively) and the highest in Norin 10 variety (V=21.6%; 25.1%, respectively). Statistical analysis of variance established high significant differences in mean values for number of grains per spike and grain weight per spike.

Nouri et al. (2011) assessed yield, yield-related traits and drought tolerance of durum wheat. The results of analysis of variance for relative water content, plant height, biomass, number of grains per spike and grain yield in rainfed and irrigated conditions indicated that genotypic differences were highly significant ($P<0.01$). This showed that drought stress reduced the yield of some genotypes while others were tolerant to drought, suggesting genetic variability of drought tolerance in this material.

Taheri et al. (2011) studied seven traits like grain yield, 1000 grain weight, biomass, harvest index, plant height, main spike length and awn length in 17 spring wheat lines with variable responses to drought stress i.e. normal irrigation, after anthesis drought stress condition, and no irrigation. Analysis of variance indicated that there were significant differences among the genotypes for all studied traits. For biomass, 1000 grain weight, grain yield and harvest index, there was no significant interaction between genotypes and levels of stress.

Tripathi et al. (2011) observed the higher genotypic and phenotypic coefficient of variation in traits like harvest index, biological yield per plant, number of productive tillers per plant, test weight and grain yield per plant. The role of additive gene action was observed in the expression of character like plant height, grain yield per plant, biological yield, harvest index and test weight.

Aharizad et al. (2012) evaluated a set of 94 bread wheat recombinant inbred lines derived from cross between two varieties using a randomized complete block design (RCBD) with two replications. Analysis of variance revealed significant differences among the lines for days to heading, peduncle length, spike length, plant height, number of spikelet per spike, number of spikes, number of grain per spike, 1000 grain weight, grain yield, percent of grain protein, and harvest index and observed higher level of genetic variation for peduncle length, number of spikes and grain yield.

Kalimullah et al. (2012) observed significant variability in forty one bread wheat genotypes for number of grains/spike, number of tillers per plant, 1000-grain weight and grain yield per plant. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for grain yield per plant and number of tillers per plant. The remaining traits exhibit moderate to low PCV and GCV estimates.

Degewione (2013) studied twenty six bread wheat genotypes to estimate the extent of genetic variability which differ significantly for days to

heading, days to maturity, plant height, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, 1000 grain weight grain and yield plot^{-1}, indicating the existence of sufficient genetic variability within different genotypes. High phenotypic coefficient of variation and genotypic coefficient of variation were recorded for number of tillers plant^{-1} and grain yield plot^{-1}. High genetic coefficient of variation was observed in grain yield plot^{-1} and days to heading.

Karim and Jahan (2013) evaluate yield and yield related traits which exhibited significant differences among different genotypes of bread wheat. The results showed that Akbar and Shourav have tallest height (69.3 cm), while Sufi was the smallest variety (54.33 cm). Shatabdi and Barkat had highest number of tillers (3.67). Pradiv had the highest spike length (16.20 cm), high number of spikelet/spike and highest grains weight per spike (2.33 gm).

2.2 Heritability and genetic advance

Baisakh and Nayak (1991) evaluated 13 wheat cultivars for 10 yield related traits with several genetic parameters and strong genetic advance for plant height.

Tiwari and Rawat (1993) have reported high estimate of heritability for days to 50% heading and high estimates of genetic advance for grain yield per plant.

Ajmal et al. (1995) found high heritability estimates along with greater values of genetic advance for number of spikes per plant, number of grains per spike, 100 grain weight, grain yield and plant height.

Chaturvedi and Gupta (1995) studied high heritability for spike length of wheat and poor heritability for 100-grain weight suggesting that the character would not give good response to selection.

Shoran (1995) reported high estimates of heritability with high genetic advance for the grains per spike.

Sharma et al. (1995) observed high estimates of heritability for biological yield per plant.

Moghaddam et al. (1997) reported moderate estimate of genetic advance for grain yield per plant was recorded by.

Uddin et al. (1997) observed highest estimates of heritability in broad sense for days to maturity.

Camargo and Ferreira (1998) estimated moderate to high narrow sense heritability for plant height in bread wheat.

Fokar et al. (1998) evaluated 56 spring wheat cultivars for thermo-tolerance which decrease from seedling to flowering stages and reported highest broad sense heritability of 89%.

Krishnawat and Sharma (1998) observed high estimates of heritability for biological yield per plant.

Narwal et al. (1999) reported high heritability for spike per plant and poor heritability for spike length in bread wheat.

Afiah et al. (2000) observed low to high estimates of heritability and genetic advance for the traits i.e. number of spikes per plant, number of grains per spike, 100 grain weight, grain yield and plant height.

Shazly et al. (2000) observed that heritability estimates in board sense were relatively higher for days to heading, days to maturity, number of grains per spike, 1000-grain weight and grain yield but were relatively low for quality characteristics including protein content and sedimentation value.

Ghimirary and Sarkar (2000) found high heritability estimates along with greater values of genetic advance for number of spikes per plant, number of grains per spike, 100 grain weight grain yield and plant height.

Gupta and Verma (2000) studied the heritability and genetic advance under normal and rainfed conditions in durum wheat (*Triticum durum* Desf.) and concluded that selection should be based on number of grains per ear and biological yield to be effective for improvement in durum grain yield under normal or rainfed conditions.

Kamboj et al. (2000) indicated that spike per plant was poorly heritable character.

Singh et al. (2001) observed high heritability for the traits like grains per spike, tillers per plant and estimates for number of tillers per plant, spike length, grains per 500-grain weight. The high estimates of genetic advance was observed for grain yield per plant.

Prasad and Pandey (2001) observed high heritability for plant height, productive tillers per plants, 1000-grains weight, protein content and sedimentation value.

Dwivedi et al. (2002) reported high heritability and genetic advance for plant height, number of productive tillers per plant, number of spikelets per spike, spike length, number of grains per spike, 1000 grain weight and yield per plant.

Sharma and Garg (2002) observed high heritability accompanied with high genetic advance in case of plant height, number of effective tillers per plant, number of spikelets per spike, ear length, number of grains per spike, 1000 grain weight and yield per plant indicates that most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits.

Pawar et al. (2002) studied the heritability for yield components in 50 wheat cultivars. They observed heritability for all the characters examined ranged from 84.13-99.75%. Genetic advance and genetic gain were highest for plant height and lowest for number of productive tillers per plant.

Khan et al. (2003) studied in wheat to determine the broad sense heritability and genetic value for plant height, number of tillers per plant and grain yield per plant. The broad sense heritability values for plant height and number of tillers per plant ranged from 49.83 to 88.83 and 52.25 to 88.82 %, respectively. The broad sense heritability for grain yield per plant ranged from 65.58 to 90.01%.The genetic advance values for plant height, number of tillers per plant and grain yield per plant ranged from 6.30 to 19.88, 1.87 to 4.42 and 4.95 to 11.61, respectively.

Kumar et al. (2003) reported high heritability coupled with high genetic advance for plant height, number of spikelets per ear, 1000-grain weight and number of days to 50% heading in wheat.

Sachan & Singh (2003) reported high heritability estimates for grain yield, number of spikelets per spike, number of seeds per spike, plant height, 100-seed weight and number of tillers per plant.

Kumar and Mishra (2004) evaluated thirty diverse wheat cultivars for genetic variation. High heritability coupled with high genetic advance as percentage of mean was observed for number of tillers/plant, 1000-kernel weight, plant height and number of spikelets/plant.

Mondal and Kour (2004) reported high to moderate heritability for number of effective tillers per m square and grain yield per plant.

Shukla and Singh (2004) observed that number of grains per spike, grain yield per plant, total biomass per plant, straw weight per plant, and spike weight per plant exhibited high heritability coupled with high genetic advance.

Porwal et al. (2005) studied 60 genotypes of wheat grown in randomized block design. High to moderate heritability coupled with high to moderate genetic advance was exhibited for characters viz., plant height, spike length, grains per spike, spikelets per spike, sedimentation value and 1000-grain weight.

Sahu et al. (2005) reported moderate to low values of heritability for grain yield.

Singh and Chaudhary (2006) observed high heritability for plant height and its component.

Aycicek and Yildirim (2006) reported heritability of yield components for 20 bread wheat genotypes. They observed low heritability for the characters such as grain yield, spike number per square meter, plant height, grain number per spike, grain weight per spike, 1000 kernel weight and time to heading.

Cheema et al. (2006) observed broad sense heritability for number of productive tillers/ plant, spike length, number of spikelets/ spike, number of grains/ spike, 1000-grain weight and grain yield/ plant as 61.62, 72.05, 47.38, 75.58, 79.94 and 80.59%, respectively and genetic advance values at 5% selection intensity were also obtained as 0.967, 1.230, 1.336, 5.658, 4.110 and 1.826, respectively.

Prasad et al. (2006) studied genotypic heritability and genetic advance in 50 wheat genotypes and exhibited high heritability along with genetic advance for days to heading, days to anthesis, plant height and number of grains per spike.

Yadav et al. (2006) showed that heritability estimates were high for all the characters studied except for peduncle length, grain filling period and grain yield per plant and also recorded high heritability coupled with high genetic advance for number of tillers.

Ahmedab et al. (2007) reported high heritability estimates and expected genetic advance for plant height, days taken to maturity, number of tillers per plant, 1000-grainweight and grain yield per plant, while the estimates for spike length and number of grains per spike were relatively low.

Memon et al. (2007) observed high heritability and high genetic advance for plant in height, number of spikelets per spike and number of grains per spike, in progeny Khirman x RWM-9313.

Menshawy (2007) reported that heritability estimates were high for plant height and number of kernels spike^{-1} while, the other characters recorded low to moderate values.

Bakshi et al. (2008) revealed that the characters viz., panicle length, 1000 grain weight and days to maturity showed low heritability coupled with low genetic advance, Whereas, number of spikelets per panicle and grain yield per plant showed high heritability coupled with high genetic advance.

Bhoite et al. (2008) reported high heritability and high expected genetic advance in spike length, productive tillers per plant and grain yield per plot.

Manal (2008) reported high heritability accompanied by high genetic advance for spike length and 1000 grain-weight, whereas low heritability coupled with low genetic advance had been observed for plant height and number of grains per spike.

Waqar-ul-haq et al. (2008) reported high heritability and high genetic advance for number of grains per spike, 1000 grain weight and grain yield per plant.

Akcura (2009) studied heritability for grain yield and 6 quality traits, which ranged from 12.9% to 50.0%. Protein content (39.9%), thousand kernel weight (35.4%), SDS sedimentation tests (27.8%) and grain yield (31.1%) showed moderate to higher heritability and highest expected genetic advance as a percentage of mean was recorded for grain yield (8.35%).

Ajmal et al. (2009) evaluated six wheat varieties and their twelve F_2 progenies for broad sense heritability and genetic advance for various plant characters and observed fairly high magnitude of broad sense heritability for plant height, tillers per plant, grains per spike and grain yield with values 0.94,

0.98, 0.92 and 0.91 respectively, and low magnitude in case of number of spikelets per spike (0.24). The values of genetic advance ranged from 0.044 in 1000 grain weight to 25.289 in plant height which suggested that selection for these traits could be practiced more effectively.

Eid (2009) reported high heritability in spike length and 1000 grain-weight while, low heritability coupled with low genetic advance in plant height and number of grains per spike.

Mohammadi et al. (2009) reported that grain filling duration had the highest heritability both in control and stress environments and kernel weight under stress had the lowest heritability.

Ferdous et al. (2010) reported days to 90% maturity, plant height, grains per spike, 100-grain weight and harvest index exhibited high heritability. Among them grains per spike, 100-grain weight and harvest index showed high genetic advance in percentage of mean.

Lagari et al. (2010) observed highest heritability for spike length (79.3%), number of grains per spike (54.5%) and main spike yield (69.5%) associated with genetic advance (2.8, 22.8 and 1.5 respectively). Whereas, moderate to high heritability recorded for peduncle length (48.75%) and number of grains per spikelet (47.2%) which associated with high genetic advance (2.3 and 0.68 respectively).

Zecevic et al. (2010) showed heritability value in broad sense for number of grains per spike was about 60%, and for grain weight per spike about 40%.

Monpara (2011) reported high heritability along with high genetic advance for number of grains per plant.

Baranwal et al. (2012) observed high heritability with low genetic advance in per cent of mean for days to heading which indicated the involvement of non-additive gene action for the expression of this traits and

selection for such trait might not be rewarding. High heritability with high genetic advance in per cent of mean for peduncle length, chlorophyll content, and grains per spike indicated that these traits were under additive gene control. However, they reported moderate heritability for spike length.

Jatoi et al. (2012) reported that physiological traits for heritability in broad sense, were moderate and high for yield and physiological traits.

Tsegaye and Dessalegn (2012) reported the values of broad-sense heritability, 11%, 19%, 52%, 35%, 24%, 52%, 81%, 21%, 30%, 23%, 50% and 90% for biological yield, days to maturity, number of spikelets per spike, number of kernels per spike, number of tillers per plant, spike length, thousand grain weight, harvest index, grain yield, vitreousness, flour protein content and days to heading, respectively. Whereas, high heritability coupled with high genetic advance as percent of mean was observed for thousand grain weight, spike length and number of spikelets per spike suggesting selection for these traits would give good response.

Ali et al. (2013) showed broad-sense heritability for number of tillers per plant, spike length, grains per spike and grain yield per plant ranged from 69.28 to 90.67%, 49.93 to 66.05%, 81.57 to 93.85% and 58.39 to 88.24%, respectively. While, the respective values of genetic advance for these traits ranged from 3.26 to 7.18, 1.28 to 2.25, 16.18 to 32.18 and 1.77 to 4.50.

Farshadfar et al. (2013) reported high heritability coupled with high genetic advance for grain yield and chlorophyll content, whereas low heritability with moderate genetic advance for relative water content.

Fellahi et al. (2013) observed the highest values of heritability for chlorophyll content (60.44%), spike length (63.05%), number of spikes per plant (61.19%), number of grain per spike (67.65%), grain yield (63.96%) and thousand kernel weight (65.35%) while, genetic gain ranged from 1.73% for days to 50% heading to 68.55% for number of spikes per plant. The traits plant height, number of spikes per plant and thousand kernel weight showed

high heritability and genetic coefficient of variation along with high genetic advance.

Hasnath et al. (2013) studied heritability for grain yield and its contributing characters and revealed the high estimate of heritability for traits *viz*., length of spike, 100-grain weight and yield. So these characters would be effective for selection in breeding programme.

Hokrani et al. (2013) evaluated quality traits for heritability and genetic advance in 95 advanced line of wheat along with five checks. The results revealed that high estimates of heritability coupled with low genetic advance were observed for protein content, starch content and sedimentation values.

Hassain et al. (2013) showed maximum heritability estimates (92.39) for 1000-grain weight, number of grains per spike (86.76), spike length (78.55), grain yield per plant (93.93) and highest values for genetic advance regarding 1000-grain weight (12.29), number of grains per spike (11.39) and spike length (2.70).

Mishra and Shukla (2013) reported high heritability coupled with high genetic advance was exhibited by characters *viz*., dry gluten content, tiller per plant, protein content, sedimentation value, wet gluten content, biological yield per plant and grains per spike. While, high heritability coupled with low genetic advance reported for days to 50% heading and days to maturity.

Farshadfar and Estehghari (2014) observed high heritability estimates (> 0.5) for all the characters investigated yield (Ys), biomass (BI), harvest index (HI), thousand seed weight (TSW), number of seed per spike (NSPS), awn length (AL), plant height (PH), spike weight (SW) and peduncle length (PL) except spike length (SL). High heritability estimates associated with high genetic gain for Ys, TSW and AL reflecting the involvement of additive gene action. Characters like HI, BI, NSPS, SW and PL showed high heritability coupled with moderate genetic advance indicating the chance of effective selection of these traits for improvement of grain yield. SL and PH displayed

low and high heritability with low genetic advance. Non-additive (dominance/epistasis) gene effects were more important for these traits.

Muhammad et al. (2014) studied 50 synthetic elite lines of wheat to estimate heritability and the results showed that harvest index exhibited highest heritability value of 83.31% while 1000-grain weight showed minimum value of 42.32%.

Salman et al. (2014) studied sixty five wheat accessions for heritability and reported highest heritability and expected genetic advance for all the traits except chlorophyll concentration index, spike length and number of spikelet spike^{-1} which exhibited moderate heritability.

Waqasa et al. (2014) estimated broad sense heritability (51.72 to 80.11%, 40.26 to 77.96%, 50.21 to 84.51% and 54.48 to 80.91) and genetic advance (1.59 to 3.36, 3.35 to 6.88, 0.17 to 0.74 and 3.55 to 6.88) for number of tillers per plant, number of grains per spike, grain weight per spike and grain yield per plant respectively.

2.3 Study on correlation coefficient analysis

The correlation coefficient analysis is the statistical measure that measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. The review of literature on correlation of different traits is illustrated bellow:

Wang et al. (1998) reported highly significant positive correlation between biomass production before heading and number of grains per ear and between biomass transported to grain after heading and grain weight.

Narwal et al. (1999) observed positive significant correlation for tillers per plant, spike length, grain per spike, 1000 grain weight with grain yield.

Budak (2000) reported that grain yield had a positive significant relationship with thousand grain weight and hectoliter weight, while protein

content had negative significant correlation with grain yield and thousand grain weights.

Prasad and Pandey (2001) reported low correlation between 1000 grain weight and yield, whereas they reported low negative correlation of yield with protein content.

Budak and Yildirim (2002) reported that grain yield had significant and positive correlation with days to heading and plant height. While, protein content had negative significant correlation with heading date, plant height and grain yield.

Patel and Jain (2002) reported that grain yield were significantly and positively correlated with number of tillers per plant and number of kernel per spike, where as it showed a non-significant and negative correlation with days to heading, days to maturity, plant height, and 1000 grain weight.

Dhaliwal and Sukhchain (2003) showed that plot yield had significant positive phenotypic correlation coefficient (PCC) with ear grain yield and 1000 – grain weight ($P \leq 0.01$). Also 1000 – grain weight showed significant PCC with ear grain weight ($P \leq 0.01$).

Dhillon et al. (2003) observed that grain yield/plant showed high magnitude of positive association with sedimentation value and the significant negative association with protein content indicated the difficulty in simultaneous improvement for these traits. 1000-grain weight exhibited significant magnitude of negative correlation with protein content and positive association with sedimentation value.

Jat and Dhakar (2003) found that grain yield in wheat were positively correlated with effective tillers/m row length (0.86), grains/ear (0.72), test weight (0.84) and grains/spikelets (0.67). Similarly, straw yield of wheat was significantly and positively correlated with dry matter accumulation at harvest (0.95), plant height (0.56) and total tillers/m row length at 25 DAS (0.67). In

contrast to this, grain yield of wheat was negatively correlated with the number of spikelet/ear (-0.50) and ear length (-0.01).

Khan et al. (2003) studied correlation in 15 wheat varieties /lines. The results showed positive and significant correlation exhibited between numbers of tillers per plant and peduncle length; spike length and grain yield per plant both at genotypic and phenotypic levels.

Singh et al. (2003) studied character association in late sown wheat and observed that grain yield had significant positive correlation with plant height and 1000-grain weight.

Phadnawis et al. (2003) showed that number of seed per ear and number of ear head has positive and significant correlation, whereas number of days to 50% flowering and maturity showed significant negative association with grain yield per plot both at the genotypic and phenotypic level.

Eslami et al. (2005) reported protein content has a positive correlation with wet and dry gluten content. Since dry gluten content showed high correlation with protein content (quantity) and SDS sedimentation volume, hence these two traits can be used as the selection criteria for improving quality of protein in durum wheat.

Shukla et al. (2005) reported yield per plant has positive correlation with spike weight per plant, kernel weight per spike, number of kernel per spike, biological yield and harvest index in rain fed condition whereas yield per plant has positive correlation with number of tillers per plant, kernel weight per spike, number of kernel per spike and biological yield under partially irrigated condition.

Akram et al. (2008) evaluated winter wheat under rainfed condition and the results revealed positive correlation in case of number of spikelet per spike, number of grains per spike and 1000 grain weight with grain yield at both genotypic and phenotypic levels.

Bilge et al. (2008) studied the relationships of CTD (Canopy Temperature Depression) with grain yield and its components for six bread and five durum wheat genotypes. The results showed that CTD was positively correlated with grain yield, spike yield, and grain numbers per spike.

Bilgin et al. (2008) reported high positive significant correlation between grain yield and grain weight/spike, test weight and 1000 grain weight. In the second experimental year, grain yield showed positive and significant correlations with 1000 grain weight, test weight and stem length.

Rashidi et al. (2008) found correlations among traits i.e., harvest index (r =0.849**), plant height (r =0.695**) and number of tiller (r =0.689**) had high correlation with grain yield.

Chander and Singh (2008) observed positive correlation of grain yield with biological yield and harvest index under moisture stress environment, negative correlation of grain yield with 'Drought susceptibility index' under moisture stress and significant positive correlation of grains per spike and grain weight with grain weight per spike under both moisture stress and non stress environments. While negative association of drought resistance index drought susceptibility index was also observed.

Subhashchandra et al. (2009) observed negative and significant association of grain yield with spike length, plant height and protein content.

Yagdi and Sozen (2009) found significant positive correlation between the seed yield, plant height and spike length. Whereas, negative and significant correlations between gluten content and seed number per spike, sedimentation value with number of spikelet per spike and seed number per spike and protein content with seed number per spike were also observed.

Tripathi et al. (2011) reported that grain yield was positively and significantly associated with plant height, spike length, number of grains per spike, 1000 grain weight and biological yield.

Mehmet and Oral (2011) observed a positive relationship between grain yield and number of spikes per square meter together with test weight, whereas days to heading and spike length were negatively correlated to grain yield.

Mohammed et al. (2011) observed positive association of grain yield at genotypic level with days for heading, harvest index and kernels number per spike.

Mohtasham et al. (2011) reported that thousand grain weight had positive significant correlation coefficient and high positive direct effect on grain yield.

Nouri (2011) observed a positive and significant correlation between yield under irrigated (Yi) and rainfed (Yr) conditions and mean productivity (MP), geometric mean productivity (GMP), and stress tolerance index (STI).

Karimizadeh et al. (2012) carried out studies to determine traits affecting grain yield in eighteen durum wheat *(Triticum durum* L.) genotypes by simple correlation coefficient under two irrigated regime (irrigated and rainfed). The results indicated that the grain yield was positively and significantly correlated with test weight (hectoliter) and thousand kernel weight in irrigated condition, and with plant height in rainfed condition.

Rahmatollah et al. (2012) noticed positive and significant correlation of test weight (hectoliter) and thousand kernel weight to grain yield in durum wheat in irrigated conditions and with plant height in rainfed condition.

Tsegaye and Dessalegn (2012) reported high degree of positive association of biological yield (rp=0.89), number of tillers per plant (rp=0.59) and thousand grain weight (rp=0.51) with grain yield.

Guendouz et al. (2013) observed that grain yield has positive phenotypic correlation with number of spikes m^{-2} and number of grains per m^{-2} under irrigated and late season water stress conditions.

2.4. Path coefficient analysis

Assuming yield is a contribution of several traits which are correlated among themselves and to the yield, path co-efficient analysis was developed (Wright, 1921; Dewey and Lu, 1959). Unlike the correlation coefficient which measures the extent of relationship, path coefficient measures the magnitude of direct and indirect contribution of the component characters to a complex character and it has been defined as a standardized, regression coefficient which splits the correlation coefficient into direct and indirect effects. The reviews of literature on contribution of different traits on yield are illustrated bellow:

Chaturvedi and Gupta (1995) studied path coefficient for 44 strains of spring wheat and found positive direct effect of plant height, days to 50% flowering, number of tillers per meter, grains per spike on grain yield.

Halloli (1997) observed positive direct effect of plant height, days to 50% flowering, number of tillers per meter, grains per spike and 1000 grain weight on grain yield in F_3 and F_4 genotypes of tetraploid wheat.

Uddin et al. (1997) showed path coefficient analysis revealed high direct effect for spikes per plant and spikelets per spike.

Simane et al. (1998) reported that the direct effect of number of spikes per square meter on grain yield whereas, grain per spike showed highest direct effect on grain yield.

Kumar and Hynshal (1998) reported that harvest index, number of effective tillers, grains per ear were the most important components of grain yield of durum wheat, while indirect effect of other characters on grain yield through harvest index was also higher.

Narwal et al. (1999) found that number of tillers/meter, spike length, grains per spike has positive and large direct effect on grain yield in advanced wheat lines.

Dokuyucu and Akkaya (1999) reported positive direct effect of number of grains per spike on grain yield.

Dencic et al. (2000) showed that number of grains per spike and grain weight per spike had a sufficient positive direct effect on yield under drought condition.

Naik (2000) studied on 200 genotypes of durum and dicoccum wheat and found that plant height and grains per spike had maximum indirect positive effect on yield *via* total biomass and harvest index.

Pochaba and Wegrzyn (2000) observed direct positive effect of grain number per ear, 1000 kernel weight, and plant height on yield and negative effect of early heading on yield.

Bergale et al. (2002) also reported that grains per spikes and tillers per plant had high positive direct effects on grain yield whereas direct effect of number of spikelets per spike was negative and moderate on grain yield.

Dwivedi et al. (2002) found that total biomass showed the highest direct effect on grain yield, followed by tillers per plant and grain weight per ear.

Shah and Deora (2002) concluded that grain yield primarily depend on harvest index, biological yield and plant height and had direct effect on yield, however these traits had contributed substantially through harvest index.

Singh and Dwivedi (2002) studied path coefficient in wheat at the genotypic and phenotypic level and showed that all characters except biological yield and harvest index per plant had small positive or negative effect on grain yield per plant but biological yield per plant had maximum direct effect on grain yield per plant followed by harvest index.

Patel and Jain (2002) observed that the number of kernels per spike, had highest positive effect on kernel yield while a negative direct effect on yield was observed for number of spikelet per spike.

Singh et al. (2003) reported that biological yield per plant, grains per ear, 1000 grain weight and effective tillers per plant had positive and higher direct effect on grain yield per plant.

Lad et al. (2003) reported that productive tillers per plant had the highest positive direct effect followed by grains per spike, grain weight per spike and length of spike.

Gupta et al. (2004) observed that number of spike per plant had the highest positive direct effect on seed yield per plant, followed by grain weight and number of spikelet per spike.

Mohammad et al. (2005) studied the positive direct effect of days to heading, days to maturity and biological yield on grain yield, while harvest index showed positive and highest direct effect on grain yield.

Aycicek and Yildirim (2006) found positive direct effect of plant height and grain weight per spike on grain yield, while negative direct effect of time to heading on grain yield was also observed.

Gashaw et al. (2007) observed maximum positive direct effect on grain yield was exerted by biological yield (1.08) followed by days to maturity (0.91) and harvest index (0.69) While, maximum negative direct effect was exerted by days to heading (-0.72) and grain filling period (-0.52).

Chander and Singh (2008) studied path coefficient analysis in twenty spring wheat genotypes under moisture stress and non stress environments. Analysis revealed that biological yield and harvest index exhibited high positive direct effects on grain yield under both the environments, whereas tillers/plant and grain weight/spike had mainly indirect effects on grain yield *via* biological yield under moisture stress.

Majumder et al. (2008) studied path coefficient analysis in twenty spring wheat varieties for grain yield and its component characters and revealed that among the different yield contributing characters grains per spike and 100-grain weight had direct and positive effect and harvest index,

days to maturity and spikes per plant had indirect and positive effect on grain yield per plant.

Nofouzi et al. (2008) reported number of seeds per spike (0.432), length of spike (0.407) and 1000 seed weight (0.385) had the highest direct positive effects on grain yield. Whereas, 1000 seed weight, number of tillers per plant and number of seeds per spike showed that plant height (0.452), length of spike (0.857), days to flowering (0.345) were the most effective components of traits, respectively.

Deshmukh et al. (2009) reported positive direct effect of number of ears/m was attributed to the indirect positive effects of 1000-grain weight and number of days to maturity on grain yield. The number of grains per ear exhibited the greatest negative direct effect on grain yield via 1000-grain weight and grain weight per ear. The 1000-grain weight also had significant negative direct effect on grain yield, which was largely compensated by its positive effect via grain weight per ear, number of grains per ear, and number of days to 50% heading.

Subhashchandra et al. (2009) reported that spike length had highest positive direct effect on yield per plant followed by productive tillers per plant and spike length, whereas productive tillers per plant also had the highest indirect positive effect on yield per plant.

Yagdi (2009) revealed that the direct and indirect effects on yield exhibited variation from year to year in durum wheat. The trait seed weight per spike had positive effect on yield during 4 years of the trial. Seed number per spike and plant height had direct negative effects.

Khan et al. (2010) studied path coefficient analysis on 16 wheat recombinant inbred lines (RILS)/varieties under moisture stress conditions and concluded that peduncle length had the highest direct effect on grain yield followed by tillers per square m, grains per spike, spike length and days to maturity whereas, peduncle extrusion, sheath length, 1000 grain weight and plant height had negative direct effect on the same parameter.

Khayatnezhad et al. (2010) studied 30 durum wheat genotypes for path analysis in a randomized block design and results showed direct effect of harvest index on yield, but the maximum direct effect of this trait through total tillers and maximum negative effect on yield related to fertile tillers was also observed.

Mohammed et al. (2011) noticed that harvest index and biomass exhibited the highest positive and significant direct effect on grain yield.

Zaeifizadeh et al. (2011) studied path analysis for grain yield, panicle length and total weight of fertile tillers per plant. They reported highest direct effect through the least fertile tillers and panicle length.

Mohtasham et al. (2011) noticed that spike number per square meter (s/m^2) had direct effect on grain yield *via* thousand kernels weight and it can be defined as another indirect selection criterion.

Abas Soleymanifard et al. (2012) showed positive and high direct effect of spike m^{-2} and 1000 grain weight on grain yield in durum wheat under drought stress.

Çifci (2012) reported in durum wheat that spike length, spikelet number per spike and grain number per spike had the maximum direct effects on grain yield.

Khan and Naqvi (2012) reported that number of spikes, number of spikelet's and number of grains had direct positive contribution to grain yield under irrigated condition.

Tsegaye and Dessalegn (2012) described phenotypic path and revealed that biological yield (0.679) and harvest index (0.48) have direct contribution towards grain yield.

Hannachi et al. (2013) observed that above ground biomass and harvest index exerted positive direct effect on grain yield, whereas straw yield had a negative direct effect on grain yield. The highest indirect effects on

grain yield were also observed with straw yield, spikes number per plant, plant height, and thousand-kernel weight through above ground biomass and with harvest index *via* straw yield.

Khan et al. (2013) reported that days to maturity, 1000-grain weight, number of grains/spike (low magnitude) had significant positive direct effects and heading days and plant height had indirect effect mainly through maturity days and 1000-grain weight on grain yield.

2.5. Multiple regression

Wang et al. (1998) studied the multiple regression analysis and showed that number of grains per ear and grain weight contributed 60.4 and 39.6 % to ear weight respectively.

Subhani et al. (2000) evaluated thirty-six bread wheat genotype *(Triticum aestivum*) for regression analysis under irrigated and drought stress condition for traits viz. tillers per plant, peduncle length, 1000 grain weight biomass per plant and grain yield and observed that regression coefficient were significant for these traits, with a unit increase in, tillers per plant, grain weight, biomass per plant and harvest index. There was an increase in grain yield per plant to a extent of 0.4074g, 9.924g, 0.4158g, and 0.8437g respectively. The plant height is more important than grain weight of mother shoot in case of drought stress condition for the contribution of grain yield per plant.

Asseng et al. (2002) studied multiple regeression analysis and reported that increased kernel number had maximum contribution to improve potential yield of wheat under certain environmental conditions limited by water supply.

Leilah and Khateeb (2005) studied multiple linear regression and stepwise regression, in order to determine relationship between wheat grain yield and its components under drought conditions. The results revealed that number of spikes/m^2, 100-grain weight, weight of grains/spike and biological yield were the most effective variables influencing grain yield.

Ashraf and Mohamed (2014) conducted field experiment for the two consecutive years. Twenty bread wheat of Egyptian cultivar were evaluated in alpha lattice design with three replication for nine traits in order to determine the relationship between yield and its component. The results based on simple linear regression analysis and linear regression of number of tillers^{-1}, spike length, number of spikelet's spike^{-1}, number of grains per spike, thousand grain weight and harvest index. It leads to increase the grain yield plant^{-1} by 0.67, 0.52, 0.32, 0.30, 0.64 and 0.63 units, respectively. Also, stepwise multiple linear regression analysis revealed that four traits included number of tillers plant^{-1}, number of grains spike^{-1}, harvest index and 1000-grain weight with R^2 = 97.29%, had justified the best prediction model.

2.6. Stability analysis

Bangarwa and Luthra (1996) studied on genotype-environment interactions derived from data on spike length, spikelets per spike and grains per spike in the parental, F_1, F_2 and backcross generations of 4 crosses of macaroni wheat grown at Hisar under 4 sowing dates. Genotype-environment interactions were observed for all the traits under study. Cormorant and the F_2 of Cormorant x Malvaraj appeared most stable for these spikelet traits**.**

Mishra and Khan (2000) studied eight promising wheat genotypes (GW 190, DL 803-3, Raj 1555, WH 147, HI 1077, HI 8381, DL 788-2 and WH 533), that were sown in 3 different dates (normal, 22 November; late, 2 December; and very late, 12 December). They revealed that DL 788-2 and GW 190 had higher adaptability and stability and may be recommended for normal and late sowing conditions. The cultivar WH 147 was responsive to rich environments and may be recommended for cultivation based on normal sowing dates.

Moshref et al. (2000) reported that entries number 17 and 4 were significantly the highest grain yield producers. Generally, moderate improvement could be obtained for grain yield and heading date (6.90 and 5.92%, respectively), while low improvement was obtained for maturity date (1.45%).

Sial et al. (2000) studied stability for yield performance and genotype x environment interaction in 12 wheat genotypes grown at 13 contrasting sites over two years. The combined analysis of variance over all environment revealed a highly significant difference for genotypes, environment and G x E interactions. The results showed that genotype SI90157 had highest mean yield with stability over all the environment, whereas genotype PN90111, Anmol 91, SP89126 and SH8921 gave the lower mean yield over all the environment with high value of S.E. (b) and S^2d. The line SI88126 gave high yield particularly in high yielding environments showing weak stability.

Sikder et al. (2001) studied on ten recommended wheat *(Triticum aestivum* L.) varieties which were exposed to two sowing conditions i.e. optimum sowing (November 30) and late sowing (December 30). The grain number per ear, 1000 grain weight and main shoot grain weight of tolerant and moderately tolerant varieties showed higher relative performance compared to sensitive varieties, but the relative ear number per plant and relative grain yield were found to range low to high in heat tolerant and moderately tolerant varieties. Thus the results suggested in addition to membrane thermo stability test, the high relative grain number per ear, 1000 grain weight and main shoot grain weight can be used to determine the heat tolerance of wheat varieties under late seeded warmer conditions.

Amin et al. (2005) evaluated ten promising wheat genotypes for grain yield stability under varied environments at nine locations and observed that interaction between genotypes and environments (G x E) was significant. None of the regression coefficients (bi) was significantly different from variety; therefore, stable performance of the genotypes predicted on the basis of deviations from regression (S^2d). The average grain yields and above average grain yields were observed in genotypes (CT-99022, SAW-98063, CT- 99155 and Saleem-2000) while high S^2d value for high yield in genotype (Saleem-2000). Based on grain yield performance, low deviation from regression and bi values the genotype (CT-99022) was more suitable for favorable environments whereas, higher grain yield, regression coefficient (bi = .983)

and low deviation from regression (S^2d = 0.065) was expressed by SAW-98063.

Okuyama et al. (2005) reported Nesser variety showed the most productive and stable performance in all environments, followed by IAPAR 17. The results indicated that Nesser gave high grain yield with superior adaptability and stability and could, thus, be considered as the most suitable genotype for late sowing and water stress condition at the end of the plant cycle.

Jenal et al. (2005) observed the genotype x environment interaction in 10 wheat cultivars sown in 6 environments. Significant differences due to genotype, environment and G x E interaction in the number of days to 75% flowering and maturity, plant height, number of effective tillers, spike length, grains per spike and grain yield were observed. Both linear and non-linear components were predominant in plant height, spike length and number of grains per spike, whereas non-linear components were observed in all characters except spike length. Cultivars K 8804, UP 262 and OW 6 were unstable for grain yield but stable for some other traits. HUW 206 was most stable genotype across different sowing dates.

Rasul et al. (2006) investigated eighteen genotypes of wheat including two check varieties i.e., AS.2002 and Inqilab 91 at twenty four agro ecological zones for grain yield and stability analysis in order to check response to Genotype x Environment interactions. They showed that mean squares due to G x E (linear) were non-significant depicting lack of genetic differences among genotypes for linear response to varying environments, while mean squares due to pooled deviations were highly significant, reflecting considerable differences among genotypes for non-linear response and only two wheat lines i.e., V-02006 and AS-2002 showed non-significant deviation from regression and their regression coefficient values were close to unity classified as stable varieties. However, AS-2002 with non-significant deviation from regression, unit regression coefficient and being superior in yield

appeared as a prominent variety, to be the most stable for yield performance under varying environments.

Ulker et al. (2006) determined the stability of grain yield in 12 wheat genotypes (*Triticum aestivum*) and the results indicated that there were significant differences and interactions among genotypes, locations and years and also the regression coefficient (b) values of the 11 genotypes ranged from 0.46 to 1.73; deviation from regression ranged from 69.9 to 2896.7. According to estimates of the two stability parameters, none of the genotypes were stable for grain yield. However, based on the linear regression coefficient and average grain yield, line 2 (Adilcevaz-40/1) and 11 (Van-Edremit/1) appeared to be promising because their yields were above the average in all of the environments.

Majid et al. (2007) studied adaptability of crop in different drought environments on the basis of yield and yield components of four wheat (*Triticum aestivum* L.) genotypes *viz*., Rawal-87, Inqalab-91, Potohar-93 and Chakwal-97. The results revealed that Chakwal-97 had highest mean during both the years but regression coefficient closest to one was for Inqalab-91 in number of grains per spike. On the basis of this trait Inqalab-91 remained most stable for the year 2002-03 and Chakwal-97 for 2003-04 and also exhibited stability for both years on the basis of thousand grains weight. Similarly, on the basis of the major parameter judging for stability, the grain yield, Inqalab-91 with highest mean for both years and with regression coefficient closest to unity in one of the years (2003-04) looked to be the most stable genotype. Deviation from the regression is the measure of genotypic stability over a set of environments. Inqalab-91, with highest mean in yield and yield components and smaller deviation from the regression, was relatively stable in drought stress environments. Inqalab-91 with almost 90% of coefficient of determination in all the regression of yield components looked to be the best, although other varieties had higher coefficient of determination than that of Inqalab-91 in some of the yield components.

Letta et al. (2008) studied Ethiopian-grown durum wheat varieties for many quality traits including test weight, flour protein, wet gluten and SDS sedimentation test under five different location during two season and showed that some varieties were stable for one quality trait and unstable for another, suggesting factors involved in G x E interaction differ between traits. The study of genotypic stability demonstrated that variety Ude showed highest stability for quality traits considered and proved to be the best with in the pool of studied genotype.

Osmanzai et al. (2008) tested forty nine breeding lines and one local check cultivar. The characters grain yield, days to heading, plant height and agronomic scores were analyzed and the experimental genotypes showed high levels of grain yield in each year. However, there were experimental genotypes in each year that produced significantly higher grain yield than the check.

Singh et al. (2008) recorded fifty genotypes of bread wheat over 8 diverse environments, i.e. 2 years x 2 sowing dates x 2 fertilizer levels for 6 characters *viz*. tiller number, grains per spike, 100-grain weight, grain yield, biological yield and harvest index. Genotype x Environment (G x E) interaction was found significant for all the characters. Genotypes Kanchan, UP-2617, HP-1868, HP-1871, HD-2866, HD-2893 and WH-779 were found to be stable across environments for grain yield.

Hamam et al. (2009) worked on stability analysis and revealed that four and three genotypes were high and intermediate yielding and stable for yield. The temperatures were decreased up to 2.50 to 6.39°C at late sowing date than at the favorable sowing date. The results indicated that the 1000-kernel weight and grain yield traits are stable under heat stress. This study indicated that higher 1000-kernel weight and days to heading are the two important traits which could be considered as potential selection criteria for yield under heat stress.

Kabir et al. (2009) studied regression techniques for eight wheat genotypes in eight different sowing dates under irrigated condition to estimate

genotype-environment interaction for grain yield. The results showed that stability analysis of variance was highly significant ($p<0.01$) proving difference among genotype, environment and environment linear (li). Variety Sourav (0.9) and Shatabdi (0.93) showed regression coefficient (bi) very close to unity with small deviation from regression (s^2di) and above average yield while, var. Pradip and line BAW 1064 had regression coefficient greater than unity with at per or above mean grain yield, therefore these genotypes aresensitive and recommended for cultivation under unfavorable condition.

Mohammed (2009) noticed that check El Nielain exhibited high yield associated with good stability and would be expected to perform well in a wide range of environments. The check Wadi Elniel ranked first in grain yield but tend to be unstable, favoring high yielding environments.

Shah et al. (2009) evaluated ten varieties viz. Kiran-95, Mehran-89, Tandojam-83, Abadgar-93, Anmol-91,Punjab-96, Chakwal 86, Shahkar-87, Parwaz-94 and Pirsabak-85, at nine different locations for three years for stability and range of adaptations for characters grain yield and grain protein percentage in spring wheat (*Triticum aestivum* L.). Data was recorded on various plant characters viz. plant height, peduncle length, productive tillers per meter, 1000-grain weight, grain protein percentage and grain yield (t/h) and relative magnitude of interaction variance components indicated relative performance for these traits was more inconsistent across locations than years and the opposite was true for spike length, spikelets per spike, grain per spike and maturity days. Also variety-location (σvl) variety-year (σ_{vy}) and variety-location-year (σ_{vly}) interactions were highly significant for all characters.

Al-Otayk (2010) studied on the heat tolerance of twelve wheat genotypes under four environmental conditions (two sowing dates and two years). The results showed that sowing at the first date increased plant height, grain yield, and harvest index. Highly significant genotype differences were recorded for all characters. The genotypes (YR-19 and YR-20) produced the highest grain yield in both seasons, while, local cultivar 'Sama' produced the

lowest grain yield. On the other hand, YR-2 and YR-3 showed below-average stability.

Macas et al. (2010) evaluated nine durum and eight bread wheat genotypes to two different sowing dates: normal and late sowing, to assure high temperatures during and after anthesis. They observed grain yield and individual grain weight were significantly affected by temperature increase. Genotype x sowing date interaction was not observed indicating that selection pressure must be applied to identify genotypes with better resistance/tolerance to heat stress.

Moshattati et al. (2010) recorded significant reduction and genotype x environment interaction for yield, yield components, as well as for other measured traits. Among the twelve screened genotypes, the genotypes ADEL-3 and ZAIEM-4 selected as the most potential heat-tolerant, stable across contrasting environments (optimum vs. late sowing) and with adequate yield potential under optimum sowing conditions compared to the check varieties.

Samrat et al. (2010) conducted an experiment to assess the stability of genotypes for different physiological and quality parameters using 49 diverse wheat (*Triticum aestivum* L. emend. Fiori & Paol) genotypes. The results showed that pooled analysis of variance with respect to all the 12 traits indicated that the variance due to environment was significant for all the 12 traits and variance for genotypic effect was also highly significant for all the traits under study. The varieties ‘HD 2923’, ‘CBW 14’, ‘CBW 17’, ‘CBW 23’, ‘CBW 12’, ‘CBW 24’, ‘RS 951’, ‘DBW 16’, ‘DBW 17, ’PBW 559‘, ’Raj 3765‘, ’PBW 343 ‘and ’NIAW 845‘ have shown higher mean values, desirable regression coefficient and deviation from the regression coefficient for yield, quality parameters and physiological traits. Based on the mean performance, linear regression and S^2d values, the above varieties can be said to be stable.

Singh et al. (2010) revealed that genotypes HD-2643, NIAW-34 and RAJ-3077 were best performing and stable for early heading and early maturity. Genotype GW-322 was screened most desirable and stable for high

mean tiller number. DL-803-3, HD-1731 and HI-977 showed highest mean performance for spikelets per spike, GW-190, K-0307, PBW-502 and PBW-550 for grains per spike, DL-788-2 and K-9107 for 100-grain weight and GW-366, K-9107 and UP-2620 for high mean harvest index. Among forty genotypes, GW-366, K-0307, SUJATA and UP-2620 were high yielding and stable and can be utilized to develop stable strains with wider adaptability.

Sharma et al. (2010) analyzed grain yield and agronomic traits for stability and genotypic superiority which were determined using genotype and genotype x environment (G x E) and showed high levels of grain yield in each year. The superior genotypes also had acceptable maturity, plant height and 1000-kernel weight.

Arain et al. (2011**)** studied stability and regression analysis for grain yield performance and genotype x environment (G x E) interaction in twelve (nine advance genotypes and 3 checks) wheat genotypes evaluated at different agro-climatic conditions. They showed that MSH-14 produced the highest mean yield (5090 kg/ha) in all environments averaged for two years, and had regression coefficient (b) close to unity (0.86) and S^2d close to zero (0.7923) which indicated wide adaptation and stability. However genotypes MSH-03 and MSH-05 ranked 2^{nd} and 3^{rd} showing regression coefficient (b=0.78 and 0.69 respectively) and deviation from regression (S^2d= 1.076 and 1.29 respectively) indicating specific adaptability and suggested that both the genotypes could be used as stress tolerant genotypes under stressed environments (such as drought, heat and salinity stress).

Mahmoud et al. (2011) aimed to determine the effect of different sowing dates (i.e., 1^{st} November, 15^{th} November, 1^{st} December and 15^{th} December) on growth, grain filling traits and yield. The results revealed that sowing date on 15^{th} November surpassed the other sowing dates in all of yield studied parameters, grain filling rate and flour percentage.

Sharma et al. (2012) conducted an experiment to determine the performance of one hundred advanced breeding lines and four check cultivars of winter wheat genotype under semi arid environment for stability analysis for

grain yield. They observed that many genotypes produce higher grain yield were more stable than four checks and 11 out of 30 highest yielding genotypes were common under both low and high productive environments

Surma et al. (2012) assessed 24 winter wheat genotypes with different grain hardness in multi environment trials at four locations. Grain samples were analyzed for hardness, protein and starch content, and wet gluten content, Zeleny sedimentation value and hectoliter weight. All parameters were evaluated on whole grains using the near infrared transmittance technique. Differences between hard and soft genotypes appeared to be significant, apart from grain hardness, for protein content and Zeleny test. Genotype was found to have a major influence only on grain hardness; for protein content, wet gluten and Zeleny sedimentation value. However, environment prevailed the influence on genotypes for starch content and hectoliter weight both sources of variation had similar importance. Genotype-by-environment interaction was found smaller effect relative to genotype and environment in terms of all the studied quality parameters. Stable genotypes pre dominate the breeding lines studied. Response of unstable genotypes to environmental conditions was non-linear in most of the cases.

Hassan et al. (2013) evaluated fifteen durum wheat genotypes under different environments, in a randomized complete blocks design with three replications in each location. The combined analysis of variance for environment (E), genotype (G) and (GxE) interaction was highly significant for all studied traits. The results showed that genotype No. 12 had desired performance (grain weight/spike) compared to the grand mean and regression coefficient (bi) which did not differ significantly from unity and zone least deviation from regression (S^2d), indicating the role of linear portion of GxE interaction in the performance of this genotype. The value of regression coefficient (bi) of genotypes No. 12 for No. of grains/spike, No. 8 and 13 for grain weight/spike, No. 1, 2, 5, 8, 9, 14 and 15 for grain yield/plant were less than one (bi<1), indicating that these genotypes were considered specially adopted to unfavorable environments. Meanwhile, the value of regression coefficient of genotypes No. 9 for plant height, No. 13 for No. of grains/spike,

No. 3,12 and 14 for grain weight/spike and No. 10 for grain yield**/**plant had bi values more than unity (bi>1) and could be adapted to optimum environment.

MATERIAL AND METHODS

The present investigation entitled **"Screening of Stable Wheat Genotypes for Morpho-Physiological and Quality Attributes under different Environments"** was carried out during the *Rabi* season of 2012-13 and 2013-14. The techniques followed and materials used during the course of investigation are presented under following subheads.

3.1 Experimental site

The experiment was carried out under Wheat Improvement Project at Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidhyalaya Jabalpur (M.P.) under irrigated timely, late and very late sown conditions. The experimental area occupied was quite uniform in respect of topography and fertility.

3.2 Climate and weather

Jabalpur is situated at 23-90^0 N latitude and 79.58^0 E longitudes at an altitude of 394 m above the mean sea level. This region has subtropical, semi-arid climate. The main features are hot and dry summer and cold winter with occasional showers. In the first experimental year the average rainfall was about 55.4 mm, received mostly during the month of February. Temperature ranged from 5.0^{o}C (minimum) during the month of December to 39.5^{o}C (maximum) during the month of April. The meteorological data of crop season is presented in table 3.2.1.

In the second experimental year the average rainfall was about 58.2 mm, received mostly during the month of February. Temperature ranged from 5.6^{o}C (minimum) during the month of January to 39.7^{o}C (maximum) during the month of April. The crop was grown under normal crop season. The meteorological data of crop season is presented in table 3.2.2.

Table 3.2.1: Weekly meteorological parameters during crop season (end of November to end of April, 2012-13)

Meteo. Week	Temperature (^{0}C)		Sunshine (hrs.)	Rainfall (mm)	RH (%)		Wind speed (km/hr)	Vapour pressure (mm)		Rain days
	Max.	Min.			Morn.	Even.		Morn.	Even.	
47	27.9	10.6	7.6	0	88	29	2.2	9.3	8.2	0
48	28.4	11.5	8.4	0	83	33	2.1	9.7	9.1	0
49	28.7	10.6	9.0	0	85	26	2.1	9.4	7.8	0
50	29.0	14.0	7.2	3.2	92	41	2.2	12.3	11.8	1
51	25.3	7.1	8.6	0	88	29	2.3	7.8	6.7	0
52	23.8	5.0	9.1	0	90	30	2.2	6.8	7.4	0
1	23.3	7.2	5.9	0	87	42	3.6	7.7	8.7	0
2	23.0	5.2	9.2	0	87	32	2.6	6.7	7.3	0
3	26.7	10.1	8.1	0	84	36	4.0	9.0	9.1	0
4	21.4	5.0	7.6	0	86	36	2.9	6.6	7.0	0
5	24.6	7.4	7.4	2.0	91	36	2.3	7.9	8.8	0
6	25.9	11.3	6.2	1	88	49	4.4	10.1	12.0	0
7	25.2	13.0	4.1	0	91	60	4.4	11.5	12.7	0
8	25.0	11.0	9.3	55.4	93	49	3.2	10.4	11.5	3
9	28.0	9.2	9.8	4.8	87	37	3.1	9.3	10.6	1
10	30.7	9.9	9.6	0	83	28	2.6	9.0	9.2	0
11	31.6	14.7	7.4	26.1	84	39	4.6	12.2	12.7	2
12	33.4	16.2	8.2	0	77	28	3.6	12.6	10.6	0
13	33.8	16.2	7.8	7.2	76	30	3.7	13.3	11.2	1
14	35.3	15.2	8.9	3.2	68	20	4.2	12.1	8.1	1
15	39.5	19.9	8.7	0	57	14	4.5	12.6	7.1	0
16	36.5	20.1	8.6	10.6	51	22	5.2	11.3	8.8	1

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Fig.3.1: Graphical representation of Metrological data (2012-13).

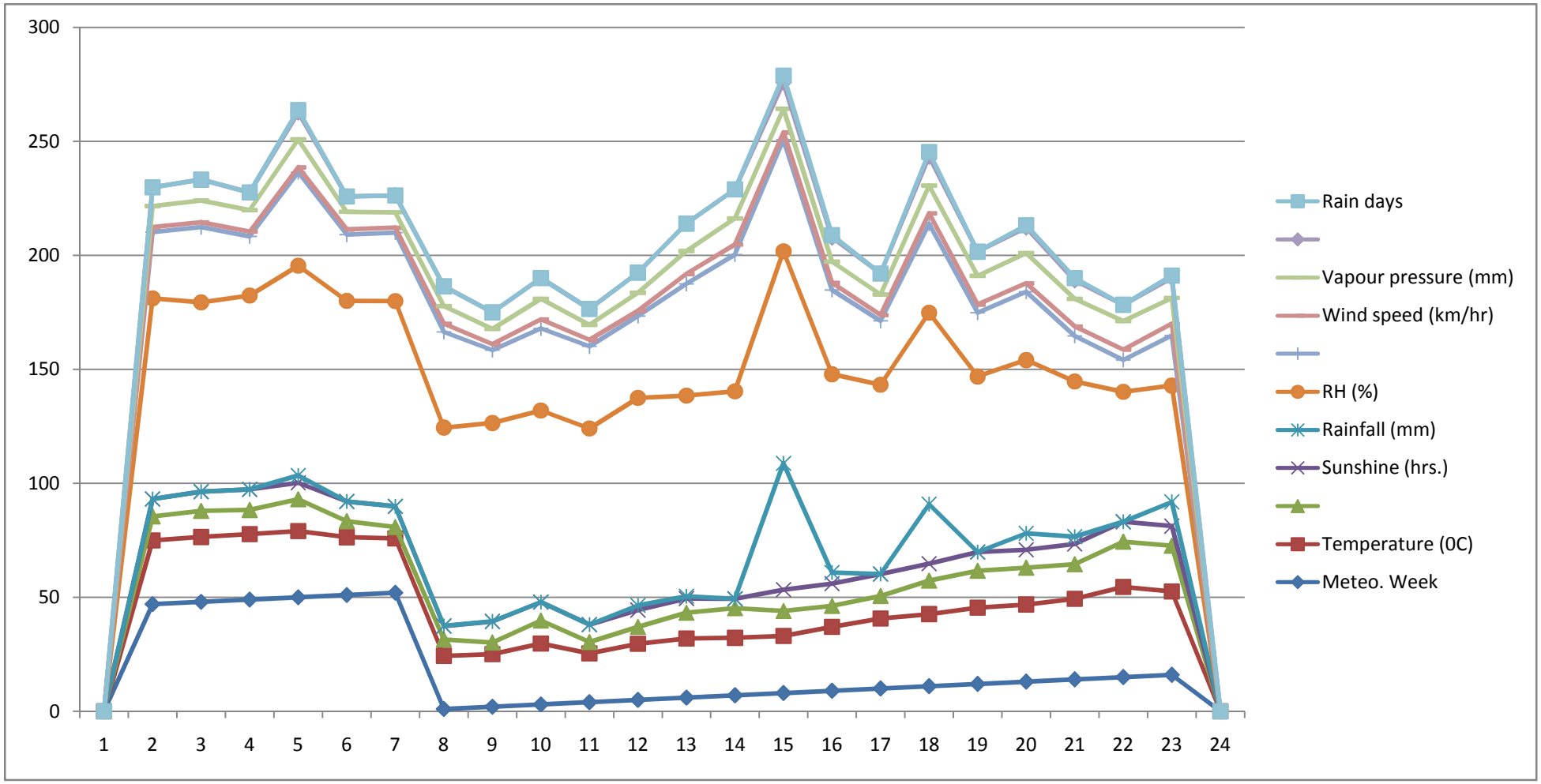

Table 3.2.2: Weekly meteorological parameters during crop season (end of November to end of April, 2013-14)

Meteo. Week	Temperature (^{0}C)		Sunshine (hrs.)	Rainfall (mm)	RH (%)		Wind speed (km/hr)	Vapour pressure (mm)		Rain days
	Max.	Min.			Morn.	Even		Morn.	Even	
47	27.9	9.2	8.8	0	86	30	2.1	9.6	9.0	0
48	27.8	9.1	8.3	0	88	30	2.3	9.4	8.3	0
49	26.3	8.5	7.7	0	91	33	2.0	8.8	8.2	0
50	25.9	7.1	8.6	0	89	30	1.9	8.4	7.4	0
51	26.0	7.5	8	0	91	34	2.0	9.5	8.2	0
52	24.5	11	5.4	0	90	44	3.0	10.2	9.9	0
1	23.5	11.1	6.6	0	90	57	3.1	11.5	11.6	0
2	22.3	16.2	6.1	1.8	94	59	2.9	10.1	12.0	1
3	22.2	12.3	4.2	6.8	95	68	4.4	11.8	13.6	1
4	22.3	10.6	6.6	0	91	61	3.9	10.7	11.6	0
5	23.7	5.6	9.6	0	93	34	1.8	7.2	7.8	0
6	28.0	10	9.4	0	91	39	2.5	9.8	10.3	0
7	23.9	9.5	7.7	12	88	41	3.8	9.4	8.9	2
8	25.5	11.9	9.2	17	93	55	3.2	11.6	12.6	1
9	24.8	14.3	7.1	58.2	91	60	4.6	13.4	13.1	4
10	26.6	11.9	7.6	1.8	87	42	2.2	12.1	11.0	0
11	30.5	12.6	8.0	2.6	84	45	2.9	14.6	14.7	1
12	34.0	13.4	8.6	0	79	27	3.2	13.8	10.5	0
13	36.4	17.6	8.6	0	77	20	2.9	14.5	9.2	0
14	37.4	18.5	9.3	0	55	16	3.9	11.2	7.4	0
15	37.4	17.9	9.3	0	57	17	3.9	11.4	8.0	0
16	37.7	20.6	9.0	0	61	24	5.1	13.9	10.8	0
17	39.7	19.9	9.5	0	50	13	3.5	12.4	7.1	0

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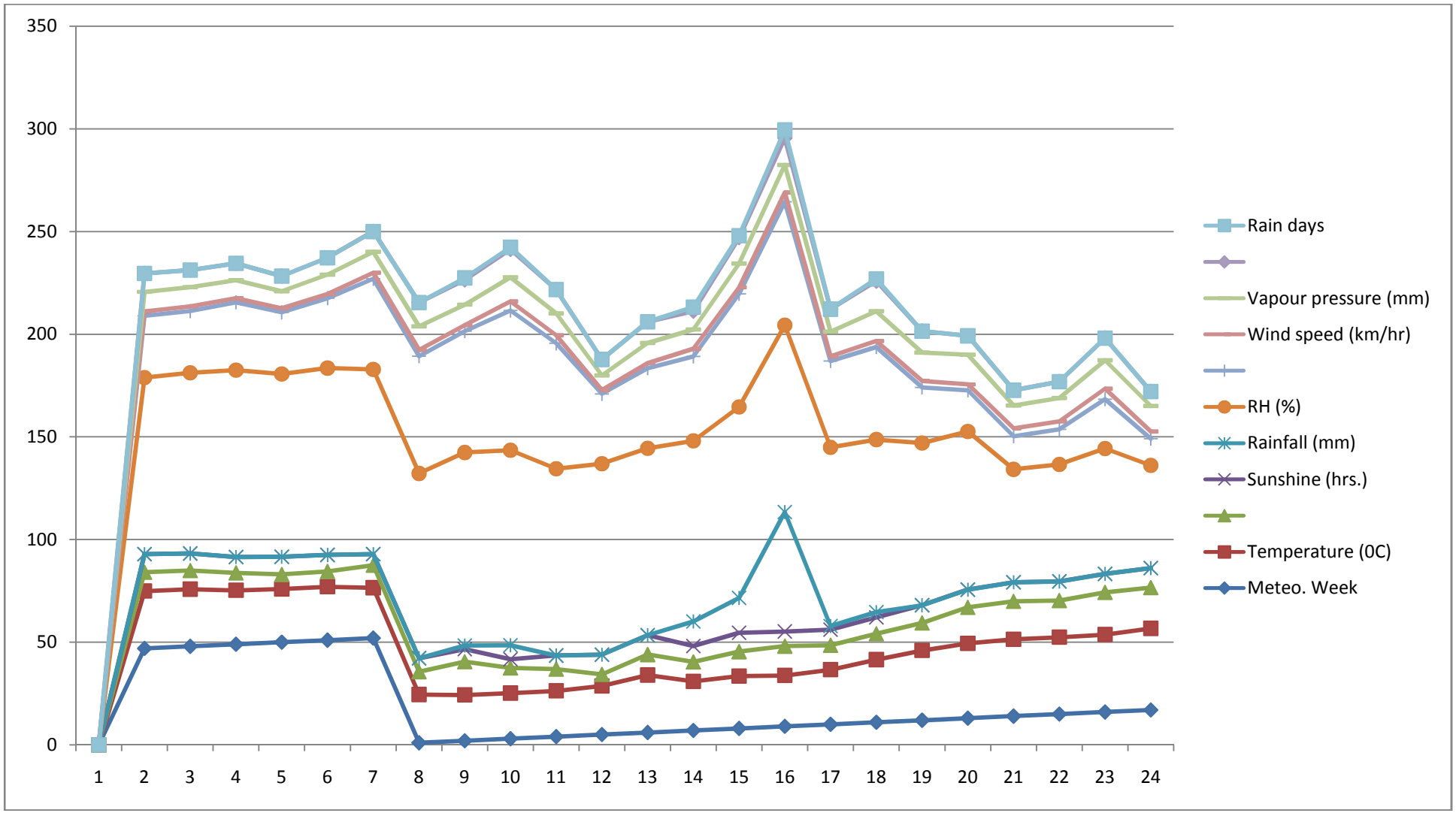
Fig.3.2.: Graphical representation of Metrological data (2013-14).



3 .3 Experimental material

The experimental material comprised of 30 promising genotypes of wheat, procured from different Wheat Improvement Projects, research centers of India and received from Centro Internationale de Mejoramiento de Maiz y Trigo (CIMMYT) Mexico, was grown in a Randomized Block Design with three replications. [Table 2.3.]. Each plot consists of four rows of 2.5 m length and 20 cm apart under irrigated normal sown, late sown and very late sown conditions during both experimental years**.**

Table 3.3.1 List of genotypes of wheat under study:

S.No	Genotype	S.No	Genotype	S.No	Genotype
1.	JW-3269	11	PBW-343/CDWR-9563-1	21	31ESWYT-110
2.	GW-366	12	MP-3349/MP-3222	22	31ESWYT-120
3.	LOK-1	13	MP-3342/PBW-343/K-9924	23	31ESWYT-121
4.	JW-3211	14	PBW-343/CDWR-9563-6	24	31ESWYT-123
5.	JW-3336	15	MP-3368/MP-4669	25	31ESWYT-125
6.	HD-2864	16	MP-3359/WH-1092	26	31ESWYT-126
7.	HD-2932	17	MP-3372/NTAW-1395	27	31ESWYT-127
8.	HI-1544	18	MP-3360/RAJ-4213	28	31ESWYT-131
9.	MP-3324/MP-3092/MP-322	19	31ESWTY-118	29	31ESWYT-132
10.	401-136/JW-17-1	20	31ESWYT-107	30	31ESWYT-133

3.4 Dates of sowing:

The sowing was made under three different environmental conditions with three different dates of sowing in both the experimental years by hand dibbling of seeds in row (Table 3.4.). All the recommended cultural packages of practices were followed to raise the healthy crop.

Table 3.4: Dates of sowing under study.

Condition	Dates Of Sowing	
	First year	Second year
Normal sown	22/11/2012 **[E1]**	25/11/2013 **[E4]**
Late sown	6/12/2012 **[E2]**	10/12/2013 **[E5]**
Very late sown	15/01/2013 **[E3]**	17/01/2014 **[E6]**

3.5. Observations recorded

The observation was recorded on five randomly selected plants from each plot and from each replication for the following characters and per plant data was obtained by averaging the values.

3.5.1. Morphological traits

1. **Days to 50% flowering (days):** The number of days required from sowing to ear head emergence for 50% flowering was recorded.
2. **Days to maturity (days):** The number of days required to achieve physiological maturity was recorded.
3. **Plant height (cm):** The height of the main shoot of each plant was recorded from the base of the plant to the tip of the main spike.
4. **Number of tillers plant^{-1}:** It was recorded by counting the number of tillers present in one plant at the time of maturity.
5. **Number of effective tillers plant^{-1}:** It was recorded by counting the numbers of productive tillers at the time of maturity**.**

6. **Number of in-effective tillers plant^{-1}:** It was recorded by counting the numbers of unproductive tillers at the time of maturity.

7. **Number of spikelets ear^{-1}:** All the spikelet in the main ear including sterile one's are counted

8. **Number of ears plant^{-1}:** It was recorded by counting the numbers of tillers bearing the ears**.**

9. **Number of grains ear^{-1}**: Total number of grains per main spike was counted after threshing the individual spike.

10. **Number of grains plant^{-1}**: Total number of grains present in a single plant counted after threshing the individual plant**.**

11. **Ear head length (cm):** The length of the spike was recorded in cm from base to tip of spike excluding awns.

12. **Ear weight (g):** It is calculated by using the following formula:

$$\text{Ear weight (g):} = \frac{\text{Weight of ears (g)}}{\text{Number of ears}}$$

13. **Peduncle length (cm):** The length of the main shoot was recorded in cm from the base to the tip of the first flag leaf up to the base of ear .

14. **Number of leaves plant^{-1}:** It was recorded by counting the numbers of leafs present in a single plant**.**

15. **1000 grain weight (g):** One thousand sound filled grains were sun dried up to 12 % moisture level, were weighed in grams.

16. **Biological yield plant^{-1} (g):** Each of the selected plants was harvested at maturity and weight recorded in grams after complete sun dry excluding roots.

17. **Yield plant^{-1} (g):** Individual plant was hand threshed, cleaned, dried up to 12 % moisture level and weighed in grams.

18. **Harvest index (%):** The harvest index was calculated by using the following formula and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield / plant (g)}}{\text{Biological yield /plant (g)}} \times 100$$

3.5.2. Physiological traits

19. **Relative water content of flag leaf:** Leaf relative water content was estimated by recording the turgid weight of fresh leaf samples by keeping in water for 4 h, followed by drying in hot air oven till constant weight is achieved.

$$\text{RWC} = \frac{\text{Fresh Weight – Dry Weight}}{\text{Turgid Weight – Dry Weight}} \times 100$$

20. **Chlorophyll content:** Chlorophyll content was estimated in 4th leaf from the top (fully expended leaflet) with the help of chlorophyll meter (SPAD-502 plus) in normal, late sown and very late sown condition plants. Readings measured in 3 plants per plot at grain filling stages. Chlorophyll content is expressed in terms of SPAD units.

21. **Canopy temperature:** Canopy temperature was recorded by the CTD instrument at grain filling stage by Infra Red Thermometer (Model LT 300 Sixth Sense).

3.5.3. Quality traits

22. **Sedimentation value (SDS value in ml):** It measures the quality of proteins and is based on the fact that gluten protein absorbs water and swells considerably when treated with lactic acid in the presence of sodium dodecyl sulphate (SDS). The volume of sediment depends on the extent of swelling of gluten protein and correlates significantly (+0.7) with loaf volume.

Apparatus:

Stop clock, water bath, 100 ml stopper measuring cylinder (these should have identical internal Diameter and the distance between the 0 and 100 ml graduations should be 160 mm approximately) and 50 ml measuring cylinders.

Reagents: Sodium dodecyl sulphate (sodium lauryl sulphate 88% lactic acid).

The desired SDS/lactic acid reagent may be prepared by dissolving 20 g SDS in one liter of distilled water, to this 20 ml of stock dilute lactic acid prepared by diluting one part by volume of lactic acid 88% with 8 parts by volume of distilled water. The reagent is shaken or otherwise agitated until homogeneous.

Procedure:

The following method permits four determinations to be carried out at the same time, an additional four tests may be started during the period in which first four sediments are setting. Fifty ml of distilled water should be poured in each of the required number of 100 ml cylinders prior to starting the test, similarly the required number of 50 ml measuring cylinders should each be pre-filled with 50 ml SDS/lactic acid reagent.

Add 6 g whole meal to 50 ml water (cylinder 1) and start the stop clock. Shake rapidly for 15 seconds, keep the clock running continuously throughout the rest of the experiment. The time for commencement of the other preparations are given, in minute, in table 3.5.2.:

Table 3.5.3. Shake and rest interval for SDS value determination

Cylinder No.	15 sec. shake in water	15 sec. shake in water	15 sec shake in water, add 50 ml SDS, invert 4 times	Invert 4 times	Invert 4 times	Invert 4 times	Read sedimentation volume
1	0.0	2.0	4.0	6.0	8.0	10.0	30.0
2	0.5	2.5	4.5	6.5	8.5	10.5	30.5
3	1.0	3.0	5.0	7.0	9.0	11.0	31.0
4	1.5	3.5	5.5	7.5	9.5	11.5	31.5

23. **Hectoliter weight (kg /hl):** The hectoliter weight of the samples was estimated using hectoliter machine developed by DWR-Karnal, which gives the weight in terms of kg per hectoliter.

24. **Protein (%): Estimation by NIR equipment:** Protein content influences the functional quality of the product and has a greater influence on overall processing quality than any other single factor. While the environment is the major determinant of the actual protein level achieved and the variability between wheat varieties is their capacity to accumulate protein is also important. Flour dough strength is related to the combination of total protein and also protein quality. It is therefore influence by the environment, but also has a major genetic component. The protein requirements of wheat for various products like chapatti, bread, biscuit and pasta are different. Protein percentage of more than 12 % in *aestivum* wheat is needed for good bread, < 10 % for biscuit, 10 to 12 % for chapatti, and > 12 % in durum wheat for good pasta products. It is estimated through non-destructive method by NIR-instrument “Infratec ^{TM} 1241 grain analyser” of FOSS.

25. **Wet gluten (%):** Gluten is a composite found in foods processed from wheat and related grain species, including barley and rye. It gives elasticity to dough, helping it to rise and to keep its shape, and often gives the final product a chewy texture. Gluten is the composite of a *gliadin* and a *glutelin*, which is conjoined with starch in the endosperm of various grass-related grains. The prolamin and glutelin from wheat (gliadin, which is alcohol-soluble, and glutenin, which is only soluble in dilute acids or alkalis) constitute about 80% of the protein contained in wheat seed. Being insoluble in water, they can be purified by washing away the associated starch. Worldwide, gluten is a source of protein, both in foods prepared directly from sources containing it, and as an additive to foods otherwise low in protein. It is estimated through non-destructive method by NIR-instrument “Infratec ^{TM} 1241 grain analyser” of FOSS.

26. Starch content: Starch is the major constitute of wheat endosperm and its importance to the properties of wheat product is recognized. Starch is also an important industrial raw material either separately or as a part of flour. It is estimated through non-destructive method by NIR-instrument "Infratec ^{TM} 1241 grain analyser" of FOSS.

27. Moisture (%): It is estimated through non-destructive method by NIR-instrument "Infratec ^{TM} 1241 grain analyser" of FOSS.

3.6. Statistical analyses for field characters

1. Analysis of variance (Burton, 1952)
2. Heritability (Hanson et. al*.,* 1956)
3. Genetic advance (Johnson et. al., 1955)
4. Correlation coefficient analysis (Miller et al., 1958)
5. Path coefficient analysis (Wright, 1921 and Dewey and Lu, 1959)
6. Multiple regression analysis (Panse and Sukhatme, 1967)
7. Stability analysis (Eberthart and Russell, 1966)

The statistical analysis of data on individual characters was carried out on the mean values over three replications. The statistical methods adopted were as follows:

Mean: The mean was calculated by following method:

$$\text{Grand mean } (\bar{X}) = \frac{\sum xi}{N}$$

Where,

$\bar{X}$ = Grand mean or over all mean of the observation

$\sum xi$ = Sum of all observations; [i= 1,2,3,…….n.]

N = Number of observations

Range:

The range for each character was determined by taking the minimum and maximum values for each trait within population.

Coefficient of variation (CV %)

Genotypic and phenotypic coefficient of variation was computed, using formula given by Burton (1952).

$$\text{Genotypic coefficient of variation (GCV \%)} = \frac{\sqrt{\sigma^2 g}}{\bar{X}} x100$$

$$\text{Phenotypic coefficient of variation (PCV\%)} = \frac{\sqrt{\sigma^2 p}}{\bar{X}} x100$$

Where,

$\sqrt{\sigma^2 g}$ = Genotypic standard deviation

$\sqrt{\sigma^2 p}$ = Phenotypic standard deviation

$\bar{X}$ = General mean of particular character

3.6.1 Analysis of variance(Burton, 1952)

The analysis of variance was carried out for all the characters separately.

Table 3.6.1: The skeleton of analysis of variance table is given below: (ANOVA)

S.No.	S.V.	d. f.	S.S.	M.S.S.	E.M.S.
1.	Replication	(r-1)	SSr	M_3	$\sigma^2_e + r\sigma^2_p$
2.	Genotypes	(g-1)	SSc	M_2	$\sigma^2_e + r\sigma^2_c$
3.	Error	(r-1) (g-1)	SSe	M_1	σ^2_e
	Total	(rg-1)			

Where,

g = number of genotypes

r = number of replication

The data related to the various experimental observations were analyzed statically using the analysis of variance technique.

3.6.2 Heritability (h^2 bs)

Heritability in broad sense was calculated by the method proposed by Allard (1960) and Hanson *et al.* (1957).

$$h^2 (bs) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

h^2 (bs) = Heritability in broad sense

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

3.6.3. Genetic advance

The estimation of genotypic and phenotypic variances and heritability were used to determine the expected genetic advance as suggested by Johnson et al., (1955) and expressed as-

$$GA = K \times \sigma^2 p \times h^2$$

Where,

K = selection intensity (2.06 at 5% level)

$\sigma^2 p$ = Phenotypic standard deviation

h^2 = Heritability (bs) in fraction

3.6.3.1. Genetic advance as percentage of mean

This was expressed by following formula:

$$\text{Genetic advance (as \% of mean)} = \frac{GA}{\overline{X}} \times 100$$

Where,

GA = Genetic advance

$\overline{X}$ = Mean

3.6.5 Estimation of correlations:

Phenotypic and genotypic correlation coefficients between characters were computed utilizing respective components of variance and co-variance, by following formula,

Phenotypic correlation (rp) =PCOVxy / √PVx . PVy

Genotypic correlation (rg) = GCOVxy / √GVx . GVy

$$r_{xy} = \frac{Cov\,(x, y)}{\sqrt{V(x) \times V\,(y)}}$$

Where,

r_{xy}	=	Correlation coefficient between character x and y,
Cov (x,y)	=	Co-variance of character x and y,
V(x)	=	Variance of character x, and
V(y)	=	Variance of character y.
rp	=	Phenotypic correlation.
rg	=	Genotypic correlation

To test the significance of correlation coefficients, the estimated values were compared with the tabulated values of Fisher and Yates (1938) at t-2 d.f. at two levels of probability, *viz*., 5% and 1%.

3.6.6. Path coefficient analysis:

The proportion of direct and indirect contributions of various characteristics to the total correlation coefficients with seed yield was estimated through path coefficient analysis as suggested by Wright (1921, 1934) and elaborated by Dewey and Lu (1959).

Path coefficient is a standardized partial regression, which measures the direct influence of one variable upon another and allows partition of correlation coefficient into components of direct and indirect effects.

To estimate various direct and indirect effects, the following set of simultaneous equations were formed and solved.

$r_{1y} = P_{1y} + r_{12}P_{2y} + r_{13}P_{3y} + \ldots + r_{1I}P_{Iy}$

$r_{2y} = r_{2y}P_{1y} + P_{2y} + r_{23}P_{3y} + \ldots + r_{2I}P_{Iy}$

$r_{Iy} = r_{I1}P_{1y} + r_{I2}P_{2y} + r_{I3}P_{3y} + \ldots + P_{Iy}$

Where,

r_{1y} to r_{Iy} = Coefficient of correlation between causal factor 1 to I and dependent character y,

r_{12} to $r_{I-1,I}$ = Coefficient of correlation among causal factors themselves, and

P_{1y} to P_{Iy} = Direct effects of characters 1 to I on character y.

Residual effect, which measures the contribution of the characters not considered in the causal scheme, was obtained as:

Residual effect :

$$(P_{RY}) = \sqrt{1 - R^2}$$

Where,

$$R^2 = \sum_{iy} P_i^2 Y + 2 \sum_{\substack{i \neq j \\ i > j}} P_{iy} \, P_{jy} \, R_{ij}$$

3.6.7 Multiple regression analysis (Panse and Sukhatme, 1967)

Panse and Sukhatme (1967) suggested a method of multiple regression equation was of the following types:-

Multiple regressions mean, models with just one dependent and two or more independent (exploratory) variables. The variable whose value is to be predicted is known as the dependent variable and the ones whose known values are used for prediction are known independent (exploratory) variables

More precisely, multiple regression analysis helps us to predict the value of Y for given values of X_1, X_2… X_n

Multiple Regression Model

In general, the multiple regression equation of Y on X_1, X_2, …, X_n is given by:

$$Y = a + b_1 X_1 + b_2 X_2 + \ldots\ldots\ldots\ldots\ldots + b_n X_n$$

$$\overline{Y} = a + b_1 \overline{X}_1 + b_2 \overline{X}_2 + \ldots\ldots\ldots\ldots\ldots\ldots + b_n \overline{X}_n$$

$a = (b_1 \overline{X}_1 + b_2 \overline{X}_2 + \ldots\ldots\ldots\ldots\ldots\ldots + b_n \overline{X}_n)$

Where,

Y = Dependent variable

$\overline{Y}$ = mean of Y

b_0 = intercept

a = value of intercept b_1, b_2 and b_n values of partial regression coefficient of independent variable x_1,x_2 and x_n on dependent variable (yield –Y) whereas x_1,x_2 and x_n are the mean of the independent variables.

Multiple correlation coefficient (R) was computed by following formula:

$R_2yh_2n = ry_1.b_1y_1 + ry_2b_1y_1 + \ldots.. + rynb_1yn$

Where,

r = phenotypic correlation coefficient

b_1 = partial regression coefficient of ith independent variable on dependent variable viz., i=1, 2, 3 and n etc

Square of multiple correlation coefficient in (r2) in percent gave coefficient of determination.

3.6.8. Estimation of Stability parameters

Prior to the pooled analysis variance, the error variances for each environment (years) are subjected to test the homogeneity of variance as per the Bartlett's test of homogeneity.

Stability analysis was carried out as per the Eberhart and Russell (1996) model. The model stated as –

$$Yij = m + bij\ lj + ij \qquad (i=1,2,3,\ldots\ldots t)$$

$$(j=1,2,\ldots\ldots s)$$

Where,

Yij = mean of the ith variety in jth environment.

m = Mean of all the varieties over all the environments.

bij = the regression coefficient of the ith variety on the

Environmental index which measures the response of variety in varying environments.

lj = the environment index which is defined as the deviation
Of the mean of all the varieties at a given location from the
Overall mean

ij = the deviation from regression of the ith variety at ith environment.

Eberhert and Russell (1996) proposed the following three stability parameters.

1. Mean performance: This parameter used for recognizing the performance of genotypes over year/locations etc.
2. Regression coefficient: It is measured as the regression of the performance of each variety under different environments or locations on the environmental or location means. A stable genotype as one with regression coefficient of unity (b=1) was considered and should not be significantly different from variety.
3. Deviation from regression coefficient: Deviation from regression should be minimum from the regression line (s^2 d= 0).

RESULTS

The present investigation was carried out for two consecutive years on 30 genotypes of bread wheat to study quantitative, physiological and qualitative traits, in order to select the genotypes suitable for different environments (timely sown, late sown and very late sown). The genotypes were grown in randomized complete block design with three replications in each environmental condition at Wheat Improvement Project, Seed Breeding Farm, JNKVV, Jabalpur. Variability analysis will help the breeder, in selection of traits as well as genotypes, for different environmental conditions and in the estimation of other important genetic parameters. Correlation was reported out to study degree of relationship between different traits. Path analysis was conducted to know direct and indirect effect of various independent traits on dependent one. Multiple regression were carried out to remove the effect of non-effective traits in regression model on grain yield. Stability analysis was performed to find genotypes stable over different environmental conditions.

The experimental results of the present investigation have been given under following heads:

4.1 Genetic variability

4.2 Heritability and Genetic advance

4.3 Correlation coefficient analysis

4.4 Path analysis

4.5 Multiple regression

4.6 Stability analysis

4.1 Genetic variability

Analysis of variance refers to observable differences in individuals of particular trait. To known the variation of observed character among the 30 different genotypes of bread wheat, analysis of variance was performed and are presented in tables 4.1.1 (a) & (b), 4.1.2 (a) & (b), and 4.1.3 (a) & (b). Analysis of variance indicated mean sum of square due to genotypes were significant for all the observed traits and considerable amount of genetic variation were present except for number of ineffective tillers plant^{-1}.

4.1.1. I Year [2012-13]

The results of I year [2012-13] with the mean sum of square of 30 bread wheat genotype as observed for 27 different traits were presented in the table [4.1.1 (a) and 4.1.1 (b)]. In the present investigation considerable amount of variability were existed for all the yield attributing traits studied under three different environments. The maximum amount of variability was observed for number of effective tillers plant^{-1} (17.81) and minimum for number of grains plant-^{1} (0.46) in E1. Whereas, in E2 the maximum amount of variability was observed for number of effective tillers plant^{-1} (11.70) and minimum for number of grains plant-^{1} (0.67). Similarly, in E3 the maximum amount of variability were observed for number of effective tillers plant^{-1} (13.40) and minimum for number of grains plant-^{1} (0.68).

4.1.2. II Year [2013-14]

Considerable amount of variability were existed for all the yield attributing traits studied under all three environments. The maximum amount of variability was observed for number of effective tillers plant^{-1} (28.70) and minimum for number of grains plant-^{1} (0.58) in E4. Whereas, the maximum amount of variability was observed for number of effective tillers plant^{-1} (22.30) and minimum for number of grains plant-^{1} (0.63) in E5. Similarly, in E6 the maximum amount of variability were observed for number of effective tillers plant^{-1} (20.3) and minimum for number of grains plant-^{1} (0.71). The results of II year [2013-14] with the mean sum of square of 30 bread wheat

genotype as observed for 27 different traits were presented in the table [4.1.2 (a) & (b)].

4.1.3. Pooled results of the two Years

Sufficient amount of variability were existed for all the yield attributing traits studied for the two consecutive years. The maximum amount of variability was observed in number of effective tillers plant^{-1} (27.86) and minimum in relative water content of flag leaf (1.39)**.** The pooled results of two years with the mean sum of square of 30 bread wheat genotype as observed for 27 different traits were presented in the table [4.1.3. (a) & (b)].

Table 4.1.1 (a) : ANOVA for first experimental year

Source of Variations	df	MSS	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Effective tillers plant^{-1}	Ineffective tillers plant^{-1}	Spikelets ear^{-1}	Ears plant^{-1}	Grains ear^{-1}	Grains plant^{-1}	Ear head length (cm)	Ear weight (g)	Peduncle length	Leaves plant^{-1}
Replicate	2	E1	30.1000	27.0778	45.2817	5.5951	1.7204	3.3298	12.1401	14.1463	42.7223	72.2641	1.6994	0.3942	45.6445	41.2714
		E2	16.3444	18.4333	42.7293	6.7643	5.1258	0.9548	7.0648	8.4348	4.2684	5.9018	5.3170	0.1717	4.0048	62.4981
		E3	2.8778	6.2111	8.7608	4.0388	6.5648	11.0280	4.8323	15.7810	15.2124	5.9843	3.4223	0.0977	10.4373	7.4151
Treatments	29	E1	24.0690	52.3008	92.5205	3.9261	4.2941	4.7236	3.9466	5.0527	163.2870	17699.8906	4.7748	0.6967	27.9592	87.5285
		E2	19.8180	63.9713	33.0660	1.5424	2.1424	1.2457	11.1594	2.0290	66.0944	14952.7256	4.7305	0.2259	22.4982	57.8644
		E3	31.7352	59.9479	56.9919	5.5558	1.9546	2.2235	3.5345	4.6998	66.0944	16537.7363	4.7305	0.1552	8.8242	56.2218
Error	58	E1	1.7207	0.8249	2.0784	1.8719	0.8541	1.3353	3.2390	1.0329	2.5053	2.6135	0.1160	0.0293	1.2589	1.4155
		E2	2.3904	0.9736	5.9743	1.6347	1.8691	0.7485	2.6374	1.7326	2.6471	4.1752	0.8546	0.0044	2.9865	1.6689
		E3	1.9352	1.0272	2.3324	1.2969	0.9073	1.1223	0.9241	1.2887	2.2697	2.8542	0.9199	0.0032	1.4789	2.1813

Table 4.1.1 (b) : ANOVA for first experimental year

Source of Variations	df	MSS	1000 grain weight (g)	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	SDS value (mm)	Hectoliter weight (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Replicate	2	E1	9.0526	21.6314	28.9318	130.9136	2.7896	44.7738	12.4188	28.1855	25.3778	0.3048	1.3448	7.6563	0.9333
		E2	8.7014	9.0217	3.3382	390.2511	6.8184	61.1410	2.3808	37.1354	63.5444	0.2208	1.4590	5.0898	4.5934
		E3	17.8792	3.3881	19.4677	55.2843	10.9254	2.9564	3.5054	10.1351	13.2333	1.2434	0.2093	1.7770	2.4671
Treatments	29	E1	50.3953	145.0017	18.8493	94.8929	88.0934	28.9489	1.3832	141.9699	24.1134	2.7234	30.8866	5.2155	0.1555
		E2	68.5396	71.8602	20.3645	181.9765	88.9140	29.7295	1.7125	35.4880	16.5904	1.3544	26.4713	8.5827	0.3875
		E3	59.3442	134.2872	6.8577	281.1774	92.0474	106.3173	1.4696	61.8597	8.2793	2.1819	12.7958	14.4825	0.7074
Error	58	E1	2.5255	1.3666	0.7938	6.7900	0.6905	2.2325	0.5196	0.5568	2.4927	0.0279	0.1913	0.6387	0.0503
		E2	2.2171	1.7921	2.5854	11.0162	0.7154	2.8603	0.7531	0.4018	9.5215	0.0096	0.2210	0.3432	0.4592
		E3	2.5445	1.1454	1.7533	43.7388	3.0064	4.7377	0.7304	2.0330	3.6126	0.4139	0.0719	0.2703	0.4900

Table 4.1.2 (a) : ANOVA for second experimental year

Source of Variations	Df	MSS	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Effective tillers plant^{-1}	Ineffective tillers plant^{-1}	Spikelets ear^{-1}	Ears plant^{-1}	Grains ear^{-1}	Grains plant^{-1}	Ear head length (cm)	Ear weight (g)	Peduncle length	Leaves plant^{-1}
Replicate	2	E4	67.9000	1.9000	15.8135	10.6493	6.5693	33.4293	11.3548	6.8410	23.1373	15.4739	1.3959	2.0209	20.4034	44.6258
		E5	25.1421	47.5743	250.1790	3.4518	1.4780	4.0072	12.8971	2.2171	65.7219	18395.8613	3.4716	0.3193	24.1473	77.5676
		E6	6.4333	7.5444	45.2315	4.4654	2.4634	12.6164	5.6603	2.4243	8.3676	13.2668	2.7360	0.7289	7.5934	11.2731
Treatments	29	E4	4.1552	13.1862	104.3444	3.5197	3.9466	8.2538	3.9999	3.0533	162.9635	17427.2695	5.1506	1.0545	23.3179	159.3327
		E5	2.1444	4.0444	4.6486	18.4542	3.2792	11.4411	9.4503	3.0489	4.2803	27.7822	5.5108	0.7124	8.3418	28.4327
		E6	41.5770	43.0042	90.5059	3.2952	1.9683	3.7157	5.1971	2.2394	67.2103	17566.7988	4.6570	0.1954	10.3963	78.2647
Error	58	E4	1.7621	1.9000	1.7163	2.6349	1.8809	4.3471	3.2352	2.0064	3.6195	4.0625	0.2534	0.0917	1.9128	1.5599
		E5	1.7192	1.7916	1.3255	3.0052	0.8406	3.4377	2.3909	0.8005	2.3785	3.9157	1.2824	0.1975	2.4036	3.1875
		E6	1.5828	1.4985	13.1473	1.1957	0.6326	1.7554	1.4714	0.6935	2.3218	3.2217	0.7147	0.0693	1.5716	1.5217

Table 4.1.2 (b) : ANOVA for second experimental year

Source of Variations	Df	MSS	1000 grain weight (g)	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	SDS value (mm)	Hectoliter weight (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Replicate	2	E4	1.1763	0.7388	5.8978	44.3194	4.5131	34.3691	0.5201	3.9204	43.0333	0.1721	0.4604	14.9803	0.0858
		E5	2.1290	25.2840	12.1948	49.1069	6.6460	36.6881	6.8441	24.4031	22.7111	0.1030	0.4991	9.8308	0.9084
		E6	22.1300	20.4516	7.4120	343.9703	17.7042	23.7088	4.9334	23.2458	7.8778	0.1098	0.2201	6.2374	0.1148
Treatments	29	E4	50.3953	2.3427	17.5834	95.8476	86.8309	28.1645	0.8616	141.9219	22.9966	2.8240	24.0292	1.4946	0.0879
		E5	67.7401	11.1391	20.5121	103.7337	87.5510	29.7621	1.4502	35.3880	25.7123	1.7452	20.3865	1.3153	0.1011
		E6	47.8929	111.7829	7.0395	361.3812	90.3625	105.8788	1.7102	59.7218	15.1893	1.9016	8.5844	3.6464	0.1342
Error	58	E4	2.5255	1.1066	1.7110	8.7592	0.8397	2.9898	1.0084	1.0987	2.3437	0.0161	0.1304	1.1194	0.0247
		E5	0.9039	3.8089	1.6515	39.8717	0.7640	3.8475	0.8997	0.9618	2.9295	0.0139	0.1115	1.2759	0.0464
		E6	2.8559	5.9200	1.6447	56.2178	3.1773	3.9191	0.9601	1.3543	2.1881	0.0284	0.0334	1.4901	0.0193

Table 4.1.3 (a): Pooled ANOVA over all the experimental years

Source of Variations	df	MSS	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Effective tillers plant^{-1}	Ineffective tillers plant^{-1}	Spikelets ear^{-1}	Ears plant^{-1}	Grains ear^{-1}	Grains plant^{-1}	Ear head length (cm)	Ear weight (g)	Peduncle length	Leaves plant^{-1}
Replicate	2		2.1685	1.6222	0.0981	2.9238	3.0733	2.9007	7.2296	1.2677	0.1396	13.2033	0.2951	0.0002	0.5734	3.9603
Locations	1		644.6296	112.0667	5422.9204	138.2696	28.9306	293.6946	39.9622	88.1447	2815.1672	449.1414	0.2894	80.0800	20.7682	332.0240
Environments	5		2795.8018	28603.6719	6688.1885	594.5724	82.7506	249.2842	67.1170	109.6517	9051.1006	441084.0625	107.4609	51.5956	1336.0027	9114.2568
Loc * Env	5		255.1242	102.8170	5167.9688	4.5187	35.6755	18.4368	1.3532	5.5588	1559.2406	3009.6558	87.8380	2.1904	81.4457	93.5898
Interactions	10		24.7263	12.7178	32.4734	9.4087	4.5299	13.9797	8.6546	9.8817	19.5697	25.4924	3.9572	0.8251	19.1704	38.3111
Overall Sum	23		411.6519	3391.4980	1732.9509	84.4933	18.6605	57.3374	16.3475	24.7011	1425.4015	52289.2891	25.3559	11.5237	179.3244	1125.8088
Treatments	29		59.0610	124.6605	293.8706	9.2240	2.9683	7.2370	16.4366	4.4887	357.4431	46855.8320	13.0415	1.4234	67.9052	143.6573
Error	667		6.4504	10.0797	22.7580	2.0792	1.5756	2.4956	3.0643	1.7595	15.6125	3280.3608	1.3386	0.1185	4.2625	23.3054

Table 4.1.3 (b): Pooled ANOVA over all the experimental years

Source of Variations	Df	MSS	1000 grain weight (g)	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	SDS value (mm)	Hectoliter weight (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Replicate	2		1.6942	0.5104	0.0555	56.0662	4.3587	1.7630	0.4879	0.0848	11.4241	0.0711	0.0644	2.0909	0.8003
Locations	1		21.6000	1505.2379	109.8817	8580.1035	396.8083	263.6070	38.6671	57.6240	516.2667	1.8027	92.5870	256.8182	46.6990
Environments	5		5763.9917	17372.8848	1842.3320	2940.8867	1066.0796	5510.5483	3788.5635	22435.7090	1315.6797	687.1354	5268.6250	259.2875	1.3864
Loc * Env	5		8.5620	1019.4210	11.8934	4762.4111	3.9646	4.4083	1.8785	11.3305	8.8388	1.1811	0.0350	168.6628	2.1276
Interactions	10		11.8749	16.0009	15.4374	191.5559	9.0076	40.3749	6.0230	25.3882	32.8707	0.4166	0.8256	8.6961	1.6605
Overall Sum	23		687.5791	2261.8164	233.6951	1530.2583	155.0406	688.2820	451.8092	2659.1619	206.8741	81.3378	625.7819	70.8154	4.2313
Treatments	29		198.8774	101.6773	61.0842	349.3154	530.4892	110.0854	2.1721	230.3332	47.2097	5.8902	61.9555	9.9378	0.5406
Error	667		10.1515	23.8245	2.9648	64.8518	1.2763	15.2876	0.9505	15.2252	6.5793	0.4624	3.6893	2.0632	0.1890

The mean performance of genotypes for all the 27 traits studied in the present investigation has been presented in appendix-I to appendix-VI and has been discussed under following heads:

Days to 50% flowering

I Year [2012-13]

E1- Days to 50% flowering ranged from 58.00 to 69.31 days with a mean value of 65.67 days. Genotype JW-3211 (58.00) was earliest followed by genotypes JW-3336 (60.00) and JW-3269 (61.00). Whereas, the more number of days to flowered were taken by the genotypes MP-3360/RAJ-4213 (69.31), 31ESWYT-126 (69.34) and 31ESWYT-118 (69.00).

E2- With an average value of 66.72, it varied from 62.0 to 71.33. The earliest flowering was observed in JW-3269 (62.00), followed by JW-3336 (62.10) and MP-3342/PBW-343/K-9924 (62.01). 31ESWYT-1070 (71.33), 401-136/JW-17-1 (71.00) and MP-3359/WH-1092 (69.37) were the genotypes reported for maximum days to 50% flowering.

E3- This trait ranges from 55.33 to 68.00 with an average value of 61.34. Minimum number of days to 50% flowering was reported in MP-3342/PBW-343/K-9924 (55.33), followed by HD-2864 (56.66) and PBW-343/CDWR-9563-6 (57.33), however the maximum numbers of days to 50% flowering were taken by the genotypes 31ESWYT-123 (68.00), 31ESWYT-1071(67.33) and 31ESWYT-1070 (66.00).

II Year [2013-14]

E4- Days to 50% flowering showed variation from 63.33 to 67.66 days, with an average of 65.50 days. 31ESWYT-123 (63.33) was the earliest genotype, followed by JW-3211 and JW-3269 (64.00 and 64.23 days, respectively), while the late flowering were showed by the HD-2864 (67.66), followed by 401-136/JW-17-1 and MP-3342/PBW-343/K-9924 (67.33 and 67.23 days, respectively).

E5- The variation for days to 50 % flowering was high. As reported by its wide range from 58.00 (JW-3336) days to 70.00 days (31ESWYT-127) days. The average value obtained from the data was 65.14 days. Genotype JW-3269 (61.00) and LOK-1 (60.67) were reported for early flowering, whereas the genotypes 31ESWYT-1070 (69.67) and 401-136/JW-17-1 (69.33) revealed late 50% flowering.

E6- It ranged from 49.33 to 63.00 days, with a mean value of 56.53 days. The earliest flowering was observed in HD-2864 (49.33), followed by 31ESWYT-121 (51.33) and JW-3211 (51.00). The genotypes reported maximum days to 50% flowering were 31ESWYT-1070 (63.00), 31ESWYT-1071 (62.00) and PBW-343/CDWR-9563-1(61.00)

Pooled results of the two Years

Days to 50% flowering showed variation from 59.83 to 66.77 days with an average of 63.48 days. Minimum number of days to 50% flowering was recorded in JW-3269 (59.83), followed by HD-2864 and LOK-1 (60.05 and 60.44 days, respectively). The maximum numbers of days to flowering were noticed in 31ESWYT-1070 (66.78), 31ESWYT-123 (66.22) and 401-136/JW-17-1 (66.05).

Days to maturity

I Year [2012-13]

E1- Days to maturity illustrated marked variation from 113.33 to 129.34 days with an average value of 125.00 days. The earliest maturity was noticed in 31ESWYT-1071 (113.33), followed by PBW-343/CDWR-9563-6 (114.67) and MP-3342/PBW-343/K-9924 (116.67), whereas the late being noticed in 31ESWYT-127 (129.34), followed by 31ESWYT-118 (128.34) and LOK-1 (127.00).

E2- Among the genotypes the numbers of days to maturity were ranged from 106.00 days (HI-1544) to 127.00 days (31ESWYT-1070), with a mean value of 113.83 days. The maximum days to maturity was noticed in

31ESWYT-126 (107.54) and HD-2864 (107.00), whereas the minimum being recorded in 31ESWYT-127 (122.00) and 31ESWYT-121 (120.33).

E3- Marked variation was observed for this trait. Mean values among the genotypes for maturity varied from 91.00 to 109.33 days, with an average value of 98.49 days. 31ESWYT-110 (91.00) recorded as early maturing genotype followed by MP-3372/NIAW-1395 (92.12) and MP-3360/RAJ-4213 (93.00). While, genotypes 31ESWYT-1070 (109.33), 31ESWYT-123 (106.66) and 31ESWYT-1072 (105.00) were taken maximum days to maturity.

II Year [2013-14]

E4- The days to maturity showed variation from 121.33 to 128.66 days, with an average of 125.53 days. The earliest maturity was noticed in HI-1544 (121.33), followed by 31ESWYT-120 (121.45) and LOK-1 (121.49), whereas the genotypes 31ESWYT-1070 (128.66), followed by 31ESWYT-107 (128.66) and 31ESWYT-118 (127.45) reported maximum days to maturity.

E5- Days to maturity estimated for this environment showed variation from 109.33 days (31ESWYT-126) to 124.00 days (31ESWYT-1070). MP-3368/MP-4669 (109.66) and GW-366 (108.33) were categorized as early maturing genotypes, however 401-136/JW-17-1 (123.00) and 31ESWYT-127 (122.00) were in the category of late maturing genotypes.

E6- MP-3359/WH-1092 (92.00), MP-3372/NIAW-1395 (93.33) and LOK-1 (94.00) were the genotypes with minimum days to maturity and the 31ESWYT-1070 (108.00), 31ESWYT-123 (105.33) and 31ESWYT-1072 (104.00) were the genotypes reported maximum days to get mature with an average 98.14 days.

Pooled results of the two Years

From the data of both the years it was observed that number of days to maturity among the genotypes were ranged from GW-366 (108.33 days) to 31ESWYT-1070 (120.27 days). Genotype reporting the earliest maturity following the earliest one was PBW-343/CDWR-9563-6 (109.33). The

genotypes 31ESWYT-127 (117.44) and 31ESWYT-121 (115.89) were noticed maximum days to maturity.

Plant height (cm)

I Year [2012-13]

E1- Plant height varied from 79.16 to 105.40 cm with a mean value of 97.49 cm. The tallest height were noticed for genotype MP-3342/PBW-343/K-9924 (105.40 cm), followed by 401-136/JW-17-1 (105.00 cm) and 31ESWYT-126 (104.00 cm), whereas the shortest being reported for JW-3336 (79.16 cm), followed by PBW-343/CDWR-9563-6 (91.46 cm) and GW-366 (90.43 cm).

E2- The mean recorded for plant height was 97.67 cm with a range of 84.90 to 102.33. The genotype 31ESWYT-1071 (102.33 cm) recorded highest plant height among all the genotypes, followed by 31ESWYT-1070 (102.20 cm) and 401-136/JW-17-1 (101.76 cm). Among the genotypes, minimum height were showed by JW-3336 (84.90 cm), followed by HD-2864 (93.20 cm) and 31ESWYT-125 (94.06).

E3- The mean value noticed for the trait was 77.83 cm. It varied from 68.80 cm (JW-3211 and PBW-343/CDWR-9563-1) to 89.50 cm (PBW-343/CDWR-9563-6). The shortest genotypes were GW-366 and JW-3336 (71.83 cm and 73.10 cm respectively).

II Year [2013-14]

E4- The plant height has recorded the mean value of 98.84 cm with a range of 79.73 to 107.30 cm. PBW-343/CDWR-9563-1, 31ESWYT-126 and MP-3342/PBW-343/K-9924 (107.30 cm, 106.40 cm and 106.36 cm respectively) reporting the plant height in decreasing trend. Whereas, the genotype JW-3336, 31ESWYT-110 and HD-2864 (79.73 cm, 92.73 cm and 92.33 cm respectively) showed the increasing trend of height.

E5- Plant height exhibited the mean value of 96.68 cm with a range of 74.46 to 109.30 cm. Tallest plant height was noticed in MP-3342/PBW-343/K-

9924 (109.30 cm), JW-3269 (107.30 cm) and 31ESWYT-1071 (106.26 cm). Genotypes HD-2932 (74.46cm), JW-3336 (76.80) and 31ESWYT-1072 (78.65 cm) reported the shortest plant height.

E6- The mean plant height was 96.46 cm with a range of 81.40 to 104.83 cm. The maximum height was obtained in the genotype 401-136/JW-17-1 (104.83 cm), followed by MP-3324/MP-3092/MP-322 (102.43 cm) and MP-3368/MP-4669 (101.50), whereas the shortest being noticed in GW-366 (81.40 cm), followed by JW-3269 (83.20 cm) and JW-3336 (84.76 cm).

Pooled results of the two Years

This trait was ranged from 79.77 to 99.83 cm with a mean value of 94.16 cm. The tallest genotype was 401-136/JW-17-1 (99.83 cm), followed by MP-3342/PBW-343/K-9924 (99.79 cm) and 31ESWYT-1071 (99.08 cm), whereas the shortest height reported by JW-3336 (79.77 cm), followed by HD-2864 (88.56 cm) and JW-3211 (88.71cm).

Number of tillers plant^{-1}

I Year [2012-13]

E1- Maximum number of tillers was reported in genotypes 31ESWYT-118 (10.33), HI-1544 (10.26), JW-3211 (10.03) and minimum in HD-2864 (5.53), with an average number of tillers 8.79.

E2- This trait ranged from 6.30 to 9.46 with a mean of 7.64 cm. The maximum tillers were observed in genotype LOK-1, MP-3360/RAJ-4213 and PBW-343/CDWR-9563-1 (9.46, 9.10 and 8.53, respectively). Minimum number of tillers was observed in MP-3342/PBW-343/K-9924 (6.30).

E3- From the data it was observed that number of tillers plant^{-1} varied from 2.50 to 7.36 with an average value of 5.20. JW-3336 (7.36), 31ESWYT-120 (7.10) and 31ESWYT-1070 (7.06) were the genotypes with highest number of tillers. However, the minimum being observed in MP-3349/MP-3222 (2.50), followed by 31ESWYT-123 (2.73) and 31ESWYT-127 (2.93).

II Year [2013-14]

E4- For this trait average value was 10.01 with a variation of 7.66 to 11.65. Genotype 31ESWYT-127 (11.65), reported the maximum number of tillers, followed by 31ESWYT-118 and HD-2932 (11.36 and 11.06). The genotype reported the lowest number of tillers was HD-2864 (7.66).

E5- Maximum number of tillers was noticed in genotype 31ESWYT-127 (10.03) and minimum in 31ESWYT-123 (6.00). The mean calculated for the trait was 8.28.

E6- It varied from 4.30 to 8.10. The maximum tillers was observed in genotype JW-3336 (8.10), followed by 31ESWYT-1070 (8.06) and 31ESWYT-120 (7.96), whereas the minimum being observed in MP-3342/PBW-343/K-9924 (4.30), with an average of 6.36.

Pooled results of the two Years

Number of tillers plant^{-1} reported wide variation from 5.73 to 8.51 with an average value of 7.71. The maximum variation was noticed in genotypes MP-3324/MP-3092/MP-322 (8.51), followed by HI-1544 (8.46) and JW-3336 (8.40), whereas the minimum being observed in 31ESWYT-123 (5.73), followed by MP-3342/PBW-343/K-9924 (6.31) and HD-2864 (6.62).

Number of effective tillers plant^{-1}

I Year [2012-13]

E1- Number of effective tillers showed a wide variation which ranged, from 2.60 (HD-2864) to 7.40 (JW-3269) and mean of this trait was 5.19.

E2- Genotype LOK-1 (7.33) reported the maximum number of effective tillers, followed by MP-3360/RAJ-4213 (7.00) and 31ESWYT-126 (6.76). Minimum effective tillers was observed in genotype MP-3342/PBW-343/K-9924 (3.56), followed by HD-2864 (4.96) and 31ESWYT-123 (4.90). The mean recorded for the trait was 5.49.

E3- For the trait average value estimated was 3.53 with a range of 1.83 to 5.53. The highest number of effective tillers was found in genotypes 31ESWYT-1070 (5.53), MP-3324/MP-3092/MP-322 (4.53), HD-2864 (4.82) and the lowest number of effective tillers in MP-3349/MP3222 (1.83), followed by 31ESWYT-123 (2.06) and 31ESWYT-1072 (2.16).

II Year [2013-14]

E4- The mean value estimated from the data was 4.78 with a range of 2.96 to 6.60. The maximum value were observed in genotype JW-3336 (6.60), followed by 31ESWYT-118 (6.20) and 31ESWYT-123 (6.06), whereas the minimum number of effective tillers were noticed in the genotypes 31ESWYT-121 (2.96), followed by 31ESWYT-127 (3.13) and MP-3342/PBW-343/K-9924 (3.00).

E5- Data obtained for the trait ranged from 2.80 to 5.26 with an average of 4.11. The maximum value for the number of effective tillers were recorded in genotype JW-3336 (5.26), followed by 31ESWYT-118 (5.16) and HD-2932 (5.03). Although, genotype 401-136/JW-17-1 (2.80) exhibited the less number of effective tillers.

E6- The maximum value was observed in genotype 31ESWYT-1072 (6.06) and minimum in 31ESWYT-107 (2.43), with the mean recorded for the trait was 3.92.

Pooled results of the two Years

Genotypes observed for both the years showed marked variation for number of effective tillers plant^{-1}, ranged from 3.88 to 5.35 with a mean of 4.51. The highest number of effective tillers were exhibited by the genotypes 31ESWYT-1071 (5.35), followed by JW-3211 (5.25) and JW-3269 (5.33). Minimum number of effective tillers was noticed in PBW-343/CDWR-9563-6 (3.88).

Number of ineffective tillers plant^{-1}

I Year [2012-13]

E1- The value 3.60 represents the mean value of the studied trait. The number of ineffective tillers varied from 1.67 (JW-3269) to 6.46 (HI-1544).

E2- Number of ineffective tillers plant^{-1} varied from 0.26 (JW-3336) to 3.30 (PBW-343/CDWR-9563-1), with a mean value of 2.15.

E3- 31ESWYT-125 (0.63) was the genotype exhibiting the lowest number of ineffective tillers as compared to genotype to PBW-343/CDWR-9563-6 (3.30) possessing the highest number of ineffective tillers. The mean value estimated for the trait was 1.67.

II Year [2013-14]

E4- Wide range of variation 1.90 to 8.51 was noticed for number of ineffective tillers. The maximum ineffective tiller was recorded in genotype 31ESWYT-127 (8.51) and minimum in 31ESWYT-123 (1.90), with an average of 5.22.

E4- The mean value calculated for the trait was 4.17, with a wide range of variation noticed from 1.30 (HD-2864) to 6.86 (31ESWYT-127).

E6- This trait varied from 0.56 to 4.33 with a mean value of 2.44. The maximum value was noted in genotype 31ESWYT-107 (4.33) and the minimum in 31ESWYT-123 (0.56).

Pooled results of the two Years

Number of ineffective tillers plant^{-1} varied from 1.60 to 4.16 with a mean value of 3.20, in which maximum value was recorded in genotypes MP-3324/MP-3092/MP-322 (4.16) and the minimum value was noticed in 31ESWYT-123 (1.60).

Number of spikelets ear^{-1}

I Year [2012-13]

E1- JW-3211 (19.73) was the genotype exhibited maximum spikelet ear^{-1}, followed by the others genotype 31ESWYT-1071 and HD-2864 (18.86 and 18.80 respectively), whereas less number of spikelet were reported by the genotypes GW-366 (14.86), followed by MP-3342/PBW-343/K-9924 and 31ESWYT-107 (15.00 and 15.66 respectively). The mean estimate for the trait was 17.51.

E2- Number of spikelet ear^{-1} ranged from 12.93 to 20.83 with a mean value of 16.16. 31ESWYT-1070, PBW-343/CDWR-9563-6 and JW-3211 reported the maximum values (20.83, 20.20 and 18.53 respectively). Although the minimum values were reported by PBW-343/CDWR-PBW-343/CDWR-9563-1, JW-3336 and LOK-1 (12.93, 13.16 and 13.96 respectively).

E3- The spikelet values per ear among the genotypes were ranged from 14.06 to 18.46. The genotype 31ESWYT-1072 (18.46) exhibited less number of spikelets per ear, followed by genotypes MP-3359/WH-1092 (18.33) and JW-3211(18.26).

II Year [2013-14]

E4- Among the genotypes highest number of spikelets ear^{-1} was recorded in JW-3211 (20.13), followed by MP-3324/MP-3092/MP-322 (19.93) and 31ESWYT-1071 (19.26). This trait ranges from 15.26 to 20.13 with a mean value of 17.88.

E5- The mean recorded for the trait was 16.87, which varies from 13.20 to 21.53. 31ESWYT-1070 (21.53), followed by PBW-343/CDWR-9563-6 (20.90) and 401-136/JW-17-1 (19.30) were the genotypes showed the maximum values and minimum value was reported in LOK-1 (13.20).

E6- The numbers of spikelets per ear exhibited mean 17.12 with range of 14.33 to 19.16. The maximum value was noted in genotype 31ESWYT-1072 (19.16), followed by MP-3359/WH-1092 (19.03) and JW-3211 (18.93).

Pooled results of the two Years

For number of spikelets ear^{-1} the mean value was observed in 17.02 which range from 14.97 to 19.13. Genotypes JW-3211 (19.13), followed by MP-3324/MP-3092/MP-322 (18.48) and 31ESWYT-1070 (18.35) exhibited highest value for the trait. Whereas, the smallest values was observed in genotypes JW-3336 (14.97), followed by GW-366 (15.45) and LOK-1 (15.82).

Number of ears plant^{-1}

I Year [2012-13]

E1- The value 6.36 represents the mean value of this trait which varied from 2.73 to 8.70. Maximum value was observed in genotype JW-3269, JW-3211 and 31ESWYT-1072 (8.70, 8.56 and 7.80 respectively). The minimum value for the trait was showed by the genotype HD-2864 (2.73).

E2- Number of ears plant^{-1} ranged from 4.03 to 7.96 with a mean value of 6.07. Genotypes LOK-1 (7.96), MP-3360/RAJ-4213 (7.76) and 31ESWYT-126 (7.00) reported highest number of ears plant^{-1}, while MP-3342/PBW-343/K-9924 (4.03), followed by PBW-343/CDWR-9563-6 (4.33) and MP-3368/MP-4669 (5.13) exhibited lowest number of ears plant^{-1}.

E3- The mean value 4.86 recorded for this trait was ranged from 2.36 to 7.33. Genotypes JW-3336 (7.33) and 31ESWYT-1070 (7.00) noticed maximum, whereas 31ESWYT-123 (2.36) and MP-3349/MP3222 (2.46), reported minimum number of ears plant^{-1}.

II Year [2013-14]

E4- The maximum value was observed in genotype 31ESWYT-1072 (7.53), followed by PBW-343/CDWR-9563-1 (7.46) and JW-3336 (7.16), whereas the minimum being was exhibited by 31ESWYT-126 (3.90), followed by MP-3359/WH-1092 (4.03) LOK-1 (4.26), with a mean value of 5.80.

E5- Number of ears plant^{-1} showed wide variations among the genotypes, with the values ranging from 3.23 (31ESWYT-107) to 7.00 (31ESWYT-1072). The average performance observed for the trait was 4.86.

E6- Mean value observed for the trait was 4.21. It ranged from 2.60 to 6.56. 31ESWYT-107 (2.60), reported minimum and 31ESWYT-1072 (6.56), reported maximum value, followed by JW-3336 (5.83) and 31ESWYT-118 (5.26),

Pooled results of the two Years

Number of ears plant^{-1} ranged from 4.48 to 6.34 with a mean value of 17.02. The maximum value was observed in genotypes 31ESWYT-1072 (6.34), followed by JW-3336 (6.25) and JW-3269 (6.11), whereas the minimum being observed in MP-3342/PBW-343/K-9924 (4.48), followed by 31ESWYT-123 (4.65) and PBW-343/CDWR-9563-6 (4.66).

Number of grains ear^{-1}

I Year [2012-13]

E1- The highest number of grains ear^{-1} were recorded in genotypes JW-3269 (67.32), GW-366 (66.00) and 31ESWYT-1071 (65.20), however the lowest was observed in 31ESWYT-123 (41.03). Average performance of the trait recorded over the genotypes showed value of 53.44.

E2- For number of grains ear^{-1} the value ranges from 33.60 (JW-3336) to 58.60 (JW-3269), with an average of 44.37. Genotypes 31ESWYT-118 (51.13) and 401-136/JW-17-1 (49.73) also reported maximum grains in an ear.

E3- This trait exhibited mean value of 34.37 grains ear^{-1}. It was ranging from 23.60 to 48.60. The maximum value was noticed in genotype JW-3269 (48.60), followed by 31ESWYT-118 (41.13), whereas the minimum was noticed in JW-3336 (23.60).

II Year [2013-14]

E4- For number of grains ear^{-1}, the mean value was 68.27 with a range of 42.15 to 68.27 grains ear^{-1}. Minimum numbers of grains were showed by genotypes 31ESWYT-123 (42.15), HD-2864 (42.71) and 31ESWYT-126

(43.24). While genotype with maximum grains ear^{-1} were JW-3269 (68.27), followed by GW-366 (67.09) and 31ESWYT-1071 (66.72).

E5- From the data it was observed that number of grains ear^{-1} varied among the genotypes. The grains ear^{-1} was ranged from 34.75 to 59.62, with a mean value of 45.53. The genotype exhibited highest number of grains ear^{-1} was JW-3269 (59.62), followed by genotypes 31ESWYT-118 (52.23) and 401-136/JW-17-1 (50.74), whereas the minimum being noticed in the genotype JW-3336 (34.75).

E6- It ranged from 34.75 to 60.34 with a mean value of 45.72. The maximum value was noticed in genotype JW-3269 (60.34), followed by 31ESWYT-118 (52.23), whereas the minimum being noticed in JW-3336 (34.75), followed by LOK-1 (36.28) and JW-3211 (39.07).

Pooled results of the two Years

The number of grains ear^{-1} varied from 39.33 to 60.45 with a mean value of 46.34. The maximum value was noticed in genotypes JW-3269 (60.45), followed by 31ESWYT-118 (53.61) and 401-136/JW-17-1 (50.91), whereas the minimum being noticed in JW-3336 (39.33), followed by LOK-1 (39.51) and HD-2864 (41.86).

Number of grains plant^{-1}

I Year [2012-13]

E1- This trait varied from 203.10 to 495.33 with a mean value of 351.24. The maximum grains plant^{-1} were noticed in genotype PBW-343/CDWR-9563-6 (495.33), followed by PBW-343/CDWR-9563-1 (493.50) and 31ESWYT-120 (428.40), whereas the minimum being recorded in HD-2932 (203.10).

E2- Marked variation was observed for this trait. Mean values among the genotypes varied from 197.80 to 476.36 with a mean value of 302.98. Genotypes MP-3359/WH-1092 (476.36) recorded highest number of grains

plant^{-1} followed by MP-3372/NIAW-1395 (417.06) and JW-3211 (413.03). Minimum number of grains plant^{-1} was noticed in 31ESWYT-1071 (197.80).

E3- The variation among the genotypes varied from 125.16 to 398.03 with an average of 245.69. GW-366 (398.03) and PBW-343/CDWR-9563-1 (366.43) showed the maximum number of grains plant^{-1}. Whereas 31ESWYT-125 (125.16) reported the lowest number of grains plant^{-1}.

II Year [2013-14]

E4- The range of variation for number of grains plant^{-1} was 204.35 to 497.48 with a mean value of 279.02. Genotype PBW-343/CDWR-9563-6 (497.48) reported highest number of grains plant^{-1} followed by genotype 31ESWYT-123 (438.01) and MP-3349/MP3222 (430.46). While, the minimum number of grains plant^{-1} was being noticed in genotype HD-2932 (204.35).

E5- Number of grains plant^{-1} varied from 199.67 to 495.76 with a mean value of 309.69. The highest value was noticed in genotype PBW-343/CDWR-9563-1 (495.76), followed by MP-3359/WH-1092 (478.23). The lowest number of grains plant^{-1} was noticed in 31ESWYT-1071 (199.67).

E6- For number of grains plant^{-1} the variation observed in mean was 126.14 to 399.12. With mean value of 252.06. Genotype 31ESWYT-125 (126.14) reported lowest grains plant^{-1} and GW-366 (399.12), followed by 401-136/JW-17-1 (368.11) reported the genotypes with highest number of grains plant^{-1}.

Pooled results of the two Years

Among different genotypes the maximum value was noticed in PBW-343/CDWR-9563-1 (395.56), followed by MP-3359/WH-1092 (382.43) and MP-3368/MP-4669 (381.11), whereas minimum were being noticed in 31ESWYT-125 (195.54), with an average of 300.88.

Ear head length (cm)

I Year [2012-13]

E1- Ear head length ranged from 7.70 cm to 13.20 cm with mean of 9.71 cm. The longest ear head length were recorded in genotypes MP-3324/MP-3092/MP-322 (13.20 cm), followed by 31ESWYT-1070 (11.56 cm) and 31ESWYT-127 (11.43 cm), whereas the shortest being recorded in PBW-343/CDWR-9563-6 (7.70 cm).

E2- The ear length exhibited mean value of 9.53 cm with a range of 7.40 to 13.46 cm. Genotypes 31ESWYT-118 (13.46 cm) expressed longest length, followed by 31ESWYT-1070 (11.60 cm) and JW-3269 (10.96 cm), however the shortest length being recorded in PBW-343/CDWR-9563-6 (7.40 cm).

E3- This trait reported variation among the different genotypes which ranged from 5.96 (31ESWYT-126) to 10.76 (JW-3269). The mean value observed for ear head length was 8.60.

II Year [2013-14]

E4- The ear head length ranged from 8.36 cm to 14.41 cm with mean value 10.81 cm. Longest ear head length was reported by MP-3342/PBW-343/K-9924 (14.41 cm), followed by 31ESWYT-1070 (12.76 cm), 401-136/JW-17-1 (12.60 cm) and shortest being recorded in JW-3336 (8.36 cm).

E5- Genotypes 31ESWYT-1070 (12.10 cm), followed by 31ESWYT-1071 (11.16 cm) and JW-3269 (11.46 cm), recorded highest length of ears. PBW-343/CDWR-9563-6 (7.90 cm) reported as genotype with shortest ear head length, with average length over all the genotypes was 9.88 cm.

E6- Mean reported by the trait was 7.93 cm with a range of 5.56 to 10.10 cm. longest ear head length was recorded in 31ESWYT-1071, MP-3359/WH-1092 and HI-1544 (10.10 cm, 9.73 cm and 9.63 cm respectively). The shortest length was recorded in genotype MP-3324/MP-3092/MP-322 (5.56 cm).

Pooled results of the two Years

Ear head length was varied from 7.80 cm to 11.30 cm with a mean value of 9.56 cm. The longest ear head length was recorded in genotype 31ESWYT-1070 (11.30 cm), followed by JW-3269 (10.88 cm) and MP-3324/MP-3092/MP-322 (10.82 cm), whereas the shortest being recorded in PBW-343/CDWR-9563-6 (7.80 cm).

Ear weight (g)

I Year [2012-13]

E1- Ear weight exhibited mean value of 2.40 (g) with a range of 1.48 to 3.50 (g). Genotype GW-366 (3.50 g) revealed the highest and MP-3368/MP-4669 (1.48 g) reported the lowest ear weight.

E2- This trait ranged from 1.22 g (MP-3368/MP-4669) to 2.42 g (JW-3269) with a mean value of 1.80 g.

E3- The variation observed for the trait ranged from 0.79 g (HI-1544) to 1.81 g (JW-3269). With a mean value of 1.12 g.

II Year [2013-14]

E4- The mean value for ear weight was 2.92 g with a variation of 1.60 to 4.08 (g). Highest ear weight exhibited by GW 366 (4.08 g), followed by MP-3324/MP-3092/MP-322 (3.78 g) and MP-3359/WH-1092 (3.61 g). The lowest ear weight was exhibited by the genotype 31ESWYT-123 (1.60 g).

E5- Average value obtained for the trait was 2.64 (g). It ranged from 1.96 to 3.19 (g). JW-3269 (3.19 g) reported the highest ear weight, followed by MP-3342/PBW-343/K-9924 (3.15 g) and 401-136/JW-17-1 (3.11 g). Lowest ear weight was exhibited by the genotype MP-3368/MP-4669 (1.96g).

E6- The ear weight showed variation from 1.67 to 2.73 (g) with an average value of 2.06 (g). The highest ear weight was observed in genotypes JW-3269, MP-3342/PBW-343/K-9924 and 31ESWYT-126 (2.73 g, 2.53 g and

2.50 g resp.), whereas the lowest being exhibited by genotype MP-3368/MP-4669 (1.67 g).

Pooled results of the two Years

Ear weight was varied from 1.49 to 2.82 (g) with a mean value of 2.15 (g). Highest ear weight was exhibited by genotypes JW-3269 (2.82 g), followed by 31ESWYT-118 (2.53 g) and MP-3324/MP-3092/MP-322 (2.49 g), and the lowest being exhibited by MP-3368/MP-4669 (1.49 g).

Peduncle length (cm)

I Year [2012-13]

E1- It varied from 15.67 to 27.33 cm with a mean value of 20.45 cm. The longest peduncle length was recorded in genotype 401-136/JW-17-1 (27.33 cm), followed by MP-3342/PBW-343/K-9924 (26.67cm) and JW-3211 (24.53 cm), whereas the shortest being observed in 31ESWYT-121 (15.67 cm), followed by LOK-1 (17.00 cm) and 31ESWYT-127 (17.20cm).

E2- Average peduncle length recorded for the trait was 20.45 cm. It varied from 12.83 to 25.93 cm with longest length in genotypes MP-3342/PBW-343/K-9924 (25.93 cm), 401-136/JW-17-1 (21.16cm) and JW-3269 (20.73cm). While, the shortest peduncle length was reported by genotype HD-2864 (12.83 cm).

E3- Variation noticed for the trait was 10.93 to 17.26 cm with the mean value observed for the trait was 13.86 cm. The longest length was recorded in genotypes MP-3342/PBW-343/K-9924 (17.26 cm), followed by PBW-343/CDWR-9563-6 (17.13cm) and GW 366 (16.73 cm). The shortest length was noted in the genotypes MP-3349/MP-3222 (10.93 cm).

II Year [2013-14]

E4- For peduncle length, range recorded was 12.20 to 25.60 cm with a mean value of 19.30 cm. The longest peduncle length was recorded in genotype JW-3211 (25.60 cm), followed by JW-3269 (23.90cm) and JW-3269

(23.60 cm), whereas the shortest being observed in 31ESWYT-1071 (12.20 cm), followed by 31ESWYT-121 (15.50 cm) and JW-3336 (15.70 cm).

E5- The peduncle length was higher in genotypes MP-3342/PBW-343/K-9924 (27.10 cm) and 401-136/JW-17-1 (23.76 cm). It varied from 13.56 to 27.10 cm. Although, it was recorded shortest in genotype HD-2864 (13.56 cm), with a mean value of 18.62 cm.

E6- MP-3349/MP-3222 (12.00 cm) and HI-1544 (12.23 cm) were the genotypes with shortest peduncle length, but the peduncle length of MP-3342/PBW-343/K-9924 (18.33 cm) was the highest, followed by HD-2864 (18.30 cm). The range of variation noticed for the trait was 12.0 to 18.33 cm and mean over all genotypes was 15.21 cm.

Pooled results of the two Years

The peduncle length was ranged from 14.43 to 23.00 cm. The mean observed for the trait was 17.52 cm. The longest peduncle length was recorded in genotype MP-3342/PBW-343/K-9924 (23.00 cm), followed by JW-3269 (20.29 cm) and PBW-343/CDWR-9563-6 (19.82 cm), whereas the shortest were being recorded in 31ESWYT-121 (14.43 cm).

Number of leaves plant^{-1}

I Year [2012-13]

E1- The range for number of leaves plant^{-1} was recorded 20.53 to 42.56 with a mean value of 30.55. The maximum number of leaves plant^{-1} was showed by genotype LOK-1 i.e. 42.56, followed by PBW-343/CDWR-9563-1 (41.60) and minimum the number of leaves plant^{-1} i.e. 20.53 was observed in genotype 31ESWYT-110.

E2- This trait showed average value of 23.60 with a variation of 12.83 to 25.93. MP-3342/PBW-343/K-9924 was the genotype with maximum leaves i.e. 25.93 and HD-2864 showed the minimum leaves per plant i.e. 12.83.

E3- MP-3349/MP3222 (6.30) and 31ESWYT-1070 (22.26), reported as the genotypes with lowest and highest number of leaves plant^{-1} respectively. The mean value for this trait noticed among the genotypes was 15.24.

II Year [2013-14]

E4- The number of leaves plant^{-1} showed wide variation from 15.41 to 45.52 with average performance over the genotypes was 30.46. The maximum number of leaves plant^{-1} was reported by the genotypes 31ESWYT-1071, Lok-1 and PBW-343/CDWR-9563-1 (45.52, 44.27 and 42.24 respectively). However, the genotype HD-2864(15.41) showed minimum number of leaves plant^{-1}.

E5- Genotypes, HD-2932 and HI-1544 (40.21 and 37.52 respectively), reported highest number of leaves plant^{-1} as compared to the genotype 31ESWYT-107 (17.98) with lowest number of leaves plant^{-1}. The trait showed the range 17.93 to 40.21, with an average value of 26.13.

E6- This trait showed wide variation from 7.65 (MP-3349/MP3222) to 28.90 (31ESWYT-120). The mean value recorded for number of leaves per plant was 17.49.

Pooled results of the two Years

For number of leaves plant^{-1}, the variation ranged from 17.21 to 30.72. The estimate of mean recorded was 23.91. The maximum value was observed in genotypes HD-2932 (30.72), followed by LOK-1 (27.68). However, the minimum value was noticed in genotype MP-3342/PBW-343/K-9924 (17.21).

1000 grain weight (g)

I Year [2012-13]

E1- 31ESWYT-1071 (36.76 g) and HI-1544 (37.28 g) showed the lowest value of 1000 grain weight but the 1000 grain weight of genotypes 31ESWYT-131 (51.39 g) was highest among all the genotypes. This trait varied from 36.76 to 51.39 (g) with a mean value of 43.44 (g).

E2- In the case of 1000 grain weight variation noticed among the genotype were 29.24 (g) (MP-3368/MP-4669) to 52.87 (g) (31ESWYT-1070) with a mean value of 40.75 (g).

E3- 1000 grain weight varied from 25.50 to 41.21 (g), with a mean value of 32.55 (g). The 1000 grain weight was highest in genotype 31ESWYT-125 (41.21 g), followed by MP-3342/PBW-343/K-9924 (40.92 g). While the genotype PBW-343/CDWR-9563-1 (25.50 g) showed lowest value of 1000 grain weight.

II Year [2013-14]

E4- Among the different genotype grain weight varied from 37.49 to 52.12 (g). Lowest weight exhibited by 31ESWYT-1071 (37.49 g). Whereas, highest grain weight was noticed in 31ESWYT-1070 (52.12 g) and HD-2932 (50.02 g). Mean grain weight was observed for the trait was 44.16 g.

E5- The highest 1000 grain weight was 53.35 g and 47.34 g for genotypes 31ESWYT-1070 and HD-2932 respectively, while the minimum value for 1000 grain weight was recorded in genotype MP-3368/MP-4669 (30.03 g). The mean calculated was 40.65 (g).

E6- The range recorded for the trait was 26.27 to 39.24 g with a mean value of 33.10 g. The highest grain weight was reported by 31ESWYT-127 (39.24 g), followed by MP-3342/PBW-343/K-9924 (38.59 g) and 31ESWYT-1070 (38.42 g), whereas the lowest exhibited by 401-136/JW-17-1 (26.27 g).

Pooled results of the two Years

1000 grain weight showed smaller variation which ranged from 33.65 to 47.95 (g), with a mean value of 39.10 (g). The highest grain weight was noticed in genotype 31ESWYT-1070 (47.95 g), followed by HD-2932 (44.20 g) and JW-3269 (42.06 g), while lowest being exhibited by 31ESWYT-1071 (33.65).

Biological yield plant^{-1} (g)

I Year [2012-13]

E1- The range for biological yield plant^{-1} was 23.71 to 49.39 (g), while the estimated mean value was 39.03 (g). 31ESWYT-126 (49.55 g) reported highest biological yield plant^{-1} followed by genotypes 31ESWYT-123 (49.39 g) and MP-3372/NIAW-1395 (48.56 g). The lowest biological yield plant^{-1} was observed in HD-2932 (23.71 g), followed by HD-2864 (25.89 g).

E2- 31ESWYT-127 (45.48 g) reported the highest value for the trait followed by JW-3269 (44.53 g). This trait ranges from 21.62 to 45.48 (g) with a mean value of 34.87 (g). MP-3342/PBW-343/K-9924 (21.62 g) was the genotype reported lowest value of biological yield plant^{-1}.

E3- Mean exhibited by the traits were 24.25 (g) with wide range of variation 12.86 to 38.38. The highest biological yield per plant noticed in genotype 31ESWYT-125 (38.38 g), followed by 31ESWYT-126 (37.72 g) and LOK-1 (37.40 g), while lowest being observed in MP-3360/RAJ-4213 (12.86 g), followed by 31ESWYT- 121 (13.21 g).

II Year [2013-14]

E4- Small amount of variation were noticed among the genotypes, which ranged from 42.60 to 46.56 (g). 31ESWYT-1072 (46.56 g), 31ESWYT-118 (45.26 g) and 31ESWYT-1071 (45.10 g) were the genotypes reported highest value for biological yield plant^{-1}. While, the lowest value for biological yield plant^{-1} was observed in genotypes 31ESWYT-107 (42.60 g). The average value recorded for the trait was 44.29 (g).

E5- Genotype MP-3372/NIAW-1395 (45.80 g), followed by HD-2864 (44.70 g) reported highest biological yield plant^{-1} as compared to genotype 31ESWYT-1071 (37.70 g), exhibited lowest biological yield plant^{-1}. Mean value noticed for this trait was 41.70 (g), which varies from 37.70 to 45.80 (g).

E6- Among the different genotypes, MP-3360/RAJ-4213 (13.76 g) was the genotype showed minimum value for biological yield plant^{-1}. As compared

to the genotypes, LOK-1 (38.30 g) and JW-3211 (37.39 g), which reported maximum value for the trait. Range showed by the trait was 13.76 - 38.30 (g) with a mean value of 22.17 (g).

Pooled results of the two Years

The biological yield plant^{-1} showed variation from 30.02 to 39.01 (g). Mean value obtained in grams was 35.43. Genotype exhibited highest value for biological yield plant^{-1} was LOK-1 (39.01 g), followed by JW-3211 (38.41 g) and JW-3269 (38.03 g), as compared to genotype MP-3360/RAJ-4213 (30.02 g) with lowest biological yield plant^{-1}.

Yield plant^{-1} (g)

I Year [2012-13]

E1- Yield plant^{-1} in grams showed marked variation from 9.33 to 19.02. The highest yielding genotype PBW-343/CDWR-9563-1 reported yield of 19.02 g per plant , followed by MP-3372/NIAW-1395 with yield 18.61 g. while lowest yield per plant was recorded in 31ESWYT-1071 (9.33 g), followed by HI-1554 (9.49 g) with a mean value of 13.66 g.

E2- Variation in yield plant^{-1} ranged from 7.34 to 17.86 (g). Mean yield plant^{-1} recorded over all the genotypes was 11.41 (g), with a highest value of yield plant^{-1} i.e. 17.86 g (PBW-343/CDWR-9563-1) and lowest value of 7.34 g (31ESWYT-110).

E3- Average value revealed by the genotypes for this trait was 7.75 (g) with a smaller variation in yield plant^{-1} ranged from 4.26 to 10.21(g). The highest yield plant^{-1} was recorded in genotype PBW-343/CDWR-9563-1 (10.21 g), followed by 31ESWYT-123 (9.82 g) and JW-3666 (9.50 g), while the lowest value was recorded in genotype MP-3360/RAJ-4213 (4.26 g), followed by 31ESWYT-1070 (5.35 g) and 31ESWYT-125 (5.52 g).

II Year [2013-14]

E4- Variation for yield plant^{-1} was ranged from 10.53 (31ESWYT-1071) to 20.22 (PBW-343/CDWR-9563-1) (g) with over all mean of 14.75 (g). High

yield plant^{-1} was reported in genotypes MP-3372/NIAW-1395 (19.13 g) and 31ESWYT-120 (18.10 g).

E5- The yield plant^{-1} showed the mean value of 12.70 (g). This trait ranged from 8.54 (g) (31ESWYT-110) to 19.06 (g) (PBW-343/CDWR-9563-1).

E6- PBW-343/CDWR-9563-1 (10.57 g) observed as genotype with highest yield plant^{-1}, followed by 31ESWYT-123 (10.18 g). Range obtained for yield plant^{-1} was 5.13 to 10.57 (g) with an average estimate of 8.07 (g). MP-3360/RAJ-4213 (4.61 g) was the genotype with lowest yield plant^{-1}.

Pooled results of the two Years

Yield plant^{-1} varied from 8.53 to 16.15 (g) with a mean value of 11.39 (g). The highest value was recorded in genotypes PBW-343/CDWR-9563-1 (16.15 g), followed by MP-3372/NIAW-1395 (14.88 g) and JW-3269 (13.99 g) while the lowest being recorded in 31ESWYT-1071 (8.53 g), followed by 31ESWYT-110 (8.78 g) and 31ESWYT-125 (8.80 g).

Harvest index (%)

I Year [2012-13]

E1- Harvest index (%) expressed highest value in genotypes PBW-343/CDWR-9563-1, HD-2932 and 31ESWYT-120 (51.38 %, 47.27 % and 43.03 % resp.) and lowest value in 31ESWYT-1071 (25.69 %). Mean value recorded for the trait was 35.42 (%), which ranged from 25.69 (%) to 51.38 (%).

E2- This trait ranged from 19.81 (%) to 46.54 (%) with an average value of 33.16%. The highest value was observed in genotype MP-3372/NIAW-1395 (51.72 %), followed by PBW-343/CDWR-9563-1 (46.54) and HI-1544 (41.83 %), while the lowest value was observed in 31ESWYT-110 (19.81%).

E3- Among the different genotypes the harvest index varied from 14.41 to 44.34 (%). The recorded mean was 33.85 (%) with highest value in

genotypes HD-2884 (44.34%) and HD-2932 (43.20 %). However, the lowest per cent observed in 31ESWYT-125 (14.41 %).

II Year [2013-14]

E4- The data varies from 23.41% (31ESWYT-1071) to 46.25% (PBW-343/CDWR-9563-1), with a mean value of 33.42 (%).

E5- Marked variation was observed for this trait. Mean values among the genotypes for harvest index was ranged from 22.10 to 43.11 (%). With an average estimate of 30.27%. Genotype PBW343/CDWR9563-1 (43.11 %) reported the highest harvest index, followed by MP-3359/WH-1092 (38.66 %). The lowest harvest index was observed in 31ESWYT-110 (22.1 %).

E6- Harvest index exhibited mean value of 41.19 (%), with a wide range of 22.40 to 64.10 (%). Genotype 31ESWYT-123 (64.10 %), followed by 31ESWYT-120 (63.84 %) and 31ESWYT-125 (57.31 %) showed the maximum value for harvest index. Whereas, the genotype LOK-1 (22.40 %) observed to be had minimum value for the trait.

Pooled results of the two Years

The harvest index (%) ranged from 30.58 to 46.89 (%) with a mean value of 38.12 (%). The highest value was observed in genotypes 31ESWYT-120 (46.89), followed by 31ESWYT-123 (46.59 %) and PBW-343/CDWR-9563-1 (46.03 %), whereas the lowest value recorded in 31ESWYT-107 (30.58 %), followed by LOK-1 (32.10 %) and JW-3336 (32.69 %).

Relative water content of flag leaf

I Year [2012-13]

E1- The relative water content of flag leaf was ranged from 71.99 to 92.30 (%) with a mean value of 82.53 (%).The maximum value was noticed in genotype HD-2864 (92.30 %), followed by 31ESWYT-118 (90.53 %) and MP-3360/RAJ-4213 (88.62 %). The minimum relative water content was noticed in genotype 31ESWYT-110 (71.99 %).

E2- Mean value observed for the trait was 80.76 (%). It ranged from 69.88 to 90.60 (%). HD-2864 was the genotype having highest value of relative water content 90.60 %, followed by 31ESWYT-118 (88.78 %) and MP-3360/RAJ-4213 (87.40 %). However, 31ESWYT-123 showed the minimum relative water content of 69.88 % among all the genotypes.

E3- For this trait wide range of variation was obtained from 69.88 to 90.60 (%) with a mean value of 77.94 (%). Genotype HD-2864 (90.60 %) showed the maximum value of relative water content, followed by 31ESWYT-118 (88.78 %) and MP-3360/RAJ-4213 (87.40 %), whereas the minimum value was noticed in 31ESWYT-123 (69.88 %).

II Year [2013-14]

E4- This trait observed ranged from 74.08 to 94.07 (%) with a mean value of 84.33 (%).The maximum value was recorded in HD-2864 (94.07 %), followed by 31ESWYT-118 (92.29 %) and 31ESWYT-120 (90.55 %), whereas the minimum being noticed in 31ESWYT-123 (74.08 %).

E5- It varied from 71.96 to 92.52 (%), with a mean value of 82.71(%). HD-2864 (92.52 %) was the genotype with highest relative water content and 31ESWYT-123 (71.96) was genotype with lowest relative water content.

E6- JW-3211 (85.66 %) and HD-2864 (89.45 %) were the genotypes with maximum value. It ranged from 68.80 to 85.66 (%), with a mean value of 79.32 (%). The minimum value was noticed in 31ESWYT-123 (68.80 %).

Pooled results of the two Years

Relative water content ranged from 70.69 to 91.17 (%) with a mean value of 81.26 (%). The maximum value was noticed in genotype HD-2864 (91.17 %), followed by 31ESWYT-118 (89.35) and PBW-343/CDWR-9563-6 (87.11 %), whereas the minimum value was noticed in 31ESWYT-123 (70.69), followed by 31ESWYT-110 (70.82 %) and LOK-1 (73.67 %).

Chlorophyll content

I Year [2012-13]

E1- Maximum value was reported by genotype GW-366 for chlorophyll content was 53.10 %, followed by LOK-1 and MP-3349/MP-3222 (52.90 % and 52.46 %). The minimum value obtained for the trait was 38.33 % in genotype 31ESWYT-118 with a mean value of 47.51 %.

E2- From the data, it was observed that chlorophyll content varied from 36.23 (31ESWYT-118) to 51.56 % (LOK-1). The mean value observed for this trait was 45.44 (%).

E3- Chlorophyll content ranged from 22.40 to 46.93 (%) with a mean value of 36.85 %.The maximum value was reported by genotype MP-3349/MP-3222 (46.93 %), followed by MP-3359/WH-1092 (46.50 %) and HI-1544 (43.13 %), whereas the minimum value noticed in MP-3372/NIAW-1395 (22.40 %).

II Year [2013-14]

E4- Chlorophyll content ranges from 39.70 to 54.51(%) with a mean value of 48.89 (%). LOK-1, GW-366 and MP-3349/MP-3222 (54.51%, 53.83 % and 53.67 % respectively), were the genotypes with higher chlorophyll content and 31ESWYT-118 (39.70 %) was the genotype with lowest amount of chlorophyll content.

E5- The genotype 31ESWYT-118 (37.16 %) observed to be had lowest value of chlorophyll content, as compared with genotypes with highest chlorophyll content GW-366 (52.13 %), followed by LOK-1 (51.93 %) and MP-3349/MP-3222 (51.60 %). The average estimated value over all genotypes was 46.53 %.

E6- The range of variation was 23.90 to 48.40 (%) with a mean value of 38.56 %. Maximum value was obtained for the genotype MP-3349/MP-3222 was 48.40 %, followed by MP-3359/WH-1092 (48.26 %). 31ESWYT-121 showed lowest value for the trait (23.90 %).

Pooled results of the two Years

Chlorophyll content ranged from 39.22 to 50.56 (%) with a mean value of 43.96 %. The maximum value was reported by genotypes MP-3349/MP-3222 (50.56 %), followed by GW-366 (48.80 %) and LOK-1 (47.19 %), whereas the minimum being reported by MP-3372/NIAW-1395 (39.22 %).

Canopy temperature

I Year [2012-13]

E1- The range of canopy temperature varied from 20.43 to 23.73 ^{0}C with an average value of 22.35 ^{0}C. The highest value was recorded in genotype 31ESWYT-123 (23.73 ^{0}C), whereas the lowest being recorded in JW-3211 (20.43^{0}C).

E2- Variation observed for the canopy temperature was from 21.16 to 24.60, with a mean canopy temperature of 22.97 ^{0}C. 31ESWYT-123 reported as genotype with highest canopy temperature among all genotype with a value of 24.60 ^{0}C, and canopy temperature with lowest value was recorded in genotype JW-3211 (21.16 ^{0}C), followed by JW-3336 (22.10 ^{0}C) and 31ESWYT-1071 (22.13 ^{0}C).

E3- Lowest canopy temperature was recorded in genotype GW-366 (28.86 ^{0}C) and highest value of canopy temperature was observed in genotype MP-3342/PBW-343/K-9924 (31.66 ^{0}C), with a mean value of 30.54 ^{0}C.

I Year [2013-14]

E4- Among the different genotype mean canopy temperature recorded was 21.96 ^{0}C. The range of variation of the trait was very small from 20.96 ^{0}C (GW-366) to 22.83 ^{0}C (31ESWYT-121).

E5- Genotype 31ESWYT-121 (20.80 ^{0}C) showed minimum value of canopy temperature and genotype JW-3211 (23.70 ^{0}C) showed the maximum value of canopy temperature. The average value recorded among the different genotypes was 22.10 ^{0}C.

E6- The canopy temperature varied from 28.40 to 31.33 with a mean value of 30.07. The lowest temperature was recorded in genotype 31ESWYT-1070 (28.40 ^{0}C), followed by GW-366 (28.80 ^{0}C). Although, PBW-343/CDWR-9563-6 (31.33 ^{0}C) was the genotype with highest canopy temperature, followed by MP-3342/PBW-343/K-9924 (31.20 ^{0}C).

Pooled results of the two Years

The canopy temperature showed very narrow range of variation which varied from 24.04 ^{0}C to 25.62 ^{0}C. Mean value of canopy temperature over all the genotypes were 25.01 ^{0}C. They minimum canopy temperature was recorded in genotype GW-366 (24.04) and the maximum canopy temperature was recorded in genotype 31ESWYT-123 (25.62).

Sedimentation value (ml)

I Year [2012-13]

E1- Wide range of variation was noticed for this trait. It ranged from 23.43 to 52.63 ml with a mean value of 33.31 ml. The maximum value was obtained in genotype MP-3342/PBW-343/K-9924 (52.63 ml), followed by MP-3349/MP-3222 (48.86 ml) and JW-3211 (45.33 ml), whereas the minimum being noticed in GW-366 (23.43 ml), followed by HD-2864 (25.43 ml) and LOK-1 (26.86 ml).

E2- Mean obtained for sedimentation value was 28.61 ml which ranged from 23.03 to 36.06 ml. Maximum value was noticed in genotype 31ESWYT-1070 (36.06), followed by 401-136/JW-17-1 (36.23 ml) and MP-3349/MP-3222 (34.93 ml), however the minimum being recorded in 31ESWYT-127 (23.03 ml), followed by LOK-1 (23.16 ml) and GW-366 (24.40 ml).

E3- For sedimentation value mean estimate recorded was 49.42 ml with a variation of 33.23 to 55.13 ml. 31ESWYT-1071 (55.13 ml) reported maximum value for sedimentation test, followed by 31ESWYT-1070 (54.23 ml) and PBW-343/CDWR-9563-6 (53.76 ml). Although minimum being noticed in genotype MP-3372/NIAW-1395 (33.23 ml).

II Year [2013-14]

E4- Genotype, MP-3342/PBW-343/K-9924 (53.10 ml) recorded highest sedimentation value followed by MP-3349/MP-3222 (49.23 ml) and JW-3211 (45.50 ml), whereas the genotypes GW-366 (24.67) showed lowest value for the trait followed by HD-2869 (26.36 ml) and 31ESWYT-118 (26.60 ml). It ranged from 24.67 to 53.10 ml with an average of 33.83 ml.

E5- It ranged from 23.30 to 36.33 ml with a mean value of 28.83 ml. The maximum value was observed in genotype 31ESWYT-1070 (36.33 ml), followed by 401-136/JW-17-1 (36.23 ml) and MP-3349/MP-322 (35.20 ml), whereas the minimum being observed in 31ESWYT-127 (23.30 ml), followed by GW-366 (24.60 ml) and 31ESWYT-118 (25.16 ml).

E6- Marked variation noticed for this trait which ranged from 34.23 to 55.76 ml with a mean value of 50.62 ml. The highest value was reported by genotype 31ESWYT-1071 (55.76 ml), followed by PBW-343/CDWR-9563-6 (54.83 ml) and JW-3211 (54.50 ml), while the lowest was obtained for MP-3372/NIAW-1395 (34.23 ml), followed by HD-2932 (45.36 ml) and 31ESWYT-1072 (45.50 ml).

Pooled results of the two Years

Sedimentation value ranged from 31.51 to 45.30 ml with a mean value of 37.43 ml. The maximum value was obtained in genotypes MP-3349/MP-3222 (45.30 ml), followed by JW-3211 (43.28 ml) and 31ESWYT-1070 (42.40 ml), whereas the minimum being obtained in GW 366 (31.51 ml), followed by MP-3372/NIAW-1395 (31.79 ml) and LOK-1 (32.52 ml).

Hectoliter weight (g/l)

I Year [2012-13]

E1- From the data it was observed that variation recorded for weights was 73.00 to 83.33 g/l with a mean value of 78.35 g/l. The highest hectoliter weight was reported by genotype GW-366 (83.33 g/l), followed by 31ESWYT-1071 (82.66 g/l) and MP-3349/MP-3222 (82.00 g/l). While the lowest being reported by genotype 31ESWYT-121 (73.00 g/l).

E2- Highest hectoliter weight was exhibited by genotypes PBW-343/CDWR-9563-6 (81.00 g/l), PBW-343/CDWR-9563-1 (80.98 g/l) and MP-3349/MP-3222 (80.33 g/l). It varied from 73.00 to 81.00 g/l with a mean value of 76.52 g/l. The lowest hectoliter weight was reported by 31ESWYT-123 (73.00 g/l).

E3- The mean value and range recorded for the character hectoliter weight were 73.10 g/l and 70.66-76.33 g/l, respectively. The lowest weights were reported by MP-3349/MP-3222 (70.66 g/l) and MP-3324/MP-3092/MP-322 (70.86 g/l) as compared to the genotype JW-3336 (76.33 g/l), followed by 31ESWYT-120 (75.66 g/l) and MP-3342/PBW-343/K-9924 (75.45 g/l), contained highest weights.

II Year [2013-14]

E4- The variation obtained for hectoliter weight varied from 75.0 to 85.00 g/l. Mean value of the trait was 80.03 g/l. Highest weight was recorded in genotype GW-366 (85.00 g/l), followed by 31ESWYT-1071 (84.00 g/l) and MP-3349/MP-3222 (83.33 g/l). The lowest weight was reported by 31ESWYT-121 (75.0 g/l).

E5- In this study 74.00 to 83.66 ml represents the range for the trait. The mean recorded was 78.98 ml. The highest value was reported by genotypes MP-3399/MP-3222 (83.66 ml), followed by PBW-343/CDWR-9563-6 (83.33 ml) and PBW-343/CDWR-9563-1 (82.67 ml), whereas the lowest being reported by 31ESWYT-120 (74.00).

E6- It varied from 71.00 to 79.33 ml with a mean value of 74.82 ml .The highest hectoliter weight was reported by genotype JW-3336 (79.33), followed by GW-366 (78.667) and PBW-343/CDWR-9563-1 (78.33 ml), whereas lowest was reported by JW-3211 (71.00 ml).

Pooled results of the two Years

Hectoliter weight varied from 74.22 to 79.94 with a mean value of 76.97. The highest value was reported by genotypes JW-3336 (79.94),

followed by PBW-343/CDWR-9563-1 (79.83) and GW-366 (79.22), whereas the lowest being reported by 31ESWYT-123 (74.22).

Protein (%)

I Year [2012-13]

E1- Protein % ranged from 10.06 to 14.23 (%) with a mean value of 11.95 %. Maximum protein % was observed in genotype MP-3342/PBW-343/K-9924 (14.23 %), followed by 31ESWYT-126 (13.30 %) and JW-3211 (13.03 %), whereas minimum being observed in 31ESWYT-125 (10.06 %), followed by 31ESWYT-1072 (10.66 %) and 31ESWYT-120 (10.40 %).

E2- The protein % ranged from 9.66 % (31ESWYT-1072) to 12.36 % (31ESWYT-1070). The mean value observed was 10.68 %. The genotype 31ESWYT-1070 (12.36 %) reported maximum protein %, followed by MP-3349/MP3222 (12.20 %).

E3- Marked variation was observed for this trait. Mean values among the genotypes for protein % were varied from 12.33 to 15.96 %, with a average of 14.39 %. The maximum protein content was observed in genotype MP-3372/NIAW-1395 (15.96 %), followed by MP-3349/MP3222 (15.86 %) and minimum in HD-2932 (12.33 %).

II Year [2013-14]

E4- This trait ranged from 10.20 to 14.30 (%) with an average performance of 11.93 %. MP-3349/MP-3222 (14.30 %) recorded highest protein percentages, followed by MP-3342/PBW-343/K-9924 (14.20 %) and 31ESWYT-126 (13.80 %), while lowest was noticed in 31ESWYT-125 (10.20 %).

E5- It ranged from 9.67 to 12.50 (%) with a mean value of 10.75 %. The maximum value was observed in genotype 31ESWYT-1070 (12.50 %) while, the minimum was observed in 31ESWYT-1072 (9.67 %).

E6- MP3349/MP3222 (16.23 %), followed by MP-3372/NIAW-1395 (16.13 %) were the genotypes reporting maximum protein (%).while the

genotype with lowest value of protein % was MP-3342/PBW-343/K-9924 (13.10 %). The range noticed for the trait was 13.10 to 16.23 (%) with a mean value of 14.69 %.

Pooled results of the two Years

Protein % ranged, from 11.17 to 14.17 (%) with a mean value of 12.40 %. The maximum value was observed in genotypes MP-3349/MP-3222 (14.17 %) and 31ESWYT-1070 (13.27 %), whereas the minimum being observed in genotype 31ESWYT-120 (11.17 %).

Wet gluten (%)

I Year [2012-13]

E1- Among all the genotype the minimum amount of wet gluten % was exhibited by genotype 31ESWYT-125 (22.73 %), while maximum were recorded in -3342/PBW-343/K-9924 (35.20 %) and MP-3349/MP-3222 (34.70 %) which ranged from 22.73 to 34.70 (%). Average showed by the trait was 28.20 %.

E2- The genotypes 401-136/JW-17-1 and MP-3349/MP3222 exhibited highest wet gluten percentage (30.40 & 29.23 (%)). Genotype with lowest wet gluten (%) was JW-3269 (19.56 %). The range of variation was 19.56 to 29.23 (%) with a mean value of 24.63 %.

E3- It ranged from 30.43 to 39.20 (%) with a mean value of 35.28 %. The maximum value was noticed in genotype MP-3372/NIAW-1395 (39.20 %), followed by 31ESWYT-110 (38.73 %) and MP-3349/MP3222 (38.67 %), while the minimum being noticed in GW-366 (30.43 %).

II Year [2013-14]

E4- This trait ranged from 21.53 % (31ESWYT-125) to 33.80 % (MP-3342/PBW-343/K-9924). The average performance of wet gluten % over all the genotypes was 27.39 %.

E5- It ranged from 19.80 to 29.20 (%) with a mean value of 23.81 %. The maximum value was noticed in genotype 401-136/JW-17-1 (29.20 %), followed by 31ESWYT-1070 (27.86 %), whereas the minimum being noticed in 31ESWYT-127 (19.80 %), followed by 31ESWYT-118 (20.46 %), JW-3269 (20.93 %).

E6- Wet gluten % ranged from 31.36 to 37.86 (%) with a mean value of 34.42 %. The maximum value was noticed in genotype MP-3372/NIAW-1395 (37.86 %), followed by MP-3342/PBW-343/K-9924 (37.53 %) and 31ESWYT-110 (37.50 %), whereas the minimum being noticed in 31ESWYT-120 (31.36 %), followed by GW-366 (31.73 %) and HD-2932 (32.26 %).

Pooled results of the two Years

Gluten content ranged, from 25.94 to 33.55 (%) with a mean value of 28.95 %. The maximum value was noticed in genotypes MP-3349/MP3222 (33.55 %), followed by 401-136/JW-17-1 (31.67 %) and MP-3342/PBW-343/K-9924 (31.56 %), whereas the minimum being noticed in GW-366 (25.94 %), followed by 31ESWYT-1072 (26.12 %) and JW-3269 (26.30 %).

Starch (%)

I Year [2012-13]

E1- The starch % in different genotypes was ranged from 65.16 to 70.50 (%). The mean of starch % over all genotypes was 68.60 (%). Maximum value was noticed in genotype MP-3360/RAJ-4213 (70.50 %), followed by 31ESWYT-125 (70.16 %) and the minimum value was recorded in 31ESWYT-1070 (65.16 %).

E2- Average value calculated was 66.26 % with variation of 63.20 to 68.80 (%). 31ESWYT-127 (68.80 %) recorded as genotype with highest starch (%), followed by MP-3359/WH-1092 (68.70 %). The 31ESWYT-1070 (63.20 %) was the genotype with lowest starch %.

E3- This trait varied from 57.23 to 67.20 (%) with a mean value of 64.28 %. Genotype 31ESWYT-127 and JW-3269 were the genotypes showed

maximum values for starch (%) (67.20 % and 67.16 %). However, the lowest value was recorded in JW-3211 (57.23 %).

II Year [2013-14]

E4- Minimum starch % was noticed in genotype JW-3211 (63.13 %) and maximum starch % reported in 31ESWYT-127 (66.53 %). The mean calculated over the means of all genotypes was 65.13 %.

E5- For starch %, mean recorded was 65.21 % with a narrow range of variation from 63.86 to 66.33 (%). The maximum value was noted in genotype MP-3342/PBW-343/K-9924 (66.33 %) and the minimum being noted in 31ESWYT-120 (63.86 %).

E6- The maximum value was noted in genotype 31ESWYT-1072 (66.86 %) and lowest starch % was recorded in genotype 31ESWYT-1070 (62.26 %), with a mean value of 64.65 %.

Pooled results of the two Years

Starch % ranged from 63.69 to 66.85 (%) with a mean value of 65.69 %. The maximum value was noted in genotype 31ESWYT-127 (66.85 %), followed by 31ESWYT-107 (66.50 %), whereas the minimum being noted in 31ESWYT-1070 (63.69 %).

Moisture (%)

I Year [2012-13]

E1- Moisture % varied from 6.83 to 7.66 (%) with an average value of 7.27 %. Maximum moisture % was reported by genotype GW-366 (7.66 %), while the minimum was recorded in 31ESWYT-107 (6.83 %).

E2- This trait varied from 6.16 to 7.50 (%) with a mean value of 6.92 %. The maximum value was recorded in genotype 31ESWYT-123 (7.50 %), whereas the minimum being recorded in 31ESWYT-110 (6.16 %).

E3- 31ESWYT-127 (7.93 %) showed highest moisture %, while PBW-343/CDWR-9563-1 (5.76 %) composed of lowest moisture %. The mean estimated over all the genotypes was 7.09 %.

II Year [2013-14]

E4- The range of variation observed for the genotypes was from 7.30 (HD-2864) to 7.86 % (JW-3211). The mean value recorded on genotypes for moisture (%) was 7.61 %.

E5- Genotype MP-3342/PBW-343/K-9924 (7.36 %) showed the minimum moisture %. While, maximum value of moisture % was observed in GW-366 (8.20 %). With a mean value for moisture percentage was 7.65 %.

E6- For moisture %, means of genotypes varied from 7.50 to 8.30 (%) with an average value of 7.78 %. The maximum value was recorded in genotype 31ESWYT-127 (8.30 %), whereas the minimum being recorded in 31ESWYT-107 (7.50 %).

Pooled results of the two Years

The moisture % ranged from 7.02 to 7.81 (%) with a mean value of 7.38 %. The maximum value was recorded in genotypes GW-366 (7.81 %), followed by 31ESWYT-1070 (7.67 %), whereas the minimum being recorded in genotype PBW-343/CDWR-9563-1 (7.02 %).

4.2.1: Heritability (%)

In the present investigation broad sense heritability, which is ratio of total genotypic variance to total phenotypic variance, have been estimated and classified as high (>70%), medium (50-70%) and low (<50%). Knowledge of heritability of trait is important for any breeding programme. The heritability estimates for different traits in the first experimental year under three environments was presented in table- 4.1.1 (b). The heritability estimates for different traits in the second experimental year under three environments was presented in table- 4.1.2 (b).

I Year [2012-13]

E1

The estimates of heritability was highest for the traits *viz.* number of grains plant^{-1} (99.96), sedimentation value (98.83), wet gluten % (98.16), relative water content of flag leaf (97.68), biological yield plant^{-1} (97.22), protein % (96.99), number of grains ear^{-1} (95.53), days to maturity (95.41), number of leaves plant^{-1} (95.30), plant height (93.55) yield plant^{-1} (88.35), ear head weight (88.36), peduncle length (87.61), 1000 grain weight (86.34), harvest index (81.22), days to 50% flowering (81.23), chlorophyll content (79.96), hectoliter weight (74.30) and starch % (70.49). Whereas, number of ears plant^{-1} (56.47) and number of effective tillers plant^{-1} (57.31) revealed medium heritability while other traits are reported for low heritability.

E2

Number of grains ear^{-1} (99.92), RWC of flag leaf (97.62), protein % (97.90), wet gluten % (97.38), sedimentation value (96.62), days to maturity (95.57), ear weight (94.34), biological yield plant^{-1} (92.87), number of leaves plant^{-1} (94.00), 1000 grain weight (90.89), starch % (88.89), number of grains ears^{-1} (88.88), harvest index (83.80), chlorophyll content (75.79) and days to 50% flowering (70.85) reported high estimate of heritability. The traits *viz.,* yield plant^{-1} (69.63), peduncle length (68.53), ear head length (60.19), plant height (60.18) and number of spikelets ear^{-1} (51.85) showed medium estimate of heritability, whereas the study of traits with low heritability was not important in the selection process.

E3

The high estimate of heritability were recorded by the traits number of grains plant^{-1} (99.95), followed by wet gluten % (98.33), biological yield plant^{-1} (97.48), days to maturity (95.03), starch % (94.60), ear weight (94.09), relative water content of flag leaf (90.80), sedimentation value (90.75), number of grains ear^{-1} (90.36), plant height (88.65), number of leaves plant^{-1} (89.20), 1000 grain weight (88.15), chlorophyll content (87.73) and days to 50 % flowering (83.69). While, medium heritability were exhibited by harvest index

(64.41), peduncle length (62.34), protein % (58.74), ear head length (58.00) and number of tillers plant^{-1} (52.26).

II Year [2013-14]

E4

Number of grains plant^{-1} (99.93), reported highest heritability, followed by other traits *viz.,* wet gluten % (98.39), protein % (98.31), sedimentation value (97.71), number of leaves plant^{-1} (97.12), relative water content of flag leaf (97.15), plant height (95.22), number of grains ear^{-1} (93.62), ear head length (86.56), chlorophyll content (87.73), 1000 grain weight (86.34), peduncle length (78.86), ear weight (77.78), harvest index (76.82), yield plant^{-1} (75.56) and hectoliter weight (74.60). Days to maturity (66.44) showed medium estimate of heritability.

E5

The traits with high heritability were number of grains plant^{-1} (99.94), plant height (98.43), wet gluten % (98.38), protein % (97.64), relative water content of flag leaf (97.43), 1000 grain weight (96.10), sedimentation value (92.27), number of grains ear^{-1} (99.88), days to maturity (89.49), number of leaves plant^{-1} (88.61), days to 50% flowering (81.95), yield plant^{-1} (79.26), peduncle length (75.10) and hectoliter weight (72.10). Chlorophyll content (69.18) and number of spikelets ear^{-1} (59.43) showed medium heritability.

E6

High heritability was exhibited by traits are number of grains plant^{-1} (99.95), wet gluten % (98.38), protein % (95.66), number of leaves plant^{-1} (94.39), sedimentation value (93.49), number of grains ear^{-1} (90.31), days to maturity (90.23), relative water content of flag leaf (90.14), chlorophyll content (89.66), days to 50% flowering (89.39), 1000 grain weight (84.02) and biological yield plant^{-1} (85.63). The traits like moisture % (66.54), hectoliter weight (66.45), plant height (66.23), ear head length (64.77), peduncle length (65.18) and yield plant^{-1} (52.23) reported medium heritability.

Pooled results of the two Years

The pooled results of two consecutive years showed very low estimates of heritability for most of the observed traits. The relative water content of flag leaf (95.84) reported high heritability. Medium estimate of heritability were showed by number of grains ear^{-1} (54.88%), yield plant^{-1} (52.13%) and 1000 grain weight (50.81%). While low heritability exhibited by other traits. The heritability estimates for different traits pooled over both the experimental years was presented in table- 4.2.3.

4.2.2: Genetic advance (as a % of mean)

The genetic advance is the improvement in mean genotypic and phenotypic value of selected plants over the parental population. Genetic advance as a percentage of mean were recorded for different traits under study. Expected genetic advance was calculated using heritability in broad sense on hypothetical basis of selection of 5% best individual plant.

The genetic advance as a percentage of mean estimates varied for different traits. Genetic advance as a percentage of mean was classified as high genetic advance- >15%, medium genetic advance 10%-15% and low genetic advance- <10%. The estimates of genetic advance as % of mean for different traits in the first experimental year under three environments were presented in table- 4.2.1 (b). The estimates of genetic advance as % of mean for different traits in the second experimental year under three environments were presented in table- 4.2.2 (b).

I Year [2012-13]

E1

The high estimates of genetic advance for traits were number of grains plant^{-1} (45.04), followed by sedimentation value (42.21), number of ineffective tillers plant^{-1} (41.08), ear weight (38.05), biological yield plant^{-1} (36.01), number of leaves plant^{-1} (35.27), yield plant^{-1} (34.78), number of effective tillers plant^{-1} (32.18), harvest index (28.41), number of ears plant^{-1} (28.16), peduncle length (28.13), number of grains ear^{-1} (27.58), ear head length

(25.51), wet gluten % (23.15), 1000 grain weight (17.06) and protein % (16.10). Whereas, traits *viz.,* relative water content of flag leaf (13.32), chlorophyll content (11.57), plant height (11.22) and number of tillers plant^{-1} (10.04) reported medium genetic advance. Other traits reported very low value of genetic advance.

E2

Number of grains plant^{-1} (47.97), harvest index (42.93), yield plant^{-1} (36.66), number of leaves plant^{-1} (36.20), ear head weight (30.23), biological yield plant^{-1} (27.52), peduncle length (24.63), wet gluten % (24.43), sedimentation value (24.21), 1000 grain weight (22.66), number of grains ear^{-1} (20.13), ear head length (19.05), number of ineffective tillers plant^{-1} (16.63) and number of spikelets ear^{-1} (15.48) reported high estimate of genetic advance. The traits *viz.,* relative water content of flag leaf (13.67), chlorophyll content (11.81) and protein % (12.77) exhibited medium genetic advance.

E3

The high estimate of genetic advance were reported by the traits *viz.,* number of grains plant^{-1} (62.23), biological yield plant^{-1} (55.87), number of leaves plant^{-1} (54.17), harvest index (43.45), ear weight (40.04), number of ineffective tillers plant^{-1} (37.10), number of tillers plant^{-1} (34.11), number of ears plant^{-1} (30.97), chlorophyll content (30.47), number of grains ear^{-1} (26.28), 1000 grain weight (25.86), yield plant^{-1} (24.32), ear head length (18.55), peduncle length (18.36) and sedimentation value (17.13). However, medium estimate of genetic advance showed by relative water content of flag leaf (13.72), wet gluten % (11.92) and plant height (10.64).

II Year [2013-14]

E4

Number of leaves plant^{-1} (48.33) reported maximum genetic advance followed by other traits *viz.,* number of grains plant^{-1} (45.67), sedimentation value (41.23), ear weight (35.22), harvest index (29.10), yield plant^{-1} (27.91), number of grains ear^{-1} (26.60), peduncle length (25.31), ear head

length (22.65), number of ineffective tillers plant^{-1} (21.62), wet gluten % (21.06), number of effective tillers plant^{-1} (18.49), 1000 grain weight (17.31), protein % (16.56). The traits *viz.,* relative water content of flag leaf (12.89), plant height (11.90) and chlorophyll content (10.48) reported medium genetic advance.

E5

Number of leaves plant^{-1} (36.94), yield plant^{-1} (36.18), peduncle length (25.80), 1000 grain weight (23.45), sedimentation value (23.25), wet gluten (22.31), plant height (19.25), number of grains ear^{-1} (19.71), number of ears plant^{-1} (17.64) and number of spikelets ear^{-1} (17.62) were the genotypes with high genetic advance. Moderate estimate of genetic advance were noticed in traits like protein (14.39), relative water content of flag leaf (13.22), harvest index (10.84), chlorophyll content (10.82), ear head length (10.72) and number of effective tillers plant^{-1} (10.39). The remaining traits recorded low estimate of genetic advance.

E6

High value of genetic advance were reported for the traits *viz.,* number of grains plant^{-1} (62.51), number of leaves plant^{-1} (57.85), biological yield plant^{-1} (51.08), harvest index (40.48), number of ineffective tillers plant^{-1} (35.48), chlorophyll content (29.49), yield plant^{-1} (24.73), ear head length (23.96), number of ears plant^{-1} (22.95), number of effective tillers plant^{-1} (22.49), 1000 grain weight (22.10), number of grains ear^{-1} (19.51), peduncle length (18.74), sedimentation value (17.35) and number of tillers plant^{-1} 16.43). Relative water content of leaf (13.29) recorded moderate value of genetic advance, followed by days to 50% flowering (12.58), ear head weight (12.55), protein % (10.84) and wet gluten % (10.04). Other traits revealed very low magnitude of genetic advance.

Pooled results of the two Years

The pooled estimates of genetic advance as % of mean for different traits over the experimental years were presented in table- 4.2.3. The traits

exhibited the highest value of genetic advance were yield plant^{-1} (30.06), number of grains plant^{-1} (28.13), ear weight (20.28), peduncle length (19.08), number of grains ear^{-1} (18.99), relative water content of flag leaf (17.24), chlorophyll content (16.98), sedimentation value (16.17) and 1000 grain weight (15.58). The moderate estimates of genetic advance were depicted by number of leaves plant^{-1} (13.48), followed by number of ineffective tillers plant^{-1} (13.04), ear head length (12.72), harvest index (12.18) and wet gluten (11.21). Other traits were reported for very low genetic advance.

Table 4.2.1 (a): Parameters of Genetic variability for yield and its component traits in bread wheat genotypes for first experimental year.

TRAITS	MEAN			RANGE						C.V.		
				Minimum			Maximum					
	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
Days to 50% flowering	65.67	66.72	61.34	58.00	84.9	68.8	69.33	102.30	89.5	1.99	2.50	1.96
Days to maturity	121.94	113.83	98.49	113.33	6.3	2.50	129.66	9.46	7.367	0.74	16.70	11.90
Plant height (cm)	97.49	97.67	77.83	79.16	3.57	1.83	105.40	7.33	5.53	1.47	14.90	11.00
Tillers plant^{-1}	8.79	7.64	5.20	5.53	0.27	0.63	10.33	3.30	3.30	15.56	10.30	13.40
Effective tillers plant^{-1}	5.19	5.49	3.53	2.60	12.9	14.07	7.40	20.83	18.47	17.81	15.10	10.80
Ineffective tillers plant-^{1}	3.60	2.15	1.67	1.66	4.03	2.36	6.46	7.967	7.33	32.10	11.70	10.40
Spikelets ear^{-1}	17.51	16.16	16.58	14.86	33.6	23.6	19.73	58.6	48.6	10.27	3.67	4.38
Ears plant-^{1}	6.36	6.07	4.86	2.73	198	125.20	8.70	476.40	398.00	15.97	0.67	0.69
Grains ear-^{1}	53.44	44.37	34.37	41.03	7.40	5.96	67.30	13.47	10.36	2.96	9.70	10.10
Grains plant-^{1}	351.24	302.98	245.69	203.10	1.22	0.79	495.93	2.427	1.81	0.46	3.70	5.02
Ear head length (cm)	9.71	9.53	8.60	7.70	12.8	10.93	13.20	25.93	17.27	3.50	9.79	8.77
Ear weight (g)	2.40	1.80	1.12	1.48	16.2	6.30	3.50	36.83	22.27	7.13	5.48	9.69
Peduncle length(cm)	20.45	17.66	13.86	15.66	29.2	25.51	27.33	52.87	41.21	5.48	3.65	4.90
Leaves plant-^{1}	30.55	23.60	15.24	20.53	21.6	12.86	42.56	45.49	38.38	3.89	3.84	4.41
1000 grain weight (g)	43.44	40.75	32.55	36.76	7.34	4.26	51.39	17.86	10.21	3.65	14.10	17.10
B. yield plant-^{1} (g)	39.03	34.87	24.25	23.71	19.8	14.41	49.55	51.73	65.37	2.99	10.00	19.50
Yield plant-^{1} (g)	13.66	11.41	7.75	9.33	69.9	67.29	19.02	90.6	88.1	6.52	1.05	2.22
Harvest index (%)	35.42	33.16	33.85	25.59	36.2	22.4	51.38	51.27	46.93	7.35	3.72	5.91
RWC of flag leaf	82.53	80.76	77.94	71.99	21.2	28.87	92.30	24.6	31.67	1.00	3.78	2.80
Chlorophyll content	47.51	45.44	36.85	38.33	23	33.23	53.10	36.07	55.13	3.14	2.22	2.89
Canopy temperature	22.35	22.97	30.54	20.43	73	70.67	23.73	81	76.33	3.22	4.03	2.60
SDS value (mm)	33.31	28.61	49.42	23.43	9.67	12.67	52.63	12.37	15.97	2.24	0.92	4.47
Hectoliter weight (g /l)	78.36	76.52	73.10	73.00	19.6	30.43	83.33	30.4	39.2	2.01	1.91	0.76
Protein (%)	11.95	10.68	14.39	10.06	63.2	57.23	14.23	68.8	67.2	1.39	0.88	0.81
Wet gluten (%)	28.20	24.63	35.28	22.73	6.17	5.76	35.20	7.50	7.93	1.55	9.79	9.87
Starch (%)	68.60	66.26	64.28	65.16	84.9	68.80	70.50	102.30	89.5	1.16	2.50	1.96
Moisture (%)	7.27	6.92	7.09	6.83	6.30	2.50	7.66	9.46	7.36	3.08	16.7	21.90

Table 4.2.1 (b): Parameters of Genetic variability for yield and its component traits in bread wheat genotypes for first experimental year.

TRAITS	PCV			GCV			ECV			h² (Broad Sense) %			GA as % of mean		
	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
Days to 50% flowering	4.61	4.29	5.62	4.16	3.61	5.14	2.00	2.32	2.27	81.24	70.85	83.69	7.72	6.26	9.68
Days to maturity	3.48	4.12	4.62	3.40	4.03	4.50	0.74	0.87	1.03	95.41	95.57	95.03	6.84	8.11	9.04
Plant height (cm)	5.82	3.97	5.82	5.63	3.08	5.48	1.48	2.50	1.96	93.55	60.18	88.65	11.22	4.92	10.64
Tillers plant^{-1}	18.20	16.58	31.68	9.42	2.30	22.90	15.57	16.74	21.89	26.78	1.92	52.26	10.04	0.66	34.11
Effective tillers plant^{-1}	27.26	25.51	31.73	20.64	5.50	16.73	17.81	24.91	26.97	57.31	4.64	27.79	32.18	2.44	18.16
Ineffective tillers plant-^{1}	13.62	14.52	13.08	19.53	18.95	16.28	12.11	10.28	13.43	45.82	18.13	24.65	41.18	16.63	37.10
Spikelets ear^{-1}	10.64	14.49	8.08	2.77	10.43	5.63	10.28	10.05	5.80	6.78	51.85	48.50	1.49	15.48	8.07
Ears plant-^{1}	24.21	22.29	32.07	18.19	5.18	21.96	15.97	21.68	23.37	56.47	5.39	46.87	28.16	2.48	30.97
Grains ear-^{1}	14.02	11.00	14.12	13.70	10.37	13.42	2.96	3.67	4.38	95.53	88.88	90.36	27.58	20.13	26.28
Grains plant-^{1}	21.87	23.31	30.22	21.87	23.30	30.22	0.46	0.67	0.69	99.96	99.92	99.95	45.04	47.97	62.23
Ear head length (cm)	13.31	15.37	15.52	12.84	11.92	11.82	3.51	9.70	10.06	93.05	60.19	58.00	25.51	19.05	18.55
Ear weight(g)	20.91	15.55	20.66	19.65	15.11	20.04	7.13	3.70	5.02	88.36	94.34	94.09	38.05	30.23	40.04
Peduncle length(cm)	15.58	17.44	14.30	14.59	14.44	11.29	5.49	9.79	8.77	87.61	68.53	62.34	28.13	24.63	18.36
Leaves plant-^{1}	17.97	19.14	29.48	17.54	18.34	27.85	3.89	5.47	9.69	95.30	91.82	89.20	35.27	36.20	54.17
1000 grain weight g	9.90	12.10	14.24	9.20	11.54	13.37	3.66	3.65	4.90	86.34	90.89	88.15	17.60	22.66	25.86
B. yield plant-^{1} (g)	17.98	14.38	27.82	17.73	13.86	27.47	3.00	3.84	4.41	97.22	92.87	97.48	36.01	27.52	55.87
Yield plant-^{1} (g)	19.11	25.56	23.97	17.96	21.33	16.82	6.52	14.09	17.08	88.35	69.63	49.25	34.78	36.66	24.32
Harvest index (%)	16.98	24.87	32.75	15.30	22.77	26.28	7.36	10.01	19.54	81.22	83.80	64.41	28.41	42.93	43.45
RWC of flag leaf	6.62	6.80	7.34	6.54	6.71	6.99	1.01	1.05	2.22	97.68	97.62	90.80	13.32	13.67	13.72
Chlorophyll content	7.02	7.57	16.86	6.28	6.59	15.79	3.15	3.72	5.91	79.96	75.79	87.73	11.57	11.81	30.47
Canopy temperature	4.02	4.51	3.88	2.40	2.46	1.63	3.23	3.78	2.80	35.65	29.81	25.23	2.95	2.77	1.68
SDS value (mm)	20.73	12.16	9.49	20.61	11.95	9.04	2.24	2.22	2.89	98.83	96.68	90.75	42.21	24.21	17.73
Hectoliter weight (g /l)	3.97	4.50	6.31	3.43	2.01	3.71	2.01	4.03	2.60	74.30	19.84	30.10	6.08	1.84	1.93
Protein (%)	8.06	6.33	6.96	7.93	6.27	5.33	1.40	0.92	4.47	96.99	97.90	58.74	16.10	12.77	8.42
Wet gluten (%)	11.45	12.16	5.89	11.34	12.01	5.84	1.55	1.91	0.76	98.16	97.54	98.33	23.15	24.43	11.92
Starch (%)	2.14	2.65	3.48	1.80	2.50	3.39	1.17	0.88	0.81	70.49	88.89	94.60	3.11	4.86	6.78
Moisture(%)	4.02	9.54	10.57	2.57	2.23	3.79	3.08	9.79	9.87	41.04	5.49	12.88	3.40	1.08	2.81

Table 4.2.2 (a): Parameters of Genetic variability for yield and its component traits in bread wheat genotypes for second experimental year.

TRAITS	MEAN			RANGE						C.V.		
				Minimum			Maximum					
	E4	E5	E6	E4	E5	E6	E4	E5	E6	E4	E5	E6
Days to 50% flowering	65.50	65.14	56.53	63.33	58	49.33	67.67	70.00	63.00	2.03	2.01	2.23
Days to maturity	124.53	114.32	98.14	121.30	109.3	92.00	128.7	124.00	108.00	1.11	1.17	1.25
Plant height (cm)	98.84	96.69	96.47	79.73	74.47	81.40	107.3	109.00	104.83	1.33	1.19	3.76
Tillers plant^{-1}	10.01	8.28	6.37	7.67	6.00	4.30	11.65	10.00	8.10	16.20	20.90	17.2
Effective tillers plant^{-1}	4.79	4.11	3.93	2.96	2.8.00	2.43	6.60	5.27	6.06	28.70	22.30	20.3
Ineffective tillers plant-^{1}	5.22	4.18	2.44	1.90	1.30	0.56	8.51	6.87	4.33	19.90	14.40	14.2
Spikelets ear^{-1}	17.88	16.87	17.13	15.27	13.20	14.33	20.13	21.5	19.16	10.10	9.17	7.08
Ears plant-^{1}	5.80	4.86	4.21	3.90	3.23	2.60	7.53	7.00	6.56	24.4	18.40	19.8
Grains ear-^{1}	54.61	45.53	45.73	42.15	34.75	34.75	68.27	59.60	60.34	3.48	3.39	3.33
Grains plant-^{1}	343.62	309.69	252.07	204.40	199.70	126.10	497.50	496.00	399.13	0.59	0.64	0.71
Ear head length (cm)	10.81	9.89	7.93	8.36	7.90	5.56	14.41	12.10	10.10	4.66	11.50	10.7
Ear weight(g)	2.92	2.64	2.07	1.60	1.96	1.67	4.08	3.19	2.73	10.40	16.80	12.7
Peduncle length(cm)	19.31	18.62	15.22	12.20	13.57	12.00	25.60	27.10	18.33	7.16	8.32	8.24
Leaves plant-^{1}	30.46	26.14	17.50	15.42	17.98	7.657	45.53	40.20	28.90	4.10	6.83	7.05
1000 grain weight g	44.17	40.65	33.11	37.49	30.03	26.27	52.12	53.40	39.24	3.60	2.34	5.10
B. yield plant-^{1} (g)	44.30	41.70	22.17	42.60	37.70	13.77	46.57	45.80	38.30	2.37	4.68	11.00
Yield plant-^{1} (g)	14.76	12.70	8.07	10.54	8.543	4.61	20.22	19.10	10.57	8.86	10.10	15.90
Harvest index (%)	33.43	51.72	41.19	23.41	40.42	22.40	46.25	65.00	64.10	8.85	12.20	18.20
RWC of flag leaf	84.33	82.72	79.32	74.08	71.97	68.81	94.07	92.50	89.45	1.09	1.06	2.25
Chlorophyll content	48.89	46.53	38.56	39.70	37.17	23.90	54.51	52.10	48.40	3.54	4.22	5.13
Canopy temperature	21.97	22.20	30.08	20.97	20.80	28.4	22.83	23.70	31.33	4.57	4.27	3.26
SDS value (mm)	33.83	28.84	50.63	24.67	23.30	34.23	53.10	36.30	55.76	3.10	3.40	2.30
Hectoliter weight (g /l)	80.03	78.99	74.82	75.00	74.00	71.00	85.00	83.70	79.33	1.91	2.17	1.98
Protein (%)	11.93	10.75	14.69	10.2	9.67	13.1	14.30	12.50	16.23	1.06	1.10	1.15
Wet gluten (%)	27.39	23.81	34.42	21.53	19.80	31.37	33.80	29.20	37.86	1.32	1.40	0.53
Starch (%)	65.14	65.22	64.65	63.13	63.87	62.27	66.53	66.30	66.86	1.62	1.73	1.89
Moisture(%)	7.61	7.66	7.78	7.30	7.36	7.50	7.86	8.20	8.30	2.07	2.81	1.78

Table 4.2.2 (b): Parameters of Genetic variability for yield and its component traits in bread wheat genotypes for second experimental year.

TRAITS	PCV			GCV			ECV			h² (Broad Sense)			GA as % of mean		
	E4	E5	E6	E4	E5	E6	E4	E5	E6	E4	E5	E6	E4	E5	E6
Days to 50% flowering	2.44	4.74	6.83	1.36	4.29	6.46	2.03	2.01	2.23	31.16	81.95	89.39	1.57	8.00	12.58
Days to maturity	1.91	3.61	3.99	1.56	3.42	3.79	1.11	1.17	1.25	66.44	89.49	90.23	2.62	6.66	7.42
Plant height (cm)	6.06	9.49	6.47	5.92	9.42	5.26	1.33	1.19	3.76	95.22	98.43	66.23	11.90	19.25	8.82
Tillers plant^{-1}	17.11	21.44	21.61	5.43	4.66	13.13	16.22	20.93	17.16	10.07	4.72	36.92	3.55	2.08	16.43
Effective tillers plant^{-1}	33.49	24.99	26.43	17.34	11.22	16.99	28.65	22.32	20.25	26.80	20.18	41.31	18.49	10.39	22.49
Ineffective tillers plant-^{1}	15.53	15.60	13.49	11.86	10.43	13.07	19.94	14.39	14.20	23.05	5.23	27.13	21.62	4.91	35.48
Spikelets ear^{-1}	10.45	14.39	9.62	2.82	11.09	6.51	10.06	9.17	7.08	7.30	59.43	45.77	1.57	17.62	9.07
Ears plant-^{1}	26.46	23.21	26.14	10.19	14.14	17.06	24.42	18.40	19.80	14.82	37.10	42.63	8.08	17.74	22.95
Grains ear-^{1}	13.79	10.64	10.70	13.35	10.09	10.17	3.48	3.39	3.33	93.62	89.88	90.31	26.60	19.71	19.91
Grains plant-^{1}	22.19	25.29	30.36	22.18	25.28	30.35	0.59	0.64	0.71	99.93	99.94	99.95	45.67	52.07	62.51
Ear head length (cm)	12.70	14.35	17.95	11.82	8.64	14.45	4.66	11.45	10.66	86.56	36.27	64.77	22.65	10.72	23.96
Ear weight(g)	21.98	18.47	16.13	19.39	7.62	9.91	10.36	16.82	12.73	77.78	17.05	37.76	35.22	6.49	12.55
Peduncle length(cm)	15.58	16.68	13.96	13.83	14.46	11.27	7.16	8.32	8.24	78.86	75.10	65.18	25.31	25.80	18.74
Leaves plant-^{1}	24.16	20.24	29.76	23.81	19.05	28.91	4.10	6.83	7.05	97.12	88.61	94.39	48.33	36.94	57.85
1000 grain weight g	9.73	11.84	12.77	9.04	11.61	11.70	3.60	2.34	5.10	86.34	96.10	84.02	17.31	23.45	22.10
B. yield plant-^{1} (g)	2.78	6.00	28.95	1.45	3.75	26.79	2.37	4.68	10.97	27.13	39.08	85.63	1.55	4.83	51.08
Yield plant-^{1} (g)	17.93	22.18	22.98	15.59	19.74	16.61	8.86	10.12	15.89	75.56	79.20	52.23	27.91	36.18	24.73
Harvest index (%)	18.39	15.12	30.51	16.12	8.92	24.48	8.85	12.21	18.20	76.82	34.81	64.41	29.10	10.84	40.48
RWC of flag leaf	6.44	6.59	7.16	6.35	6.50	6.80	1.09	1.06	2.25	97.15	97.43	90.14	12.89	13.22	13.29
Chlorophyll content	6.90	7.59	15.97	5.92	6.32	15.12	3.54	4.22	5.13	73.73	69.18	89.66	10.48	10.82	29.49
Canopy temperature	4.46	4.69	3.66	1.01	1.93	1.66	4.57	4.27	3.26	5.10	16.94	20.66	-0.47	1.64	1.56
SDS value (mm)	20.49	12.23	9.01	20.25	11.75	8.71	3.10	3.40	2.30	97.71	92.27	93.49	41.23	23.25	17.35
Hectoliter weight (g /l)	3.80	4.11	3.41	3.28	3.49	2.78	1.91	2.17	1.98	74.60	72.16	66.45	5.83	6.11	4.67
Protein (%)	8.18	7.15	5.50	8.11	7.07	5.38	1.06	1.10	1.15	98.31	97.64	95.65	16.56	14.39	10.84
Wet gluten (%)	10.39	11.01	4.93	10.30	10.92	4.90	1.32	1.40	0.53	98.39	98.38	98.84	21.06	22.31	10.04
Starch (%)	1.71	1.74	2.30	0.54	0.18	1.31	1.62	1.73	1.89	10.05	1.01	32.54	0.35	0.04	1.54
Moisture(%)	2.81	3.32	3.08	1.91	1.76	2.52	2.07	2.81	1.78	45.98	28.24	66.54	2.66	1.93	4.23

Table 4.2.3 : Pooled parameters of genetic variability for yield and its component traits in bread wheat genotypes for over both experimental year.

TRAITS	Mean	RANGE		C.V.	PCV	GCV	ECV	h² (Broad Sense)%	Gen.Adv as % of Mean 1%
		MAXIMUM	MINIMUM						
Days to 50% flowering	63.48	59.83	66.77	4.01	4.82	2.69	4.00	31.18	3.97
Days to maturity	111.87	108.33	120.27	2.83	3.62	2.26	2.84	38.71	3.70
Plant height (cm)	94.16	79.77	99.83	5.06	6.53	4.12	5.07	39.83	6.87
Tillers plant^{-1}	7.71	5.73	8.51	18.69	20.40	8.17	18.69	16.03	8.63
Effective tillers plant^{-1}	4.50	3.88	5.35	27.86	28.54	6.17	27.86	4.68	3.53
Ineffective tillers plant-^{1}	3.20	1.60	4.16	19.21	51.75	15.99	49.22	9.54	13.04
Spikelets ear^{-1}	17.02	14.97	19.13	10.28	11.46	5.06	10.28	19.51	5.91
Ears plant-^{1}	5.36	4.48	6.34	24.74	25.79	7.26	24.75	7.93	5.40
Grains ear-^{1}	46.34	39.33	60.45	8.52	12.69	9.40	8.53	54.88	18.39
Grains plant-^{1}	300.88	195.54	395.56	19.03	25.09	16.35	19.04	42.46	28.13
Ear head length (cm)	9.56	7.80	11.30	12.09	14.74	8.43	12.09	32.69	12.72
Ear weight(g)	2.15	1.49	2.82	15.94	20.24	12.47	15.94	37.96	20.28
Peduncle length(cm)	17.52	14.43	23.00	11.78	15.94	10.73	11.78	45.34	19.08
Leaves plant-^{1}	23.91	17.21	30.72	20.18	22.90	10.81	20.19	22.29	13.48
1000 grain weight g	39.10	33.65	47.95	8.14	11.62	8.28	8.15	50.81	15.58
B. yield plant-^{1} (g)	34.38	30.02	39.01	14.19	15.43	6.05	14.19	15.36	6.26
Yield plant-^{1} (g)	11.39	8.53	16.15	15.11	21.84	15.77	15.11	52.13	30.06
Harvest index (%)	38.12	30.35	46.89	21.12	23.55	10.43	21.12	19.59	12.18
RWC of flag leaf	81.26	70.69	91.17	1.39	6.82	6.67	1.39	95.84	17.24
Chlorophyll content	43.96	39.22	50.56	8.89	10.31	5.22	8.89	25.62	6.98
Canopy temperature	25.01	24.04	25.62	3.89	4.03	1.04	3.90	6.66	0.71
SDS value (mm)	37.43	31.51	45.30	10.42	13.92	9.23	10.42	43.97	16.17
Hectoliter weight (g /l)	76.97	74.22	79.94	3.33	3.86	1.95	3.33	25.54	2.60
Protein (%)	12.40	11.17	14.17	5.48	7.05	4.43	5.48	39.47	7.35
Wet gluten (%)	28.95	25.29	33.55	6.63	9.09	6.21	6.63	46.74	11.21
Starch (%)	65.69	63.69	66.85	2.18	2.41	1.01	2.19	17.49	1.11
Moisture (%)	7.38	7.02	7.81	5.88	6.18	1.89	5.88	9.36	1.53

4.3. Correlation coefficient analysis between characters (Pooled)

It is the statistical tool, provides degree and direction of relationship between variables at phenotypic, genotypic and environmental levels. Phenotypic correlation is the association between two variables, which can be directly observed. It is worked out from phenotypic variance and co-variance. Genotypic correlation i.e., inherent or heritable association between two variables is estimated from genotypic variance and co-variance. The environmental correlation is the association between two variables which is entirely due to environmental effect. It is estimated from environmental variance and co-variances. The correlation coefficients for different pair of character were studied and results are presented in table [4.3.1 (a) and (b)] and [4.3.2 (a) and (b)]. In general the result showed that genotypic correlation coefficients were higher than phenotypic correlation coefficient for almost all the characters under study, which were in turn higher than environmental correlation.

Grain yield plant^{-1}

The grain yield plant^{-1} was significantly and positively associated with numbers of grains plant^{-1} (0.5483), harvest index (0.4489), numbers of effective tillers plant^{-1} (0.3541), biological yield plant^{-1} (0.3417), ear weight (0.2229), numbers of spikelet ear^{-1} (0.2407), numbers of tillers plant^{-1} (0.2391) and wet gluten % (0.1287). Whereas, relative water content (-0.1527) and protein % (-0.1138) showed significant negative association with grain yield.

Days to 50% flowering

Days to 50% flowering showed significant positive correlation with days to maturity (0.2879), numbers of spikelets ear^{-1} (0.1887), ear head length (0.1572), sedimentation value (0.1531), plant height (0.1301) and harvest index (0.1112). It was significantly and negatively correlated with chlorophyll content (-0.1993).

Days to maturity

Days to maturity reported positive significant association with number of spikelets ear^{-1} (0.1853), ear length (0.1572), sedimentation value (0.1444) and 1000 grain weight (0.1216). Whereas, chlorophyll content (-0.2052) and hectoliter weight (-0.1186) showed strong significant negative correlation with days to maturity.

Numbers of tillers plant^{-1}

It exhibited strong significant positive correlation with numbers of ineffective tillers plant^{-1} (0.6853), numbers of ears plant^{-1} (0.4075), numbers of effective tillers plant^{-1} (0.3386) and numbers of leafs plant^{-1} (0.2488). However, it revealed strong significant negative correlation with canopy temperature (-0.1467).

Numbers of effective tillers plant^{-1}

Numbers of effective tillers plant^{-1} reported strong significant positive correlation with numbers of ears plant^{-1} (0.7231) and numbers of leafs plant^{-1} (0.1122). It showed strong significant negative association with number of ineffective tillers plant^{-1} (-0.4533).

Number of ineffective tillers plant^{-1}

Number of ineffective tillers plant^{-1} exhibited significant positive correlation with number of leafs plant^{-1} (0.1488) and significant negative correlation with number of ears plant^{-1} (-0.1737).

Number of spikelets ear^{-1}

Number of spikelets ear^{-1} showed strong significant negative correlation with numbers of leafs plant^{-1} (-0.7018) and significant negative correlation with starch % (-0.1195).

Number of ears plant^{-1}

Number of ears plant^{-1} reported significant positive association with numbers of leafs plant^{-1} (0.1760).

Number of grains ear^{-1}

Number of grains ear^{-1} exhibited strong significant positive correlation with ear weight (0.5851), ear length (0.2882) and relative water content (0.1390). Strong significant negative correlation were reported by sedimentation value (-0.9833) and high significant negative correlation were reported by protein % (-0.1597) and wet gluten % (-0.1603) with number of grains ear^{-1}.

Numbers of grains plant^{-1}

Numbers of grains plant^{-1} exhibited strong and significant positive correlation with yield plant^{-1} (0.5483), harvest index (0.2388), chlorophyll content (0.1147) and biological yield plant^{-1} (0.1860). High significant negative correlation was reported by relative water content (-0.2937), 1000 grain weight (-0.2843), ear weight (-0.2271) and ear head length (-0.1095) with number of grains plant^{-1}.

Ear head length

Significant and positive correlation was reported by ear head length with ear weight (0.2537). Whereas, high significant negative correlation showed by ear head length with hectoliter weight (-0.2059) and chlorophyll content (-0.1000).

Ear weight

Ear weight showed high significant positive association with 1000 grain weight (0.3656) and relative water content (0.1282), whereas high significant negative association with sedimentation value (-0.1222).

Peduncle length

Peduncle length exhibited significant positive correlation with sedimentation value (0.1517), relative water content (0.1404) and 1000 grain weight (0.1000).

Numbers of leafs plant^{-1}

Numbers of leafs plant^{-1} exhibited significant positive correlation with protein % (0.113). Associations of other traits studied were very low in magnitude and non-significant of either sign.

Biological yield plant^{-1}

Biological yield plant^{-1} reported strong significant negative correlation with harvest index (-0.3450) and relative water content (-0.1916).

Harvest index

Harvest index showed significant positive association with starch % (0.1095). It was significantly and negatively associated with sedimentation value (-0.1045) and protein content (-0.1179).

Relative water content of flag leaf

Relative water content of leaf exhibited significant positive correlation with hectoliter weight (0.1360) and starch % (0.1178). However, the significant negative correlation reported with chlorophyll content (-0.1002).

Chlorophyll content

Chlorophyll content exhibited significant positive correlation with starch % (0.1089). Associations of other traits studied were very low in magnitude and non-significant of either sign.

Sedimentation value

Sedimentation value revealed strong significant positive correlation with wet gluten (0.6419) and protein % (0.6068). It also, showed significant negative correlation with hectoliter weight (-0.1060) and starch % (-0.1135).

Protein %

Protein % reported strong significant positive correlation with wet gluten % (0.7973) and high significant negative correlation with starch % (-0.2141).

Wet gluten %

Wet gluten % showed significant negative correlation with starch % (-0.1917). Associations of other traits studied were very low in magnitude and non-significant of either sign.

Table 4.3.1 (a): Genotypic correlation between yield and other traits. [POOLED]

Traits	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant-1	Effective tillers plant-^{1}	Ineffective tillers per plant	Spikelets ear^{-1}	Ears plant-^{1}	Grains ear-^{1}	Grains plant-1	Ear head length (cm)	Ear weight(g)	Peduncle length(cm)	Leaves plant^{-1}
Days to 50% flowering	**1.0000**	0.5558	0.4775	-0.124	-0.204	-0.0416	0.5327	-0.0132	0.032	0.1901	0.3501	-0.1393	-0.1891	-0.0335
Days to maturity		**1.0000**	0.1479	-0.0386	0.1591	-0.1335	0.3575	0.1931	0.1154	-0.1803	0.5177	0.1304	-0.242	0.0542
Plant height (cm)			**1.0000**	-0.2172	-0.6241	0.0717	0.4335	-0.4696	0.368	0.0343	0.3425	0.1279	0.2487	-0.0833
Tillers plant^{-1}				**1.0000**	0.6017	0.9015	0.1074	0.7411	0.2263	0.2332	0.0309	0.3016	-0.1684	0.5629
Effective tillers plant^{-1}					**1.0000**	0.1967	0.1897	1.104	0.4701	-0.1043	0.3096	0.5246	-0.1153	0.2424
Ineffective tillers plant^{-1}						**1.0000**	0.029	0.3114	0.023	0.3428	-0.1298	0.0859	-0.1442	0.5596
Spikelets ear^{-1}							**1.0000**	0.1795	0.159	0.0113	0.2328	-0.019	-0.1113	0.0537
Ears plant^{-1}								**1.0000**	0.4629	-0.1135	0.2796	0.4483	-0.1989	0.3331
Grains ear^{-1}									**1.0000**	-0.0202	0.5392	0.7344	0.2425	0.0919
Grains plant^{-1}										**1.0000**	-0.1298	-0.342	0.0392	-0.0202
Ear head length (cm)											**1.0000**	0.5055	-0.1132	0.0282
Ear weight(g)												**1.0000**	0.2206	0.1249
Peduncle length(cm)													**1.0000**	-0.2286
Leaves plant-^{1}														**1.0000**
1000 grain weight g														
B. yield plant^{-1} (g)														
Yield plant^{-1} (g)														
Harvest index (%)														
RWC of flag leaf														
Chlorophyll content														
Canopy temperature														
SDS value (mm)														
Hectoliter weight (g /l)														
Protein (%)														
Wet gluten (%)														
Starch (%)														
Moisture(%)														

Table 4.3.1 (b): Genotypic correlation between yield and other traits. [POOLED]

Traits	1000 grain weight (g)	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	SDS value (mm)	Hectoliter weight (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Days to 50% flowering	-0.217	0.0344	0.0337	0.1501	-0.0489	-0.2851	0.1754	0.2299	-0.2178	0.0098	0.0488	-0.1451	0.1306
Days to maturity	0.1697	-0.0068	-0.0903	-0.0314	0.1141	-0.4948	0.1969	0.2753	-0.5495	0.1576	0.1108	-0.2452	0.4521
Plant height (cm)	-0.184	0.0398	-0.0034	-0.0676	0.0627	-0.2272	0.1924	0.1608	-0.3705	-0.0797	0.0571	-0.0971	-0.077
Tillers plant^{-1}	0.2275	0.0973	0.1733	-0.0908	0.1387	-0.1845	-0.6683	-0.3503	0.2248	-0.1863	-0.2516	-0.1458	-0.1218
Effective tillers plant^{-1}	0.3563	0.0442	-0.0113	-0.0569	0.0346	-0.3942	-0.2779	-0.2853	-0.0452	-0.1429	-0.4122	-0.3626	0.0103
Ineffective tillers plant-^{1}	0.0861	0.0955	0.2188	-0.0806	0.1516	-0.0129	-0.6697	-0.2754	0.3005	-0.1512	-0.0854	0.0176	-0.1552
Spikelets ear^{-1}	-0.074	0.0482	-0.1689	-0.2061	-0.0318	-0.3565	0.07	0.4073	-0.422	0.1544	0.244	-0.8188	0.1093
Ears plant-^{1}	0.2449	-0.1112	-0.1007	-0.115	0.1882	-0.4043	-0.4435	-0.258	0.1805	-0.1818	-0.3532	-0.2843	-0.1038
Grains ear-^{1}	-0.016	0.0801	0.1343	-0.0086	0.19	-0.1279	-0.251	-0.0502	-0.2159	-0.1621	-0.2026	-0.0111	0.1004
Grains plant-^{1}	-0.432	0.5642	0.842	0.5235	-0.4341	0.1555	-0.1783	-0.1017	0.118	-0.0419	-0.0687	-0.0458	-0.1144
Ear head length (cm)	0.2236	0.1466	-0.0762	-0.1415	-0.047	-0.3541	0.1961	0.2048	-0.3748	0.1631	0.0693	-0.3581	0.4206
Ear weight(g)	0.5947	-0.0024	-0.0573	-0.1796	0.1812	-0.0071	-0.5469	-0.1203	-0.1248	-0.1373	-0.242	-0.0026	0.2088
Peduncle length(cm)	0.1272	-0.0009	0.2369	0.2464	0.2092	-0.0811	-0.0732	0.1377	-0.0499	0.0138	0.1523	0.2552	-0.2946
Leaves plant-^{1}	0.1606	0.2056	0.1677	-0.0361	0.1499	-0.1708	-0.1933	-0.4011	0.1607	-0.2206	-0.2971	0.3013	-0.2824
1000 grain weight g	**1.0000**	-0.0588	-0.1529	-0.0952	0.0686	-0.1232	-0.3498	-0.1363	0.0056	-0.0396	-0.1378	-0.1541	0.1358
B. yield plant-^{1} (g)		**1.0000**	0.5235	-0.0128	-0.4774	0.2794	-0.3982	-0.0727	-0.1797	-0.033	-0.1965	-0.0102	0.0688
Yield plant-^{1} (g)			**1.0000**	0.7758	-0.2145	-0.0514	-0.3112	-0.3807	0.029	-0.2284	0.2944	0.1912	-0.124
Harvest index (%)				**1.0000**	0.0475	-0.3175	0.1289	-0.5232	-0.0524	-0.5032	-0.4301	0.258	-0.0172
RWC of flag leaf					**1.0000**	-0.2191	0.2074	-0.0515	0.2641	-0.1395	0.0122	0.255	-0.15
Chlorophyll content						**1.0000**	-0.3331	0.1215	0.3908	0.1323	0.0435	0.1777	0.1396
Canopy temperature							**1.0000**	0.2812	-0.2679	0.0815	0.2995	0.1508	-0.0962
SDS value (mm)								**1.0000**	-0.1848	0.8312	0.8609	-0.4426	-0.047
Hectoliter weight (g /l)									**1.0000**	0.0089	-0.0123	0.2164	-0.3453
Protein (%)										**1.0000**	0.8823	-0.3781	0.0637
Wet gluten (%)											**1.0000**	-0.3792	-0.2362
Starch (%)												**1.000**	-0.2199
Moisture(%)													**1.0000**

Table 4.3.2 (a): Phenotypic correlation between yield and other traits. [POOLED]

Traits	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant-1	Effective tillers plant-1	Ineffective tillers per plant	Spikelets ear-1	Ears plant-1	Grains ear-1	Grains plant-1	Ear head length (cm)	Ear weight(g)	Peduncle length(cm)	Leaves plant-1
Days to 50% flowering	**1.0000**	0.2879***	0.1301***	0.0462	-0.0112	0.0524	0.1887***	0.0211	0.0094	0.0821	0.1572***	-0.0221	-0.0255	-0.0498
Days to maturity		**1.0000**	0.0861*	-0.0243	0.0124	-0.0326	0.1853***	0.0446	0.0479	-0.0806	0.1572***	0.0583	-0.0597	-0.0246
Plant height (cm)			**1.0000**	-0.0716	-0.0789	-0.0068	0.1095*	-0.0749	0.1172**	-0.0667	0.1714***	0.1238**	0.1155**	-0.0683
Tillers plant^{-1}				**1.0000**	0.3386***	0.6853***	-0.0676	0.4075***	0.0918	-0.0081	-0.0396	0.0618	-0.0354	0.2488***
Effective tillers plant^{-1}					**1.0000**	-0.4533	-0.0379	0.7231***	0.0477	-0.0029	-0.0227	0.0139	-0.0689	0.1122**
Ineffective tillers plant-^{1}						**1.0000**	-0.0347	-0.1737***	0.05	-0.0054	-0.02	0.0478	0.0198	0.1488***
Spikelets ear^{-1}							**1.0000**	0.0075	0.0504	-0.0276	0.0955*	0.056	-0.0139	-0.1018*
Ears plant-^{1}								**1.0000**	0.0827	-0.0685	0.003	0.0659	-0.0515	0.176***
Grains ear-^{1}									**1.0000**	-0.0131	0.2882***	0.5851***	0.0387	0.0288
Grains plant-^{1}										**1.0000**	-0.1095*	-0.2271***	-0.0374	-0.0094
Ear head length (cm)											**1.0000**	0.2537	-0.0578	-0.0599
Ear weight(g)												**1.0000**	0.0501	-0.0096
Peduncle length(cm)													**1.0000**	-0.0873*
Leaves plant-^{1}														**1.0000**
1000 grain weight g														
B. yield plant-^{1} (g)														
Yield plant-^{1} (g)														
Harvest index (%)														
RWC of flag leaf														
Chlorophyll content														
Canopy temperature														
SDS value (mm)														
Hectoliter weight (g /l)														
Protein (%)														
Wet gluten (%)														
Starch (%)														
Moisture (%)														

Table 4.3.2 (b): Phenotypic correlation between yield and other traits. [POOLED]

Traits	1000 grain weight g	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	SDS value (mm)	Hectoliter weight (g/l)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Days to 50% flowering	-0.0439	0.02	-0.2196	0.1112**	-0.0196	-0.1993***	0.0419	0.1531**	-0.0158	0.0984*	0.0922*	-0.0632	0.0603
Days to maturity	0.1216**	-0.0362	-0.0502	0.0406	0.0654	-0.2052***	0.0544	0.1444***	-0.1186**	0.0621	-0.0242	-0.0981*	0.0832
Plant height (cm)	-0.027	-0.0029	0.0203	-0.0289	0.0394	-0.074	0.0304	0.1034*	-0.1869***	-0.0162	0.0396	-0.0165	0.0038
Tillers plant^{-1}	0.0065	-0.0186	0.2391**	0.0143	0.0329	-0.0996*	-0.1467***	-0.0600	0.0957*	-0.0171	-0.015	-0.0339	0.0379
Effective tillers plant^{-1}	0.0031	0.0987*	0.3541**	0.0091	-0.0044	-0.0876*	-0.0646	0.0447	0.024	0.0488	-0.0137	-0.093*	0.0162
Ineffective tillers plant-^{1}	0.0037	-0.0941*	-0.0047	0.0065	0.0346	-0.0265	-0.0889*	-0.0915*	0.0721	-0.054	-0.0037	0.0398	0.0234
Spikelets ear^{-1}	0.0471	-0.0066	-0.0518	-0.0066	-0.0139	-0.0387	0.0024	0.0552	-0.0945*	0.0397	0.096*	-0.1195**	0.003
Ears plant-^{1}	0.0341	0.0453	-0.0187	0.0086	0.0323	-0.083	-0.0833	0.0475	0.0238	0.036	0.0003	-0.0807	0.0086
Grains ear-^{1}	-0.076	-0.0402	0.0915	0.0664	0.139**	-0.0356	-0.0409	-0.1983***	-0.0491	-0.1597***	-0.1603***	-0.0435	-0.0114
Grains plant-^{1}	-0.2842***	0.186***	0.5483***	0.2388***	-0.2937***	0.1147	-0.0898*	0.0416	0.0433	0.0012	-0.0093	0.0747	-0.0654
Ear head length (cm)	0.0862	-0.0025	0.0427	-0.0329	-0.0172	-0.1000*	0.0469	-0.0132	-0.2059***	0.0226	-0.0053	-0.0886*	0.0805
Ear weight(g)	0.3656***	-0.0333	0.2229**	0.0441	0.1282**	-0.0152	-0.025	-0.1222**	0.0045	-0.0561	-0.0521	-0.0374	0.0309
Peduncle length(cm)	0.1000*	-0.0202	0.0544	0.0617	0.1404**	-0.0674	0.007	0.1517	0.0288	0.0627	0.0855*	0.063	-0.0594
Leaves plant-^{1}	0.0127	-0.0141	0.091	0.0854*	0.0752	0.0315	-0.014	-0.0232	0.0874	0.113**	0.0167	-0.026	-0.0068
1000 grain weight g	**1.0000**	0.0252	-0.0645	-0.0212	0.0718	-0.0621	-0.0001	-0.0567	0.0482	-0.0206	0.0002	-0.0054	0.0462
B. yield plant-^{1} (g)		**1.0000**	0.3417***	-0.345***	-0.1916***	0.0429	0.0545	0.0432	-0.077	-0.001	-0.018	-0.0748	-0.0931*
Yield plant-^{1} (g)			**1.0000**	0.4489***	-0.1527***	0.0588	-0.0207	0.0996	0.0937	-0.1138**	0.1287**	0.0918	-0.0315
Harvest index (%)				**1.0000**	0.0198	-0.0303	0.0256	-0.1045*	-0.0059	-0.1179**	-0.076	0.1095*	-0.0101
RWC of flag leaf					**1.0000**	-0.1002*	0.0671	-0.0308	0.136***	-0.0818	0.0136	0.1178**	-0.0418
Chlorophyll content						**1.0000**	-0.0287	0.094*	0.0345	-0.0692	-0.0627	0.1089*	-0.0257
Canopy temperature							**1.0000**	0.0561	-0.0682	-0.0217	0.049	-0.0711	0.021
SDS value (mm)								**1.0000**	-0.106*	0.6068***	0.6419***	-0.1135**	0.0817
Hectoliter weight (g /l)									**1.0000**	-0.0767	-0.0755	0.1365**	-0.074
Protein (%)										**1.0000**	0.7973***	-0.2141***	0.0731
Wet gluten (%)											**1.0000**	-0.1917***	-0.0167
Starch (%)												**1.0000**	-0.0362
Moisture (%)													**1.0000**

4.4. Path coefficient analysis (Pooled)

Path coefficients are standardized partial regression coefficients. It partition the observed correlation between dependent variable and independent variable in direct and indirect effects in such a manner that observed correlation between dependent trait and independent trait is equal to the sum of direct and all possible indirect effects.

Path coefficient analysis, which measures the direct and indirect effect of one variable through another on the end product, was carried out using genotypic as well as phenotypic correlation considering grain yield per plant as a dependable variable. The observed genotypic and phenotypic correlation coefficient on grain and its components were partitioned into direct and indirect effects and have been presented in table 4.4.1 and 4.4.2.

In general the genotypic direct and indirect effects were higher in magnitude as compared to phenotypic direct and indirect effects. The genotypic and phenotypic direct and indirect effects followed the same pattern. The pooled results (2012-13 & 2013-14) obtained by path coefficient analysis at genotypic level are presented trait wise.

Direct effect

The genotypic path coefficient analysis of different yield contributing and associated traits on seed yield per plant revealed that traits *viz.,* sedimentation value (2.3994) exhibited highest positive direct effect on grain yield plant^{-1}, followed by, wet gluten % (1.6919), hectoliter weight (1.6573), biological yield plant^{-1} (1.0845), moisture % (1.7365), starch % (0.8741), number of grains ear^{-1} (0.7404), harvest index (0.4163), number of tillers plant^{-1} (0.2692). However, number of spikelets ear^{-1} (-0.0285), number of grains plant^{-1} (-0.0626), 1000 grain weight (-0.1071), days to 50% flowering (-0.3081), ear head length (-0.4353), days to maturity (-0.5593), plant height (-0.5652), relative water content of flag leaf (-0.7586), canopy temperature (-0.8644), number of ears plant-^{1} (-0.9583), chlorophyll content (-2.6142) and protein % (-2.8440) showed negative direct effect on grain yield plant^{-1}.

Indirect effects

Days to 50% flowering

It showed positive and small indirect effect on grain yield plant^{-1} (0.0337). Negative indirect effect of days to 50 % was recorded on grain yield *via* other trait days to maturity (-0.1712). Other indirect effects of this trait via other traits were relatively low and negligible.

Days to maturity

Days to maturity reported small negative indirect effect on grain yield plant^{-1} (-0.0903). Positive indirect effect of days to maturity on grain yield plant^{-1} *via* other traits were found to be high for hectoliter weight (0.3073), chlorophyll content (0.2768) and starch % (0.1372). Negative indirect effect on grain yield *via* other traits were days to 50% flowering (-0.3109), ear head length (-0.2895) and moisture % (-0.2529).

Plant Height

Plant height recorded negative and small indirect effect on grain yield plant^{-1} (-0.0034). Positive indirect effect of plant height on grain yield plant^{-1} *via* other traits were found to be high for number of ears plant^{-1} (0.2654) and hectoliter weight (0.2094). Whereas, the negative indirect effect was showed *via* other traits days to 50% flowering (-0.2699), number of spikelets ear^{-1} (-0.2450), and number of grains ear^{-1} (0.2080).

Number of tillers plant^{-1}

The indirect effect of number of tillers plant^{-1} on grain yield plant^{-1} was positive and large (0.1733). Whereas, the positive indirect effect exerted on grain yield *via* number of ears plant^{-1} (0.1995) and negative indirect effect was reported on grain yield through canopy temperature (0.1799).

Number of spikelets ear^{-1}

Number of spikelets ear^{-1} reported small negative indirect effect on grain yield plant^{-1} (-0.1689). Indirect effect exerted by number of spikelets ear^{-1} on grain yield plant^{-1} *via* other traits were found to be negligible.

Number of ears plant^{-1}

Number of ears plant^{-1} exhibited positive indirect effect on grain yield plant^{-1} (0.1733). Positive indirect effect of number of ears plant^{-1} on grain yield plant^{-1} *via* other traits were found to be high for plant height (0.4500), canopy temperature (0.4250), chlorophyll content (0.3874), wet gluten % (0.3385) and starch % (0.2724). Whereas, negative indirect effect exerted on grain yield *via* number of tillers plant^{-1} (-0.7102), number of grains ear-1 (-0.4436), ear head length (-0.2679) and 1000 grain weight (-0.2347).

Number of grains ear^{-1}

Number of grains ear^{-1} revealed positive indirect effect on grain yield plant^{-1} (0.1343). it showed with high positive indirect effect on grain yield plant^{-1} exerted *via* other traits ear head length (0.3993), number of ears plant^{-1} (0.3427) and plant height (0.2725). While, it reported negative indirect effect on grain yield plant^{-1} *via* canopy temperature (-0.1858), hectoliter weight (-0.1599), wet gluten % (-0.1500) and protein % (0.1200).

Number of grains plant^{-1}

Number of grains plant^{-1} exhibited large positive indirect effect **(**0.8420) on grain yield plant^{-1}. Indirect effect of number of grains plant^{-1} on grain yield plant^{-1} *via* other traits were found to be negligible.

Ear Length

The indirect effect of ear head length on grain yield plant^{-1} was negative and small (-0.0762). The positive indirect effect exerted on grain yield by other traits via hectoliter weight (0.1631), starch % (0.1559) and chlorophyll content (0.1541). However, negative indirect effect was recorded on grain yield plant^{-1} *via* number of grains ear $^{-1}$ (-0.2347), days to maturity (-0.2253) and moisture % (-0.1831).

1000-grain weight

The indirect effect of 1000 grain weight on grain yield plant^{-1} was negative and small (-0.1529). Indirect effect of 1000 grain weight on grain yield plant^{-1} *via* other traits were found to be negligible.

Biological yield per plant^{-1}

Biological yield plant^{-1} recorded large and positive indirect effect on grain yield plant^{-1} (0.5235). The positive indirect effect exerted on grain yield plant^{-1} *via* other traits number of grains ear^{-1} (0.6119), chlorophyll content (0.3030), ear head length (0.1590), number of tillers plant^{-1} (0.1055). High negative indirect effect was recorded on grain yield plant^{-1} *via* relative water content (-0.5177), canopy temperature (-0.4319), wet gluten % (-0.2131) and hectoliter weight (-0.1949).

Harvest Index

The harvest Index reported large positive indirect effect on grain yield plant^{-1} (0.7758). The positive indirect effect exerted on grain yield *via* other traits number of grains plant^{-1} (0.2179) and starch % (0.1074). Negative indirect effect was recorded on grain yield plant^{-1} *via* sedimentation value (-0.2178), protein % (-0.2095), wet gluten % (-0.1791) and chlorophyll content (-0.1322).

Relative Water Content (RWC)

Relative water content had small negative indirect effect on grain yield plant^{-1}(-0.2145). The positive indirect effect exerted on grain yield *via* other traits were found to be high for biological yield plant^{-1} (0.3621), followed by number of grains plant^{-1} (0.3293), chlorophyll content (0.1662), moisture % (0.1138). Whereas, it exerted negative indirect effect *via* hectoliter weight (-0.2004), starch % (-0.1934), canopy temperature (-0.1573) and number of grains ear^{-1} (-0.1441).

Chlorophyll content

Chlorophyll content showed small negative indirect effect on grain yield plant^{-1} (-0.0514). The positive indirect effect exerted on grain yield *via* other traits were found to be high in days to maturity (1.2936), followed by number of ears plant^{-1} (1.0569), number of spikelets ear^{-1} (0.9321), ear head length (0.9257), canopy temperature (0.8708), harvest index (0.8301), days to 50% flowering (0.7454), relative water content (0.5727), plant height (0.5938), number of tillers plant^{-1} (0.4823), number of grains ear^{-1} (0.3343), 1000 grain weight (0.3221). However, the negative indirect effect were reported *via*

hectoliter weight (-1.0216), biological yield plant^{-1} (-0.7303), starch % (-0.4645) and number of grains plant^{-1} (-0.4645) and protein % (-0.3458).

Canopy temperature

Canopy temperature observed recorded small negative indirect effect on grain yield plant^{-1} (-0.3112). It exerted high positive effect on grain yield plant^{-1} *via* other traits number of tillers plant^{-1} (0.5776), followed by number of ears plant^{-1} (0.3834), biological yield plant^{-1} (0.3442), 1000 grains weight (0.3024), chlorophyll content (0.2879), hectoliter weight (0.3442) and number of grains ear^{-1} (0.2170). Whereas, negative indirect effect reported *via* wet gluten % (-0.2589), sedimentation value (-0.2431), relative water content (-0.1793) and days to maturity (-0.1702), ear head length (-0.1695) and days to 50% flowering (-0.1517).

Sedimentation value

The indirect effect of sedimentation value on grain yield plant^{-1} was negative (-0.3807). The positive indirect effect exerted on grain yield plant^{-1} *via* other traits were found to be high in wet gluten % (2.0656), followed by protein % (1.9944), number of spikelets ear^{-1} (0.9773), canopy temperature (0.6747), days to maturity (0.6605), days to 50% flowering (0.5516), ear head length (0.4913). Negative indirect effect showed by grain yield *via* harvest index (-1.2552), starch % (-1.0619), number of tillers plant^{-1} (-0.8406) and numbers of ears plant^{-1} (-0.6191), hectoliter weight (-0.4434), 1000 grain weight (-0.3271), number of grains plant (-0.2439).

Hectoliter weight

Hectoliter weight recorded positive indirect effect on grain yield plant^{-1} was positive (0.0290). Positive indirect effect exerted by hectoliter weight on grain yield plant^{-1} *via* other traits were found to be high for chlorophyll content (0.6476), relative water content (0.4377), number of tillers plant^{-1} (0.3726), wet gluten % (0.3587) and number of ears plant^{-1} (0.2992) while, negative indirect effect *via* other traits reported by days to maturity (-0.9107), number of spikelets ear^{-1} (-0.6993) and ear head length (-0.6212) and plant height (-0.6140).

Protein %

Protein % showed negative indirect effect on grain yield plant^{-1} (-0.2284). Positive indirect effect exerted by protein % on grain yield plant^{-1} *via* other traits were found to be high for harvest index (1.4310), starch % (1.0754), number of tillers plant^{-1} (0.5298), number of ears plant^{-1} (0.5174) and number of grains ear^{-1} (0.4611) whereas, negative indirect effect *via* other traits reported by sedimentation value (-2.3640), wet gluten % (-2.5094), ear length (-0.4638) and days to maturity (-0.4482).

Wet gluten %

Wet gluten reported negative and small indirect effect (-0.2944) on grain yield plant^{-1}. The positive indirect effect exerted on grain yield plant^{-1} *via* other traits were found to be high in protein % (1.4928), followed by sedimentation value (1.4566), canopy temperature (0.5068), and number of spikelets ear-1 (0.4128). Negative indirect effect was exhibited by grain yield plant^{-1} *via* harvest index (-0.7277), starch % (-0.6415), number of ears plant^{-1} (-0.5977) and number of tillers plant^{-1} (-0.4256).

Starch %

The indirect effect of starch % on grain yield plant^{-1} was positive (0.1912). The positive indirect effect exerted on grain yield plant^{-1} *via* other traits i.e. relative water content (0.2229) and harvest index (0.2255). Negative indirect effect was reported on grain yield plant^{-1} *via* number of spikelets ear^{-1} (-0.7157), sedimentation value (-0.3868) and ear head length (-0.3130).

Moisture %

The indirect effect of moisture % on grain yield plant^{-1} was negative and small (-0.2284). The positive indirect effect of moisture % exerted on grain yield *via* other traits were found to be high for days to maturity (0.7851) followed by ear head length (0.7303), chlorophyll content (0.2424) and 1000 grain weight (0.2358) . Negative indirect effect was reported on grain yield plant^{-1} *via* hectoliter weight (-0.5996), wet gluten % (-0.4101), starch % (-0.3819), relative water content (-0.2605) and number of grains plant^{-1} (-0.1987).

Table 4.4.1: Path coefficient based on phenotypic correlation coefficient. (Pooled)

Traits	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Spikelet ear^{-1}	Ears plant^{-1}	Grains ear^{-1}	Grains plant^{-1}	Ear length (cm)	1000 grain weight (g)	B Y P-^{1} (g)	HI (%)	RWC	CC	CT	SDS value (mm)	Hectoliter (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Days to 50% flowering	**-0.0702**	-0.0202	-0.0091	-0.0032	-0.0132	-0.0015	-0.0007	-0.0058	-0.0110	0.0031	-0.0014	-0.0078	0.0014	0.0140	-0.0029	-0.0107	0.0011	-0.0069	-0.0065	0.0044	-0.0042
Days to maturity	-0.0034	**-0.0120**	-0.0010	0.0003	-0.0022	-0.0005	-0.0006	0.0010	-0.0019	-0.0015	0.0004	-0.0005	-0.0008	0.0025	-0.0007	-0.0017	0.0014	-0.0007	0.0003	0.0012	-0.0010
Plant height (cm)	0.0102	0.0068	**0.0785**	-0.0056	0.0086	-0.0059	0.0092	-0.0052	0.0135	-0.0021	-0.0002	-0.0023	0.0031	-0.0058	0.0024	0.0081	-0.0147	-0.0013	0.0031	-0.0013	0.0003
Tillers plant^{-1}	0.0019	-0.0010	-0.0029	**0.0407**	-0.0028	0.0166	0.0037	-0.0003	-0.0016	0.0003	-0.0008	0.0006	0.0013	-0.0041	-0.0060	-0.0024	0.0039	-0.0007	-0.0006	-0.0014	0.0015
Spikelets ear^{-1}	-0.0035	-0.0034	-0.0020	0.0012	**-0.0183**	-0.0001	-0.0009	0.0005	-0.0017	-0.0009	0.0001	0.0001	0.0003	0.0007	0.0000	-0.0010	0.0017	-0.0007	-0.0018	0.0022	-0.0001
Ears plant^{-1}	-0.0006	-0.0014	0.0023	-0.0125	-0.0002	**-0.0307**	-0.0025	0.0021	-0.0001	-0.0010	-0.0014	-0.0003	-0.0010	0.0025	0.0026	-0.0015	-0.0007	-0.0011	0.0000	0.0025	-0.0003
Grains ear^{-1}	0.0003	0.0013	0.0032	0.0025	0.0014	0.0023	**0.0275**	-0.0004	0.0079	-0.0021	-0.0011	0.0018	0.0038	-0.0010	-0.0011	-0.0055	-0.0014	-0.0044	-0.0044	-0.0012	-0.0003
Grains plant-^{1}	0.0298	-0.0293	-0.0242	-0.0029	-0.0100	-0.0248	-0.0047	**0.3629**	-0.0397	-0.1031	0.0675	0.0867	-0.1066	0.0416	-0.0326	0.0151	0.0157	0.0004	-0.0034	0.0271	-0.0237
Ear length (cm)	0.0005	0.0005	0.0005	-0.0001	0.0003	0.0000	0.0008	-0.0003	**0.0029**	0.0003	0.0000	-0.0001	-0.0001	-0.0003	0.0001	0.0000	-0.0006	0.0001	0.0000	-0.0003	0.0002
1000 grain weight (g)	-0.0017	0.0046	-0.0010	0.0002	0.0018	0.0013	-0.0029	-0.0107	0.0032	**0.0376**	0.0009	-0.0008	0.0027	-0.0023	0.0000	-0.0021	0.0018	-0.0008	0.0000	-0.0002	0.0017
B Y P-^{1} (g)	0.0094	-0.0171	-0.0014	-0.0088	-0.0031	0.0214	-0.0190	0.0877	-0.0012	0.0119	**0.4717**	-0.1627	-0.0903	0.0202	0.0257	0.0204	-0.0363	-0.0005	-0.0085	-0.0353	-0.0439
HI (%)	0.0587	0.0214	-0.0152	0.0076	-0.0035	0.0045	0.0351	0.1260	-0.0173	-0.0112	-0.1820	**0.5277**	0.0104	-0.0160	0.0135	-0.0551	-0.0031	-0.0622	-0.0401	0.0578	-0.0053
RWC	-0.0006	0.0020	0.0012	0.0010	-0.0004	0.0010	0.0043	-0.0090	-0.0005	0.0022	-0.0059	0.0006	**0.0307**	-0.0031	0.0021	-0.0009	0.0042	-0.0025	0.0004	0.0036	-0.0013
CC	-0.0025	-0.0026	-0.0009	-0.0013	-0.0005	-0.0011	-0.0005	0.0015	-0.0013	-0.0008	0.0005	-0.0004	-0.0013	**0.0127**	-0.0004	0.0012	0.0004	-0.0009	-0.0008	0.0014	-0.0003
CT	-0.0006	-0.0008	-0.0005	0.0022	0.0000	0.0013	0.0006	0.0014	-0.0007	0.0000	-0.0008	-0.0004	-0.0010	0.0004	**-0.0152**	-0.0009	0.0010	0.0003	-0.0007	0.0011	-0.0003
SDS value (mm)	-0.0082	-0.0077	-0.0055	0.0032	-0.0030	-0.0025	0.0106	-0.0022	0.0007	0.0030	-0.0023	0.0056	0.0016	-0.0050	-0.0030	**-0.0536**	0.0057	-0.0325	-0.0344	0.0061	-0.0044
Hectoliter (g /l)	0.0002	0.0018	0.0028	-0.0015	0.0014	-0.0004	0.0007	-0.0007	0.0031	-0.0007	0.0012	0.0001	-0.0021	-0.0005	0.0010	0.0016	**-0.0152**	0.0012	0.0012	-0.0021	0.0011
Protein (%)	0.0063	0.0040	-0.0010	-0.0011	0.0025	0.0023	-0.0102	0.0001	0.0014	-0.0013	-0.0001	-0.0075	-0.0052	-0.0044	-0.0014	0.0386	-0.0049	**0.0637**	0.0508	-0.0136	0.0047
Wet gluten (%)	-0.0071	0.0019	-0.0031	0.0012	-0.0074	0.0000	0.0124	0.0007	0.0004	0.0000	0.0014	0.0059	-0.0011	0.0049	-0.0038	-0.0497	0.0058	-0.0617	**-0.0774**	0.0148	0.0013
Starch (%)	-0.0017	-0.0026	-0.0004	-0.0009	-0.0032	-0.0021	-0.0012	0.0020	-0.0024	-0.0001	-0.0020	0.0029	0.0031	0.0029	-0.0019	-0.0030	0.0036	-0.0057	-0.0051	**0.0266**	-0.0010
Moisture(%)	0.0026	0.0036	0.0002	0.0017	0.0001	0.0004	-0.0005	-0.0029	0.0035	0.0020	-0.0041	-0.0004	-0.0018	-0.0011	0.0009	0.0036	-0.0032	0.0032	-0.0007	-0.0016	**0.0438**
Yield plant-1 (g)	**0.0196**	**-0.0502**	**0.0203**	**0.0239**	**-0.0518**	**-0.0187**	**0.0615**	**0.5483**	**-0.0427**	**-0.0645**	**0.3417**	**0.4489**	**-0.1527**	**0.0588**	**-0.0207**	**-0.0996**	**-0.0337**	**-0.1138**	**-0.1287**	**0.0918**	**-0.0315**

B Y P-^{1} (g) = **Biological yield plant-^{1} (g)** **CT** = **Canopy temperature** **RWC** = **RWC of flag leaf**

HI (%) = **Harvest index (%)** **CC** = **Chlorophyll content** **SDS value (mm)** = **Sedimentation value (mm)**

Table 4.4.2: Path coefficient based on genotypic correlation coefficient. (Pooled)

Traits	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Spikelet ear^{-1}	Ears plant^{-1}	Grains ear^{-1}	Grains plant^{-1}	Ear length (cm)	1000 grain weight (g)	B Y P-^{1} (g)	HI (%)	RWC	CC	CT	SDS value (mm)	Hectoliter (g/l))	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Days to 50% flowering	**-0.3081**	-0.1712	-0.1471	0.0382	-0.1641	0.0041	-0.0099	-0.0586	-0.1079	0.0670	-0.0106	-0.0463	0.0151	0.0878	-0.0540	-0.0708	0.0671	-0.0030	-0.0150	0.0447	-0.0402
Days to maturity	-0.3109	**-0.5593**	-0.0827	0.0216	-0.1999	-0.1080	-0.0645	0.1008	-0.2895	-0.0949	0.0038	0.0176	-0.0638	0.2768	-0.1101	-0.1540	0.3073	-0.0881	-0.0620	0.1372	-0.2529
Plant height (cm)	-0.2699	-0.0836	**-0.5652**	0.1227	-0.2450	0.2654	-0.2080	-0.0194	-0.1936	0.1040	-0.0225	0.0382	-0.0354	0.1284	-0.1088	-0.0909	0.2094	0.0450	-0.0323	0.0549	0.0435
Tillers plant^{-1}	-0.0334	-0.0104	-0.0585	**0.2692**	0.0289	0.1995	0.0609	0.0628	0.0083	0.0612	0.0262	-0.0244	0.0373	-0.0497	-0.1799	-0.0943	0.0605	-0.0502	-0.0677	-0.0393	-0.0328
Spikelets ear^{-1}	-0.0152	-0.0102	-0.0124	-0.0031	**-0.0285**	-0.0051	-0.0045	-0.0003	-0.0066	0.0021	-0.0014	0.0059	0.0009	0.0102	-0.0020	-0.0116	0.0120	-0.0044	-0.0070	0.0233	-0.0031
Ears plant^{-1}	0.0126	-0.1851	0.4500	-0.7102	-0.1721	**-0.9583**	-0.4436	0.1088	-0.2679	-0.2347	0.1066	0.1102	-0.1803	0.3874	0.4250	0.2473	-0.1730	0.1742	0.3385	0.2724	0.0995
Grains ear^{-1}	0.0237	0.0854	0.2725	0.1676	0.1178	0.3427	**0.7404**	-0.0150	0.3993	-0.0119	0.0593	-0.0064	0.1407	-0.0947	-0.1858	-0.0372	-0.1599	-0.1200	-0.1500	-0.0082	0.0744
Grains plant-^{1}	-0.0119	0.0113	-0.0021	-0.0146	-0.0007	0.0071	0.0013	**-0.0626**	0.0081	0.0270	-0.0353	-0.0328	0.0272	-0.0097	0.0112	0.0064	-0.0074	0.0026	0.0043	0.0029	0.0072
Ear length (cm)	-0.1524	-0.2253	-0.1491	-0.0135	-0.1013	-0.1217	-0.2347	0.0565	**-0.4353**	-0.0973	-0.0638	0.0616	0.0204	0.1541	-0.0853	-0.0891	0.1631	-0.0710	-0.0302	0.1559	-0.1831
1000 grain weight (g)	0.0233	-0.0182	0.0197	-0.0244	0.0080	-0.0262	0.0017	0.0463	-0.0240	**-0.1071**	0.0063	0.0102	-0.0073	0.0132	0.0375	0.0146	-0.0006	0.0042	0.0148	0.0165	-0.0145
B Y P-^{1} (g)	0.0373	-0.0073	0.0432	0.1055	0.0523	-0.1207	0.0868	0.6119	0.1590	-0.0638	**1.0845**	-0.0139	-0.5177	0.3030	-0.4319	-0.0789	-0.1949	-0.0358	-0.2131	-0.0111	0.0746
HI (%)	0.0625	-0.0131	-0.0281	-0.0378	-0.0858	-0.0479	-0.0036	0.2179	-0.0589	-0.0396	-0.0053	**0.4163**	0.0198	-0.1322	0.0537	-0.2178	-0.0218	-0.2095	-0.1791	0.1074	-0.0072
RWC	0.0371	-0.0865	-0.0476	-0.1052	0.0242	-0.1428	-0.1441	0.3293	0.0356	-0.0520	0.3621	-0.0360	**-0.7586**	0.1662	-0.1573	0.0391	-0.2004	0.1058	-0.0093	-0.1934	0.1138
CC	0.7454	1.2936	0.5938	0.4823	0.9321	1.0569	0.3343	-0.4064	0.9257	0.3221	-0.7303	0.8301	0.5727	**-2.6142**	0.8708	-0.3176	-1.0216	-0.3458	-0.1136	-0.4645	-0.3649
CT	-0.1517	-0.1702	-0.1663	0.5776	-0.0605	0.3834	0.2170	0.1541	-0.1695	0.3024	0.3442	-0.1114	-0.1793	0.2879	**-0.8644**	-0.2431	0.2316	-0.0705	-0.2589	-0.1304	0.0832
SDS value (mm)	0.5516	0.6605	0.3858	-0.8406	0.9773	-0.6191	-0.1204	-0.2439	0.4913	-0.3271	-0.1745	-1.2552	-0.1236	0.2915	0.6747	**2.3994**	-0.4434	1.9944	2.0656	-1.0619	-0.1127
Hectoliter (g /l)	-0.3610	-0.9107	-0.6140	0.3726	-0.6993	0.2992	-0.3579	0.1955	-0.6212	0.0093	-0.2978	-0.0868	0.4377	0.6476	-0.4440	-0.3063	**1.6573**	0.0147	-0.0205	0.3587	-0.5722
Protein (%)	-0.0279	-0.4482	0.2266	0.5298	-0.4391	0.5171	0.4611	0.1191	-0.4638	0.1126	0.0940	1.4310	0.3967	-0.3762	-0.2319	-2.3640	-0.0253	**-2.8440**	-2.5094	1.0754	-0.1812
Wet gluten (%)	0.0826	0.1875	0.0966	-0.4256	0.4128	-0.5977	-0.3428	-0.1162	0.1172	-0.2331	-0.3325	-0.7277	0.0207	0.0735	0.5068	1.4566	-0.0209	1.4928	**1.6919**	-0.6415	-0.3996
Starch (%)	-0.1269	-0.2143	-0.0849	-0.1274	-0.7157	-0.2485	-0.0097	-0.0401	-0.3130	-0.1347	-0.0089	0.2255	0.2229	0.1553	0.1318	-0.3868	0.1892	-0.3305	-0.3314	**0.8741**	-0.1922
Moisture(%)	0.2267	0.7851	-0.1337	-0.2116	0.1898	-0.1803	0.1744	-0.1987	0.7303	0.2358	0.1194	-0.0299	-0.2605	0.2424	-0.1671	-0.0816	-0.5996	0.1107	-0.4101	-0.3819	**1.7365**
Yield plant-1 (g)	**0.0337**	**-0.0903**	**-0.0034**	**0.1733**	**-0.1689**	**-0.1007**	**0.1343**	**0.8420**	**-0.0762**	**-0.1529**	**0.5235**	**0.7758**	**-0.2145**	**-0.0514**	**-0.3112**	**-0.3807**	**0.0290**	**-0.2284**	**-0.2944**	**0.1912**	**-0.1240**

B Y P-^{1} (g) = Biological yield plant-^{1} (g) **CT** = Canopy temperature **RWC** = RWC of flag leaf

HI (%) = Harvest index (%) **CC** = Chlorophyll content **SDS value (mm)** = Sedimentation value (mm)

4.5 Multiple linear regression analysis

Multiple regression analysis has become one of the most widely used statistical tools for analyzing functional relationship among variable, which expressed in the form of equation connecting the dependent variable and one or more independent variable.

The contribution of various yield components towards yield was obtained by squared value of multiple correlation coefficients. The multiple regression equation taking various independent variables ranged from 72.27 to 98.20. The best character combination involving fourteen traits *viz*., number of effective tillers plant^{-1} (X5), number of grains ear^{-1} (X9), number of grains plant^{-1} (X10), ear weight (g) (X12), peduncle length (cm) (X13), number of leaves plant^{-1} (X14), 1000 grain weight (g) (X15), biological yield plant^{-1} (X16), harvest index (X18), chlorophyll content (X20), canopy temperature (X21), sedimentation value (X22), and protein % (X24). Since this combination accounted for 98.20 percentage of total variation.

A total fifteen equations taking various traits together were constructed. Other combinations of eleven traits, which were next to best combinations was traits *viz*., days to maturity (X2), number of effective tillers plant^{-1} (X5), number of grains ear^{-1} (X9), number of grains plant^{-1} (X10), ear weight (g) (X12), peduncle length (cm) (X13), number of leaves plant^{-1} (X14), 1000 grain weight (g) (X15), biological yield plant^{-1} (X16), harvest index (X18), chlorophyll content (X20), sedimentation value (X22), and protein % (X24), followed by combination of thirteen traits days to maturity (X2), number of effective tillers plant^{-1} (X5), number of grains ear^{-1} (X9), number of grains plant^{-1} (X10), ear weight (g) (X12), peduncle length (cm) (X13), number of leaves plant^{-1} (X14), 1000 grain weight (g) (X15), biological yield plant^{-1} (X16), harvest index (X18), chlorophyll content (X20), canopy temperature (X21), sedimentation value (X22), and protein % (X24).

Substantial contribution of 97.61% and 87.44% towards grain yield plant^{-1} was observed when the combinations of eleven and thirteen traits, respectively were taken. The multiple regression equation taking all the

major yield components together accounted for 72.59% of variability towards grain yield plant^{-1}.

Table 4.5: Multiple regression equations, multiple correlation coefficients and relative contribution of important traits to express variation in grain yield plant^{-1}

S. No.	Equations	R	Relative contribution to yield plant^{-1}	Trait combinations
1.	Y= -13.410 + 0.027 X2 + 0.088 X5 + 0.063 X9 + 0.014 X10-0.528 X12 + 0.058 X13 + 0.030 X14 + 0.060 X15 + 0.167 X16 + 0.089 X18 + 0.059 X21	0.988	97.61	11
2.	Y= -13.682 + 0.015 X2 + 0.089 X5 + 0.062 X9 + 0.015 X10 - 0.503 X12 + 0.061 X13 + 0.030 X14 + 0.058 X15 + 0.166 X16 + 0.088 X18 + 0.105 X21 -0.009 X22	0.872	76.03	12
3.	Y= -14.625 + 0.029 X2 + 0.090 X5 + 0.062 X9 + 0.014 X10 -0.536 X12 + 0.062 X9 + 0.026 X14 + 0.058 X15 + 0.169 X18 + 0.089 X18 + 0.092 X21 - 0.029 X22 + 0.156 X24	0.935	87.44	13
4.	Y= - 16.648 + 0.031 X5 + 0.061 X9 + 0.014 X10 - 0.567 X12 + 0.063 X13 + 0.023 X14 + 0.058 X15+ 0.167 X16 + 0.091 X18+ 0.028 X20+ 0.115 X21- 0.035 X22 + 0.0190 X24	0.991	98.20	14
5.	Y= - 20.49 + 0.030 X2 + 0.097 X5 + 0.059 X9 + 0.014 X10 - 0.523 X12 + 0.057 X13 + 0.021 X14 + 0.055 X15 + 0.017 X16+ 0.091 X18 + 0.026 X20 + 0.115 X21- 0.034 X22 + 0.202 X24 + 0.055 X26	0.872	76.03	15
6.	Y= 20.777 + 0.026 X2 + 0.103 X5 + 0.056 X9 + 0.014 X10 + 0.076 X11 -0.521 X12 + 0.60 X13 + 0.023 X14 + 0.053 X15 + 0.169 X16 + 0.091 X18 + 0.027 X20 + 0.115 X21 -0.033 X22 +0.199 X23 + 0.063 X26	0.874	76.38	16
7.	Y= - 18.866 - 0.031 X1 + 0.032 X2 + 0.104 X5 + 0.055 X9 + 0.014 X10 + 0.093 X11 - 0.569 X12 + 0.060 X13 + 0.022 X14 + 0.053 X15 + 0.170 X16 + 0.092 X18 + 0.025 X20 + 0.104 X21 - 0.033 X22 + 0.186 X24 +0.061 X26	0.871	75.86	17
8.	Y= - 18.715 - 0.029 X21 + 0.033 X2 + 0.101 X4 - 0.029 X5 + 0.056 X9 + 0.014 X10 + 0.092 X11 - 0.566 X12 + 0.060 X13 + 0.021 X14 + 0.054 X15 + 0.170 X16 + 0.092 X18 + 0.025 X20 + 0.104 X21 - 0.032 X22 + 0.191 X24 + 0.059 X26	0.871	75.86	18
9.	Y= - 19.553 - 0.029 X1 + 0.033 X2 + 0.007 X3 + 0.101 X5 - 0.030 X7 + 0.054 X9 + 0.014 X10 + 0.097 X11 - 0.591 X12 + 0.058 X13 + 0.021 X14 + 0.054 X15 + 0.171 X16 + 0.025 X19 + 0.111 X20 -0.034 X22 + 0.202 X24 + 0.059 X26	0.874	76.38	19
10.	Y= - 19.390 - 0.030 X1 + 0.034 X2 + 0.008 X3 + 0.103 X4 - 0.033 X5 + 0.053 X9 + 0.014 X10 + 0.096 X11 - 0.576 X12 + 0.051 X13 + 0.022 X14 + 0.053 X15 + 0.171 X16 + 0.093 X18 + 0.025 X20 + 0.110 X21 - 0.038 X22 + 0.132 X24 + 0.036 X25 + 0.057 X26	0.871	75.86	20

S. No.	Equations	R	Relative contribution to yield per plant	Trait combinations
11.	Y= - 18.062 - 0.031 X1 + 0.034 X2 + 0.007 X3 + 0.102 X5 - 0.034 X7 + 0.053 + X9 + 0.014 X10 + 0.090 X11 - 0.552 X12 + 0.058 X13 + 0.023 X14 + 0.053 X15 + 0.171 X16 + 0.093 X18 + 0.026 X20 + 0.106 X21 - 0.038 X22 - 0.038 X22 - 0.0161 X23 + 0.133 X24 + 0.035 X25 + 0.057 X26	0.864	74.64	21
12.	Y= - 18.232 - 0.031 X1 + 0.034 X2 + 0.007 X3 + 0.028 X4 + 0.093 X5 - 0.034 X7 + 0.053 X9 + 0.014 X10 + 0.091 X11 - 0.566 X12 + 0.058 X13 + 0.021 X14 + 0.053 X15 + 0.171 X16 + 0.093 X18 + 0.026 X20 + 0.026 X20 + 0.109 X21 - 0.038 X22 - 0.017 X23 + 0.13 X24 + 0.033 X25 + 0.059 X26	0.864	74.64	22
13.	Y= -18.209-0.030 X1 + 0.034 X2 + 0.006 X3 + 0.032 X4 + 0.113 X5 - 0.033 X7 -0.028 X8 + 0.053 X9 + 0.014 X10 + 0.092 X11 - 0.567 X12 + 0.059 X13 + 0.021 X14 + 0.053 X15 + 0.171 X16 + 0.093 X18 + 0.026 X20 + 0.109 X21 - 0.038 X22 - 0.017 X23 + 0.130 X24 + 0.035 X25 + 0.060 X26	0.862	74.31	23
14.	Y= -18.44 - 0.030 X1 + 0.033 X2 + 0.006 X3 + 0.032 X4 + 0.113 X5 - 0.033 X7 - 0.027 X8 + 0.053 X9 + 0.014 X10 + 0.092 X11 - 0.570 X12 + 0.058 X13 + 0.021 X14 + 0.053 X15 + 0.171 X16 + 0.093 X18 + 0.005 X19 + 0.0271 X20 + 0.109 X21 - 0.038 X22 - 0.019 X23 + 0.138 X24 + 0.033 X25 + 0.059 X26	0.856	72.27	24
15.	Y= -18.69 -0.030 X1+0.033 X2+ 0.006 X3+ 0.030 X4+ 0.114 X5- 0.033 X7-0.027X8+ 0.052 X9+ 0.014 X10+0.092 X11- 0.579 X12+ 0.058 X13+ 0.021 X14+ 0.053 X15+ 0.171X16+ 0.092 X18+0.005X19+0.027X20+ 0.110X21- 0.039X22 0.019X23+0.130X24+0.036X25+0.060X26+0.038X27	0.852	72.59	25

4.6. Stability analysis:

The stability analysis was carried out for the traits under study as per Eberthart and Russell Model (1966). The analysis of variance for stability analysis for quantitative, physiological and qualitative traits has been presented in table (4.6. (a) & 4.6 (b)).

All genotypes were evaluated for the two experimental years under six different environments. The wheat genotypes were planted under three environmental conditions timely sown, late sown, very late sown in the first and second experimental years. The differences among the environment were highly significant among all the traits. The genotype x environment interaction

Table 4.6.(a): Stability anova table for quantitative, qualitative and physiological traits

Source	DF	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant-1	No. of effective tillers plant-1	No. of ineffective-tillers per plant	No. of spikelets ear-1	No. of ears plant-1	No. of grains ear-1	No. of grains plant-1	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)
Rep within Env.	12.00	6.99	3.62	9.03	2.78***	1.43	4.04***	2.81*	2.82***	5.45	7.88	1.12	0.23***	5.36*
Varieties	29.00	19.69***	41.55***	97.96***	3.07***	0.99	2.41***	5.48***	1.50*	119.15***	15618.61***	4.35***	0.47***	22.64***
Env.+ (Var.* Env.)	150.00	20.63***	137.84***	86.25***	3.75***	1.42**	2.93***	1.96*	1.66***	68.49***	5565.88***	1.80***	0.50***	9.52***
Environments	5.00	449.77***	3835.00***	1942.35***	89.10***	17.72***	55.28***	11.79***	21.24***	1602.39***	59242.44***	26.06***	12.51***	190.38***
Var.* Env.	145.00	5.83	10.35	22.25	0.80***	0.85	1.13*	1.62	0.99	15.60***	3714.96***	0.96	0.08	3.28
Environments (Lin.)	1.00	2248.83***	19175.01***	9711.74***	445.48***	88.59***	276.38***	58.97***	106.19***	8011.95***	296212.19***	130.30***	62.55***	951.89***
Var.*Env.(Lin.)	29.00	9.68**	17.12**	21.69	2.43***	0.63	2.41***	2.39*	1.13	51.49***	9842.57***	1.67**	0.14**	5.96***
Pooled Deviation	120.00	4.70***	8.37***	21.64***	0.38	0.88***	0.78	1.38***	0.92***	6.40***	2110.29***	0.76***	0.06***	2.53***
Pooled Error	348.00	0.62	0.45	1.48	0.65	0.39	0.71	0.77	0.42	0.87	1.16	0.23	0.02	0.65
Total	179.00	20.47	122.24	88.15	3.64	1.35	2.85	2.53	1.64	76.70	7194.53	2.21	0.49	11.64

Table 4.6. (b): Stability table for quantitative, physiological and quality traits

Source	DF	No. of leaves plant^{-1}	1000 grain weight (g)	Biological yield plant-1 (g)	Yield plant-1 (g)	Harvest index (%)	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sds value (mm)	Hectoliter weight (g / liter)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)
Rep within Env.	12.00	10.86	3.39	4.47	4.29***	56.32	2.75***	11.31***	1.70***	7.06	9.77**	0.12	0.23	2.53	0.51***
Varieties	29.00	47.89***	66.29***	33.89*	20.36***	116.44***	176.83***	36.70***	0.72**	76.78***	15.74***	1.96***	20.65***	3.31**	0.18***
Env.+ (Var.* Env.)	150.00	65.71***	35.08***	109.24***	10.43***	102.91***	5.85**	39.19***	17.35***	115.75***	11.27***	3.50***	27.57***	4.07***	0.19***
Environments	5.00	1249.85***	771.11***	2552.66***	254.56***	1599.11***	169.13***	752.90***	507.97***	2996.78***	211.02***	91.90***	708.66***	74.18***	3.58***
Var.* Env.	145.00	24.87***	9.70**	24.98	2.01***	51.31	0.22***	14.58***	0.43***	16.40*	4.38	0.46**	4.08*	1.65	0.07
Environments (Lin.)	1.00	6249.24***	3855.57***	12763.28***	1272.78***	7995.57***	845.63***	3764.51***	2539.85***	14983.90***	1055.10***	459.48***	3543.30***	370.91***	17.91***
Var.*Env.(Lin.)	29.00	71.16***	22.39***	41.68**	6.05***	46.49	0.83***	68.03***	0.74**	33.57***	6.94**	1.09***	8.50***	1.64	0.09
Pooled Deviation	120.00	12.86***	6.31***	20.12***	0.96***	50.77***	0.06	1.18	0.34	11.70***	3.61***	0.29***	2.87***	1.60***	0.06
Pooled Error	348.00	0.64	0.75	0.84	0.56	9.24	0.51	1.14	0.27	0.36	1.28	0.03	0.04	0.29	0.06
Total	179.00	62.82	40.13	97.03	12.04	105.10	33.55	38.79	14.65	109.43	11.99	3.25	26.45	3.95	0.19

showed significant differences for most of the traits except days to 50% flowering, days to maturity, plant height, number of effective tillers plant^{-1}, number of spikelets ear^{-1}, number of ear plant^{-1}, ear head length, ear weight, peduncle length, biological yield plant^{-1}, harvest index, canopy temperature, hectoliter weight, starch and moisture (%).The variation due to environment (linear) was found significant for all the traits. However, pooled deviation was found to be significant for all traits except number of tillers plant^{-1}, number of ineffective tillers plant^{-1} , relative water content of flag leaf, chlorophyll content, canopy temperature and moisture (%).

Days to 50% flowering:-

The genotypes JW-3269, JW-3336, MP-3349/WH-1092 and 31ESWYT-125 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed the above average stability of these genotypes. Whereas, the GW 366, LOK-1, JW-3211, HI-1544, HD-2864, HD-2932, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-6, MP-3372/NIAW-1395 and 31ESWYT-121 showed regression coefficient above unity and also with very low mean value over the environment indicating below average stability of these genotypes. However, the genotypes MP-3368/MP-4669, MP-3360/RAJ-4213, 401-136/JW-17-1 and 31ESWYT-118 reported regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. The genotypes 31ESWYT-107 and 31ESWYT-120 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for environmental changes in the expression of this trait. (Fig:-4.1(A))

Days to maturity:-

The genotypes MP-3349/MP-3222, PBW-343/CDWR-9563-6, 31ESWYT-120 and 31ESWYT-125 had regression coefficient lesser than unity coupled with mean value less than grand mean revealed above average stability of these genotype. Whereas, the genotypes JW-3269, GW-366, LOK-

1, HD-2864, HD-2932, MP-3342/PBW-343/K-9924, MP3349/WH-1092, MP-3368/MP-4669, PBW-343/CDWR-9563-1, MP-3372/NIAW-1395 and 31ESWYT-107 had regression coefficient above unity with low mean value over the environment, indicating below average stability of these genotypes. MP-3360/RAJ-4213, 31ESWYT-118 and 31ESWYT-127 had regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. JW-3336 and 31ESWYT-123 were found to be stable genotypes with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.1(B))

Plant height

The genotypes JW-3336, HD-2864, HD-2932, MP-3349/MP-3222, MP-3360/RAJ-4213, 31ESWYT-110 and 31ESWYT-1072 had regression coefficient lesser than unity coupled with mean value lesser to grand mean, revealed above average stability of these genotype. 31ESWYT-123, HI-1544, JW-3211 and GW-366 were the genotypes had regression coefficient above unity with low mean value over the environment, indicating below average stability of these genotypes. The genotypes namely JW-3269, LOK-1, MP-3342/PBW-343/K-9924, MP-3349/WH-1092, MP-332/NTAW-13, 31ESWYT-107, 31ESWYT-118, 31ESWYT-120, 31ESWYT-121, 31ESWYT-125, 31ESWYT-126 and 31ESWYT-1070 were observed to be had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. Genotype PBW-343/CDWR-9563-1 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum indicating less susceptibility of these genotypes for changed environmental condition in expression of this traits . (Fig:-4.1 (C))

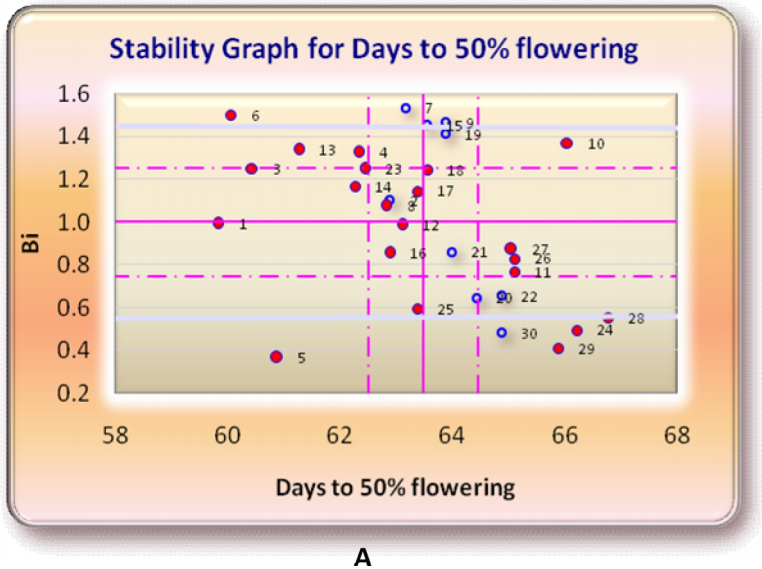
Number of tiller plant^{-1}:-

The genotypes HD-2864, 401-136/JW-17-1, PBW-343/CDWR-9563-6, 31ESWYT-121, 31ESWYT-125 and 31ESWYT-1071 had regression

coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. MP-3349/MP3222, PBW-343/CDWR-9563-6, 31ESWYT-123 and 31ESWYT-126 were the genotypes showed regression coefficient above unity with low mean value over the environment indicating below average stability these genotypes. The genotypes namely, GW 366, LOK-1, JW-3211, HI-1544, HD-2864, PBW-343/CDWR-9563-1, MP-3359/WH-1092, MP-3360/RAJ-4213, 31ESWYT-118, 31ESWYT-127 and 31ESWYT-1072 reported regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. Genotypes MP-3324/MP-3092/MP-322 and 31ESWYT-107 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for change in environmental conditions in the expression of this character. (Fig:-4.1 (D)).

Table 4.6.1: Stability parameters for various traits

	Days to 50 % flowering			Days to maturity			Plant height			Number of effective tillers plant^{-1}		
Variety	**Mean**	**βi**	**S²Di**	**Mean**	**βi**	**S²Di**	**Mean**	**βi**	**S²Di**	**Mean**	**βi**	**S²Di**
JW-3269	59.833	0.991	1.353*	111.200	1.060	3.977***	94.189	1.294	72.813***	8.256	0.727	-0.410
GW-366	62.889	1.102	0.683	108.800	1.022	2.853***	89.600	1.083	72.999***	7.828	1.527*	-0.361
LOK-1	60.444	1.249	1.356*	109.300	1.145	14.467***	94.394	1.064	15.588***	7.817	1.374	0.256
JW-3211	62.333	1.326	23.241***	113.000	0.847	5.121***	88.717	1.248	32.849***	8.244	1.221	-0.556
JW-3336	60.889	0.366	9.304***	112.200	0.877	1.051*	79.772	0.385*	11.555***	8.406	0.595	0.424
HD-2864	60.056	1.499	6.819***	110.200	1.113	15.233***	88.561	0.944	7.968***	6.628	0.209	0.616
HD-2932	63.167	1.534**	-0.316	110.300	1.064	7.688***	91.394	0.959	113.517***	8.289	1.325*	-0.575
HI-1544	62.833	1.075**	2.667**	109.900	0.972	12.799***	92.667	1.074	14.032***	8.467	1.259	-0.496
MP-3324/MP-3092/MP-322	63.889	1.466	-0.270	112.900	0.998	5.164***	98.772	1.237	9.338***	8.517	0.752*	-0.618
401-136/JW-17-1	66.056	1.371	1.378*	115.100	0.943	10.280***	99.839	1.061	9.483***	6.828	0.978	-0.647
PBW343/CDWR9563-1	65.111	0.768	3.090***	111.200	1.138	3.968***	94.967	0.473**	-0.543	7.850	1.228	-0.383
MP3349/MP-3222	63.111	0.985	2.416**	110.600	0.968	0.029	90.739	0.889*	-1.295	7.289	1.715*	-0.335
MP-3342/PBW-343/K-9924	61.278	1.337	9.872***	110.700	1.039	7.803***	99.794	1.168	23.057***	6.311	1.222*	-0.631
PBW-343/CDWR-9563-6	62.278	1.168	3.023**	109.300	0.936	7.167***	96.311	0.363	35.301***	7.111	0.208**	-0.457
MP-3368/MP-4669	63.556	1.453**	-0.322	110.900	1.011	5.751***	94.817	0.827	7.622***	7.633	1.316	-0.501
MP-3359/WH1092	62.889	0.855	3.050**	109.900	1.237	6.286***	96.933	1.174	6.588***	8.206	1.343*	-0.624
MP-3372/NIAW-1395	63.389	1.145	3.799***	109.400	1.168	5.631***	96.344	1.245	4.029*	8.467	0.725	-0.547
MP-3360/RAJ-4213	63.556	1.245	3.995***	112.100	1.278*	2.450***	93.700	0.875	16.908***	8.150	1.118	-0.317
31ESWYT-118	63.889	1.411	1.155	112.800	1.262	5.934***	97.000	1.149	0.075	8.422	1.298	0.152
31ESWYT-107	64.444	0.648*	0.111	111.800	1.080	5.216***	95.989	1.291	4.839**	8.100	0.888*	-0.696
31ESWYT-110	64.000	0.859	1.113	108.300	1.191	2.836***	92.728	0.931	14.741***	7.775	0.669*	-0.582
31ESWYT-120	64.889	0.656	0.687	110.600	0.963	15.873***	96.722	1.251	3.965*	8.072	0.348**	-0.620
31ESWYT-121	62.444	1.248	13.013***	115.900	0.892	7.449***	94.861	1.094	3.384*	7.633	0.926	-0.609
31ESWYT-123	66.222	0.496	6.766***	114.700	0.683**	2.043**	93.761	1.067	8.773***	5.739	1.019	-0.271
31ESWYT-125	63.389	0.597	3.802***	111.100	0.946	6.563***	94.528	1.065	9.099***	6.600	0.900	-0.450
31ESWYT-126	65.111	0.830	1.807*	112.100	0.977	30.018***	96.956	1.174	24.090***	7.708	1.015	-0.481
31ESWYT-127	65.056	0.873	3.746***	117.400	1.068	6.857***	94.161	0.968	0.195	7.947	1.474	0.131
31ESWYT-131	66.778	0.552	5.490***	120.300	0.763	11.203***	95.578	1.130	3.259	8.164	0.348**	-0.506
31ESWYT-132	65.889	0.411*	2.315**	112.300	0.746	17.627***	99.083	0.999	7.974	7.017	0.752	-0.293
31ESWYT-134	64.889	0.484	1.102	112.100	0.612*	5.337***	92.036	0.514	65.274	7.975	1.521	0.402
Population Mean	**63.485**			**111.9**			**94.164**			**7.715**		



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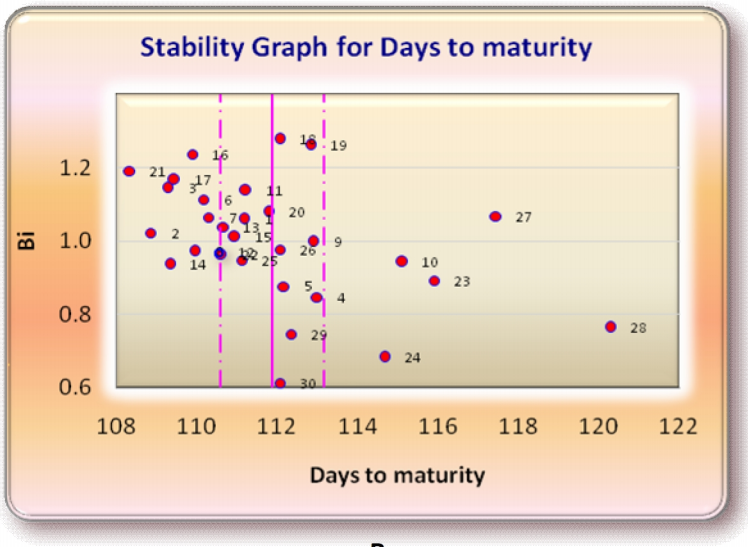

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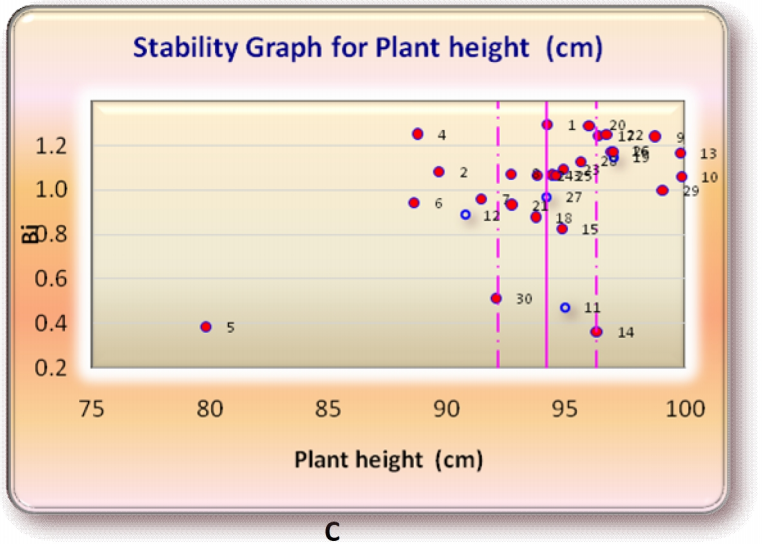

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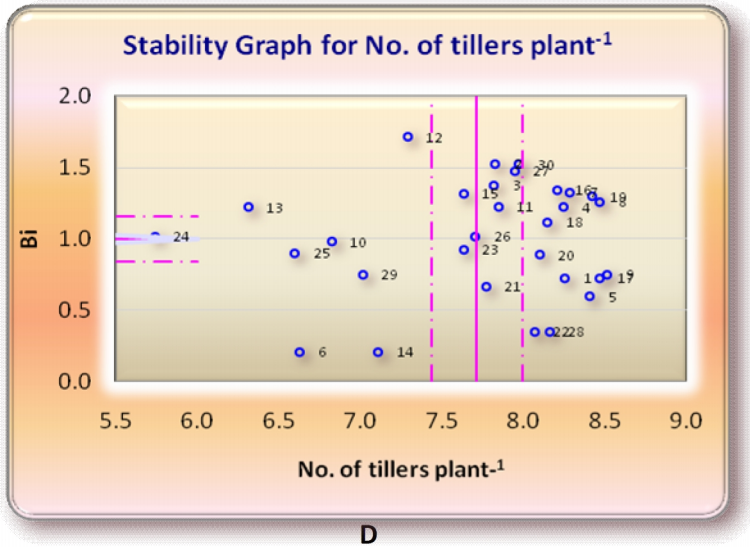


D

Fig. 4.1. Figure A, B, C, D showing stability graphs.

Number of effective tillers plant^{-1}

The genotypes HD-2864, HI-1544, MP-3324/MP-3092/MP-322, 401-136/JW-17-1, MP-3342/PBW-343/K-9924, 31ESWYT-110 and 31ESWYT-120 observed to be had regression coefficient less than unity coupled with mean value lesser to grand mean, revealed above average stability of these genotype. MP-3359/WH-1092, MP-3368/MP-4669, GW-366 and LOK-1 were the genotypes showed regression coefficient above unity with low mean value over the environment, indicating below average stability these genotypes. The genotypes namely, JW-3269, JW-3211, MP-3372/NIAW-1395, MP-3360/RAJ-4213 and 31ESWYT-1072 reported regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes 31ESWYT-125 and 31ESWYT-1071 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of these traits. (Fig:-4.2(A))

Number of ineffective tillers plant^{-1}

JW-3269, MP-3342/PBW-343/K-9924, HD-2864, 31ESWYT-123 31ESWYT-125 and 31ESWYT-1071 were the genotypes noticed to be had regression coefficient lesser than unity coupled with mean value lesser to grand mean, revealed above average stability of these genotype. Whereas, the genotypes JW-3211, 401-136/JW-17-1, MP-3349/MP-3222, 31ESWYT-121 and 31ESWYT-1072 reported regression coefficient above unity and low mean value over the environment, indicating below average stability these genotypes. The genotypes namely, GW-366, LOK-1, HD-2932, HI-1544, MP-3324/MP-3092/MP-322 MP-3368/MP-4669, MP-3359/WH-1092, MP-3360/RAJ-4213, 31ESWYT-118, 31ESWYT-126, 31ESWYT-127 and 31ESWYT-1070 had regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes PBW-343/CDWR-9563-6 and MP-3372/NIAW-1395 were found to be stable with mean value greater than grand

mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for change in environmental conditions in expression of this trait.(Fig:-4.2(B).

Number of spikelets per spike:-

The genotypes GW-366, MP-3342/PBW-343/K-9924 and 31ESWYT-107 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. HD-2864, HI-1544, PBW-343/CDWR-9563-1, JW-3269, JW-3336, LOK-1, MP-3349/MP-3222, 31ESWYT-118, 31ESWYT-125, 31ESWYT-123, and 31ESWYT-127 were the genotypes noticed to be had regression coefficient above unity and low mean value over the environment indicating below average stability of these genotypes. MP-3368/MP-4669, JW-3211, 31ESWYT-110, 31ESWYT-120 and 31ESWYT-126 were the genotypes showed regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this trait. Genotypes MP-3368/MP-4669, 31ESWYT-1071 and 31ESWYT-121 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait.(Fig:-4.2 (C))

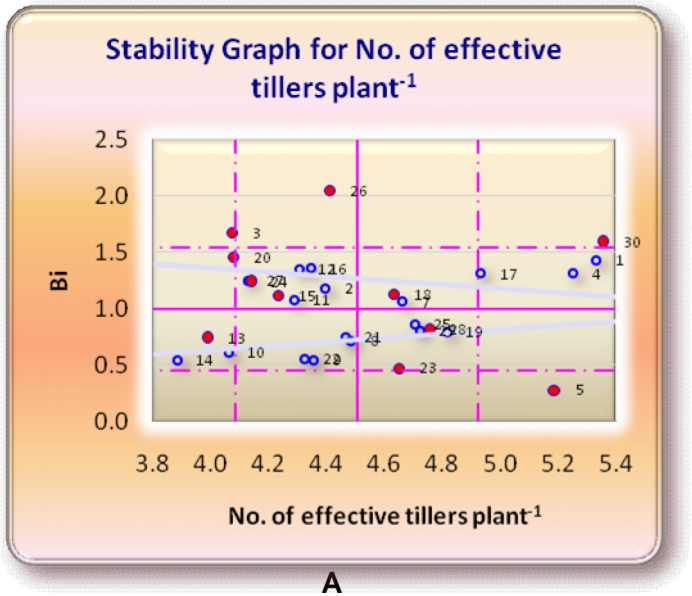
Number of ears plant^{-1}

The genotypes HD-2864, 401-136/JW-17-1, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-6, 31ESWYT-120 and 31ESWYT-123 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. Genotypes GW 366, LOK-1, MP-3349/MP3222, MP-3368/MP-4669, MP-3359/WH-1092, 31ESWYT-107, 31ESWYT-126 and 31ESWYT-127 were observed to be had regression coefficient above unity and low mean value over the environment, indicating below average stability of these genotypes. The genotypes namely JW-3269, JW-3211, HD-2932, PBW-343/CDWR-9563-1, MP-3372/NIAW-1395 and MP-3360/RAJ-4213 had regression coefficient greater than unity

coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes JW-3336, HI-1544, 31ESWYT-110 and 31ESWYT-121 were reported to be stable with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of these traits.(Fig:-4.2(D).

Table 4.6.2: Stability table for various traits

Variety	Number of effective tillers plant^{-1}			Number of ineffective tillers plant^{-1}			Number of spikelets ear^{-1}			Number of ears plant^{-1}		
	Mean	βi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di
JW-3269	5.333	1.432	0.517	2.922	0.358	0.064	16.028	1.695	-0.445	6.117	1.509	0.286
GW-366	4.394	1.182	0.097	3.433	1.228	-0.357	15.450	-0.303*	-0.563	5.133	1.769**	-0.463
LOK-1	4.072	1.678	0.978*	3.744	1.707**	-0.762	15.828	2.244	0.965	4.867	1.953	0.851*
JW-3211	5.250	1.316	-0.188	2.994	1.161	-0.649	19.139	1.030	-0.731	6.072	1.525	-0.039
JW-3336	5.189	0.283	1.248**	3.217	0.681	2.266**	14.978	1.610	-0.322	6.250	-0.511	0.901*
HD-2864	4.194	-0.144	0.520	2.433	0.113	0.241	16.644	3.054	0.642	4.756	-0.063	1.327**
HD-2932	4.661	1.065	0.577	3.628	1.680	-0.267	17.150	0.211	-0.094	5.694	1.151	0.067
HI-1544	4.484	0.714	0.175	3.983	1.554	0.357	16.172	2.306*	-0.409	5.461	0.939	-0.294
MP-3324/MP-3092/MP-322	4.356	0.544	0.515	4.161	1.356	-0.325	18.483	1.233	0.287	5.606	1.049	-0.163
401-136/JW-17-1	4.061	0.612	0.185	2.767	1.062	0.129	17.644	0.216	0.714	5.000	0.324	-0.254
PBW343/CDWR9563-1	4.289	1.081	0.318	3.561	0.777	0.076	16.344	2.629	2.933**	5.550	1.552	-0.001
MP3349/MP-3222	4.306	1.354	0.308	2.983	1.295	-0.162	16.611	1.480	-0.720	5.072	1.241	0.997*
MP-3342/PBW-343/K-9924	3.989	0.741	0.591*	2.322	0.654	-0.298	15.956	0.108	3.025**	4.489	0.879	0.418
PBW-343/CDWR-9563-6	3.883	0.547*	-0.350*	3.228	0.093**	-0.587	17.433	-0.898	8.318***	4.661	0.361	0.010
MP-3368/MP-4669	4.233	1.120	0.629	3.400	1.031	-0.361	17.789	0.297*	-0.718	5.011	1.417	0.350
MP-3359/WH1092	4.344	1.358	0.250	3.861	1.483	-0.242	17.700	0.642	0.101	5.028	1.250	0.511
MP-3372/NIAW-1395	4.933	1.313	-0.281	3.533	0.677	-0.288	16.939	1.083	-0.715	5.489	1.325	-0.341
MP-3360/RAJ-4213	4.633	1.130	0.958*	3.517	1.732**	-0.699	17.294	0.046	-0.447	5.611	1.232	0.368
31ESWYT-118	4.817	0.798	0.511	3.606	1.096	0.663	16.150	2.676	0.820	6.091	0.742	0.172
31ESWYT-107	4.078	1.459	0.977*	4.022	0.708	0.683	16.433	-0.691	0.447	5.017	1.444	1.552**
31ESWYT-110	4.467	0.755	-0.178	3.308	0.538	-0.420	17.383	2.072	0.027	5.450	0.765	-0.159
31ESWYT-120	4.322	0.557	-0.251	3.750	0.580	-0.511	17.911	1.305	-0.542	5.239	0.407	0.786*
31ESWYT-121	4.650	0.476	0.777*	2.983	1.415	-0.181	17.422	0.615	-0.649	5.472	0.593*	-0.453
31ESWYT-123	4.139	1.238	0.660	1.600	0.376*	-0.381	16.706	1.208	-0.097	4.656	0.962	1.175*
31ESWYT-125	4.706	0.864	-0.104	1.894	0.589	-0.483	16.678	1.189	-0.711	5.389	0.765	0.102
31ESWYT-126	4.411	2.050	1.146**	3.297	1.279	0.897	17.222	1.842	0.555	4.906	1.937	0.830*
31ESWYT-127	4.128	1.253	0.455	3.819	2.117	0.698	16.756	1.676	0.025	4.994	1.272	-0.196
31ESWYT-131	4.756	0.827	1.227**	3.408	1.013	0.482	18.356	-1.363	4.820	5.678	0.769	1.074*
31ESWYT-132	4.722	0.807	0.111	2.294	0.468	-0.238	18.333	0.900	-0.570	5.700	0.561	0.373
31ESWYT-134	5.356	1.593	1.372**	2.619	1.179	-0.477	17.694	-0.114	0.240	6.344	0.881	2.840***
Population Mean	**4.505**			**3.201**			**17.02**			**5.360**		



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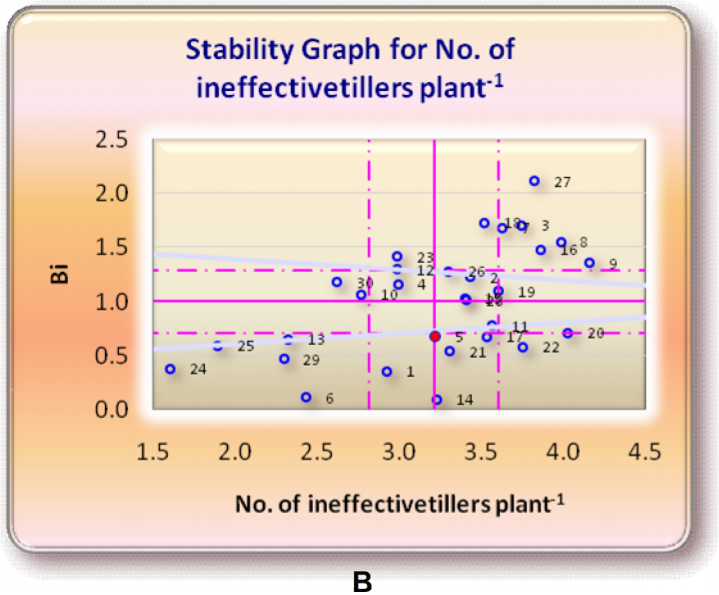

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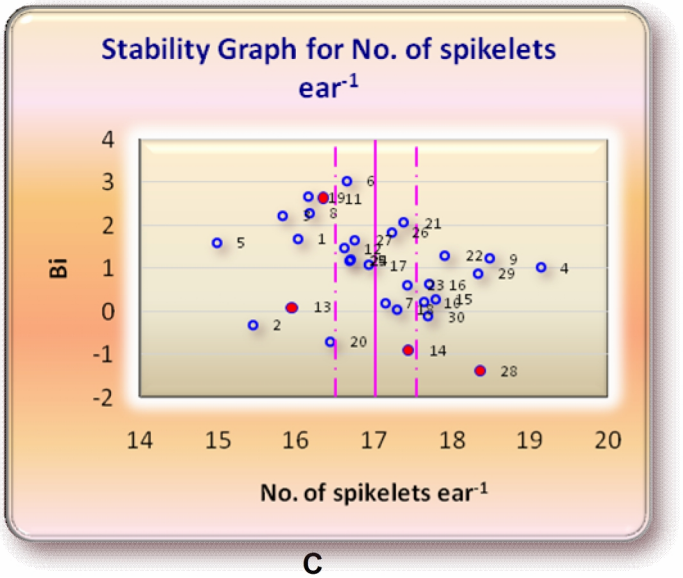

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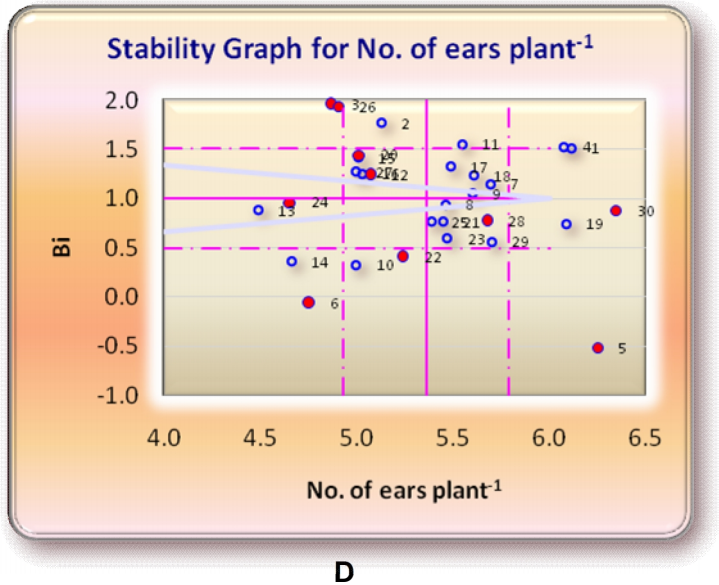


D

Fig. 4.2. Figure A, B, C, D showing stability graphs.

Number of grains ear^{-1}

The genotypes HD-2864, MP-3368/MP-4669, MP-3360/RAJ-4213, 31ESWYT-107, 31ESWYT-110, 31ESWYT-121, 31ESWYT-123, and 31ESWYT-125 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. PBW-343/CDWR-9563-6, HI-1544, LOK-1, GW-366 and 31ESWYT-121 were the genotypes noticed to be had regression coefficient above unity and also with low mean value over the environment, indicating below average stability of these genotypes. The genotypes namely MP-3324/MP-3092/MP-322, MP-3359/WH-1092, PBW-343/CDWR-9563-6, 31ESWYT-118, 31ESWYT-127 and 31ESWYT-1071 were obtained to be had regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes MP-3349/MP3222, MP-3372/NIAW-1395 401-136/JW-17-1, HD-2932, JW-3211 and 31ESWYT-120 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for change of environment condition in expression of this trait (Fig:-4.3 (A).

Number of grains plant^{-1}

The genotypes HD-2864, HD-2932, MP-3324/MP-3092/MP-322 and 31ESWYT-1071 had regression coefficient lesser than unity coupled with mean value less than grand mean revealed above average stability of these genotype. Genotypes LOK-1, MP-3360/RAJ-4213, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-6, 31ESWYT-121, 31ESWYT-118, 31ESWYT-125, 31ESWYT-127 and 31ESWYT-1070 reported regression coefficient above unity with low mean value over the environment, indicating below average stability of these genotypes. Whereas, the genotypes JW-3269, JW-3211, PBW-343/CDWR-9563-1, MP-3349/MP3222, MP-3372/NIAW-1395, 31ESWYT-107 and 31ESWYT-120 reported regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes HI-1544 and 31ESWYT-126 was obtained to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from minimum regression, indicating less susceptibility of these genotypes for change of environment condition in expression of this trait.(Fig:-4.3(B).

Ear length:-

The genotypes HI-1544, HD-2864, LOK-1, JW-3336, PBW-343/CDWR-9563-1, PBW-343/CDWR-9563-6, MP-3368/MP-4669, MP-3372/NIAW-1395, MP-3360/RAJ-4213 and 31ESWYT-1072 exhibited regression coefficient lesser than unity coupled with mean value less than grand mean revealed above average stability of these genotype. HD-2932, JW-3211, GW-366, 31ESWYT-107, 31ESWYT-110, 31ESWYT-120, 31ESWYT-121 and 31ESWYT-125 were the genotypes noticed to be had regression coefficient above unity and low mean value over the environment, indicating below average stability these genotypes. However, the genotypes MP-3324/MP-3092/MP-322, 401-136/JW-17-1, 31ESWYT-118, and 31ESWYT-1070 observed to be had regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes JW-3269 and 31ESWYT-126 were reported to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from minimum regression, indicating less susceptibility of these genotypes for change of environment condition in expression of this trait. (Fig:-4.3 (C))

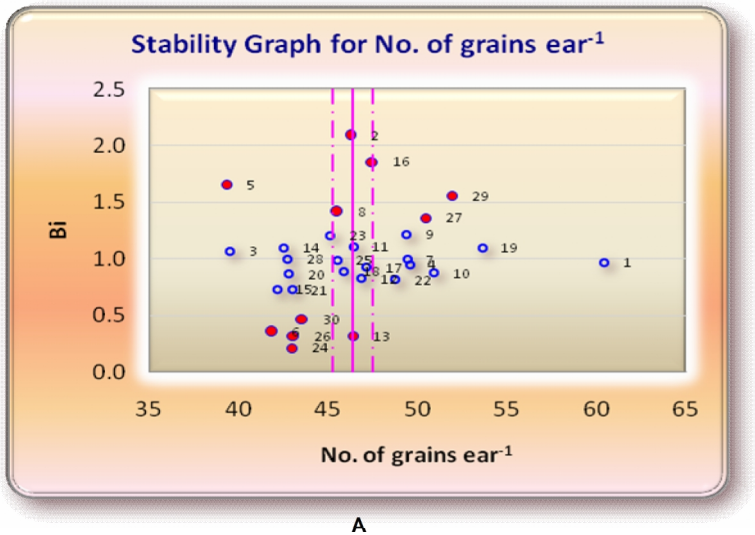
Ear weight:-

LOK-1, JW-3336, HD-2864, PBW-343/CDWR-9563-6, MP-3368/MP-4669, MP-3372/NIAW-1395, MP-3360/RAJ-4213, 31ESWYT-107, 31ESWYT-110, 31ESWYT-123 and 31ESWYT-1072 were the genotypes noticed to be had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotypes. The genotypes PBW-343/CDWR-9563-6, 401-136/JW-17-1, HI-1544 and JW-3336 reported regression coefficient above unity with low mean value over the environment, indicating below average stability of these genotypes. Whereas, the genotypes namely, JW-3269, GW-366, HD-2932, MP-3342/PBW-343/K-9924, 401-136/JW-17-1, MP-3359/WH-1092, 31ESWYT-118, 31ESWYT-120, 31ESWYT-121, 31ESWYT-126, 31ESWYT-1070 and 31ESWYT-1071 exhibited regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character. Genotypes 31ESWYT-125 and 31ESWYT-127 were observed to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less

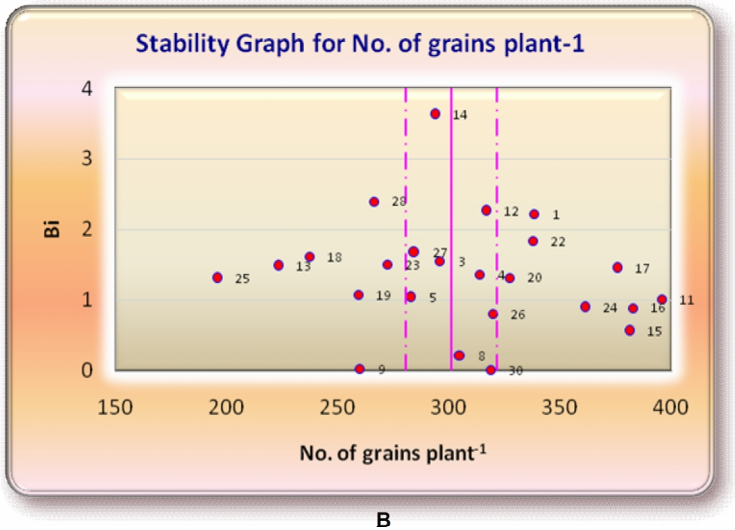
susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.3(D).

Table 4.6.3: Stability table for various traits

Variety	Number of grains ear^{-1}			Number of grains plant^{-1}			Ear length			Ear weight		
	Mean	Bi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di
JW-3269	60.457	0.972	-0.942	338.00	2.219**	655.85***	10.889	0.982	-0.213	2.828	1.015	-0.022
GW-366	46.230	2.089*	39.511***	334.20	-0.387	8467.41***	8.672	1.087	-0.128	2.496	1.602	0.259***
LOK-1	39.519	1.071	-0.776	295.60	1.552	1880.28***	9.473	0.803	0.672**	1.851	0.934	-0.024
JW-3211	49.570	0.949*	-0.962	313.50	1.364	6611.51***	9.356	1.204	0.156	2.278	1.100	0.006
JW-3336	39.331	1.656	13.930***	282.70	1.037	98.09***	8.910	0.911	1.937***	1.941	1.150	0.040
HD-2864	41.864	0.357*	12.863***	242.50	-0.269*	1375.34***	9.217	0.739	0.703**	2.066	0.927	-0.002
HD-2932	49.404	0.995	-1.020	238.10	-0.622**	67.87***	9.400	1.476	-0.121	2.571	1.180	0.032
HI-1544	45.508	1.415*	4.230***	304.90	0.217**	21.04***	9.489	0.266	0.135	2.056	1.203	0.042*
MP-3324/MP-3092/MP-322	49.398	1.219*	0.531	259.80	0.028	6999.58***	10.824	3.103*	0.940**	2.498	1.457*	0.025
401-136/JW-17-1	50.905	0.877*	-0.645	323.40	-0.061	7169.55***	10.722	1.325	-0.087	2.125	1.057	0.070**
PBW343/CDWR9563-1	46.400	1.109	-0.499	395.60	1.011	4901.7***	9.011	0.820	0.036	1.969	1.018	-0.016
MP3349/MP-3222	46.850	0.825*	-0.010	316.50	2.260**	186.45***	9.928	0.845	0.327	2.224	1.059	0.008
MP-3342/PBW-343/K-9924	46.396	0.321*	14.242***	223.10	1.484	443.50***	9.572	0.944	-0.216	2.388	0.666	0.148***
PBW-343/CDWR-9563-6	42.504	1.096	-0.668	293.10	3.629**	2632.25***	7.800	0.439	-0.058	1.889	0.648	0.050*
MP-3368/MP-4669	42.129	0.734*	1.009	381.10	0.563	723.51***	8.989	0.043*	0.015	1.494	0.538*	0.007
MP-3359/WH1092	47.459	1.859*	21.668***	382.40	0.890	6140.26***	9.546	0.742	3.830***	2.239	1.360	0.142***
MP-3372/NIAW-1395	47.120	0.926*	-0.885	375.60	1.451	930.79***	9.444	0.462	0.419*	1.962	0.847	-0.019
MP-3360/RAJ-4213	45.877	0.891*	-0.703	237.20	1.620*	283.58***	9.183	0.242*	-0.084	1.827	0.706	0.022
31ESWYT-118	53.618	1.098	-0.607	259.00	1.075	2756.19***	10.756	1.531	5.735***	2.538	1.176	0.007
31ESWYT-107	42.818	0.865*	-0.481	327.00	1.319**	32.533**	7.992	1.091	-0.105	1.959	0.972	-0.020
31ESWYT-110	42.974	0.729*	1.123	304.40	-0.548*	1550.34***	9.550	1.115	-0.079	2.011	0.736	0.015
31ESWYT-120	48.721	0.817*	-0.112	337.60	1.840**	115.99***	9.106	1.259	0.200	2.203	1.099	-0.010
31ESWYT-121	45.083	1.210*	0.386	272.10	1.506**	80.86***	8.400	1.724	0.045	2.187	1.232	0.080**
31ESWYT-123	42.969	0.214*	19.341***	361.20	0.893	2518.85***	10.170	0.355	0.083	1.698	0.433	0.085**
31ESWYT-125	45.489	0.991	-0.931	195.50	1.307	37.931**	9.300	1.166	0.793**	2.229	0.830	0.012
31ESWYT-126	43.050	0.322	21.793***	319.700	0.809	10.15***	10.307	0.793	-0.228	2.261	1.023	0.084**
31ESWYT-127	50.421	1.364	3.991***	284.40	1.671	883.10***	10.156	2.006*	0.077	2.302	0.891	0.063*
31ESWYT-131	42.702	1.002	-0.999	266.20	2.401	581.03***	11.306	1.649*	-0.051	2.336	1.052	-0.008
31ESWYT-132	51.895	1.558	8.806	242.80	-0.269	1373.58***	10.464	0.588	0.370*	2.274	1.239	-0.002
31ESWYT-134	43.547	0.471	8.034	318.60	0.011	3738.19***	9.094	0.289	-0.040	2.074	0.848	-0.021
Population Mean	**46.340**			**300.9**			**9.568**			**2.159**		



A



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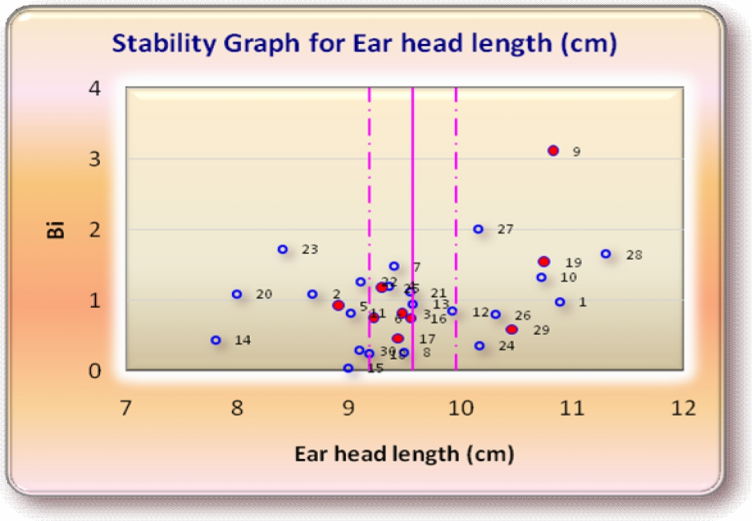

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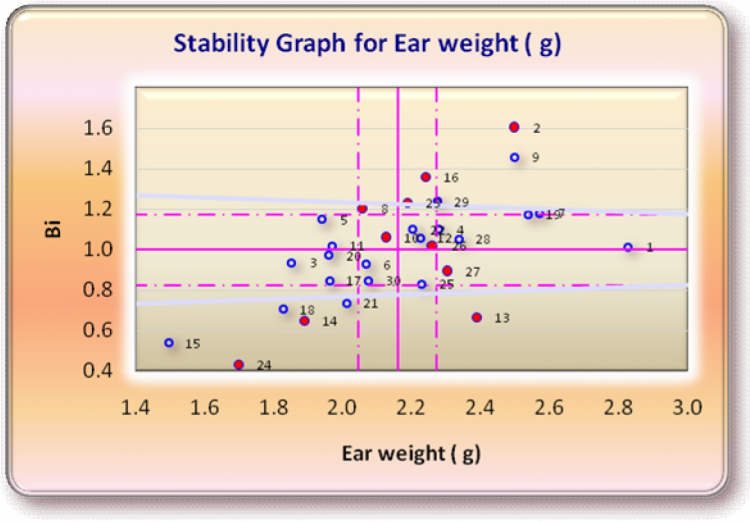


D

Fig. 4.3. Figure A, B, C, D showing stability graphs.

Peduncle length

The genotypes LOK-1, MP-3359/WH-1092, 31ESWYT-110, 31ESWYT-121, 31ESWYT-125, 31ESWYT-127, 31ESWYT-1071, 31ESWYT-123, and 31ESWYT-120 showed regression coefficient less than unity coupled with mean value less than grand mean, revealed above average stability of these genotypes. Whereas, the genotypes MP-3372/NIAW-1395, MP-3349/MP3222, MP-3324/MP-3092/MP-322, HD-2864 and 31ESWYT-1070 reported regression coefficient above unity and also low mean value over the environment indicating below average stability these genotypes. JW-3269, JW-3211, HD-2932, 401-136/JW-17-1, MP-3342/PBW-343/K-9924, MP-3360/RAJ-4213, 31ESWYT-107, 31ESWYT-118 31ESWYT-126 and 31ESWYT-1072 were the genotypes noticed to be had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. PBW-343/CDWR-9563-1, PBW-343/CDWR-9563-6 and GW-366 were the stable genotypes with mean value greater than grand mean and regression coefficient less than one with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of these traits.(Fig:-4.4 (A))

Number of leaves plant^{-1}

HD-2864, 401-136/JW-17-1, MP-3342/PBW-343/K-9924, 31ESWYT-110, 31ESWYT-118, 31ESWYT-120, and 31ESWYT-121 were the genotypes showed regression coefficient less than unity coupled with mean value less than grand mean revealed above average stability of these genotype. The genotypes GW-366, JW-3211, MP-3349/MP3222, MP-3368/MP-4669, 31ESWYT-123, 31ESWYT-125 and 31ESWYT-1072 had regression coefficient above unity with low mean value over the environment, indicating below average stability these genotypes. The genotypes namely, JW-3269, LOK-1, HD-2932, PBW-343/CDWR-9563-1, PBW-343/CDWR-9563-6, MP-3360/RAJ-4213, 31ESWYT-107 and 31ESWYT-1071 reported regression coefficient greater than unity coupled with high mean value

indicating specific adaptation of these genotypes for exploitation of this character. Genotypes, MP-3324/MP-3092/MP-322, JW-3336 and 31ESWYT-127 were reported to be stable with mean value greater than grand mean and regression coefficient less than one with deviation from regression minimum, indicating less susceptibility of these genotypes for change of environment condition in expression of these traits.(Fig:-4.4 (B))

1000 grain weight

The genotypes MP-3372/NIAW-1395, 31ESWYT-123, 31ESWYT-127 and 31ESWYT-1071 showed regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. The genotypes MP-3368/MP-4669, MP-3360/RAJ-4213, PBW-343/CDWR-9563-1, 401-136/JW-17-1, HI-1544 and JW-3211 exhibited regression coefficient above unity and also with low mean value over the environment, indicating below average stability these genotypes. The genotypes namely, LOK-1, HD-2932, HD-2864, MP-3324/MP-3092/MP-322, MP-3359/WH-1092, 31ESWYT-118, 31ESWYT-126, 31ESWYT-1070 and 31ESWYT-1072 were observed to be had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. Genotypes, JW-3269, MP-3342/PBW-343/K-9924 and JW-3336 showed stable performance with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait.(Fig:-4.4 (C))

Biological yield per plant:-

HI-1544, MP-3324/MP-3092/MP-322, 31ESWYT-110 and 31ESWYT-1071 were the genotypes noticed to be regression coefficient less than unity coupled with mean value less than grand mean revealed above average stability of these genotypes. Genotypes MP-3360/RAJ-4213, 401-136/JW-17-1, MP-3342/PBW-343/K-9924, HD-2932, JW-3336, HD-2864, 31ESWYT-120, 31ESWYT-121, 31ESWYT-118, and HI-1544 had regression coefficient

above unity and also with low mean value over the environment indicating below average stability these genotypes. The genotypes namely, JW-3269, MP-3368/MP-4669, MP-3359/WH-1092, MP-3372/NIAW-1395, 31ESWYT-123, 31ESWYT-127, 31ESWYT-1070 and 31ESWYT-1072 showed regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. Genotype MP-3349/MP3222 was found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of this genotype for changed environmental condition in expression of this trait.(Fig:-4.4 (D).

Table 4.6.4: Stability parameters for various traits

Variety	Peduncle length			Number of leaves plant^{-1}			1000 grain weight			Biological yield plant^{-1}		
	Mean	βi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di	Mean	βi	S²Di
JW-3269	20.294	1.356	0.307	26.152	1.419	17.814	42.064	0.759	0.572	38.304	1.043	17.029***
GW-366	18.100	0.260**	-0.314	22.107	1.322	36.805	41.127	0.620	11.613***	34.907	0.789	3.283**
LOK-1	14.967	0.803	-0.010	27.769	2.388**	4.946***	39.177	1.015	1.272*	39.019	0.163**	3.907***
JW-3211	18.844	1.660	8.006***	21.917	1.120	17.012***	37.445	1.436	6.312**	38.419	0.256*	11.442***
JW-3336	16.228	0.329	1.860*	25.846	0.430**	-0.740	40.862	0.711*	0.475	32.194	1.085	6.130***
HD-2864	17.233	1.162	19.569***	22.640	0.103	24.255***	41.277	1.696**	-0.676	32.329	1.072	49.388***
HD-2932	19.244	1.333	-0.061	30.728	1.457	30.750***	44.209	1.233*	-0.373	31.203	1.086	55.689***
HI-1544	15.367	1.265	0.651	23.935	0.666	48.031***	33.740	1.145	2.626**	32.900	0.590	37.855***
MP-3324/MP-3092/MP-322	17.267	1.137	0.407	24.006	0.629**	-0.572	41.421	1.812**	2.759**	33.181	0.918	18.884***
401-136/JW-17-1	19.261	2.080	9.101***	20.908	0.801	3.263**	34.473	1.231	6.434***	33.860	1.253	4.755***
PBW343/CDWR9563-1	17.961	0.702**	-0.708	27.159	2.134**	3.519**	35.257	1.031	0.569	36.410	0.850	4.058***
MP3349/MP-3222	14.900	1.244	1.803*	21.559	1.735*	8.777***	38.849	1.078	5.084***	34.392	0.934	-0.466
MP-3342/PBW-343/K-9924	23.000	1.478	5.277***	17.214	0.878	-0.106	40.955	0.211**	0.204	30.787	1.107	28.176***
PBW-343/CDWR-9563-6	19.833	0.757**	-0.754	24.966	1.135	14.327***	39.726	0.269	9.125***	34.957	0.959	19.330***
MP-3368/MP-4669	17.722	1.080	0.386	22.733	1.037	-0.639	34.897	1.353	43.097***	34.436	1.333	14.091***
MP-3359/WH1092	17.250	0.838	1.508*	26.178	0.625*	1.937***	40.052	1.219	0.850	34.871	1.101	7.333***
MP-3372/NIAW-1395	17.356	1.189	-0.521	24.332	0.418*	3.042**	35.525	0.848	2.723**	35.781	1.211	22.252***
MP-3360/RAJ-4213	18.306	1.512	0.400	26.860	1.556	8.954***	36.095	1.295*	-0.082	30.024	1.447**	2.958**
31ESWYT-118	18.267	1.058	0.668	22.396	0.157**	4.788***	41.498	1.177	2.793**	31.658	1.429**	2.642**
31ESWYT-107	19.789	1.054	0.572	24.001	1.339	48.114***	37.287	1.007	-0.767	35.723	0.645	15.783***
31ESWYT-110	16.056	0.290**	-0.690	18.823	0.215*	9.824***	40.199	0.514	16.243***	33.009	0.932	13.540***
31ESWYT-120	17.372	0.599	0.021	23.298	0.126*	15.590***	38.495	1.499**	0.454	33.524	1.036	4.870***
31ESWYT-121	14.439	0.625**	-0.559	23.446	0.898	5.447***	38.854	1.350	0.889	30.555	1.382*	5.208***
31ESWYT-123	17.461	0.848	0.892	20.276	1.372*	2.362**	34.639	0.828	21.333***	35.259	1.225	43.438***
31ESWYT-125	16.911	0.342**	0.114	22.524	1.044	-0.093	41.996	0.357*	2.240**	35.543	0.610	50.462***
31ESWYT-126	18.978	1.156	0.330	25.562	0.831	5.299***	41.556	1.056	1.973*	38.003	0.865	56.247***
31ESWYT-127	15.167	0.705	0.079	24.777	0.678**	-0.077	39.102	0.220**	1.435*	36.809	1.200	34.974***
31ESWYT-131	15.733	1.031	-0.060	26.281	0.432*	2.294*	47.953	1.282	7.364***	34.619	1.309	20.183***
31ESWYT-132	14.556	0.662	3.484***	26.988	1.675	22.394***	33.654	0.713**	-0.731	33.717	0.936	7.029***
31ESWYT-134	17.756	1.446**	-0.063	22.033	1.377	19.055***	40.896	1.035	18.087***	35.203	1.233	14.125***
Population Mean	**17.521**			**23.91**			**39.109**			**34.387**		

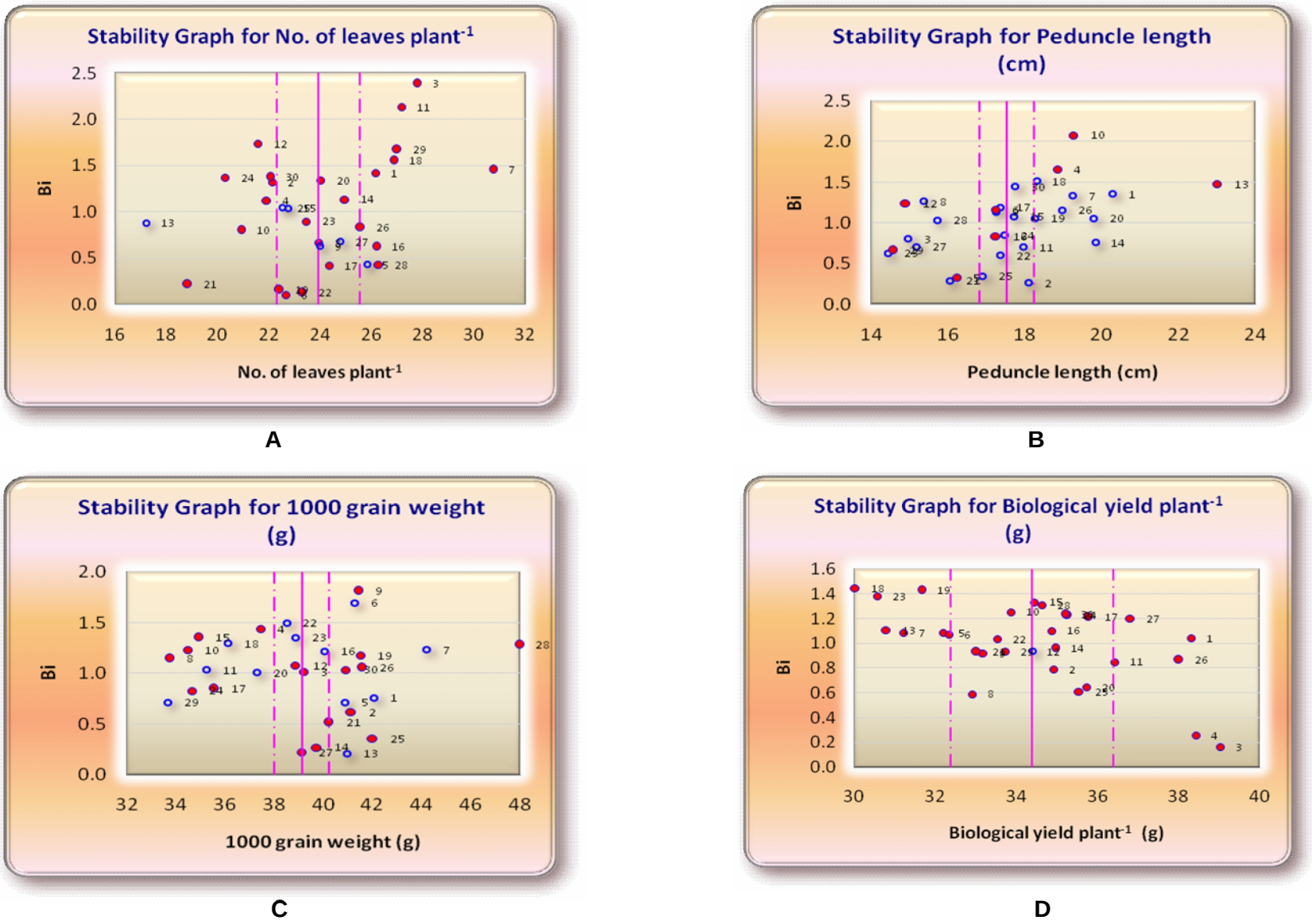


Fig. 4.4. Figure A, B, C, D showing stability graphs.

Grain yield plant^{-1}:-

The genotypes LOK-1, JW-3211, JW-3336, HI-1544, HD-2932, MP-3324/MP-3092/MP-322, 31ESWYT-110, 31ESWYT-125 and 31ESWYT-1071 reported regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. The genotypes PBW-343/CDWR-9563-6, MP-3360/RAJ-4213, 31ESWYT-118, 31ESWYT-121 and 31ESWYT-1070 exhibited regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes. The genotypes namely, JW-3269, GW-366, 401-136/JW-17-1, MP-3359/WH-1092, MP-3368/MP-4669, PBW-343/CDWR-9563-1, MP-3372/NIAW-1395, 31ESWYT-107, 31ESWYT-120 and 31ESWYT-127 reported regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character. Genotypes 31ESWYT-126 and 31ESWYT-123 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.5 (A).

Harvest index:-

The genotypes LOK-1, JW-3211, JW-3336, MP-3324/MP-3092/MP-322, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-1, and 31ESWYT-107 were observed to be had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype. Whereas, the genotypes HI-1544, MP-3360/RAJ-4213, 31ESWYT-110, 31ESWYT-125, 31ESWYT-126, 31ESWYT-127, 31ESWYT-1070 and 31ESWYT-1071 showed regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes. HD-2932, HD-2864, 31ESWYT-118, 31ESWYT-120 and 31ESWYT-1072 were the genotypes noticed to be had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these. MP-3359/WH-1092 and 401-136/JW-17-1 were the genotypes

showed stable performance with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.5 (B).

Relative water content of flag leaf

The genotypes JW-3269, MP-3349/MP3222, MP-3372/NIAW-1395, 31ESWYT-121, 31ESWYT-125, CIMMYT- 8 and 31ESWYT-1070 exhibited regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype.

The genotypes GW-366, LOK-1, JW-3211, PBW-343/CDWR-9563-6, 31ESWYT-123 and 31ESWYT-110 were observed to be had regression coefficient above unity and low mean value over the environment indicating below average stability these genotypes.

However, the genotypes JW-3336, HD-2932, 401-136/JW-17-1 and PBW-343/CDWR-9563-1 exhibited regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character.

Genotypes, HD-2864 and 31ESWYT-118 were found to be stable with mean value greater than grand mean and regression coefficient less than one, with minimum deviation from regression, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.5 (C))

Chlorophyll content

The genotypes HD-2864, HD-2932, MP-3324/MP-3092/MP-322, MP-3368/MP-4669,31ESWYT-118, 31ESWYT-123 and 31ESWYT-126 were observed to be regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype.

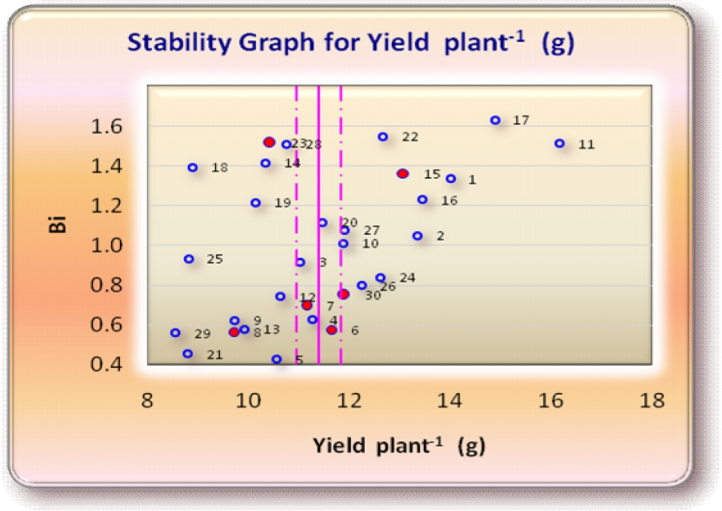
While, the genotypes 401-136/JW-17-1, PBW-343/CDWR-9563-1, MP-3360/RAJ-4213, 31ESWYT-1070, 31ESWYT-121, and 31ESWYT-110 reported regression coefficient above unity with low mean value over the environment indicating below average stability these genotypes.

The genotypes namely GW-366, LOK-1, PBW-343/CDWR-9563-6, 31ESWYT-125 and 31ESWYT-1071 had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character.

Genotypes, MP-3349/MP3222 and 31ESWYT-107 showed stable performance with mean value greater than grand mean and regression coefficient less than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.5 (D))

Table 4.6.5: Stability parameters for various traits

Variety	Grain yield plant^{-1}			Harvest index			Relative water content of flag leaf			Chlorophyll content		
	Mean	βi	S^2Di	**Mean**	βi	S^2Di	**Mean**	βi	S^2Di	**Mean**	βi	S^2Di
JW-3269	13.999	1.336*	-0.117	38.698	0.683	1.286	79.912	0.938	-0.524	44.710	0.592**	-1.003
GW-366	13.354	1.049	0.002	40.847	0.531	1.292	73.811	1.063	-0.423	48.895	1.153*	-1.150
LOK-1	11.031	0.917	-0.443	32.106	0.964	65.397***	73.671	1.002	-0.560	47.191	1.684**	-0.527
JW-3211	11.261	0.626**	-0.609	32.692	0.968	36.555**	76.179	1.260*	-0.452	43.923	1.491*	0.102
JW-3336	10.557	0.425**	-0.522	37.897	0.931	21.518*	84.258	1.073	-0.439	44.017	0.912**	-1.462
HD-2864	11.641	0.574	4.848***	43.142	1.534	28.874**	91.176	0.926**	-0.580	43.121	0.394**	-0.421
HD-2932	11.148	0.695	2.199**	42.225	1.199	39.759**	83.333	1.189	-0.427	41.942	0.840**	-1.332
HI-1544	9.696	0.565*	1.786**	35.429	1.646	129.258***	83.976	0.973	-0.576	46.043	0.375**	-0.790
MP-3324/MP-3092/MP-322	9.727	0.621	-0.386	34.176	0.930	23.407*	82.692	1.383**	-0.399	41.658	-0.033**	1.343
401-136/JW-17-1	11.884	1.010	-0.517	38.580	0.563*	-4.281	84.772	1.427**	-0.438	43.179	1.219**	-1.456
PBW343/CDWR9563-1	16.158	1.513*	0.690	46.033	0.408	31.466**	79.780	1.417**	-0.414	42.893	1.215**	-1.468
MP3349/MP-3222	10.633	0.742	0.818	33.361	0.511*	-3.230	80.530	0.802*	-0.512	50.562	0.493**	-1.036
MP-3342/PBW-343/K-9924	9.915	0.579*	0.064	37.099	0.811	20.717*	84.149	0.795**	-0.535	44.803	0.491**	-1.111
PBW-343/CDWR-9563-6	10.334	1.414**	-0.399	33.494	0.856	39.331**	87.110	0.847**	-0.576	44.852	1.064	-1.400
MP-3368/MP-4669	13.071	1.363	0.971*	41.996	0.995	27.878**	74.308	0.871**	-0.569	43.143	0.323**	-0.678
MP-3359/WH1092	13.442	1.230	-0.047	39.886	0.337**	-5.377	74.877	0.919**	-0.582	46.434	-0.084**	0.708
MP-3372/NIAW-1395	14.881	1.633*	0.489	43.643	0.255	28.277**	80.369	0.927**	-0.584	39.226	2.444**	3.167*
MP-3360/RAJ-4213	8.893	1.392	0.646	36.447	1.573	18.650*	87.770	0.858*	-0.544	42.522	1.192*	-0.971
31ESWYT-118	10.134	1.215*	-0.530	38.857	1.345	6.868	89.353	0.939*	-0.579	39.656	-0.475**	3.129*
31ESWYT-107	11.464	1.115	-0.503	35.910	0.945	62.498***	85.331	0.930	-0.405	46.376	0.813*	-1.121
31ESWYT-110	8.784	0.453*	0.419	32.910	1.473	10.330	70.829	1.015	-0.525	43.643	1.547**	-1.167
31ESWYT-120	12.654	1.550**	-0.241	46.897	1.258	51.858***	87.418	0.991	-0.570	45.832	0.720**	-1.232
31ESWYT-121	10.425	1.515	1.515*	38.238	0.463	28.937**	79.460	0.975	-0.561	41.739	2.855**	4.556**
31ESWYT-123	12.606	0.839	-0.096	46.595	0.665	263.663***	70.696	1.045	-0.531	42.946	0.945	-1.418
31ESWYT-125	8.802	0.933	-0.557	34.902	1.681	135.047***	77.758	0.931	-0.547	44.669	1.448**	-1.048
31ESWYT-126	12.235	0.798**	-0.625	36.927	1.178	53.516***	79.940	0.883	-0.461	42.617	0.492**	-0.752
31ESWYT-127	11.901	1.079	-0.595	37.022	1.085	30.385**	85.017	0.876**	-0.572	42.877	1.070**	-1.477
31ESWYT-131	10.752	1.511**	-0.512	36.537	1.403	16.060*	79.853	0.959**	-0.585	40.582	2.376**	3.184*
31ESWYT-132	8.538	0.559**	-0.470	30.359	1.503**	-9.153	83.454	0.825**	-0.567	44.754	1.454**	-0.819
31ESWYT-134	11.893	0.751	0.998*	40.939	1.306	47.815***	86.209	0.960	-0.571	44.100	0.988	-1.474
Population Mean	**11.394**			**38.128**			**81.266**			**43.964**		



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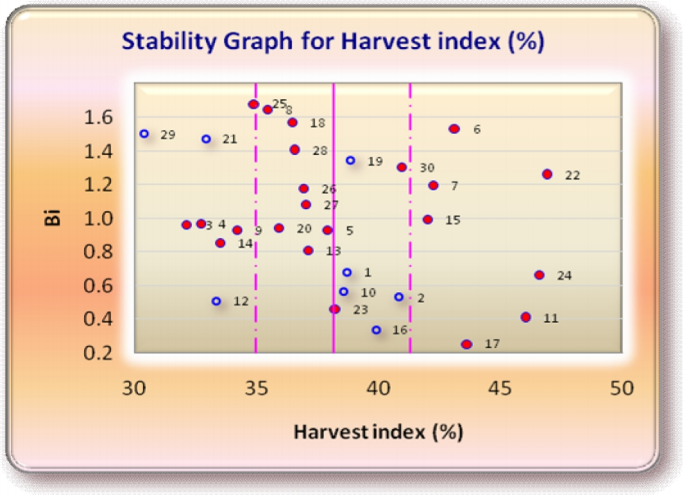

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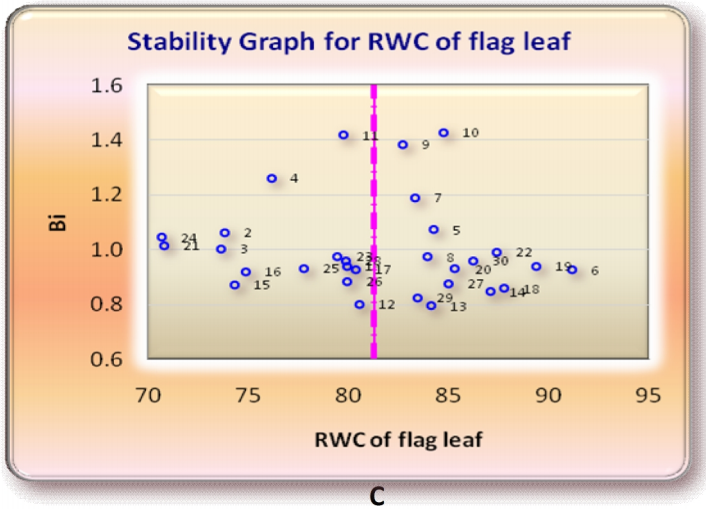

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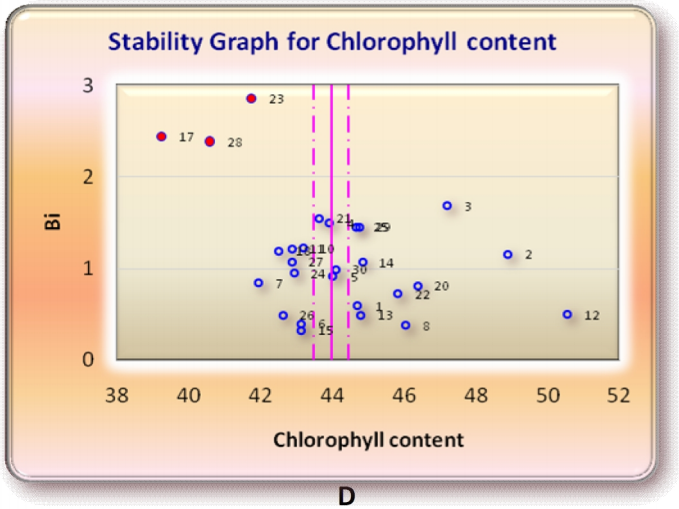


D

Fig. 4.5. Figure A, B, C, D showing stability graphs.

Canopy temperature

JW-3269, GW-366, PBW-343/CDWR-9563-1, 401-136/JW-17-1, MP-3359/WH-1092, 31ESWYT-107, 31ESWYT-118 and 31ESWYT-1070 were the genotypes showed regression coefficient less than unity coupled with mean value less than grand mean, revealed that these genotype had above average stability.

The genotypes MP-3349/MP3222, JW-3211, LOK-1, 31ESWYT-125, 31ESWYT-110, and HI-1544 had regression coefficient above unity and also with low mean value over the environment, indicating below average stability.

Whereas, the genotypes JW-3336, HD-2932, HI-1544, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-6, 31ESWYT-120, 31ESWYT-121, 31ESWYT-123, 31ESWYT-127 and 31ESWYT-1072 exhibited regression coefficient greater than unity coupled with high mean value indicating, specific adaptation of these genotypes for exploitation of this trait.

Genotypes, MP-3372/NIAW-1395 and HD-2864 exhibited stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.6 (A))

Sedimentation value

Genotypes JW-3269, HD-2932, PBW-343/CDWR-9563-1, MP-3372/NIAW-1395, 31ESWYT-120 and 31ESWYT-1072 reported regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability.

The genotypes LOK-1, JW-3336, HD-2864, MP-3324/MP-3092/MP-322, MP-3359/WH-1092, 31ESWYT-127, 31ESWYT-125, 31ESWYT-121 and 31ESWYT-118 reported regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes.

However, the genotypes PBW-343/CDWR-9563-6, MP-3368/MP-4669, MP-3360/RAJ-4213, 31ESWYT-107, 31ESWYT-110, 31ESWYT-123 and 31ESWYT-1071 exhibited regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this trait.

Genotype 401-136/JW-17-1 was found to be stable with mean value greater than grand mean and regression coefficient less than one with deviation from regression minimum, indicating less susceptibility of this genotype for changed environmental condition in expression of this trait. (Fig:-4.6(B).

Hectoliter weight

The genotypes JW-3269, 31ESWYT-120 31ESWYT-121, 31ESWYT-123, 31ESWYT-125 31ESWYT-126, 31ESWYT-127 and 31ESWYT-1070 were the genotypes noticed to be had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotypes.

Genotypes MP-3372/NIAW-1395, MP-3368/MP-4669, 401-136/JW-17-1, MP-3360/RAJ-4213 and JW-3211 showed regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes.

The genotypes namely, GW-366, LOK-1, HD-2864, HD-2932, HI-1544, 401-136/JW-17-1, MP-3349/MP3222, PBW-343/CDWR-9563-6, 31ESWYT-107, 31ESWYT-110, 31ESWYT-118 and 31ESWYT-1071 showed regression coefficient greater than unity coupled with high mean value, indicating specific adaptation of these genotypes for exploitation of this character.

While, the genotypes JW-3336, PBW-343/CDWR-9563-1 and 31ESWYT-1072 were found to be stable with mean value greater than grand mean and regression coefficient less than one with minimum deviation from

regression, indicating less susceptibility of these genotypes for changed environmental condition in expressing this trait. (Fig:-4.6 (C))

Protein %

JW-3269, GW-366, LOK-1, HD-2864, HD-2932, HI-1544, PBW-343/CDWR-9563-1, 31ESWYT-120 and 31ESWYT-125 were observed to be had regression coefficient less than unity coupled with mean value less than grand mean revealed above average stability of these genotype.

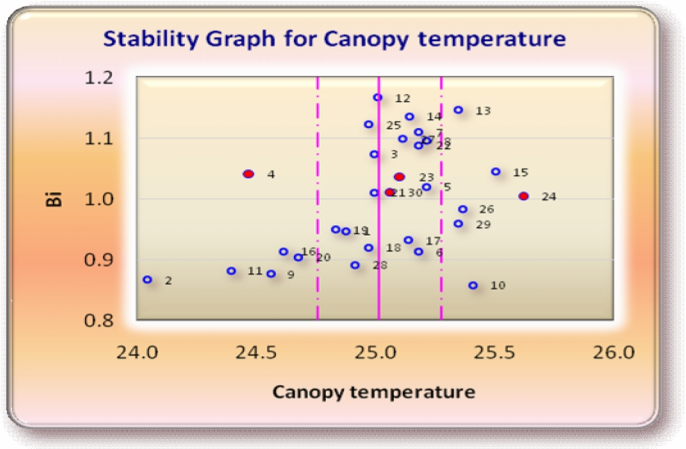
The genotypes MP-3360/RAJ-4213, MP-3359/WH-1092, 31ESWYT-107, 31ESWYT-118, 31ESWYT-127, 31ESWYT-121, 31ESWYT-1071 and 31ESWYT-1072 reported regression coefficient above unity and low mean over the environment indicating below average stability these genotypes.

While, the genotypes JW-3211, JW-3336, MP-3342/PBW-343/K-9924, MP-3368/MP-4669, MP-3372/NIAW-1395, MP-3360/RAJ-4213 and 31ESWYT-110 exhibited regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character.

Genotypes, MP-3349/MP3222 and 401-136/JW-17-1 showed stable performance with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed of environmental condition in expression of this trait. (Fig:-4.6 (D))

Table 4.6.6: Stability parameters for various traits

Variety	Canopy temperature			Sedimentation value			Hectoliter weight			Protein %		
	Mean	βi	S^2Di	**Mean**	βi	S^2Di	**Mean**	βi	S^2Di	**Mean**	βi	S^2Di
JW-3269	24.878	0.946*	-0.300	35.822	0.854	1.475***	75.444	0.907	-0.433	12.117	0.787	0.473***
GW-366	24.044	0.867*	-0.150	31.511	1.092	8.137***	79.222	1.096	8.459***	12.028	0.867	0.073*
LOK-1	24.994	1.074	-0.209	32.528	1.145*	0.218	77.611	1.428	-0.303	11.939	0.775**	-0.029
JW-3211	24.472	1.041	1.597***	43.283	0.931	26.528***	75.222	1.267	0.743	13.067	1.121	0.270***
JW-3336	25.217	1.020	-0.201	35.656	1.331*	4.886***	79.944	0.815	-0.938	12.711	1.140	0.212***
HD-2864	25.183	0.913	-0.062	34.317	1.007	16.433***	77.722	1.245	-0.623	12.044	0.933	0.170***
HD-2932	25.183	1.110	0.155	33.122	0.850	4.377***	77.722	1.276	-0.920	11.933	0.486**	0.110**
HI-1544	25.217	1.095	-0.164	38.672	0.940	10.752***	77.167	1.511	0.800	12.328	0.772	0.144***
MP-3324/MP-3092/MP-322	24.561	0.876*	-0.217	36.972	1.191**	-0.505	75.000	1.055	5.085**	12.633	1.085	-0.002
401-136/JW-17-1	25.411	0.858	-0.027	40.528	0.716*	4.213***	76.444	1.208	7.087***	12.722	0.833	0.166***
PBW343/CDWR9563-1	24.394	0.882	0.175	37.206	0.765	10.048***	78.500	0.463	4.870**	12.350	0.845	0.377***
MP3349/MP-3222	25.011	1.167*	-0.196	45.306	0.628	30.850***	78.667	2.091*	2.269*	14.178	0.945	0.150***
MP-3342/PBW-343/K-9924	25.350	1.146*	-0.190	42.850	0.593	124.260***	76.056	0.147*	-0.233	12.867	0.292	1.696***
PBW-343/CDWR-9563-6	25.144	1.136	0.039	40.439	1.164	9.652***	79.833	1.212	0.670	12.922	0.751*	0.035
MP-3368/MP-4669	25.506	1.045	0.008	39.111	1.085	2.042**	76.722	1.044	0.599	12.544	1.338*	0.060*
MP-3359/WH1092	24.617	0.913	-0.224	34.967	1.076	2.781***	77.444	0.536	6.503***	11.994	1.167**	-0.017
MP-3372/NIAW-1395	25.139	0.932*	-0.293	31.794	0.176**	0.569	76.667	1.331	2.969*	12.572	1.554**	0.136***
MP-3360/RAJ-4213	24.972	0.920	-0.029	39.861	1.016	2.250***	76.111	1.254	0.690	12.800	1.085**	-0.028
31ESWYT-118	24.833	0.949	-0.224	34.700	1.364*	6.773***	79.056	1.634	0.305	11.844	1.197	0.116**
31ESWYT-107	24.678	0.904	0.051	38.400	1.073	2.787***	77.444	1.352	1.292	12.361	1.307*	0.119***
31ESWYT-110	24.994	1.011	-0.296	40.017	1.022	-0.149	78.056	1.153	2.927*	12.483	1.291**	0.004
31ESWYT-120	25.183	1.089	-0.007	34.156	0.842**	-0.259	76.667	0.399	6.478***	11.172	0.980	0.018
31ESWYT-121	25.106	1.036	0.479*	36.867	1.225	1.408**	74.500	0.850	6.520***	12.250	1.339**	0.000
31ESWYT-123	25.622	1.004	0.716*	38.517	1.065	0.451	74.222	0.490*	-1.083	12.417	0.911	0.099**
31ESWYT-125	24.972	1.122*	-0.173	35.494	1.265	9.943***	74.500	0.237**	-0.794	12.067	0.942	1.734***
31ESWYT-126	25.367	0.984	0.256	40.967	1.111	44.923***	75.278	0.464*	-0.322	12.711	0.964	1.082***
31ESWYT-127	25.117	1.099	-0.099	34.822	1.408**	0.066	75.444	0.563*	-0.764	11.750	1.055	0.146
31ESWYT-131	24.917	0.891**	-0.303	42.144	0.923	5.669***	75.833	0.938	1.133	13.278	0.761	0.297***
31ESWYT-132	25.350	0.959	-0.178	38.939	1.270*	3.724***	78.278	1.205	7.307	12.372	1.269**	0.017
31ESWYT-134	25.061	1.011	0.638*	34.189	0.873**	-0.549	78.333	0.828	1.133	11.544	1.207*	0.029
Population Mean	**25.017**			**37.439**			**76.970**			**12.40**		



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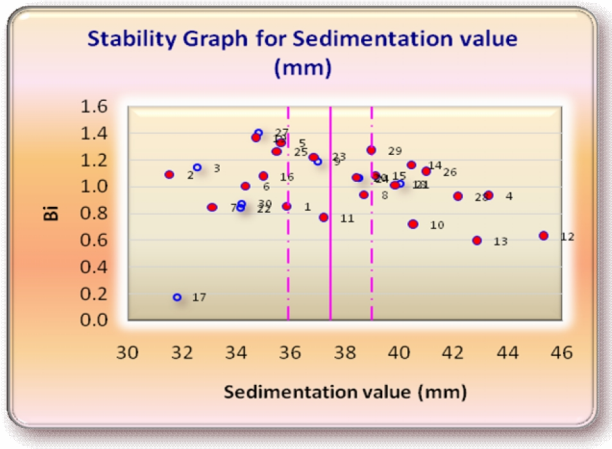

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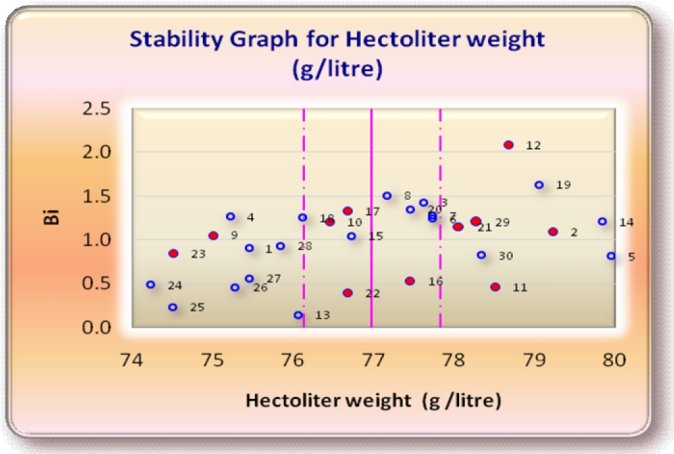

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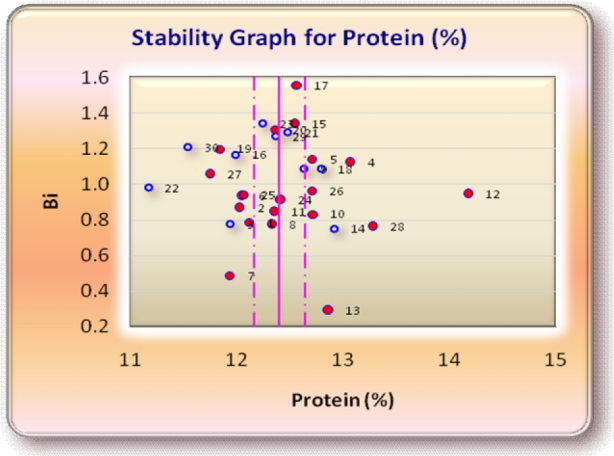


D

Fig. 4.6. Figure A, B, C, D showing stability graphs.

Wet gluten %

The genotypes JW-3269, GW-366, LOK-1, HD-2864, HD-2932, 31ESWYT-123 and 31ESWYT-125 reported regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype.

The genotypes MP-3324/MP-3092/MP-322, PBW-343/CDWR-9563-1, MP-3359/WH-1092, MP-3372/NIAW-1395, 31ESWYT-1071, 31ESWYT-1072, 31ESWYT-127, 31ESWYT-121 and 31ESWYT-118 had regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes.

The genotypes namely, JW-3336, MP-3324/MP-3092/MP-322, MP-3368/MP-4669, 31ESWYT-107, 31ESWYT-110 and 31ESWYT-126 had regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character.

Whereas, the genotypes MP-3349/MP3222, PBW-343/CDWR-9563-6, 401-136/JW-17-1 and MP-3360/RAJ-4213 reported stable performance with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.7 (A))

Starch %

Genotypes MP-3349/MP3222, MP-3359/WH-1092, 31ESWYT-107, 31ESWYT-110, 31ESWYT-120, 31ESWYT-121 and 31ESWYT-1070, GW-366 and HD-2932 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability.

Whereas, the genotypes MP-3372/NIAW-1395 MP-3368/MP-4669, 401-136/JW-17-1, JW-3211, LOK-1, HD-2864, and MP-3324/MP-3092/MP-322 reported regression coefficient above unity with low mean over the environment indicating below average stability.

The genotypes namely, HI-1544, JW-3336, MP-3360/RAJ-4213 and 31ESWYT-125 exhibited regression coefficient greater than unity coupled with high mean value showing specific adaptation of these genotypes for exploitation of this trait.

Genotypes, 31ESWYT-123 and PBW-343/CDWR-9563-6 were obtained to be had stable performance with mean value greater than grand mean and regression coefficient less than one with deviation from regression minimum, indicating less susceptibility of these genotypes for changed environmental condition in expression of this trait. (Fig:-4.7(B))

Moisture %

The genotypes JW-3336, HD-2864, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-6, 31ESWYT-107, 31ESWYT-118, 31ESWYT-125, 31ESWYT-121 and 31ESWYT-1072 had regression coefficient lesser than unity coupled with mean value lesser to grand mean revealed above average stability of these genotype.

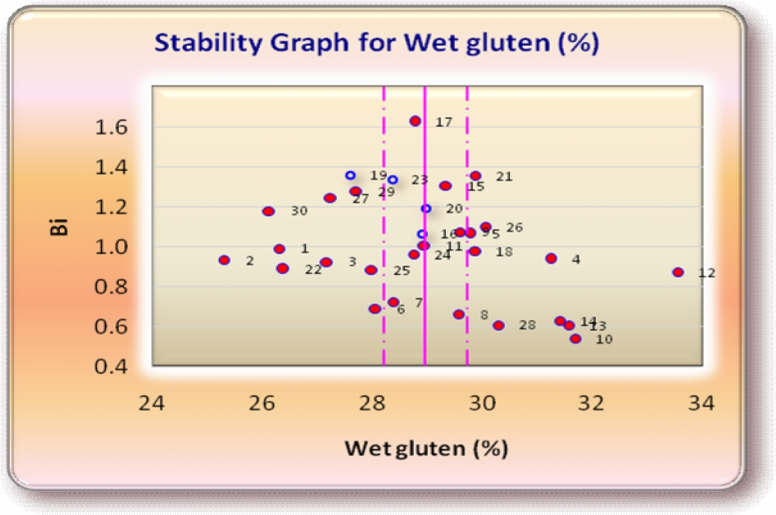
The genotypes MP-3372/NIAW-1395, MP-3359/WH-1092, PBW-343/CDWR-9563-1, 401-136/JW-17-1, HD-2932, 31ESWYT-126 and 31ESWYT-110 reported regression coefficient above unity and also with low mean value over the environment indicating below average stability these genotypes.

The genotypes namely JW-3269, HI-1544, MP-3368/MP-4669, MP-3360/RAJ-4213 and 31ESWYT-127 exhibited regression coefficient greater than unity coupled with high mean value indicating specific adaptation of these genotypes for exploitation of this character.

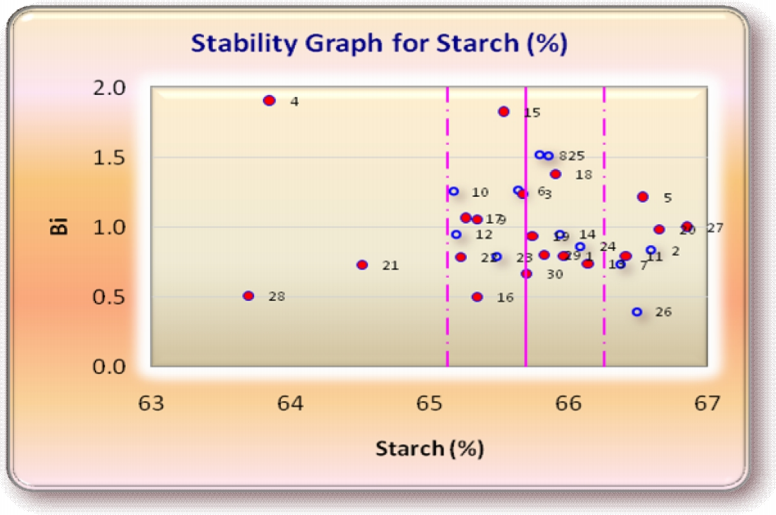
Genotypes, GW-366 and 31ESWYT-120 were found to be stable with mean value greater than grand mean and regression coefficient lesser than one with deviation from regression minimum indicating less susceptibility of these genotypes for changed environmental condition in expression of these traits. (Fig:-4.7 (C).

Table 4.6.7: Stability parameters for various traits

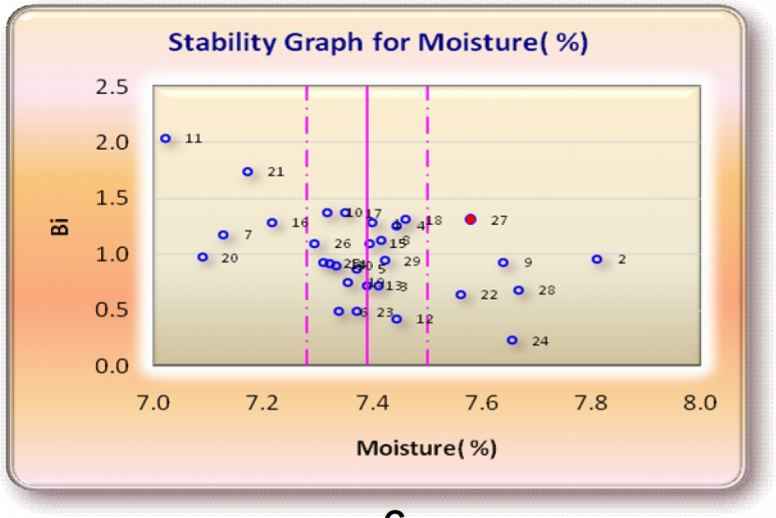
Variety	Wet gluten %			Starch %			Moisture %		
	Mean X25	βi	S^2Di	**Mean X26**	βi	S^2Di	**Mean X27**	βi	S^2Di
JW-3269	26.300	0.990	4.620***	65.972	0.794	2.196***	7.400	1.280	-0.040
GW-366	25.294	0.935	2.076***	66.594	0.836	0.286	7.811	0.960	-0.063
LOK-1	27.172	0.924	1.971***	65.667	1.238	1.025**	7.411	0.715	-0.045
JW-3211	31.239	0.936	0.869***	63.856	1.903	7.243***	7.444	1.255	-0.018
JW-3336	29.778	1.065	0.250***	66.533	1.213	0.878**	7.372	0.871	-0.069
HD-2864	28.056	0.690	12.074***	65.633	1.265*	-0.249	7.339	0.486	-0.019
HD-2932	28.378	0.724*	0.568***	66.372	0.732	0.363	7.128	1.178	-0.016
HI-1544	29.567	0.661	3.237***	65.789	1.518*	0.051	7.417	1.127	0.053
MP-3324/MP-3092/MP-322	29.589	1.074	3.064***	65.339	1.057	2.306***	7.639	0.928	-0.004
401-136/JW-17-1	31.678	0.540**	0.909***	65.172	1.257	0.232	7.317	1.374	-0.021
PBW343/CDWR9563-1	28.944	1.004	2.575***	66.417	0.793	0.968**	7.022	2.037	0.104
MP3349/MP-3222	33.550	0.872	1.958***	65.194	0.949	0.289	7.444	0.421	-0.044
MP-3342/PBW-343/K-9924	31.567	0.605	10.413***	66.144	0.741	3.858***	7.389	0.717	-0.032
PBW-343/CDWR-9563-6	31.394	0.626**	0.199***	65.939	0.949	-0.042	7.322	0.914	0.019
MP-3368/MP-4669	29.339	1.305**	0.124**	65.533	1.822	2.827***	7.394	1.100	-0.068
MP-3359/WH1092	28.894	1.063	0.026	65.339	0.502	3.067***	7.217	1.284	-0.050
MP-3372/NIAW-1395	28.772	1.625**	0.159**	65.256	1.062	0.830*	7.350	1.371	-0.030
MP-3360/RAJ-4213	29.872	0.978	0.741***	65.906	1.383	0.556*	7.461	1.311	-0.066
31ESWYT-118	27.606	1.358**	-0.018	65.744	0.937	0.564*	7.356	0.753	-0.018
31ESWYT-107	28.978	1.194**	0.042	66.650	0.987	0.707*	7.089	0.974	0.038
31ESWYT-110	29.861	1.355**	0.483***	64.511	0.733	1.378***	7.172	1.741	0.035
31ESWYT-120	26.378	0.887	1.064***	65.222	0.786	1.441***	7.561	0.640	-0.063
31ESWYT-121	28.356	1.337**	-0.045	65.483	0.789	0.241	7.372	0.488	-0.042
31ESWYT-123	28.750	0.961	1.075***	66.083	0.862	-0.080	7.656	0.230	-0.027
31ESWYT-125	27.989	0.885	18.175***	65.856	1.515*	-0.155	7.311	0.922	-0.037
31ESWYT-126	30.044	1.099	13.673***	66.489	0.397	0.359	7.294	1.097	-0.050
31ESWYT-127	27.244	1.243	1.646***	66.850	0.998	2.186***	7.578	1.305	0.144 *
31ESWYT-131	30.278	0.607*	1.310***	63.694	0.510	0.655*	7.667	0.679	0.060
31ESWYT-132	27.711	1.277	0.941***	65.822	0.803	1.818***	7.422	0.943	-0.008
31ESWYT-134	26.122	1.179	0.615***	65.694	0.667	1.399***	7.333	0.899	-0.035
Population Mean	**28.957**			**65.692**			**7.390**		



A



B



C

Fig. 4.7. Figure A, B, C, D showing stability graphs.

DISCUSSION

India is the second largest producer of wheat with record food production in the recent past from a gradual transition, chronic shortage to self-sufficiency in the important cereal crops especially in wheat. This has been achieved due to hard and painstaking work of wheat scientist by manipulating the yield components and consequent availability of right type of plant ideotype and sound production technology.

Improving yield, quality and stress resistance are the main objectives of the entire breeding programmes. Success of any breeding programme for evolving improved crop varieties depends largely on the range of variability present in the crop species for important economic traits. Along with the superior yield performance and quality traits, stabilizing wheat production was also one of the aim of any breeding experiment now a days. Yield reflects the contribution of all the components traits and is considered as the final result of many traits. Every plant contains an inherent production capacity that operates on water, energy, nutrients and other natural resources required for normal plant growth. The ultimate aim of the plant breeder is to improve the yield or economic produce by improving the efficiency of plant genotypes through the study of different characters.

Global climate change and global warming in particular has started to show its impact on crop production. Wheat is one of the most sensitive crop to heat and it had been estimated that rise in temperature by $1^{o}C$ may lead to yield losses between 3–17% (average 11%) in northwestern India and Pakistan. Targeted wheat varieties with high stable yields in heat stressed environments can restores the wheat productivity in those areas vulnerable to climatic changes induced by heat and drought stress. Central parts of India including the states *viz*., Madhya Pradesh, Chhattisgarh, Gujarat, Southern Rajasthan (Kota and Udaipur divisions) and Bundelkhand region of Uttar

Pradesh, which amounts for more than 5.0 million hectares of wheat producing area, in which wheat cultivation can play an important role in combating the early heat stress. Therefore, attempts are to be made in wheat genotypes to select the high yielding genotypes with high heat tolerance under moisture stress of late sown and very late sown conditions to combat with the global climatic change and global warming. Earlier, wheat sowing was being performed in rainfed, irrigated normal and irrigated late sown conditions, but now a day's irrigated wheat sowing gets more delay in different areas due to long duration of paddy and increasing cropping intensity. Prevalence of high temperature during post anthesis is one of the key production constraints in irrigated late sown wheat. The high temperature influences the expression of different physiological, phenological, yield components and quality traits, which ultimately cause reduction in economic yield and quality of produce.

Therefore, the present investigation was designed to estimate the genetic variability, heritability, correlation coefficient analysis, path analysis, stability and multiple regression analysis under six different environmental conditions for the two consecutive years in timely sown, late sown and very late sown conditions, so that much information could be exploited for breeding in different range of environmental conditions from normal to high temperature stressed very late sown bread wheat genotypes. The expected improvement will primarily depend upon the magnitude and the nature of genetic variability present in base population. Presence of genetic variability serves as an insurance against the adverse climatic condition. Furthermore, the understanding of correlation among yield and its components characters is desirable to aim at rational improvement in yield through selection.

The experimental finding of the present investigation has been discussed under the following heads.

5.1 Genetic variability

5.2 Heritability and Genetic advance (expressed as percentage of mean)

5.3 Correlation analysis

5.4 Path coefficient analysis

5.4 Multiple regression analysis

5.5 Stability analysis

5.1 Genetic variability

The findings of the present investigation have been interpreted and discussed in light of the similar research work carried out by other research worker. Broad spectrum variability is fundamental for success of breeding programme since it provides opportunity to the breeder for making useful selections. Wide range of variability existing among the 30 genotypes, for all the 27 traits was necessary to isolate significantly superior genotypes. A critical survey of genetic variability is necessary for smooth and effective planning as well as evaluation and screening of desirable material in wheat.

Analysis of variance revealed highly significant differences among the genotypes for most of the traits indicating considerable genetic variation in the material. Wide ranges of variability presented in the experimental material indicated better scope for selection and utilization of important physiological, yield and quality attributes in wheat breeding. The phenotypic expression of the character is the manifestation of genotype, environment and interaction between genotype and environment. The phenotypic coefficient of variation measures the extent of genetic variability present in the crop species and also enables to quantify the extent of variability present in the different traits. Therefore total variance needs to be partioned into heritable and non-heritable components to assess the true breeding nature of that particular trait.

Analysis of variance indicated that difference among the genotypes were highly significant for all the traits studied viz., days to 50% flowering, days to maturity, plant height, number of tillers plant^{-1}, number of effective tillers plant^{-1}, number of spikelet ear^{-1}, number of ears plant^{-1}, number of grains ear^{-1}, number of grains plant^{-1}, ear head length (cm), ear weight (g), peduncle length (cm), number of leaves plant^{-1}, 1000 grain weight (g), biological yield plant^{-1}, harvest index, grain yield plant^{-1}, relative water content of flag leaf, chlorophyll content, canopy temperature, hectoliter

weight, protein %, sedimentation value, starch %, wet gluten % and moisture %, except for number of in-effective tillers plant^{-1} which indicates that genotypes were highly diversified.

I Year

In all the three situations i.e., timely, late and very late sown (E1, E2 and E3 respectively), the phenotypic and genotypic coefficients of variation was reported highest for number of effective tillers plant^{-1} and lowest for the starch %.

II Year

A highest phenotypic and genotypic coefficient of variation was observed for number of effective tillers plant^{-1}and lowest for starch %.

Pooled (2012-23 & 2013-14)

Considering the pooled analysis, the highest phenotypic and genotypic coefficient of variation were reported for number of effective tillers plant^{-1}, followed by number of ineffective tillers plant^{-1}, number of ears plant^{-1}, number of grains plant^{-1}, harvest index, number of leaves plant^{-1}, grain yield plant^{-1}, number of tillers plant^{-1}, ear weight, peduncle length, biological yield plant^{-1}, ear head length, sedimentation value, number of grains ear^{-1}, 1000 grain weight, number of spikelet ear^{-1}, chlorophyll content, wet gluten, protein %, relative water content of flag leaf, plant height, moisture %, days to 50% flowering, days to maturity, starch %.

High magnitude of genotypic coefficient of variation indicates presence of substantial amount of genetic variability in the population and also little influence of environment on expression of traits. Phenotypic coefficients of variation estimates were higher than genotypic coefficient of variation for all the traits. This is due to the occurrence of error variance in to phenotypic coefficient of variance. Similar findings were reported by Ghimiray and Sarkar (2000), Menshawy (2007), Bisht and Gahalain (2009), Chandra et al., (2009) , Riaz et al., (2010) and Degewione (2013).

Grain yield plant^{-1} reported high value of phenotypic and genotypic coefficient of variation were in conformity with the findings of Hamada (2003), Kumar and Mishra (2004), Malik (2005), Tripathi et al., **(**2009), Kotal et al., (2010), Riaz et al., (2010), Tripathi et al., (2011), (Kalimullah et al., (2012) and Degewione (2013).

Number of effective tillers plant^{-1} reported high value of phenotypic and genotypic coefficient of variation. Similar findings were also reported by Pawar et al., (2002), Mondal et al., (2004), Cheema et al., (2006), Ali et al., (2008), Tripathi et al., (2009), Gholamin et al., (2010 a), Tripathi et al., (2011) and Kotal et al., (2010).

Higher phenotypic and genotypic coefficient of variation was observed for number of ears plant^{-1}, was in conformity with the result of Phadnawis et al.**,** (2003).

Higher phenotypic and genotypic coefficient of variation observed for harvest index were in conformity with the research's of Shukla et al., (2000), Chandrashekhar and Kerketta (2004), Malik (2005), Tripathi et al., (2009), Kotal et al., (2010), Tripathi et al., (2011) and Aharizad et al., (2012).

Total number of tillers plant^{-1} recorded high magnitude of phenotypic and genotypic coefficient of variation. This results was in conformity with the findings reported by Chandrashekhar and Kerketta (2004), Kumar and Mishra (2004), Malik (2005), Maniee et al., (2009), Gholamin et al, (2010 a), Tripathi et al., (2011), Kalimullah et al., 2012) and Degewione (2013).

Ear weight recorded high value of phenotypic and genotypic coefficient of variation were supported by the findings Pochaba and Wegrzyn (2000), Gholamin et al, (2010 a) and Zecevic et al., (2010)

Traits *viz*., peduncle length, biological yield plant^{-1}, ear head length, sedimentation value, number of grains ear^{-1}, 1000 grain weight and number of spikelet ear^{-1} showed moderate value of phenotypic and genotypic coefficient of variation. Whereas the traits viz., chlorophyll content, wet gluten, protein content, relative water content of flag leaf,

plant height, moisture content, days to 50% flowering, days to maturity, starch content exhibited low value of phenotypic and genotypic coefficient of variation.

The biological yield plant^{-1} showed moderate value of phenotypic and genotypic coefficient of variation was in agreement with the findings advocated by Kaur et al., (2008) and Aharizad et al., (2012).

Ear head length showed moderate value of phenotypic and genotypic coefficient of variation. This result was in agreement with the views of Ali et al., (2008), Aharizad et al., (2012), Baranwal et al., (2012) and Degewione (2013). Contradictory results have been observed by Maniee et al., (2009) for the same trait.

Number of grains ear^{-1} showed moderate value of phenotypic and genotypic coefficient of variation. This result was in agreement with the findings of Kumar et al., (2003), Ajmal et al., (2009), Kotal et al., (2010) and Kalimullah et al., (2012)

For 1000 grain weight moderated value of phenotypic and genotypic coefficient of variation were reported which are in conformity with the findings reported by Hamada (2003), Khan et al., (2007), Ali et al., (2008), Majumder et al., (2008), Kalimullah et al., (2012) and Degewione (2013). However, Kumar et al., (2003), Ajmal et al., (2009), Riaz et al., (2010), Baranwal et. al., (2012) and Hasnath et al, (2013) reported low value of phenotypic and genotypic coefficient of variation for this trait.

Number of spikelet ear^{-1} showed moderate value of phenotypic and genotypic coefficient of variation. The results was in agreement with the findings advocated by Kumar et al., (2003), Hamada (2003), Ali et al., (2008), Majumder et al., (2008) and Bisht and Gahalain (2009). These results were contradictory to the views of Aharizad et al., (2012), Degewione (2013) and Hasnath et al, (2013).

The grain protein content reported low values of phenotypic and genotypic coefficient of variation was in conformity with the findings of Aharizad et al., (2012). Chlorophyll content and peduncle length exhibited

low values of phenotypic and genotypic coefficient of variation was advocated by the finding of Baranwal et al., (2012).

5.2 Heritability and genetic advance (expressed as percentage of mean)

Heritability (broad sense) is a measure of proportion of phenotypic variation contributed by genotypic variation for a given trait. It is the good index of transmission of characters from parent to their offspring. The estimates of heritability can be utilized for the prediction of genetic gain, which indicates the genetic improvement that would results from the selection of best individuals. Selection based on particular character will be effective when its heritability estimates are high. Hence estimates of heritability are essential prerequisite for formulation of an effective selection method for the genetic improvement. The success of improvement of a particular trait depends on the relationship between the phenotype and genotype. This relationship is very well judged through heritability estimates.

Since the heritability values are influenced by environment, therefore the utility of genetic material and also other factors will be restricted. High heritability alone does not ascertain any desirable gain from selection unless sufficient genetic advance attributable to additive gene action is present. The estimates of heritability in broad sense include contribution from additive as well as non-additive gene effects thus they are of limited importance. However, high heritability coupled with high genetic advances as percentage of mean are considered significant. According to Panse (1957), If the heritability is mainly due to non additive effect (dominance and epistatis), the genetic gain would be low while, in case where heritability is chiefly due to additive gene effects, high genetic advance may be expected.

Due to these reason, estimates of heritability in broad sense and genetic advances as percentage of mean should always be viewed and interpreted simultaneously. In the present study, broad sense heritability has been computed, which indicates the degree of genetic determination i.e. extent to which individual phenotypes are determined by their genotypes.

Heritability and genetic advance are presented according to their sowing environments in both the years (2012 & 2013). E1 and E4 environments representing the timely sown condition for the first (2012) and second (2013) experimental year, respectively in table 5.1. Whereas, E2 and E5 representing the late sown conditions of both the years (2012 & 2013, respectively) in the table 5.2. Similarly, E3 and E6 representing the very late sown conditions of both the years (2012 & 2013 respectively), in the table no. 5.3.

5.2.1 High heritability coupled with high genetic advance

Timely sown (E1 & E4)

Traits *viz*., number of grains ear^{-1}, number of grains plant^{-1}, ear weight, peduncle length, yield plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, harvest index, wet gluten, protein and sedimentation value showed high heritability coupled with high genetic advance under timely sown condition (E1 & E4). Whereas, high estimate of heritability and genetic advance for biological yield plant^{-1} in E1only.

Late sown (E2 & E5)

Number of grains ear^{-1}, ear weight, number of leaves plant^{-1}, 1000 grain weight and sedimentation value were the traits reported high heritability coupled with high genetic advance under late sown condition **(**E2 & E5). However, the traits *viz.*, number of grains plant^{-1}, biological yield plant^{-1} and chlorophyll content reported the same only under E2. Whereas, the traits like plant height, peduncle length, yield plant^{-1} and wet gluten reported the high heritability coupled with high genetic advance under E5.

Very Late sown (E3 & E6)

High heritability coupled with high genetic advance were recorded for the traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, biological yield plant^{-1} and sedimentation value under very late sown condition (E3 & E6). Whereas, high heritability and

high genetic advance reported by harvest index and wet gluten in E3 only and by chlorophyll content in E6 only.

5.2.2 High heritability coupled with moderate genetic advance

Timely sown (E1 & E4)

Plant height, relative water content and chlorophyll content revealed high heritability coupled with moderate genetic advance under both the environments.

Late sown (E2 & E5)

High heritability coupled with moderate genetic advance under both the environments was observed for traits *viz*., plant height and relative water content. Wet gluten showed high estimates of heritability and moderate genetic advance only in E2 and protein under E5.

Very Late Sown (E3 & E6)

Protein % and relative water content noticed high heritability coupled with moderate genetic advance under very late sown condition (E3 & E6). However, the chlorophyll content showed the same estimate only in E3 and days to maturity in E6 noticed high heritability coupled with moderate genetic advance.

Pooled (2012 & 2013)

Relative water content of flag leaf showed high heritability coupled with moderate genetic advance over both the years.

5.2.3 High heritability coupled with low genetic advance

Timely sown (E1 & E4)

Number of ineffective tillers plant^{-1} reported high heritability coupled with low genetic advance timely sown situations (E1 & E4). However, the traits *viz.,* days to 50% flowering, days to maturity and starch % in E1 and ear head length showed in E4 the high estimate of heritability coupled with low genetic advance.

Late sown (E2 & E5)

The traits days to 50% flowering and days to maturity, showed high heritability coupled with low genetic advance under late sown situations (E2 & E5), whereas starch % in E2, and number of grains plant^{-1} and hectoliter weight found high heritability with low genetic advance in E5 only.

Very Late sown (E3 & E6)

Days to maturity showed high heritability coupled with low genetic advance under very late sown condition (E3 & E6), whereas for days to 50% flowering and starch content only in E3**.**

5.2.4 Medium heritability and high genetic advance

Timely sown (E1 & E4)

Number of effective tillers plant^{-1} and number of ears plant^{-1} showed the medium estimates of heritability and high genetic advance in E1 only.

Late sown (E2 & E5)

In E2, medium estimates of heritability and high genetic advance were reported by the traits *viz.,* number of tillers plant^{-1}, peduncle length, ear head length and harvest index while, for number of spikelets ear^{-1} in E5.

Very Late sown condition (E3 & E6)

Ear head length, peduncle length, and yield plant^{-1} revealed medium heritability with high genetic advance under very late sown (E3 & E6). While, for number of spikelets ear^{-1} reported the same only for E3.

Pooled (2012 & 2013)

Number of grains ear^{-1}, 1000 grain weight and yield plant^{-1}showed medium heritability estimates with high genetic advance over all the environments.

5.2.5 Medium heritability and low genetic advance

Timely sown condition (E1 & E4)

Days to maturity showed medium heritability and low genetic advance estimate in E4 only.

Late sown condition (E2 & E5)

Protein content in E2, showed this combination.

Very Late sown condition (E3 & E6)

Plant height showed this combination in very late sown condition (E3 & E6), while hectoliter weight in E6, reported medium heritability along with low genetic advance.

5.2.7 Low heritability and high genetic advance

Timely sown (E1 & E4)

This estimate was presented by ear head length in E1 and number of effective tillers plant^{-1} in E4.

Late sown (E2 & E5)

Number of ears plant^{-1} in late sown condition (E2 & E5) and number of ineffective tillers plant^{-1} and yield plant^{-1} showed low heritability and high genetic advance in E2.

Very Late sown (E3 & E6)

Traits *viz*., number of tillers plant^{-1}, number of effective tillers plant^{-1}, number of ears plant^{-1} and harvest index showed this combination in E6, while number of ineffective tillers plant^{-1} showed low heritability and high genetic advance in both E3 & E6.

Pooled results (2012 & 2013)

Number of grains plant^{-1}, ear weight, peduncle length, chlorophyll content and sedimentation value revealed low heritability and high genetic advance over both the years.

Other character reported whether low estimates of heritability low estimate of genetic advance or both. Therefore, not considered as very important trait in wheat improvement programme.

Considering the results of the two years under different sowing conditions, the traits along with the heritability and genetic advance were presented in the table no. 5.1.

Table 5.1. Estimate of heritability and genetic advance under all the conditions.

Traits	TIMELY SOWN				LATE SOWN				VERY LATE SOWN				POOLED	
	E1		E4		E2		E5		E3		E6			
	h^2	GA	h^2	GA	h^2	GA	h2	GA	h^2	GA	h^2	GA	h^2	GA
Days to 50% fLering	H	L	L	L	H	L	H	L	H	L	H	M	L	L
Days to maturity	H	L	M	L	H	L	H	L	H	L	H	L	L	L
Plant height (cm)	H	M	H	M	H	M	H	H	M	L	M	L	L	L
No. of tillers plant^{-1}	L	M	L	L	M	H	L	L	L	L	L	H	L	L
No. of effective tillers plant^{-1}	M	H	L	H	L	L	L	M	L	L	L	H	L	L
No. of ineffective tillers plant^{-1}	L	H	L	H	L	H	L	L	L	H	L	H	L	M
No. of spikelets ear^{-1}	L	L	L	L	L	L	M	H	M	H	L	L	L	L
No. of ears plant^{-1}	M	H	L	L	L	H	L	H	L	L	L	H	L	L
No. of grains ear^{-1}	H	H	H	H	H	H	H	H	H	H	H	H	M	H
No. of grains plant^{-1}	H	H	H	H	H	H	H	L	H	H	H	H	L	H
Ear head length (cm)	L	H	H	L	M	H	L	M	M	H	M	H	L	M
Ear weight(g)	H	H	H	H	H	H	L	L	H	H	L	M	L	H
Peduncle length(cm)	H	H	H	H	M	H	H	H	M	H	M	H	L	H
No. of leaves plant^{-1}	H	H	H	H	H	H	H	H	H	H	H	H	L	M
1000 grain weight (g)	H	H	H	H	H	H	H	H	H	H	H	H	M	H
Biological yield plant^{-1} (g)	H	H	L	L	H	H	L	L	H	H	H	H	L	L
Yield plant^{-1} (g)	H	H	H	H	L	H	H	H	M	H	M	H	M	H
Harvest index (%)	H	H	H	H	M	H	L	M	H	H	L	H	L	M
RWC of flag leaf	H	M	H	M	H	M	H	M	H	M	H	M	H	H
Chlorophyll content	H	M	H	M	H	H	M	M	H	M	H	H	L	H
Canopy temperature	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Sedimentation value (mm)	H	H	H	H	H	H	H	H	H	H	H	H	L	H
Hectoliter weight (g / liter)	H	L	H	L	L	L	H	L	L	L	M	L	L	L
Protein (%)	H	H	H	H	M	L	H	M	H	M	H	M	L	L
Wet gluten (%)	H	H	H	H	H	M	H	H	H	H	H	M	L	M
Starch (%)	H	L	L	L	H	L	L	L	H	L	L	L	L	L
Moisture(%)	L	L	L	L	L	L	L	L	L	L	M	L	L	L

H- High M- Medium L - Low

High heritability accompanied with high genetic advance was indicative of the presence of additive gene effects and the selection for such traits will be rewarding for further improvement.

Yield plant^{-1} reported high heritability coupled with high genetic advance under timely sown (2012 & 2013) and late sown (2013). Similar, findings were reported by, Ajmal et al. (1995), Singh et al. (1999), Ghimirary and Sarkar (2000), El-Shazly et al., (2000), Sharma & Garg (2002), Dwivedi et al., (2002), Sachan and Singh (2003), Shukla and Singh (2004), Bakshi et al., (2008) and Bhoite et al., (2008).

1000 grain weight recorded high heritability estimates coupled with high genetic advance under timely, late and very late conditions during both years (2012 & 2013). Similar findings were reported by the work of Ajmal et al.,(1995), Chaturvedi and Gupta (1995), El-Shazly et al., (2000), Prasad and Pandey (2001), Dwivedi et al., (2002), Sharma & Garg (2002), Kumar et al., (2003), Kumar and Mishra (2004), Sachan & Singh (2003), Cheema et al., (2006), Ahmedab et al., (2007), Manal (2008), Waqar-ul-haq et al., (2008), Eid (2009), Ferdous et al., (2010) Tsegaye and Dessalegn (2012), Hasnath et. al, (2013), Hussain et al., (2013) and Farshadfar and Estehghari (2014), but not in agreement with the results of Porwal et al., (2005), Aycicek and Yildirim (2006), Bakshi et al., (2008), Akcura (2009), Ajmal et al., (2009), Fellahi et al., (2013) and Muhammad et al., (2014).

High heritability coupled with high genetic advance number of grains ear^{-1} under timely, late and very late sown conditions during both the years (2012 & 2013) in the present study were supported by Afiah et al., (2000), El-Shazly et al., (2000), Ghimirary and Sarkar 2000), Singh et al., (2001), Sharma & Garg (2002), Dwivedi et al., (2002), Sachan & Singh (2003), Shukla and Singh (2004), Porwal et al., (2005), Memon et al., (2007), Waqar-ul-haq et al., (2008), Ajmal et al., (2009), Ferdous et al., (2010), Monpara (2011), Baranwal et al., **(**2012), Ali et al., (2013), Hussain et al., (2013), Mishra and Shukla (2013) and Waqasa et al.,

(2014), While, contradictory with the findings of Aycicek and Yildirim (2006), Cheema et al., (2006), Ahmedab et al., (2007), Manal (2008), Eid (2009), Lagari et al. (2010) and Zecevic et al., (2010).

High estimates of heritability coupled with high genetic advance in timely sown (2012 & 2013), late sown (2012) and very late sown (2012 & 2013) conditions for number of grains plant^{-1} in the present study were supported by Monpara (2011).

High heritability coupled with high genetic advance was reported by harvest index under timely sown and very late sown condition of both experimental years (2012 & 2013). Similar findings were advocated by the work of Ferdous et al., (2010) and Muhammad et al., (2014).

High estimate of heritability coupled with high genetic advance for biological yield plant^{-1} were observed in timely sown (2012), late sown (2012) and very late sown (2012 & 2013) conditions, are in agreement with the findings of Sharma et al., (1995), Krishnawat and Sharma (1998), Gupta and Verma (2000), Shukla and Singh (2004), Mishra and Shukla (2013), Farshadfar and Estehghari (2014) and Muhammad et al., (2014) contradictory with findings of Tsegaye and Dessalegn (2012).

Ear weight showed high estimate of heritability along with high genetic advance in timely (2012 & 2013) and late sown (2013) conditions. Similar findings were accompanied by the work of Shukla and Singh (2004), Zecevic et al., (2010), Tsegaye and Dessalegn (2012), Farshadfar and Estehghari (2014) and Waqasa et al., (2014). However, Aycicek and Yildirim (2006) reported low estimate of heritability and low genetic advance for ear weight.

High estimate of heritability and genetic advance were reported by peduncle length in timely sown (2012 & 2013) and late sown (2013) conditions was in agreement with the findings elucidated by Baranwal et al., **(**2012).

Chlorophyll content reported high estimate of heritability and genetic advance in late sown and very late sown conditions (2012 & 2013 respectively), supported by the findings of Barnwal et al., (2012), Farshadfar et al., (2013) and Fellahi et al., (2013). While, this was in contradictory with the findings of Salman et al., (2014), as they reported low estimates for the same.

Protein content recorded high heritability accompanied with high genetic advance under timely sown situations during both the experimental years (2012 & 2013). This result was in agreement with the findings of Prasad and Pandey (2001), but not in conformity with the findings of Akcura (2009) and Tsegaye and Dessalegn (2012), they reported moderate heritability with low genetic advance and El-Shazly et al., (2000) showed low estimate for the trait.

High estimate of heritability and high genetic advance were reported for sedimentation value under all the situations timely, late and very late sown during both the experimental years (2012 & 2013). Similar findings were reported by Prasad and Pandey (2001), Porwal et al., (2005), Mishra and Shukla (2013) and Hokrani et al., (2013) and contradictory by El-Shazly et al., (2000).

Wet gluten % reported high heritability and genetic advance in timely (2012), late (2013) and very late sown (2013) conditions, was in agreement with the findings of Mishra and Shukla (2013).

The moderate estimate of heritability coupled with high genetic advance in very late sown (2012 & 2013) condition was reported for yield plant^{-1}. This result was in conformity with the findings of Mondal et al., (2004), Mondal and Kour (2004), Sahu et al., (2005), Akcura (2009), Jatoi et al., (2012) and Tsegaye and Dessalegn (2012).

The relative water content of flag leaf showed high heritability along with moderate genetic advance under timely, late and very late sown

situations of both the years (2012 & 2013), was in accordance with the findings of Jatoi et al., (2012) and Farshadfar et al., (2013).

In timely sown conditions (2012 & 2013), high heritability with high estimate of genetic advance was reported for harvest index. Similar result was advocated by Farshadfar and Estehghari (2014).

Plant height reported high heritability with moderate genetic advance under timely and late sown conditions of both the experimental year (2012 & 2013). This result was in agreement with the findings of Camargo and Ferreira (1998), Khan et al. (2003), Pawar et al. (2002), Porwal et al., (2005) and Eid (2009) and contradictory with the findings of Afiah et al., (2000) Ghimirary and Sarkar (2000), Kumar et al., (2003), Kumar and Mishra (2004) Aycicek and Yildirim (2006), Ahmedab et al., (2007), Menshawy 2007), Ajmal et al., (2009), Ferdous et al., (2010) and Fellahi et al., (2013)

Moderate heritability with high genetic advance was recorded for ear head length and number of spikelet ear^{-1}. These result were in conformity with the findings of Cheema et al., (2006), Ahmedab et al., (2007), Lagari et al. (2010), Baranwal et al., (2012), Ali et al., (2013), Fellahi et al., (2013), Salman et al., (2014), Farshadfar and Estehghari (2014) and Hussain et al., (2013). Bhoite et al., (2008), Manal (2008), Eid (2009), Tsegaye and Dessalegn (2012) and Hasnath et al, (2013) found dissimilar results under late sown (2012) and very late sown (2012 & 2013) conditions.

The findings of Yadav et al., (2006) and Lagari et al., (2010) confirms this result that peduncle length reported high heritability coupled with moderate genetic advance.

High heritability coupled with low genetic advance was found for days to 50% flowering under all the timely, late and very late sown conditions for both the experimental years. It is indicative of presence of non-additive dominant gene action. The high heritability is being exhibited

due to favorable influence of environment rather than genotype and selection for such trait may not be rewarding.

Other traits reporting low heritability accompanied with low genetic advance, indicates that the traits were highly influenced by environmental effects and further selection for such traits would not be effective.

5.2.8 Promising genotypes for different dates of sowing:-

On the basis of performance of all the genotypes for yield and its contributing traits (number of tillers plant^{-1}, number of effective tillers plant-1, ear weight genotype, number of grains ear-1, number of grains plant-1, 1000 grain weight, biological yield, harvest index, sedimentation value, wet gluten, starch and moisture percentage) the top promising genotypes out 30 genotypes under study has been selected. The genotypes founded suitable for normal sown, late sown and very late sown conditions as well as with major yield contributing traits are presented in table 5.2.1. Whereas, the genotypes reported high quality index, are presented in table 5.2.2.

These findings indicates that due consideration should be given to these varieties for better yield potential at the time of formulation of wheat breeding programme and also for selection of genotypes for these quality attributes genotypes.

Table: 5.2.1 Promising genotypes suitable under different sowing conditions for yield and yield contributing traits.

Traits	Timely sown	Late sown	Very late sown
Number of tillers plant-1	**31ESWYT-118**, HI-1544, **JW-3211**, **HD-2932**, 31ESWYT-127	LOK-1, **HD-2932**, MP-3360/RAJ-4213, PBW-343/CDWR-9563-1, **31ESWYT-118**, 31ESWYT-127	31ESWYT-120, 31ESWYT-131, **JW-3336**
Number of effective tiller plant-1	**JW-3269**, **JW-3211**, **JW-3336**, **31ESWYT-118**, **31ESWYT-134**, 31ESWYT-123	LOK-1, MP-3360/RAJ-4213, **JW-3336, HD-2932**, **31ESWYT-118** , 31ESWYT-126	31ESWYT-131, MP-3324/MP-3092/MP-322, HD-2864, **JW-3336**, 31ESWYT-132, **31ESWYT-134**
Number of spikelet ear-1	**JW-3211**, HD-2864, MP-3349/MP3222, 31ESWYT-132	31ESWYT-131, PBW-343/CDWR-9563-6, 401-136/JW-17-1, **JW-3211**	31ESWYT-134, LOK-1, MP-3359/WH-1092, **JW-3211**
Number of grains ear-1	**JW-3269,** GW-366, 31ESWYT-132	**JW-3269**, **31ESWYT-118** , 401-136/JW-17-1	**JW-3269**, **31ESWYT-118**
Number of grains plant-1	PBW-343/CDWR-9563-6, **PBW-343/CDWR-9563-1**, MP-3349/MP3222, 31ESWYT-120, 31ESWYT-123	MP-3359/WH-1092, MP-3372/NIAW-1395, **PBW-343/CDWR-9563-1**, JW-3211	GW-366, **PBW-343/CDWR-9563-1**, 401-136/JW-17-1, MP-3368/MP-4669
Ear weight	MP-3359/WH-1092, JW-3336, GW-366, MP-3324/MP-3092/MP-322	**JW-3269**, **HD-2932,** 31ESWYT-131, 401-136/JW-17-1, MP-3342/PBW-343/K-9924	**JW-3269**, MP-3342/PBW-343/K-9924 31ESWYT-126 , 31ESWYT-127
1000 grain weight	**31ESWYT-131** , **HD-2932**,31ESWYT-134, HI-1544	**HD-2932,** GW-366, MP-3324/MP-3092/MP-322, **31ESWYT-131**	31ESWYT-125, MP-3342/PBW-343/K-9924, **31ESWYT-131**, 31ESWYT-127
Biological yield plant-1	**31ESWYT-126**, **31ESWYT-118** , 31ESWYT-123, 31ESWYT-134, **MP-3372/NIAW-1395**	31ESWYT-127, 31ESWYT-131, **MP-3372/NIAW-1395,** MP-3368/MP-4669, HD-2864, JW-3269	31ESWYT-107, JW-3211, 31ESWYT-125, **31ESWYT-126,** LOK-1
Harvest index	PBW-343/CDWR-9563-1, **HD-2932** MP-3372/NIAW-1395, 31ESWYT-120	MP-3372/NIAW-1395, PBW-343/CDWR-9563-1, HI-1544, HD-2864	HD-2864, **HD-2932**, 31ESWYT-120 31ESWYT-123, 31ESWYT-125

Table: 5.2.2 Promising genotypes suitable under different sowing conditions for quality traits.

Traits	**Timely sown**	**Late sown**	**Very late sown**
Sedimentation value	MP-3342/PBW-343/K-9924, **MP-3349/MP3222,** JW-3211	**31ESWYT-131,** 401-136/JW-17-1, **MP-3349/MP3222**	31ESWYT-132, **31ESWYT-131,** PBW-343/CDWR-9563-6 MP-3372/NIAW-1395
Hectoliter weight	GW-366, 31ESWYT-132, MP-3349/MP3222	MP-3324/MP-3092/MP-322, PBW-343/CDWR-9563-6, **PBW-343/CDWR-9563-1**	JW-3336, MP-3342/PBW-343/K-9924, **PBW-343/CDWR-9563-1,** GW-366
Protein %	**MP-3342/PBW-343/K-9924** JW-3211, **MP-3349/MP3222** 31ESWYT-126	31ESWYT-131, 31ESWYT-125, **MP-3342/PBW-343/K-9924**	MP-3372/NIAW-1395, MP-3324/MP-3092/MP-322, MP-3368/MP-4669, **MP-3349/MP3222**
Wet gluten %	**MP-3342/PBW-343/K-9924, MP-3349/MP3222** 31ESWYT-126	401-136/JW-17-1, **MP-3349/MP3222,** PBW-343/CDWR-9563-6, 31ESWYT-131	MP-3372/NIAW-1395 **MP-3349/MP3222, MP-3342/PBW-343/K-9924** 31ESWYT-110
Starch%	MP-3360/RAJ-4213 MP-3372/NIAW-1395 PBW-343/CDWR-9563-6 31ESWYT-125 , **31ESWYT-127**	**31ESWYT-127,** MP-3359/WH-1092 MP-3368/MP-4669, 31ESWYT-132 **31ESWYT-134**	**31ESWYT-127,** MP-3342/PBW-343/K-9924, JW-3269 **31ESWYT-134,** 31ESWYT-107 HD-2932
Moisture %	**31ESWYT-107**, 31ESWYT-126 , 31ESWYT-134 , PBW-343/CDWR-9563-6, **HD-2864**	401-136/JW-17-1, **PBW-343/CDWR-9563-1**, MP-3372/NIAW-1395, MP-3342/PBW-343/K-9924 31ESWYT-110, 31ESWYT-121	**PBW-343/CDWR-9563-1 31ESWYT-107**, HI-1544, **HD-2864**

****Bold text showed the common genotypes among all the conditions**

5.3. Correlation analysis:

Correlation studies provide information on the nature and extent of association between any two pairs of metric characters. Correlation between any two traits results due to genotypic and environmental causes. Grain yield is the end product of interactions of many factors known as contributing components hence it is complex trait. Understanding of the interaction of characters among themselves and with the environment has been of great use in the plant breeding. From Correlation studies, it could be possible to bring about genetic up gradation in one character by selection of the other pair.

In general, the genotypic correlation coefficient values were higher than the phenotypic values. This indicated that how much of phenotypic correlation coefficients are influenced by environment. In the present study, all possible pooled correlation coefficient at genotypic and phenotypic levels among 27 traits themselves and with grain yield per plant were estimated. The phenotypic correlation coefficients were discussed here.

In present investigation, the grain yield plant^{-1} was significantly and positively associated with numbers of grains plant^{-1}, harvest index, numbers of effective tillers plant^{-1}, biological yield plant^{-1}, ear weight, numbers of spikelet ear^{-1}, numbers of tillers plant^{-1} and wet gluten %. Relative water content and protein %, showed significant negative association with grain yield.

The above results are in accordance with Wang et al., (1998) for biomass per plant and number of grains per ear. While, Narwal et al., (1999), Patel and Jain (2002), Phadnawis (2003) and Guendouz et al., (2013), reported positive of tillers per plant, spike length and grain per spike with grain yeild. Malik (2005), Mohammed et al., (2011) and Tsegaye and Dessalegn (2012), also reported positive correlation of grain yield with number of tillers per plant, biological yield and harvest index, whereas Jat and Dhakar (2003) reported its positive correlation with effective tillers per plant and spike weight. However, Shukla et al., (2005) showed number of tillers per plant, kernel weight per spike, number of kernel per spike, harvest

index and biological yield have positive association with grain yield. Akram et al., (2008) and Chander and Singh (2008) also reported positive association of grain yield with biological yield and harvest index, whereas positive correlation were also reported by Tripathi et al., (2011) for number of grains per spike and biological yield with grain yield.

However grain yield per plant had negative significant correlation with protein %. These results were in accordance with the results of Prasad and Pandey (2001), Budak and Yildirim (2002), Dhillon et al., (2003), Subhashchandra et al., (2009) and Yagdi and Sozen (2009).

Number of grains ear^{-1} exhibited strong significant positive correlation with ear weight, ear length and relative water content. Chander and Singh (2008) also reported strong positive correlation of number of grains ear^{-1} with ear weight, and supports the present finding. Whereas, strong significant negative correlation of number of grains ear^{-1} with sedimentation value, protein % and wet gluten % were in conformity with the finding of Yagdi and Sozen (2009).

Harvest index reported significant positive association with days to 50 % flowering, number of grains plant^{-1} and starch %. While, it was significantly and negatively associated with biological yield plant^{-1}, sedimentation value and protein %.

Number of effective tillers plant^{-1} reported high significant positive correlation with numbers of ears plant^{-1} and numbers of leafs plant^{-1}, whereas strong significant negative correlation with number of ineffective tillers plant^{-1}

Biological yield plant^{-1} recorded significant positive correlation with number of grains plant^{-1} and strong significant negative with harvest index and relative water content.

Ear weight showed high significant positive association with1000 grain weight, number of grains ear^{-1} and relative water content, whereas high significant negative association with number of grains plant^{-1} and sedimentation value with.

Number of spikelets ear^{-1} exhibited significant positive correlation with days to 50% flowering and days to maturity, however significant negative correlation with numbers of leafs plant^{-1} and starch.

Numbers of tillers plant^{-1} showed high significant positive correlation with numbers of ineffective tillers plant^{-1}, numbers of ears plant^{-1}, numbers of effective tillers plant^{-1} and numbers of leafs plant^{-1}. However, it revealed strong significant negative correlation with canopy temperature.

Relative water content of leaf exhibited significant positive correlation with number of grains ear^{-1}, ear weight, peduncle length, hectoliter weight and starch %. However, it has significant negative correlations with number of grains plant^{-1}, biological yield plant^{-1} and chlorophyll content.

Protein % reported strong significant positive correlation with wet gluten %, sedimentation value, number of leaf plant^{-1} and high significant negative with harvest index and starch %. These findings support the present results of Eslemi et al., (2005), they reported positive correlation of protein % with sedimentation and wet gluten %. Dhillon et al., (2003) also reported high significant positive association of protein % with sedimentation value.

In the present investigation, positive correlation coefficient between any two characters suggested that they can improve simultaneously and improvement in one will automatically improve the other. However, such simultaneous improvement is not possible for those traits which are negatively correlated. Therefore, such traits can be improved by indirect selection.

Most of the quality traits reported negative correlation with grain yield like protein % and wet gluten % indicated the difficulty in simultaneous improvement of these traits. For a more efficient approach towards improvement of grain quality along with yield, selection should be exercised based on quality components i.e. protein content, sedimentation value along with yield and its components, but the negative correlation of yield and its components with protein content made it more complex. The present studies,

therefore, suggest that selection should be based on protein content and sedimentation value along with yield per se

5.4 Path coefficient

The correlation coefficient between characters exhibits the relationship existing between pair of characters. But, a dependent character is an interaction of product of many mutually associated component characters and change in any one component will disturb whole network of cause and effect system.

The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect relationship between the variables. The path coefficient partition the association into direct and indirect effects via other dependent variables. The path coefficient analysis also measure the relative importance of causal factors involved. This is simply standardized regression analysis. Path diagram facilitates the understanding of the nature of cause and effect system. The path analysis suggested by Dewey and Lee (1959) helps to resolve these correlations further and throws more light on the way in which component traits contribute towards specifically identifying important component traits.

In the present investigation path coefficient analysis has been performed at genotypic and phenotypic level taking grain yield as dependent variable. In general genotypic direct and indirect effects were slightly higher in magnitude as compared to phenotypic effects.

In the present study sedimentation value exhibited highest positive direct effect on grain yield plant^{-1}, followed by wet gluten %, hectoliter weight, biological yield plant-^{1}, moisture %, starch %, number of grains ear^{-1}, harvest index and number of tillers plant^{-1}. Direct selection for these traits may rewarded in other words these traits should given importance while practicing selection, aimed at improvement of grain yield in wheat.

Similar results were observed by Chaturvedi and Gupta (1995), Halloli (1997), Uddin et al., (1997), Simane et al., (1998), Narwal et al., (1999), Pochaba and Wegrzyn (2000), Lad et al., (2003), Majumder et al., (2008) Nofouzi et al., (2008), Çifci (2012), Khan and Naqvi (2012) and Khan et al.,

(2013) for number of grains ear^{-1} and number of tillers plant^{-1}. Shah and Deora (2002), Singh and Dwivedi (2002), Mohammad et al., (2005), Gashaw et al., (2007), Chander and Singh (2008), Gohlamin et al., (2010), Khayatnezhad et al., (2010) and Tsegaye et al., (2012) for harvest index and biological yield.

However number of spikelets ear^{-1}, number of grains plant^{-1}, 1000 grain weight, days to 50% flowering, ear head length, days to maturity, plant height, relative water content of flag leaf, canopy temperature, number of ears plant-^{1}, chlorophyll content and protein %, reported direct negative effect on grain yield per plant. Patel and Jain (2002) revealed the above findings for number of spikelets ear^{-1}. Aycicek and Yildirim (2006) and Gashaw et al., (2007) reported for days to 50% flowering. Whereas, Deshmukh et al., (2009), showed sam results for 1000 grain weight and Yagdi (2009) was also reported for plant height.

Majority of indirect effects of various independent traits *via* other traits were extremely low of either signs. There were only few traits (harvest Index, biological yield plant$^{\mathbf{-1}}$, number of grains plant^{-1}, number of tillers plant^{-1}, number of ears plant^{-1} number of grains ear^{-1} and starch %), having high to moderate positive indirect effects.

The number of tillers plant^{-1} exhibited positive indirect effect on grain yield plant^{-1} *via* number of ears plant^{-1}.

Number of grains plant^{-1} exhibited large positive indirect effect on grain yield plant^{-1} *via* other traits were found to be negligible.

Biological yield plant$^{\mathbf{-1}}$ recorded large and positive indirect effect on grain yield plant^{-1} *via* number of grains ear^{-1}, chlorophyll content, ear head length and number of tillers plant$^{\mathbf{-1}}$. These findings are in accordance with Naik (2000) and Chander and Singh (2008).

The harvest Index exerted large positive indirect effect on grain yield plant^{-1} *via* other traits number of grains plant^{-1} and starch %. Similar results were reported by Kumar and Hynshal (1998), Naik (2000) and Majumder et al., (2008).

The study on correlation and path coefficient revealed that the traits number of tillers plant^{-1}, number of grains plant^{-1}, biological yield plant^{-1} and harvest index showed positive and significant correlation with grain yield plant^{-1} as well as they have direct positive effect on grain yield plant^{-1}. Thus these traits might be considered for selecting the high yielding genotypes.

Relative water content of flag leaf being a important physiological trait showed negative indirect effect on grain yield plant^{-1} *via* biological yield plant^{-1}, number of grains plant^{-1}, chlorophyll content and moisture %. This implies that selection for both traits simultaneously was not possible and increasing the relative water content will reduces the grain yield plant^{-1} , while the decreasing its content may help the breeder to increase the grain yield.

Protein % showed negative indirect effect on grain yield plant^{-1} *via* harvest index, starch %, number of tillers plant^{-1}, number of ears plant^{-1} and number of grains ear^{-1}

Wet gluten reported negative and small indirect effect on grain yield plant^{-1} *via* other traits were found to be high in protein %, sedimentation value, canopy temperature and number of spikelets ear^{-1}

Selection for quality trait along with improvement in yield was not an easy task for breeders due to existence of strong negative correlation between grain yield plant^{-1} and the quality traits. Increase in protein and gluten content of wheat will affect the grain yield. As we increase the protein content there may be decrease in grain yield as negative direct effects were exerted by these important quality traits.

5.5 Multiple linear regressions

Multiple regression equations involving various traits combinations were prepared (Table 4.5) to find out relative contribution of these characters to express the total variation in grain yield plant^{-1}. The relative contribution to yield was maximum (98.20 per cent) when number of effective tillers plant^{-1} (X5), number of grains ear^{-1} (X9), number of grains plant^{-1} (X10), ear weight (g) (X12), peduncle length (cm) (X13), number of leaves plant^{-1} (X14), 1000 grain weight (g) (X15), biological yield plant^{-1} (X16), harvest index (X18), chlorophyll content (X20), canopy temperature (X21),

sedimentation value (X22), and protein % (X24) were taken to construct regression equation. However, among the total fifteen equations which were constructed out of these combination of fourteen traits had the most efficient prediction power (98.20 per cent), followed by the combinations of eleven (97.61 per cent) and thirteen traits (98.20 per cent).

It is clear that traits *viz*., number of effective tillers plant^{-1} (X5), number of grains ear^{-1} (X9), number of grains plant^{-1} (X10), ear weight (g) (X12), peduncle length (cm) (X13), number of leaves plant^{-1} (X14), 1000 grain weight (g) (X15), biological yield plant^{-1} (X16), harvest index (X18), chlorophyll content (X20), canopy temperature (X21), sedimentation value (X22), and protein % (X24) were the most patent traits in explaining the variation in grain yield plant^{-1}. The regression analysis revealed that, grain yield plant^{-1} mainly depends on these traits and were the important significant independent variables for gain in variability in grain yield plant^{-1}. The overall results reflect the importance of above mentioned eleven variables in wheat selection for breeding programs. These findings are in accordance with the results obtained by Asseng et al., (2002), Subhani et al., (2000) Leilah and Khateeb (2005) and Ashraf and Mohamed (2014).

Days to 50% flowering, days to maturity, plant height, total number of tillers plant^{-1}, number of spikelets ear^{-1}, number of ears plant^{-1}, ear head length, relative water content of flag leaf, hectoliter weight, starch %, wet gluten and moisture % showed erratic behavior and could not contribute to yield when considered in combination with other traits. The traits *viz.,* exhibited days to maturity, plant height, number of spikelets ear^{-1}, number of ears plant^{-1}, ear head length, relative water content of flag leaf, starch %, and moisture % exhibited negative correlation and negative direct effect with grain yield plant^{-1}. The fourteen traits combinations explained above was the most prominent traits in expressing grain yield plant^{-1}. Path coefficient analysis (Table 4.4.1 & 4.4.2) which also indicated the direct positive effect of traits *viz*., sedimentation value exhibited highest positive direct effect on grain yield plant^{-1}, followed by wet gluten %, hectoliter weight, biological yield plant-^{1}, moisture %, starch %, number of grains ear^{-1}, harvest index and number of tillers plant^{-1} on grain yield plant^{-1}. These traits also recorded high heritability

and high genetic advance as a percentage of mean. This can be supported by visualizing the multiple regeression equation which indicated that whenever these traits were included in the equation, it resulted in increased value of coefficient of determination.

5.5.3 Wheat characteristics identified as crucial in wheat grain yield with each one of the used statistical technique

The multiple statistical procedures which have been used in this study showed that the total number of tillers plant^{-1}, number of spikelet ear^{-1}, number of effective tillers-plant^{-1}, ear weight, number of grains ear^{-1}, number of grains plant^{-1}, 1000 grain weight, biological yield, harvest index, sedimentation value, wet gluten, starch and moisture percentage were considered the most important yield variables in the present study.(table 5.5.3).

Table 5.5.3: Wheat traits identified as crucial in wheat grain yield with each one of the used statistical technique

Traits	Simple correlation	Path coefficient	Multiple regression	Traits	Simple correlation	Path coefficient	Multiple regression
Days to 50% flowering				1000 grain weight g			√
Days to maturity				Biological yield plant^{-1} (g)	√		√
Plant height (cm)				Yield plant^{-1} (g)			
No. of tillers plant^{-1}	√	√		Harvest index (%)	√		√
No. of effective tillers plant^{-1}	√	√	√	RWC of flag leaf			
No. of ineffective tillers plant^{-1}				Chlorophyll content			
No. of spikelets ear^{-1}	√			Canopy temperature			
No. of ears plant^{-1}				Sedimentation value (mm)		√	
No. of grains ear^{-1}		√	√	Hectolitre weight (g / litre)		√	
No. of grains plant^{-1}	√		√	Protein (%)			
Ear head length (cm)				Wet gluten (%)		√	
Ear weight (g)	√		√	Starch (%)		√	
Peduncle length(cm)				Moisture (%)		√	

Thus, high yield of wheat under *Kymore* platue and *Satpura* hills zone of Madhya Pradesh possibly be obtained by selecting breeding materials with high total number of tillers plant^{-1}, more number of effective tillers plant^{-1}, heavy ear weight, high number of grains ear^{-1}, high number of grains plant^{-1}, high 1000 grain weight, more biological yield and harvest index. Along with these major traits selection of some of the important genetic traits might be considered, which were contributing to grain yield are sedimentation value, wet gluten, starch and moisture percentage.

5.6. Stability

Genotype x environment interaction is the major important tool of the plant breeder in developing improved varieties. When varieties are compared over a series of environments for relative ranking usually it differs. This causes difficulties in determining the significant superiority of any variety. This interaction in usually present whether the varieties are pure lines, single cross, double cross hybrids, top crosses or any other material with which the breeder working for reducing G x E interactions. Breeder should select stable genotype that interact less with the environments in which they are to be grown. The genotype should be evaluated by growing it in more number of environments to evaluate stable genotypes which may aided the breeder to select out the suitable genotypes for varying range of environment.

The pooled analysis of variance revealed that the difference among the genotypes were highly significant for all the traits except number of tillers plant^{-1}, number of ineffective tillers plant^{-1}, relative water content of flag leaf, chlorophyll content, canopy temperature and moisture (%).

The genotype x environment interaction showed significant differences for most of the observed traits except days to 50% flowering, days to maturity, plant height, number of effective tillers plant^{-1}, number of spikelets ear^{-1}, number of ear plant^{-1}, ear head length, ear weight, peduncle length, biological yield plant^{-1}, harvest index, canopy temperature, hectoliter weight, starch and moisture (%). Traits reporting high significant genotypes x

environment interactions under study suggested that these characters are highly influenced by the change in the environmental conditions. The above findings are in agreement with the finding of Bangarwa and luthra (1966), Alle and Pathania (2008) and Hakim et al. (2008).

The variance due to environment linear was significantly different for all the traits, indicating the genetic control of response to the environments.

Genotype x environment interaction (linear) was also significant for days to 50% flowering, days to maturity, number of tillers plant^{-1}, number of tillers plant^{-1}, number of ineffective tillers plant^{-1}, number of spikelets ear^{-1}, number of grains ear^{-1}, number of grains plant^{-1}, ear head length (cm), ear weight (g), peduncle length (cm), number of leaves plant^{-1},1000 grain weight (g), biological yield plant^{-1} (g), yield plant^{-1} (g), RWC of flag leaf, chlorophyll content, canopy temperature, sedimentation value (mm), hectoliter weight (g/liter) and protein (%). This indicated the differential response of the genotype to different agro-climate conditions.

Genotypes, 31ESWYT-107, 31ESWYT-110, 31ESWYT-118, 31ESWYT-120, 31ESWYT-121, 31ESWYT-123, 31ESWYT-125, 31ESWYT-126, 31ESWYT-127, 31ESWYT-132, 31ESWYT-134, JW-3336, PBW-343/CDWR-9563-1, MP-3324/MP-3092/MP-322, PBW-343/CDWR-9563-6, MP-3372/NIAW-1395, MP-3368/MP-4669, HI-1544, MP-3349/MP3222, 401-136/JW-17-1, HD-2932, JW-3211, JW-3269, GW-366, MP-3342/PBW-343/K-9924, MP-3359/WH-1092, HD-2864 and MP-3360/RAJ-4213, showed stability for the different traits under the present investigation, with mean value greater than grand mean and regression coefficient lesser than one with minimum deviation from regression.

Eberhart and Russell (1966) stated that stable variety would be one, having high mean yield with near unit regression coefficient (b-1) and deviation from regression as small as possible. Yield stability is genetically controlled, (Scott, 1967) and hence selection for the yield stability will be effective.

Wide variation in mean grain yields of wheat genotypes over six environments or sowing conditions timely, late and very late demonstrated for the two consecutive years (2012 and 2013). Considering the diversity among the test environments, substantial year to year variation was expected and such year to year disparity was also supported by the variation in average national wheat yields not only in India but also in different countries. Many genotypes were higher in grain yield with stable performance under different environments.

In timely sown condition (2012), genotypes 31ESWYT-123, 31ESWYT-126 and 31ESWYT-134 were superior to others, showing higher mean yield and stability. Genotypes, 31ESWYT-123 and 31ESWYT-126 were more superior to others in grain yield in late sown condition (2012) with yield stability. Whereas, in vary late sowing conditions (2012), stability in yield were showed by the genotypes LOK-1, JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123, 31ESWYT-126 and 31ESWYT-132.

In timely sown (2013), genotypes 31ESWYT-123 and 31ESWYT-126 were superior to others, showing high mean yield and stability. Genotypes, 31ESWYT-123, 31ESWYT-126 and 31ESWYT-132 were more superior to others in grain yield for late sown condition (2013) with yield stability. However, in very late sown condition (2013), stable performances in yield were showed by the genotypes JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123 and 31ESWYT-126.

Pooled analysis of variance revealed that genotypes, 31ESWYT-123 and 31ESWYT-126 possessing regression coefficient near unity and also low value of deviation from regression with high mean yield over all the trails for the two years and are considered as stable genotypes. Genotype, 31ESWYT-123 reported stability over all the six environments in grain yield but also in other traits days to maturity and starch %. Stable performance for yield was also recorded in genotype 31ESWYT-126, which also showed stability for number of grains plant^{-1} and ear head length. So the use of such stable genotypes in the hybridization programme will lead to the development of phenotypically stable, wider adaptive and high potential cultivars for the

above important trait and selection of superior genotypes for timely, late and very late conditions, which lead to stabilization in crop production over the years and location.

SUMMARY, CONCLUSIONS AND SUGGESTIONS

FOR FUTURE RESEARCH WORK

6.1. Summary:-

The present investigation entitled “Screening of stable wheat genotypes for morpho-physiological and quality attributes under different environments” was carried out under Wheat Improvement Project at Seed Breeding Farm, Department of Plant Breeding & Genetics, J.N.K.V.V. Jabalpur during *Rabi* season 2012-13 and 2013-14. The experimental material comprised of a collection of 30 promising lines. These genotypes were planted in randomized completely block design with three replications under three different sowing conditions (timely, late and very late sown). This investigation was carried out to estimate the genetic variability, heritability, genetic advance, correlation coefficient, path coefficient, multiple regression and stability analysis between yield and its component traits, to identify the importance of individual character and formulating selection criteria for improvement in yield under different conditions.

Five plants were selected randomly from each replication from each genotype and observations were recorded on 27 characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of tillers plant^{-1}, number of effective tillers plant^{-1}, number of in-effective tillers plant^{-1}, number of spikelets ear^{-1}, number of ears plant^{-1}, number of grains ear^{-1} , number of grains plant^{-1} , ear head length (cm), ear weight (g), peduncle length (cm), number of leaves plant^{-1},1000 grain weight (g), biological yield plant^{-1} (g), yield plant^{-1} (g), harvest index (%), relative water content of flag leaf, chlorophyll content, canopy temperature, sedimentation value (mm), hectoliter weight (g/liter), protein (%), wet gluten (%), starch (%) and moisture (%), as per standard procedure.

The analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all the characters except for number of

effective tillers plant^{-1} under all the sowing conditions (timely, late and very late sown), which revealed that there was considerable genetic variability amongst the material under study.

The values of phenotypic coefficient of variation for all the traits under study were found to be more than genotypic coefficient of variation. High genotypic and phenotypic coefficient of variation were found for number of effective tillers plant^{-1}, number of ineffective tillers plant^{-1} and number of grains plant^{-1}, under timely sown condition (E1), whereas, relative high magnitude of phenotypic and genotypic coefficient of variation for number of in-effective tillers plant^{-1}, number of effective tillers ears^{-1} and number of grains plant^{-1} were recorded under timely sown condition (E4). Under late sown condition (E2), the phenotypic and genotypic coefficient of variation was reported high for number of in-effective tillers plant^{-1}, yield plant^{-1} (g), number of effective tillers plant^{-1}. While, traits *viz.,* number of effective tillers plant^{-1}, number of grains plant^{-1} and number of effective tillers plant^{-1} reported high estimates of phenotypic and genotypic coefficient of variation under late sown (E5). High phenotypic and genotypic coefficients of variation were observed by the traits *viz.,* number of in-effective tillers plant^{-1}, harvest index (%) and number of ears plant^{-1} under very late sown (E3) and by the traits *viz.,* number of effective tillers plant^{-1}, harvest index (%) and number of grains plant^{-1} under very late sown condition (E6). Phenotypic and genotypic coefficient of variation estimates were also found high for the traits *viz.,* number of effective tillers plant^{-1}, number of ineffective tillers plant^{-1}, number of ears plant^{-1} and number of grains plant^{-1} in pooled analysis.

High heritability coupled with high genetic advance (as percentage of mean) were recorded in timely sown condition (E1 & E4) for the traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, ear weight, peduncle length, yield plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, harvest index, sedimentation value, wet gluten, protein and sedimentation value whereas, the biological yield plant^{-1} reported the high estimate only under E1. In late sown condition (E2 & E5), traits *viz.,* number of grains ear^{-1}, ear weight, number of leaves plant^{-1}, 1000 grain weight and sedimentation value reported

high heritability coupled with high genetic advance. However, the traits *viz.*, number of grains plant^{-1}, biological yield plant^{-1} and chlorophyll content reported the same only under late sown (E2) and plant height, peduncle length, yield plant^{-1} and wet gluten in late sown (E5). Number of grains ear^{-1}, number of grains plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, biological yield plant^{-1} and sedimentation value were the traits reported high heritability coupled with high genetic advance under very late sown condition **(**E3 & E6). Whereas, harvest index and wet gluten revealed this estimate under very late sown (E3) and chlorophyll content in very late sown condition (E6).

The pooled correlation was worked out to determine the nature and extent of association between any two pairs of characters. In general, the genotypic correlation coefficient values were higher than the phenotypic values. Grain yield plant^{-1} shared positive significant association with numbers of grains plant^{-1}, harvest index , numbers of effective tillers plant^{-1}, biological yield plant^{-1}, ear weight, numbers of spikelet ear^{-1}, numbers of tillers plant^{-1}. So it could be possible to bring about gene upgradation in one character by selection of the other pair. However, grain yield plant^{-1} reported significant negative association with relative water content, protein % and wet gluten %, this indicates that simultaneous improvement in both the traits were not possible.

Pooled path coefficient analysis revealed that sedimentation value, wet gluten %, hectoliter weight, biological yield plant-^{1}, moisture %, starch %, number of grains ear^{-1}, harvest index and number of tillers plant^{-1}, exhibited high direct positive effect on grain yield plant^{-1}. Whereas, number of grains plant^{-1}, 1000 grain weight, days to 50% flowering, ear head length, days to maturity, plant height, relative water content of flag leaf, and protein % showed direct negative effect on grain yield plant^{-1}. The positive high direct effect of traits on grain yield suggests that selection based on these traits would improve the grain yield.

The multiple regression analysis revealed that, grain yield plant^{-1} mainly depends on traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, ear weight, 1000 grain weight, biological yield plant^{-1} and harvest index. These aforesaid traits contributed significantly towards grain yield plant^{-1} and accounts for major counter part of variability in this dependent trait.

Stability analysis revealed that in timely sowing condition (E1), genotypes 31ESWYT-123, 31ESWYT-126 and 31ESWYT-134, whereas, in timely sown (E4), genotypes 31ESWYT-123 and 31ESWYT-126 were found superior to others in showing high mean yield and stability.

In late sown (E2), genotypes 31ESWYT-123 and 31ESWYT-126 while, in late sown (E5), 31ESWYT-123, 31ESWYT-126 and 31ESWYT-132, were proves their superiority to over others by showing stable performance with high mean grain yield.

Whereas, in vary late sowing conditions (E3), stability in yield were showed by the genotypes LOK-1, JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123, 31ESWYT-126 and 31ESWYT-132. However, in very late sown (E6), stable performances in yield were showed by the genotypes JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123 and 31ESWYT-126.

Genotypes, 31ESWYT-123 and 31ESWYT-126 possessing regression coefficient near unity and also low value of deviation from regression with high mean yield over all the trails for the two years and are considered most stable genotypes in the present study. These genotypes might be released as a variety suitable for wide range of environmental condition besides this, it may be used as donor parent in further breeding programme.

6.2 Conclusion

1. Higher magnitude of PCV and GCV were observed for traits *viz.,* number of in-effective tillers plant^{-1}, harvest index (%) and number of grains plant^{-1} in all the situations of sowing. Thus the above characters were given due importance.

2. High heritability coupled with high genetic advance as percentage of mean was observed for number of grains plant^{-1} number of grains ear^{-1}, 1000 grain weight sedimentation value and number of leaves plant^{-1}, under all the planting situations. This indicates, contribution of additive genetic variation and attention should be required at time of selection.

3. Highly significant genotypes x environment intractions were observed for all the character under study, suggesting that these characters are highly influenced by the change in the environmental conditions.

4. The genotypes MP-3372/NIAW-1395, PBW-343/CDWR-9563-1, JW-3269, JW-3336 , 31ESWYT-118 and HD-2932, were found promising for timely sowing whereas, genotypes LOK-1, HD-2932, JW-3336, PBW-343/CDWR-9563-1, MP-3372/NIAW-1395, and JW-3269 were emerging for late sown and LOK-1, HD-2932, JW-3336, 31ESWYT-126 and PBW-343/CDWR-9563-1 under very late sown condition respectively. The performance of genotypes PBW-343/CDWR-9563-1, HD-2932, MP-3372/NIAW-1395, and JW 3269 were found promising over all the planting situations. The above findings indicates that due consideration should be given to above genotypes for better yield potential at the time of formation of sowing programme of wheat.

5. Grain yield plant^{-1} exhibited positive significant association with numbers of grains plant^{-1}, harvest index, numbers of effective tillers plant^{-1}, biological yield plant^{-1}, ear weight, numbers of spikelet ear^{-1} and numbers of tillers plant^{-1}. Improvement in one trait by selection of the other pair will also improve the yield.

6. Path coefficient analysis revealed that sedimentation value, wet gluten %, hectoliter weight, biological yield plant-^{1}, moisture %, starch %, number of grains ear^{-1}, harvest index and number of tillers plant^{-1}, exhibited high direct positive effect on grain yield plant^{-1} were the main yield contributing traits, so it should be given more emphasis.

7. Multiple regression analysis revealed that, variability in grain yield plant^{-1} were mainly contributed by the traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, ear weight, 1000 grain weight, biological yield plant^{-1} and harvest index.

8. Genotypes, 31ESWYT-123 and 31ESWYT-126 showed regression coefficient near unity and low value of deviation from regression with high mean yield over all the environments for the two consecutive years and are considered as stable genotypes with wider adaptability.

9. The promising genotypes *viz*., MP-3349/MP3222, MP-3342/PBW-343/K-9924, PBW-343/CDWR-9563-1, 31ESWYT-107, 31ESWYT-127, 31ESWYT-131, and 31ESWYT-134 were identified for quality traits.

6.3. Suggestions for Further Work

1. More number of genotypes of diverse origin of indigenous collections may be included for screening under high temperature conditions.

2. The desirable and stable genotypes identified for physiological and economic traits under high temperature conditions should be involved in further breeding programmes.

3. The important identified traits should find place while breeding for such conditions to obtain desirable progress.

4. Physiological traits like membrane thermo-stability, stomata conductance, leaf water potential and floret percentage should be included in further studies on these aspects.

5. More number of quality traits *viz*., beta carotene, chapatti making quality, alveo-gram index and doughing period should be included for future quality study.

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APPENDIX I

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant^{-1}	No. of effective tillers plant^{-1}	No. of ineffective tillers plant^{-1}	No. of spikelets ear^{-1}	No. of ears plant^{-1}	No. of grains ear^{-1}	No. of grains plant^{-1}	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant^{-1}	1000 grain weight (g)	Biological yield plant^{-1} (g)	Yield plant^{-1} (g)
JW-3269	61	125	100.1	9.07	7.4	1.67	17.13	8.7	67.3	425.27	10.77	3.1	22.83	37.67	46.1	46.353	16.65
GW-366	64	119	90.43	10.1	6.03	4.07	14.87	7.13	66	377.9	8.767	3.5	18.4	31.3	42.46	35.493	15.12
LOK-1	62	127	93.5	8.9	4.23	4.67	17.33	6.5	47.53	395.4	8.567	2.01	17	42.57	42.41	36.837	13.34
JW-3211	58	125.33	95.3	10	6.93	3.1	19.73	8.57	56.13	322.27	8.767	2.55	24.53	31.4	42.68	34.63	12.27
JW-3336	60	122	79.17	9.3	3.4	5.9	15.8	4.2	54.07	337.13	8.3	2.45	16.33	28.47	44.74	34.44	11.35
HD-2864	61.67	126	91.9	5.53	2.6	2.93	18.8	2.73	41.5	204.03	10.83	2.1	22.53	27.4	48.86	25.89	10.86
HD-2932	66.67	125	98.63	10	5.77	4.27	16.57	7.8	56.4	203.1	9.567	3.13	23.87	37.53	49.29	23.713	11.21
HI-1544	67	123.67	92.87	10.3	3.8	6.47	17.93	6.53	57.13	311.7	9.4	2.17	18.53	24.5	37.29	28.323	9.497
MP-3324/MP-3092/MP-322	68	121	102.8	9.53	4.8	4.73	19.53	6.3	58.93	355.37	13.21	2.96	20.07	27.23	48.08	31.403	11.19
401-136/JW-17-1	68	124.67	105	7.77	4.23	3.53	17.67	5.13	56.73	376.6	11.4	2.15	27.33	25.53	37.76	42.817	14.43
PBW343/CDWR9563-1	68.67	120.33	95.23	9.43	4.13	5.3	17.67	6.67	54.87	493.5	8.467	2.23	19.57	41.6	40.66	36.96	19.02
MP3349/MP-3222	66	119.67	94.47	8.83	5.07	3.77	17.4	6.37	51.9	427.47	9.2	2.17	18.47	30.33	41.61	39.213	13
MP-3342/PBW-343/K-9924	67.33	116.67	105.4	7.57	4.73	2.83	15	5.5	45.67	304.57	9.433	2.81	26.67	22.63	41.99	39.26	11.52
PBW-343/CDWR-9563-6	67.33	114.67	91.47	7.47	4.37	3.1	17.13	5.43	50.73	495.93	7.7	1.79	22.3	34.27	38.21	44.87	13.97
MP-3368/MP-4669	67.33	120	97.53	9.77	6.47	3.3	17.67	7.73	46.33	424.63	8.433	1.48	20.73	29.3	46.2	45.163	15.8
MP-3359/WH1092	66.33	121.67	103.5	9.7	6.4	3.3	17.53	7.3	64.37	370.67	11.22	2.99	19.77	30.3	46.45	44.663	16.51
MP-3372/NIAW-1395	67.33	118.67	102.9	9.33	5.93	3.4	17.67	6.93	53.43	422.53	8.667	2.01	20.2	27.43	37.72	48.58	18.61
MP-3360/RAJ-4213	69.33	126	96.17	9.17	5.33	3.83	17.27	6.73	51.8	322.47	8.733	1.93	23.43	38.47	41.13	37.25	13.09
31ESWYT-118	69	128.33	101.6	10.3	4.57	5.77	18.53	7.6	61.93	273.57	9.6	2.94	21.03	26.47	48.13	38.453	13.25
31ESWYT-107	65	119	102.7	9.17	3.77	5.4	15.67	4.93	48.4	386.73	8.493	2.02	24.4	36.8	41.72	42.29	14.33
31ESWYT-110	65.67	118	91.87	8.57	4.47	4.1	18.47	5.87	47.1	250.7	10.1	1.99	16.6	20.53	38.92	33.397	10.15
31ESWYT-120	64.67	116	101.2	8.07	4.53	3.53	18.47	5.2	53.87	428.4	10	2.48	19.1	23.53	46.06	39.457	16.9
31ESWYT-121	65	122.33	99.8	8.77	6	2.77	17.8	6.27	54.5	345.87	9.5	2.8	15.67	27.63	45.69	38.02	15.17
31ESWYT-123	68.33	123	96.67	6.43	4.2	2.23	17	4.83	41.03	435.23	9.293	1.89	19.87	29.6	41.88	49.393	14.92
31ESWYT-125	63.67	124	97.33	7.7	5.63	2.07	17.4	6.1	52.3	253.8	10.43	2.1	17.83	28.33	42.47	30.3	11.09
31ESWYT-126	69.33	126.67	104	9	6.93	2.07	18.07	7.43	41.57	357.13	10.29	1.98	22.23	28.37	47.45	49.55	14.02
31ESWYT-127	66	129.67	96.6	8.53	6	2.53	18.2	6.8	61.9	342.5	11.43	2.9	17.2	29.5	40.1	46.617	14.14
31ESWYT-131	65.33	124.67	97.57	8.27	5.77	2.5	17.4	6.13	49.97	362.27	11.57	2.57	17.57	31.1	51.39	43.683	14.66
31ESWYT-132	67	113.33	102.3	7.47	5.03	2.43	18.87	5.67	65.2	253.23	10.59	2.55	18.07	33.47	36.76	36.517	9.337
31ESWYT-134	65	117	96.67	9.53	7.13	2.4	16.87	7.8	44.6	277.27	8.433	2.24	21.43	33.2	48.87	47.397	14.34
Mean	**65.67**	**121.94**	**97.49**	**8.79**	**5.19**	**3.6**	**17.51**	**6.36**	**53.44**	**351.24**	**9.705**	**2.4**	**20.45**	**30.55**	**43.44**	**39.031**	**13.66**

(continue….)

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	35.93	80.82	46.77	22.23	33.87	77.67	12.67	26.4	68.53	7.57
GW-366	42.64	75.37	53.1	21.7	23.43	83.33	12.13	22.93	69.33	7.67
LOK-1	36.18	74.73	52.9	21.9	26.87	80	11.57	24.17	70.03	7.23
JW-3211	35.47	77.61	48.6	20.43	45.33	78.33	13.03	31.77	67.6	7.6
JW-3336	32.91	85.63	47.17	22.4	27.7	81	11.6	28.67	70.2	7.37
HD-2864	42.28	92.3	44.73	22.83	25.43	79.33	11.27	23.47	69.17	7.3
HD-2932	47.28	85.04	45.17	22.37	27.53	80.33	11.4	27.4	68.27	7.1
HI-1544	33.69	85.29	47.73	22.4	31.3	81	11.5	27.4	69.97	7.6
MP-3324/MP-3092/MP-322	35.58	84.62	41.83	22.1	32.5	74.67	12.27	30.93	69.33	7.57
401-136/JW-17-1	33.7	86.69	47.43	23.27	35.27	76	12.13	30.7	68.87	7.43
PBW343/CDWR9563-1	51.39	81.76	47.2	21.27	37.27	76.67	12.6	30.2	68.7	7.23
MP3349/MP-3222	33.23	81.65	52.47	21.93	48.87	82	14.13	34.7	68.4	7.13
MP-3342/PBW-343/K-9924	29.34	85.14	46.67	22.57	52.63	75	14.23	35.2	69.73	7.53
PBW-343/CDWR-9563-6	31.17	88.11	48.57	21.6	39.37	81	12.8	31.5	68.8	7.13
MP-3368/MP-4669	34.98	75.35	44.33	22.7	32.87	77	11.73	28.07	69.67	7.37
MP-3359/WH1092	36.97	76.09	46.27	21.93	28.8	75.33	11.37	28.2	65.53	7
MP-3372/NIAW-1395	38.3	81.58	47.67	22.57	32.03	80.33	11.47	27	68.2	7.4
MP-3360/RAJ-4213	34.99	88.63	46.4	22.7	33.7	79.33	12.23	28.47	70.5	7.27
31ESWYT-118	34.43	90.59	38.33	22.7	26.4	80.67	11.13	26.8	68.3	7.23
31ESWYT-107	33.86	86.6	49.57	23.17	31.63	81.33	11.23	28.5	69.5	6.83
31ESWYT-110	30.33	71.99	48.93	22.1	35	77.67	11.73	28.13	66.2	7.5
31ESWYT-120	43.04	88.62	48.37	21.93	30.03	79.33	10.4	24.8	68.4	7.5
31ESWYT-121	39.85	80.89	51.8	22.3	30.47	73	11.53	27.4	67.33	7.03
31ESWYT-123	30.23	72.15	46.37	23.73	35.2	74.67	12.5	29.4	68.93	7.3
31ESWYT-125	36.67	78.68	49.67	21.93	26.7	74.67	10.07	22.73	70.17	7.03
31ESWYT-126	28.3	80.77	44.33	23.33	43.37	74.67	13.3	33.57	67.5	6.97
31ESWYT-127	30.32	86.13	46.77	21.83	28.3	75.33	11.77	27.9	69.57	7.07
31ESWYT-131	33.58	81.08	48.67	22.33	35.6	78	12.33	29.03	65.17	7.03
31ESWYT-132	25.59	84.46	49.8	23	31.33	82.67	11.63	25.63	68.27	7.2
31ESWYT-134	30.27	87.45	47.67	23.2	30.47	80.33	10.67	24.8	67.73	7
Mean	**35.42**	**82.53**	**47.51**	**22.35**	**33.31**	**78.36**	**11.95**	**28.2**	**68.6**	**7.27**

APPENDIX II

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant^{-1}	No. of effective tillers plant^{-1}	No. of ineffective tillers plant^{-1}	No. of spikelets ear^{-1}	No. of ears plant^{-1}	No. of grains ear^{-1}	No. of grains plant^{-1}	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant^{-1}	1000 grain weight (g)	Biological yield plant^{-1} (g)	Yield plant^{-1} (g)
JW-3269	62	111.33	99	7.33	5.4	1.93	14.37	5.83	58.6	376.73	10.97	2.43	20.73	22	41.37	44.53	15.12
GW-366	66.33	109.33	95.87	7.77	4.63	3.13	15.63	6.27	37.97	225.47	8.867	1.84	17.6	27.93	48.32	35.63	14.37
LOK-1	65.33	108.33	98.87	9.47	7.33	2.13	13.97	7.97	37.2	253.77	10.15	1.57	14.07	30.07	42.19	37.4	10.54
JW-3211	69.33	113	97.13	8.03	6.03	2	18.53	6.53	47.93	413.03	9.8	2.14	16.5	17.2	44.58	36.49	11.24
JW-3336	62	115	84.9	6.43	6.17	0.27	13.17	6.37	33.6	276.97	9.88	1.36	15.73	25.33	40.6	30.36	10.2
HD-2864	62.33	107	93.2	8.13	4.97	3.17	14.07	6.17	43.63	282.63	8.433	1.9	12.83	24.4	43.58	39.48	14.07
HD-2932	68	108.67	99.13	7.77	6.1	1.67	16.03	6.27	47.47	242.63	9.633	2.18	19.9	36.83	45.95	38.4	12.92
HI-1544	64.33	106	97.6	7.93	6.13	1.8	14.57	6.43	41.03	310.4	8.933	1.52	14.57	18.2	37.08	26.65	11.19
MP-3324/MP-3092/MP-322	69	119	97.63	7.97	5.83	2.13	18.43	6.47	46.13	212.83	10.37	2.13	16.9	23.9	46.07	37.46	9.007
401-136/JW-17-1	71	114	101.8	7.2	4.7	2.5	18	5.23	49.73	224.6	10.27	1.93	21.17	23.3	38.76	31.28	11.49
PBW343/CDWR9563-1	69	116	98.27	8.53	5.23	3.3	12.93	6.27	43.87	353.67	9.333	1.58	18.27	28	35.99	38.38	17.86
MP3349/MP-3222	67.67	112	94.47	7.8	5.07	2.73	15.2	5.53	45.9	317.03	10.5	2.01	13.87	25.43	43.84	34.51	9.14
MP-3342/PBW-343/K-9924	62	114.33	97.13	6.3	3.57	2.73	14.17	4.03	48.4	207.2	9.633	1.97	25.93	16.23	40.59	21.62	8.753
PBW-343/CDWR-9563-6	65.67	112.33	100.6	6.6	4.13	2.47	20.2	4.33	40	256.33	7.4	1.7	19.7	21	42.17	31.27	10.38
MP-3368/MP-4669	68.33	114.67	96.8	7.4	4.13	3.27	17.53	5.13	41.8	352.37	8.667	1.22	17.1	22.9	29.24	34.09	14.78
MP-3359/WH1092	62.67	117	97.33	8.17	5.4	2.77	16.33	5.9	40.27	476.37	7.8	1.63	18.83	23.47	40.48	32.74	13.61
MP-3372/NIAW-1395	69.67	114.67	100.7	7.87	6.1	1.77	15.77	6.53	45.63	417.07	10.33	1.73	18.03	21.87	37.97	31.81	16.44
MP-3360/RAJ-4213	68.33	116	97.67	9.1	7	2.1	17.07	7.77	44.6	227.33	8.933	1.73	19.9	22.83	38.84	32.86	7.947
31ESWYT-118	67.33	112.67	98.93	6.8	5.27	1.53	14.7	5.47	51.13	324.07	13.47	2.08	17.6	22	40.64	34.65	9.927
31ESWYT-107	65.67	115	97.43	7.93	6	1.93	17.43	6.73	41.67	334.4	7.6	1.63	20.03	16.73	39.17	29.06	11.13
31ESWYT-110	68	113	98.47	7.33	5.3	2.03	15.17	6	42.67	345.4	9.133	1.94	15.97	16.97	45.42	37.07	7.343
31ESWYT-120	67.67	117.33	100.3	7.93	5.33	2.6	16.47	5.87	47.9	337.57	8.5	1.92	18.23	21.67	39.99	30.99	12.45
31ESWYT-121	67.67	120.33	100.3	7	5.3	1.7	17.47	5.67	41.87	272.03	8	1.62	14.97	26.3	38.79	32.88	8.507
31ESWYT-123	67.33	115	98.7	6.8	4.9	1.9	15.13	5.47	45.6	307.5	10.4	1.36	18.9	19.23	31.25	35.15	11.7
31ESWYT-125	66	109	94.07	7.1	5.07	2.03	16	5.77	43.43	205.1	8.4	1.9	16.57	23.17	43.77	36.05	8.417
31ESWYT-126	66.67	107	94.87	8.2	6.77	1.43	14.9	7	44.4	322	10.13	1.81	20.4	26.93	40.86	37.62	11.92
31ESWYT-127	67	122	97.4	7.33	5.5	1.83	15.77	6	46.43	325.9	9.833	1.7	14.4	25.6	40.5	45.49	12.34
31ESWYT-131	71.33	127	102.2	7.93	6.43	1.5	20.83	6.9	40.8	303.33	11.6	2.16	16.33	26.67	52.87	41.76	10.86
31ESWYT-132	67.67	115	102.3	7.3	5.07	2.23	17.97	5.97	46.6	197.8	9.567	1.6	15.63	25.47	34.29	36.56	8.48
31ESWYT-134	66.33	113	96.87	7.63	5.8	1.83	16.87	6.3	44.7	387.9	9.467	1.67	19.17	26.3	37.25	33.77	10.32
Mean	**66.72**	**113.83**	**97.67**	**7.64**	**5.49**	**2.15**	**16.16**	**6.07**	**44.37**	**302.98**	**9.533**	**1.8**	**17.66**	**23.6**	**40.75**	**34.87**	**11.41**

(continue….)

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	33.97	79.22	44.87	23.07	27.1	75	10.2	19.57	67.17	6.77
GW-366	40.32	73.81	51.27	22.07	24.4	76	10.53	20.23	67.07	7.33
LOK-1	28.2	73.16	51.07	23.37	23.17	77.67	10.67	23.37	64.33	7.27
JW-3211	30.79	76.04	48.3	21.17	30.7	74	10.73	26.8	67.87	6.9
JW-3336	33.55	84.26	45.53	22.9	25.9	79	11.2	24.6	67.9	7
HD-2864	35.64	90.6	42.17	23.53	28.8	76.67	10.3	28.03	66.5	7.37
HD-2932	33.57	83.28	42.53	22.53	27.53	77.33	11.27	26.1	67.8	6.8
HI-1544	41.83	83.39	45.57	22.33	33.23	77	11.33	28.4	67.37	7.1
MP-3324/MP-3092/MP-322	24.06	82.62	39.57	22.93	26.43	77	10.7	23.8	63.23	7.5
401-136/JW-17-1	36.78	84.63	45.1	24.5	36.07	79	10.87	30.4	65.23	6.53
PBW343/CDWR9563-1	46.54	79.66	44.83	22.1	27.73	80	10.57	23.6	67.4	6.3
MP3349/MP-3222	26.47	79.75	50.3	22.27	34.93	80.33	12.2	29.13	64.57	7.3
MP-3342/PBW-343/K-9924	40.62	83.41	44.93	22.7	28.1	74.67	11.43	26.97	63.47	6.87
PBW-343/CDWR-9563-6	33.23	86.54	46.43	22.47	27.47	81	11.5	29	66.53	6.6
MP-3368/MP-4669	43.43	73.68	42.4	22.6	30.9	77.67	10.53	24.13	68.4	6.77
MP-3359/WH1092	41.52	74.36	44.27	22.8	26.9	78.67	10.07	24.57	68.7	6.5
MP-3372/NIAW-1395	51.72	79.9	45.7	23	29.3	73.67	10.3	22.03	65.23	6.43
MP-3360/RAJ-4213	24.21	87.47	45.07	22.97	32.3	75.33	10.93	26.5	65.17	6.83
31ESWYT-118	28.66	88.78	36.23	22.97	25	80	10	21.67	67.4	7.3
31ESWYT-107	38.44	84.27	46.97	22.13	30.53	76	10.37	23.73	68.13	7.07
31ESWYT-110	19.81	69.99	46.67	22.9	31.57	79.67	10.47	24.6	64.8	6.17
31ESWYT-120	40.20	86.75	46.23	23.53	27.2	73.67	9.667	23.57	63.7	7.13
31ESWYT-121	25.66	78.92	48.43	23.57	27.13	75	10.13	22.63	67.2	7.13
31ESWYT-123	33.32	69.88	44.03	24.6	28.27	73	10.6	24.1	65.7	7.5
31ESWYT-125	23.64	77.18	47.6	22.67	27.03	73.33	11.43	27.63	66.77	6.77
31ESWYT-126	31.62	79.07	42.37	24.07	25.47	74.33	10.37	22.67	67.5	6.73
31ESWYT-127	27.13	84.4	44.47	22.4	23.03	76	9.7	21	68.8	6.63
31ESWYT-131	25.96	79.38	46.9	23.1	36.07	73.67	12.37	28.53	63.2	7.43
31ESWYT-132	23.18	82.83	47.9	23.73	29.5	75	10.4	21.5	65.27	6.73
31ESWYT-134	30.61	85.55	45.5	24	26.47	76	9.7	20.13	65.53	6.8
Mean	**33.15**	**80.76**	**45.44**	**22.97**	**28.61**	**76.52**	**10.68**	**24.63**	**66.26**	**6.92**

APPENDIX III

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant-1	No. of effective tillers plant-1	No. of ineffective tillers plant-1	No. of spikelets ear-1	No. of ears plant-1	No. of grains ear-1	No. of grains plant-1	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant-1	1000 grain weight g	Biological yield plant-1 (g)	Yield plant-1 (g)
JW-3269	58.00	96.33	73.50	6.76	3.63	3.13	16.20	5.36	48.60	208.96	10.96	1.81	15.40	16.60	37.25	24.53	8.85
GW-366	61.00	95.00	71.83	4.13	3.20	0.93	15.13	4.03	27.96	398.03	8.86	1.02	16.73	9.06	36.41	25.76	9.50
LOK-1	58.33	95.00	76.37	4.20	3.36	0.83	16.00	4.00	27.20	234.00	10.15	0.86	12.20	8.53	31.96	37.40	8.17
JW-3211	64.33	102.00	68.80	5.40	3.93	1.46	18.26	5.36	37.93	202.60	9.80	1.043	14.06	14.26	27.60	35.60	8.89
JW-3336	60.33	101.00	73.33	7.36	4.33	3.03	15.20	7.33	23.60	232.33	9.88	0.86	14.26	21.66	36.37	20.36	8.63
HD-2864	56.66	97.00	73.10	5.60	4.43	1.16	16.46	5.23	33.63	238.13	8.43	1.01	12.56	20.26	30.21	19.48	8.61
HD-2932	61.00	96.00	76.70	5.06	3.20	1.86	17.40	4.56	37.46	266.40	9.63	1.34	14.66	16.03	35.94	18.40	7.93
HI-1544	58.67	97.67	74.50	5.60	4.06	1.53	15.40	5.46	31.03	291.33	8.93	0.79	11.16	17.16	25.58	27.91	6.69
MP-3324/MP-3092/MP-322	60.33	99.33	78.43	6.83	4.53	2.30	16.73	5.96	36.13	208.16	10.36	1.05	13.40	18.56	29.04	27.46	7.94
401-136/JW-17-1	65.00	102.00	82.73	4.23	3.23	1.00	16.06	4.06	39.73	366.43	10.26	1.01	12.20	12.96	25.50	21.28	8.35
PBW343/CDWR9563-1	61.33	95.67	87.30	4.90	3.00	1.90	17.53	4.43	33.86	337.16	9.33	0.97	15.23	10.43	28.76	26.37	10.21
MP3349/MP-3222	59.33	97.00	76.20	2.50	1.83	0.66	16.33	2.46	35.90	202.10	10.50	1.11	10.93	6.30	30.93	24.51	8.37
MP-3342/PBW-343/K-9924	55.33	95.00	80.60	3.56	2.70	0.86	17.80	3.20	38.40	154.23	9.63	1.57	17.26	9.83	40.92	22.01	8.09
PBW-343/CDWR-9563-6	57.33	98.00	89.50	6.63	3.33	3.30	14.06	5.56	30.00	126.36	7.40	1.10	17.13	17.43	36.71	21.27	5.77
MP-3368/MP-4669	59.34	98.6667	81.20	4.46	2.73	1.73	17.26	3.83	31.80	363.70	8.66	0.89	14.13	13.96	28.10	24.08	7.60
MP-3359/WH1092	60.00	93.00	78.03	5.16	3.36	1.80	18.33	5.13	30.26	297.60	7.80	0.98	13.86	21.03	32.41	22.73	8.76
MP-3372/NIAW-1395	60.00	92.00	76.37	6.93	4.06	2.86	16.73	5.30	35.63	284.43	10.33	1.04	13.06	20.80	29.25	21.81	8.55
MP-3360/RAJ-4213	59.00	93.00	79.43	5.30	4.43	0.86	16.86	5.10	34.60	158.86	8.93	0.94	13.06	15.56	27.30	12.86	4.26
31ESWYT-118	60.00	94.33	78.10	5.70	3.00	2.70	15.00	5.16	41.13	176.90	13.46	1.41	14.73	20.26	34.29	14.65	5.84
31ESWYT-107	64.00	97.33	75.10	6.03	3.36	2.66	15.30	5.90	31.66	256.80	7.60	0.97	16.26	14.63	30.61	29.06	7.55
31ESWYT-110	60.33	91.00	76.96	6.30	3.80	2.50	17.40	5.86	32.66	313.46	9.13	1.15	14.66	13.56	35.29	27.07	7.48
31ESWYT-120	65.00	96.67	76.13	7.10	4.26	2.83	17.13	6.93	37.90	244.30	8.50	1.10	14.86	17.60	29.03	20.99	7.23
31ESWYT-121	65.66	103.33	77.33	5.46	4.46	1.00	16.60	5.36	31.86	195.46	8.00	0.96	11.86	14.80	30.31	13.21	5.55
31ESWYT-123	68.00	106.67	76.43	2.73	2.06	0.66	16.73	2.36	35.60	337.67	10.40	1.11	14.06	9.83	29.86	15.15	9.82
31ESWYT-125	59.00	99.00	76.80	3.80	3.16	0.63	15.66	3.73	33.43	125.16	8.40	1.37	14.60	13.76	41.21	38.38	5.52
31ESWYT-126	61.66	103.00	78.10	4.93	3.70	1.23	17.80	4.86	34.40	276.73	10.13	1.20	14.66	17.56	35.05	37.72	9.38
31ESWYT-127	64.00	102.00	78.10	4.70	3.56	1.13	16.20	4.66	36.43	182.23	9.83	1.47	12.30	18.76	36.59	25.48	7.99
31ESWYT-131	66.00	109.33	76.86	7.36	5.53	1.83	15.93	7.26	30.80	129.36	11.60	1.22	11.86	22.26	39.55	21.76	5.35
31ESWYT-132	67.33	103.33	82.76	4.33	3.46	0.86	17.26	4.26	36.60	274.03	9.56	1.06	12.00	14.23	28.84	26.55	6.02
31ESWYT-134	64.00	105.00	84.23	2.93	2.16	0.76	18.46	2.86	34.70	287.70	9.46	1.22	12.53	9.46	35.38	23.65	9.63
Mean	**61.34**	**98.48**	**77.82**	**5.20**	**3.53**	**1.67**	**16.57**	**4.85**	**34.36**	**245.69**	**9.53**	**1.12**	**13.86**	**15.24**	**32.54**	**24.25**	**7.75**

Contd.....

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	36.06	76.72	40.23	30.10	45.36	72.33	13.50	30.80	67.16	6.83
GW-366	37.15	70.28	40.83	28.86	45.43	75.00	13.86	30.43	66.60	7.60
LOK-1	21.96	70.26	35.43	30.96	46.00	72.67	13.50	33.66	63.93	7.03
JW-3211	24.97	71.82	33.26	30.30	52.86	71.67	15.26	37.06	57.23	6.76
JW-3336	42.29	80.62	37.53	30.96	52.60	76.33	15.20	36.10	66.26	7.00
HD-2864	44.34	88.10	40.10	30.50	48.00	72.00	14.13	34.13	63.56	6.86
HD-2932	43.20	79.36	36.03	31.13	43.33	72.67	12.66	33.46	65.20	6.40
HI-1544	23.85	80.78	43.13	31.20	50.00	71.66	14.00	34.70	63.20	6.53
MP-3324/MP-3092/MP-322	29.00	78.02	41.43	29.46	51.20	70.66	14.90	35.83	63.36	7.00
401-136/JW-17-1	39.64	79.93	34.46	30.16	49.63	71.33	14.43	35.80	62.53	6.90
PBW343/CDWR9563-1	38.66	74.99	34.30	29.46	44.73	75.33	13.56	34.83	66.80	5.76
MP3349/MP-3222	33.96	77.98	46.93	31.43	51.16	70.66	15.86	38.73	64.50	7.40
MP-3342/PBW-343/K-9924	36.72	81.57	41.06	31.66	46.96	75.66	12.93	34.46	67.20	7.23
PBW-343/CDWR-9563-6	26.94	84.31	37.53	31.06	53.76	75.06	14.10	35.56	65.40	7.53
MP-3368/MP-4669	31.10	71.43	40.56	31.33	52.53	72.33	15.43	37.76	60.40	7.13
MP-3359/WH1092	38.73	71.86	46.50	29.53	48.36	74.66	14.46	35.83	64.36	7.06
MP-3372/NIAW-1395	39.09	77.31	22.40	30.30	33.23	72.00	15.96	39.20	62.76	7.13
MP-3360/RAJ-4213	33.13	84.84	34.10	30.06	52.36	71.66	15.03	36.53	63.80	7.13
31ESWYT-118	39.91	86.27	42.46	30.07	51.00	72.00	13.73	36.23	65.36	6.80
31ESWYT-107	26.04	82.35	40.46	29.60	51.66	73.33	15.16	36.50	66.20	6.33
31ESWYT-110	27.66	67.44	32.70	30.46	52.33	72.33	15.13	38.73	62.26	6.50
31ESWYT-120	34.42	84.12	40.56	30.93	44.53	75.66	13.23	32.56	64.80	7.50
31ESWYT-121	42.26	76.30	22.43	31.06	52.50	71.00	15.13	36.83	64.60	7.43
31ESWYT-123	65.37	67.29	36.20	30.93	51.36	73.00	14.23	34.60	64.86	7.86
31ESWYT-125	14.41	74.59	34.50	31.26	52.00	74.00	14.50	35.40	63.20	7.26
31ESWYT-126	24.89	76.96	38.80	30.73	53.03	73.00	14.26	35.70	66.93	7.13
31ESWYT-127	31.25	82.15	35.30	31.23	52.33	73.33	13.43	34.76	67.20	7.93
31ESWYT-131	24.70	76.67	24.30	29.86	54.23	72.00	15.06	34.00	62.50	7.80
31ESWYT-132	22.90	80.75	34.66	30.83	55.13	73.66	14.96	35.23	62.80	7.56
31ESWYT-134	40.81	83.05	37.10	30.60	44.86	75.33	14.13	33.00	63.46	7.36
Mean	**33.85**	**77.93**	**36.84**	**30.53**	**49.41**	**73.10**	**14.39**	**35.28**	**64.28**	**7.09**

APPENDIX IV

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant-1	No. of effective tillers plant-1	No. of ineffective tillers plant-1	No. of spikelets ear-1	No. of ears plant-1	No. of grains ear-1	No. of grains plant-1	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant-1	1000 grain weight g	Biological yield plant-1 (g)	Yield plant-1 (g)
JW-3269	64.33	123.33	102.1	10.43	6.5	3.93	17.53	7	68.27	426.62	11.97	3.7	23.9	39.4	46.83	44.63	17.85
GW-366	67	124	92.8	10.7	5.1	5.6	15.27	5.83	67.09	377.33	9.567	4.08	19.47	23.03	43.19	43.27	16.32
LOK-1	64.67	121.33	95.53	10.67	3.53	7.13	17.73	4.27	48.62	398.75	9.7	2.52	17.77	44.28	43.15	42.93	14.54
JW-3211	64	122.33	96.17	10.73	5.4	5.33	20.13	6.3	57.27	323.81	10.4	3.01	25.6	33.08	43.42	44.73	13.47
JW-3336	66.67	121.67	79.73	10.33	6.6	3.73	16.2	7.17	55.22	337.62	8.367	3.04	15.7	28.92	45.47	45.83	12.1
HD-2864	67.67	125	92.33	7.667	4.63	3.03	19.2	5.43	42.72	206.05	10.4	2.69	23.6	15.42	49.6	44.03	12.06
HD-2932	66.33	122.67	101.4	11.07	3.33	7.73	16.97	5.37	57.65	204.35	10.77	3.62	20.27	35.53	50.02	44.9	12.41
HI-1544	66.67	121.33	93.47	11.1	4.83	6.27	18.33	5.2	58.68	312.05	10.6	2.72	19.6	26.53	38.02	44.27	10.7
MP-3324/MP-3092/MP-322	66.67	125	106.1	10.43	3	7.43	19.93	6.27	60.26	209.93	14.41	3.78	21.13	28.97	48.81	44.07	12.39
401-136/JW-17-1	67.33	125.33	107.3	8.9	4.63	4.27	18.07	5.63	57.74	377.98	12.6	2.74	17.83	24.15	38.49	44.9	15.63
PBW343/CDWR9563-1	64.67	125	97.47	10.6	6.03	4.57	18.07	7.47	55.93	354.73	9.667	2.9	19.4	42.24	41.39	45.33	20.22
MP3349/MP-3222	66	123	94.2	10.67	5.27	5.4	17.8	6.53	53.13	430.47	10.4	3.1	19.53	32.26	42.34	44.3	14.2
MP-3342/PBW-343/K-9924	67	126	106.4	9.333	5.57	3.77	15.4	6.1	46.81	307.65	10.63	2.3	22.7	24.33	42.72	43.53	12.72
PBW-343/CDWR-9563-6	65	124.33	91.57	8	4.43	3.57	17.53	4.57	51.92	497.49	8.9	2.13	21.23	36.08	38.94	43.73	15.17
MP-3368/MP-4669	66.67	126	98.67	10.23	4.27	5.97	18.07	4.97	47.3	426.27	9.633	1.75	21.33	30.13	46.94	43.77	16.31
MP-3359/WH1092	65.67	124.33	105.5	11.33	3.7	7.63	17.93	4.03	65.46	372.73	12.42	3.61	16.53	32.03	47.18	44.87	16.5
MP-3372/NIAW-1395	64	123.33	104.2	10.53	5.63	4.9	17.57	5.83	54.54	424.64	9.867	2.61	19.93	29.09	38.45	44.07	19.13
MP-3360/RAJ-4213	64.67	126.33	98.33	10.4	3.33	7.07	17.2	4.83	52.89	324.52	9.933	2.09	19.7	40.06	41.87	44.4	14.29
31ESWYT-118	65.67	127	102	11.37	6.2	5.17	18.93	6.7	63.04	275	10.8	3.64	22.1	19.96	48.86	45.27	14.45
31ESWYT-107	66.33	128.33	104.1	10.2	5.97	4.23	16.07	6.7	49.55	389.49	9.693	2.76	19.93	38.44	42.46	42.6	15.53
31ESWYT-110	64.67	123.67	92.73	9.683	5.23	4.45	18.87	5.83	48.09	254.13	11.3	2.43	16.67	20.79	39.66	43.83	11.35
31ESWYT-120	66	121.33	101.3	9.167	4.17	5	18.87	5.1	54.86	429.73	11.2	3.15	17.13	25.03	46.8	43.9	18.1
31ESWYT-121	64	125.67	101.4	9.767	2.97	6.8	18.2	5.6	55.84	348.21	10.7	3.37	15.5	27.72	46.42	44.63	16.37
31ESWYT-123	63.33	124	98.8	7.967	6.07	1.9	17.4	6.6	42.15	438.02	10.49	1.61	17.17	31.28	42.61	44.17	16.12
31ESWYT-125	64.33	122.67	98.93	8.4	4.9	3.5	17.8	6.3	53.61	255.78	11.63	2.91	17.5	30.03	43.21	44.9	12.29
31ESWYT-126	66.33	127.33	106.4	10	3.4	6.6	18.47	3.9	43.24	359.14	11.49	3.06	19.7	30.44	48.18	42.67	15.22
31ESWYT-127	65	127	97	11.65	3.13	8.52	18.6	4.7	62.9	344.16	12.63	3.08	17.57	27.99	40.83	43.7	15.34
31ESWYT-131	65.33	128.67	98.27	9.517	3.73	5.78	17.8	5.13	50.99	366.29	12.77	3.17	18.63	26.26	52.12	44.03	15.86
31ESWYT-132	64.33	127	103.5	8.467	6	2.47	19.27	7.1	66.72	256.76	11.79	3.29	12.2	45.53	37.49	45.1	10.54
31ESWYT-134	64.67	123	97.73	10.88	6.03	4.85	17.27	7.53	45.69	279.03	9.633	2.77	19.9	24.83	49.6	46.57	15.54
Mean	**65.5**	**124.53**	**98.84**	**10.01**	**4.79**	**5.22**	**17.88**	**5.8**	**54.61**	**343.62**	**10.81**	**2.92**	**19.31**	**30.46**	**44.17**	**44.3**	**14.76**

Contd.....

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	40.02	82.89	48.46	22.13	34.3	79	12.43	27.6	63.8	7.67
GW-366	37.73	76.77	53.84	20.97	24.67	85	11.27	24.63	65.5	7.87
LOK-1	33.89	76.73	54.51	21.6	27.5	81	11.6	25.4	65.07	7.43
JW-3211	30.12	79.74	50.34	21.43	45.5	80	13.27	30.6	63.13	7.87
JW-3336	26.41	87.23	48.37	22.67	28.2	83	11.67	28.37	65.13	7.53
HD-2864	27.41	94.07	46.09	21.67	26.37	81.67	11.2	23.2	65.47	7.3
HD-2932	27.64	86.68	46.38	21	27.33	82	11.37	26.13	65.63	7.33
HI-1544	24.18	87.02	48.69	22.3	31.47	82.33	11.5	26.2	64.87	7.83
MP-3324/MP-3092/MP-322	28.21	86.59	43.38	21.47	32.4	76	12.3	29.73	65	7.67
401-136/JW-17-1	34.84	88.83	49.34	22.27	35.43	77.67	12.13	29.5	65.5	7.77
PBW343/CDWR9563-1	46.25	83.8	48.76	22.73	38.3	78	12.7	29	65.97	7.53
MP3349/MP-3222	32.05	83.21	53.67	21.2	49.23	83.33	14.3	33.5	65.07	7.6
MP-3342/PBW-343/K-9924	29.22	86.78	47.89	22.27	53.1	77.33	14.2	33.8	65.33	7.73
PBW-343/CDWR-9563-6	34.7	89.78	49.94	22.53	39.53	82.67	12.8	30.3	64.83	7.33
MP-3368/MP-4669	37.25	77.08	45.69	22.2	33.4	78.67	11.5	26.7	64.77	7.63
MP-3359/WH1092	37.71	77.73	47.51	21.57	28.8	77	11.33	26.87	64.3	7.37
MP-3372/NIAW-1395	43.41	83.21	48.89	22.43	32.47	82.33	11.37	25.73	66.2	7.73
MP-3360/RAJ-4213	32.2	90.29	47.63	21.4	34.47	81	12.33	27.1	65.67	7.8
31ESWYT-118	31.94	92.29	39.7	21.93	26.6	82.67	11.3	25.6	64.87	7.5
31ESWYT-107	36.46	88.54	50.99	21.53	32.87	82.33	11.43	27.3	64.67	7.3
31ESWYT-110	25.93	74.12	50.66	22	35.7	80	11.63	26.8	65.1	7.73
31ESWYT-120	41.24	90.55	49.96	21.2	30.53	80.33	10.57	23.6	65.73	7.77
31ESWYT-121	36.63	82.49	53	22.83	30.83	75	11.6	26.2	65	7.57
31ESWYT-123	36.53	74.08	47.91	22.37	35.77	76.33	12.27	28.2	65.83	7.77
31ESWYT-125	27.37	80.65	51.05	22.1	27.4	76.33	10.2	21.53	64.67	7.73
31ESWYT-126	35.66	82.87	46.04	22.33	44.8	77	13.6	32.37	65.87	7.7
31ESWYT-127	35.1	87.8	48.06	22.5	28.83	76.67	11.6	26.63	66.53	7.67
31ESWYT-131	36.01	82.78	49.96	22.3	36.07	80	12.23	27.7	64.67	7.6
31ESWYT-132	23.41	86.1	51.02	22.47	32.2	84	11.47	26.23	65.57	7.53
31ESWYT-134	33.39	89.25	49.07	21.67	30.97	82.33	10.8	25.2	64.37	7.5
Mean	**33.43**	**84.33**	**48.89**	**21.97**	**33.83**	**80.03**	**11.93**	**27.39**	**65.14**	**7.61**

APPENDIX V

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant-1	No. of effective tillers plant-1	No. of ineffective tillers plant-1	No. of spikelets ear-1	No. of ears plant-1	No. of grains ear-1	No. of grains plant-1	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant-1	1000 grain weight g	Biological yield plant-1 (g)	Yield plant-1 (g)
JW-3269	61	113	107.3	8.43	4.47	3.97	15.07	5.17	59.62	379.03	11.47	3.19	22.43	23.53	42.82	44.33	16.32
GW-366	64	109.33	105.27	9.13	4.23	4.9	16.33	4.27	39.06	227.1	9.367	2.64	18.23	31.18	39.21	42.63	15.57
LOK-1	60.67	110	100.67	8.4	3.2	5.2	13.2	3.53	38.28	256	10.63	2.39	15.5	31.57	42.62	41.23	11.74
JW-3211	67.33	113.33	81.4	9.13	4.63	4.5	19.23	4.93	49.07	415.4	10.3	2.93	17.23	19.2	38.02	41.67	12.44
JW-3336	58	114.33	76.8	8.9	5.27	3.63	13.87	6.6	34.75	278.8	10.7	2.13	19.33	26.9	40.84	40.9	11.4
HD-2864	62.67	110	86.267	6.03	4.73	1.3	14.17	4.93	44.85	284.67	8.933	2.68	13.57	26.9	44.43	44.7	15.27
HD-2932	65	112.33	74.467	9.47	5.03	4.43	17.8	5.27	48.72	244.5	10.13	2.77	21.03	40.21	47.34	42.5	14.12
HI-1544	64.33	113.67	97	9.57	4.1	5.46	15.27	4.87	42.58	312.37	9.433	3.04	16.1	37.52	38.11	41.43	12.39
MP-3324/MP-3092/MP-322	65.33	115	105.27	8.77	4.2	4.57	18.83	4.57	47.46	215.07	11.03	3.05	17.63	25.51	46.72	40.2	10.21
401-136/JW-17-1	69.33	123	97.4	7.47	2.8	4.67	19.3	5.03	50.74	226.97	11.03	3.11	23.77	24.62	40.05	43.93	12.69
PBW343/CDWR9563-1	66	116	95.9	7.9	3.77	4.13	13.63	4.67	44.93	495.77	9.833	2.31	19	29.22	35.2	44.13	19.06
MP3349/MP-3222	62.33	114	92.8	8.97	4.57	4.4	15.9	5.23	47.13	318.83	10.83	2.86	14.6	27.38	42.67	40.33	10.34
MP-3342/PBW-343/K-9924	63	114.67	109.3	6.8	4.23	2.57	14.87	4.57	49.55	209.13	10.13	3.15	27.1	18.29	40.92	40.03	9.953
PBW-343/CDWR-9563-6	63	111.33	104.2	6.63	3.47	3.17	20.9	4.33	41.19	258.23	7.9	2.55	20.43	22.45	44.84	41.2	11.58
MP-3368/MP-4669	65.67	109.67	93.2	8.43	4.37	4.07	18.23	4.63	42.77	354.37	9.167	1.96	17.83	24.32	30.03	44.97	15.98
MP-3359/WH1092	65.67	111.33	98.4	8.97	4	4.97	17.03	4.13	41.36	478.23	8.3	2.35	19.57	26.81	40.6	41.77	16.15
MP-3372/NIAW-1395	63	114.67	96.2	8.53	4.1	4.43	16.47	4.27	46.74	418.93	9.1	2.41	18.77	23.41	39.74	45.8	17.64
MP-3360/RAJ-4213	64	115.33	89.367	8.9	3.5	5.4	18.4	4.83	45.69	229.23	9.433	2.43	19.6	26.93	39.35	39	9.147
31ESWYT-118	67	117.33	101.27	9.9	5.17	4.73	15.4	6.34	52.24	326	10.7	2.86	18.33	23.41	41.99	41.37	11.13
31ESWYT-107	66.33	114	100.17	8.5	2.93	5.57	18.13	3.23	42.81	336.57	8.1	2.48	20.77	17.98	38.38	41.37	12.33
31ESWYT-110	66.33	112	99.767	7.73	4.5	3.23	15.87	5.3	43.66	347.77	9.633	2.62	16.7	18.41	45.85	38.7	8.543
31ESWYT-120	66.33	117	103.87	8.2	3.83	4.37	18.7	4.43	48.9	339.8	9	2.68	18.97	23.06	39.28	42.2	13.65
31ESWYT-121	61	121.67	96.467	8.43	5	3.43	17.17	5.3	43.21	273.87	8.5	2.27	15.7	28.09	40.84	38.6	11.04
31ESWYT-123	69	114	100.57	6	3.67	2.33	15.83	4.5	46.72	309.67	10.9	2.18	19.63	20.78	30.22	41.87	12.9
31ESWYT-125	66.67	113	102.1	6.73	4.93	1.8	16.7	5.53	44.74	207.3	8.9	2.75	17.3	24.93	43.79	42.13	9.617
31ESWYT-126	66.67	109.33	103.7	7.58	3.2	4.38	15.6	3.57	46.07	324.33	10.63	3	21.13	30.99	41.98	41.87	13.12
31ESWYT-127	70	122	97.933	10	3.17	6.87	16.47	4.1	47.43	327.8	10.33	2.38	15.13	27.03	37.35	42.23	13.54
31ESWYT-131	69.67	124	98.7	7.83	3.27	4.57	21.53	4.6	41.83	305.33	12.1	2.86	17.07	28.12	53.36	41.37	12.06
31ESWYT-132	67	114	106.27	7.7	3.93	3.77	18.67	6.1	48.12	199.67	11.17	2.78	16.37	27.51	34.93	37.7	9.68
31ESWYT-134	68	110.33	78.65	9.43	4.93	4.5	17.53	7	45.79	390	8.933	2.43	19.9	27.87	38.12	40.83	11.52
Mean	**65.14**	**114.32**	**96.688**	**8.28**	**4.11**	**4.18**	**16.87**	**4.86**	**45.53**	**309.69**	**9.888**	**2.64**	**18.62**	**26.14**	**40.65**	**41.7**	**12.7**

Contd.....

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	36.82	81.4433	45.7667	22.0667	27.2667	75.6667	10.3	20.9333	64.7	7.7333
GW-366	36.55	75.36	52.1333	22.2667	24.6	77.3333	10.5	21.8	65.3667	8.2
LOK-1	28.48	75.3133	51.9333	21.8	23.3667	81.3333	10.6	23.8667	65.4667	7.7667
JW-3211	29.87	78.3267	47.7667	23.7	30.8	76.3333	10.8	25.5	64.2	7.7333
JW-3336	27.79	86.0133	46.5	22.0667	26.1333	81	11.1333	24.8	64.6	7.6333
HD-2864	34.17	92.5233	43.8333	23.1	29.2333	80	11.1667	26.8	64.9667	7.6333
HD-2932	33.23	85.0633	44	23.0667	27.6333	79	11.4333	24.9	64.9667	7.6
HI-1544	29.79	85.2733	46.4	22.1667	33.4	78	11.3667	27.2	64.4333	7.7667
MP-3324/MP-3092/MP-322	25.42	84.74	40.4667	22.5	26.6	80.3333	10.7	22.6	65.6	7.9333
401-136/JW-17-1	29.01	86.9133	46.0667	22.6333	36.2333	82.3333	12.0667	29.2	64.7	7.3667
PBW343/CDWR9563-1	43.11	81.85	46.0667	22.0667	27.9333	82.6667	10.3667	22.4	65.6667	7.6333
MP3349/MP-3222	25.4	81.4667	51.6	22.2667	35.2	83.6667	12.3333	27.7	65.0333	7.7333
MP-3342/PBW-343/K-9924	24.9	85.1967	45.5333	21.7	28.2667	77	11.3	25.7	66.3333	7.3667
PBW-343/CDWR-9563-6	28.14	88.3633	47.9	21.8667	27.6667	83.3333	11.5333	27.6333	65.6333	7.5333
MP-3368/MP-4669	35.58	75.5667	43.6667	23.4	31.1667	80.6667	10.4667	22.8	65.6667	7.7
MP-3359/WH1092	38.66	76.1467	45.8	22.5	27.3667	82.6667	10.1333	23.3667	65.6333	7.5333
MP-3372/NIAW-1395	38.63	81.6833	46.5	22.6667	29.5	77	10.2	20.8	65.5667	7.6
MP-3360/RAJ-4213	23.28	89.2933	46.3	23.1	32.5667	76.3333	11.0333	25.3	65.0333	7.6667
31ESWYT-118	26.79	90.6367	37.1667	21.7	25.1667	83.6667	9.8	20.4667	64.2	7.5
31ESWYT-107	29.66	86.3567	47.8333	22.2667	30.6667	78.3333	10.5333	22.5333	65.5333	7.5
31ESWYT-110	22.1	72.2767	48	22.2667	31.7667	82.6667	10.4333	23.4	65.9667	7.4
31ESWYT-120	32.28	88.8367	47.5	22.6	27.3667	74	9.7	22.3667	63.8667	7.7667
31ESWYT-121	28.67	80.6767	50.8667	20.8	27.5	80.6667	9.9333	21.4333	64.7667	7.4667
31ESWYT-123	30.8	71.9667	45.1667	21.2667	28.5	75.3333	10.6333	22.8	65.5667	7.7667
31ESWYT-125	22.91	79.3033	48.8667	21.3	27.3667	74.3333	11.5667	26.4333	65.6	7.4667
31ESWYT-126	31.26	81.3233	43.4	21.4	25.6333	77	10.2	21.4667	66.0667	7.6
31ESWYT-127	32.08	86.22	45.6333	22.0333	23.3	77.6667	9.7	19.8	64.6667	7.8667
31ESWYT-131	29.11	81.2367	47.8	22.5	36.3333	76	12.5	27.8667	64.3667	7.9667
31ESWYT-132	25.61	84.6167	48.9667	22.1	29.7	77	10.4	22.0333	66.1667	7.6333
31ESWYT-134	28.05	87.5067	46.5	20.8	26.8333	78.3333	9.6667	20.4667	66.2	7.6667
Mean	**30.27**	82.7164	46.5311	22.1989	28.8356	78.9889	10.75	23.8122	65.2178	7.6578

APPENDIX VI

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers plant-1	No. of effective tillers plant-1	No. of ineffective tillers plant-1	No. of spikelets ear-1	No. of ears plant-1	No. of grains ear-1	No. of grains plant-1	Ear head length (cm)	Ear weight (g)	Peduncle length (cm)	No. of leaves plant-1	1000 grain weight g	Biological yield plant-1 (g)	Yield plant-1 (g)
JW-3269	52.67	98	83.2	7.5	4.6	2.9	15.87	4.63	60.35	211.65	9.2	2.73	16.47	17.71	38.02	25.44	9.21
GW-366	55	96.33	81.4	5.13	3.17	1.97	15.47	3.27	39.29	399.13	6.6	1.9	18.17	10.13	37.18	26.66	9.26
LOK-1	51.67	94	101.43	5.27	2.77	2.5	16.73	2.93	38.28	235.75	7.63	1.75	13.27	9.6	32.73	38.31	7.85
JW-3211	51	102	93.5	6.13	4.57	1.57	18.93	4.73	49.07	203.74	7.07	1.99	15.13	16.36	28.37	37.39	9.25
JW-3336	58.33	99	84.7	8.1	5.37	2.73	15.63	5.83	34.75	233.15	6.33	1.8	16	23.79	37.14	21.27	9.66
HD-2864	49.33	96	94.567	6.8	3.8	3	17.17	4.03	44.85	239.68	8.27	2.01	18.3	21.45	30.98	20.39	8.97
HD-2932	52	97	98.033	6.33	4.53	1.8	18.13	4.9	48.72	267.65	6.67	2.38	15.73	18.22	36.71	19.3	8.29
HI-1544	56	97.33	100.57	6.33	3.97	2.37	15.53	4.27	42.58	291.25	9.63	2.09	12.23	19.69	26.35	28.82	7.72
MP-3324/MP-3092/MP-322	54	98	102.43	7.57	3.77	3.8	17.43	4.07	47.46	357.36	5.57	2.01	14.47	19.86	29.81	18.5	7.63
401-136/JW-17-1	55.67	101.7	104.83	5.4	4.77	0.63	16.77	4.9	50.74	368.11	8.77	1.81	13.27	14.88	26.27	18.95	8.71
PBW343/CDWR9563-1	61	94.33	95.633	5.73	3.57	2.17	18.23	3.8	44.93	338.57	7.43	1.82	16.3	11.46	29.53	27.28	10.6
MP3349/MP-3222	57.33	97.67	92.3	4.97	4.03	0.93	17.03	4.3	47.13	203.33	8.13	2.08	12	7.657	31.7	23.49	8.73
MP-3342/PBW-343/K-9924	53	97.33	99.967	4.3	3.13	1.17	18.5	3.53	49.55	155.71	7.97	2.53	18.33	11.96	38.59	18.25	8.45
PBW-343/CDWR-9563-6	55.33	95.33	100.57	7.33	3.57	3.77	14.77	3.73	41.19	127.89	7.5	2.06	18.2	18.57	37.48	27.4	5.13
MP-3368/MP-4669	54	96.67	101.5	5.5	3.43	2.07	17.97	3.77	42.77	365.34	9.37	1.67	15.2	15.78	28.87	14.55	7.96
MP-3359/WH1092	57	92	98.833	5.9	3.2	2.7	19.03	3.67	43.03	299.03	9.73	1.88	14.93	23.44	33.18	22.45	9.12
MP-3372/NIAW-1395	56.33	93.33	97.7	7.6	3.77	3.83	17.43	4.07	46.74	286.21	8.37	1.96	14.13	23.39	30.02	22.61	8.91
MP-3360/RAJ-4213	56	95.67	101.23	6.03	4.2	1.83	16.97	4.4	45.69	160.62	9.13	1.82	14.13	17.3	28.07	13.77	4.62
31ESWYT-118	54.33	97.33	100.1	6.43	4.7	1.73	14.33	5.27	52.24	178.34	6.5	2.29	15.8	22.27	35.06	15.56	6.2
31ESWYT-107	59.33	97	96.5	6.77	2.43	4.33	16	2.6	42.81	258.03	6.47	1.9	17.33	19.42	31.38	29.96	7.91
31ESWYT-110	59	92.33	96.567	7.03	3.5	3.53	18.53	3.83	43.66	315.13	8	1.93	15.73	22.67	36.06	17.98	7.84
31ESWYT-120	59.67	95.33	97.5	7.97	3.8	4.17	17.83	3.9	48.9	245.63	7.43	1.89	15.93	28.9	29.8	23.61	7.59
31ESWYT-121	51.33	102	93.833	6.37	4.17	2.2	17.3	4.63	43.21	197.14	5.7	2.09	12.93	16.13	31.08	15.98	5.91
31ESWYT-123	61.33	105.3	91.4	4.5	3.93	0.57	18.13	4.17	46.72	339.12	9.53	2.04	15.13	10.93	32.01	25.83	10.2
31ESWYT-125	60.67	99	97.933	5.87	4.53	1.33	16.5	4.9	45.41	126.14	8.03	2.34	17.67	14.92	37.52	21.49	5.88
31ESWYT-126	60	99	94.667	6.53	2.47	4.07	18.5	2.67	48.62	278.74	9.17	2.5	15.73	19.07	35.82	18.59	9.74
31ESWYT-127	58.33	102	97.933	5.43	3.4	2.03	15.3	3.7	47.43	183.9	6.87	2.27	14.4	19.78	39.24	17.33	8.05
31ESWYT-131	63	108	99.867	8.07	3.8	4.27	16.63	4.03	41.83	130.73	8.2	2.04	12.93	23.27	38.43	15.11	5.71
31ESWYT-132	62	101.3	97.267	6.83	4.83	2	17.97	5.1	48.12	275.22	10.1	2.36	13.07	15.73	29.61	19.87	7.17
31ESWYT-134	61.33	104	98.067	7.43	6.07	1.37	19.17	6.57	45.79	289.79	8.63	2.11	13.6	10.53	36.15	19	9.99
Mean	**56.53**	**98.14**	**96.468**	**6.37**	**3.93**	**2.44**	**17.13**	**4.21**	**45.73**	**252.07**	**7.93**	**2.07**	**15.22**	**17.5**	**33.11**	**22.17**	**8.07**

Contd.....

Character	Harvest index	RWC of flag leaf	Chlorophyll content	Canopy temperature	Sedimentation value (mm)	Hectolitre weight (g / litre)	Protein (%)	Wet gluten (%)	Starch (%)	Moisture(%)
JW-3269	36.2	78.37	42.17	29.67	47.03	73	13.6	32.5	64.47	7.83
GW-366	37.24	71.27	42.2	28.4	46.53	78.67	13.87	31.73	65.7	8.2
LOK-1	22.4	71.84	37.3	30.33	48.27	73	13.7	32.57	65.17	7.73
JW-3211	24.8	73.54	35.27	29.8	54.5	71	15.3	35.7	63.1	7.8
JW-3336	42.22	81.8	39	30.3	53.4	79.33	15.47	36.13	65.1	7.7
HD-2864	44.14	89.45	41.8	29.47	48.07	76.67	14.2	32.7	64.13	7.57
HD-2932	42.98	80.58	37.53	31	45.37	75	13.47	32.27	66.37	7.53
HI-1544	24.35	82.1	44.73	30.9	52.63	73	14.27	33.5	64.9	7.67
MP-3324/MP-3092/MP-322	45.45	79.57	43.27	28.9	52.7	71.33	14.93	34.63	65.5	8.17
401-136/JW-17-1	39.75	81.64	36.67	29.63	50.53	72.33	14.7	34.47	64.2	7.9
PBW343/CDWR9563-1	38.63	76.61	36.2	28.73	47.27	78.33	14.3	33.63	63.97	7.67
MP3349/MP-3222	34.03	79.13	48.4	30.97	52.43	72	16.23	37.53	63.6	7.5
MP-3342/PBW-343/K-9924	36.67	82.79	42.73	31.2	48.03	76.67	13.1	33.27	64.8	7.6
PBW-343/CDWR-9563-6	24.93	85.56	38.73	31.33	54.83	75.33	14.8	34.37	64.43	7.8
MP-3368/MP-4669	51.87	72.74	42.2	30.8	53.8	74	15.6	36.57	64.3	7.77
MP-3359/WH1092	38.71	73.07	48.27	29.37	49.57	76.33	14.6	34.53	63.5	7.83
MP-3372/NIAW-1395	39.32	78.53	24.2	29.87	34.23	74.67	16.13	37.87	63.57	7.8
MP-3360/RAJ-4213	33.47	86.09	35.63	29.6	53.77	73	15.23	35.33	65.27	8.07
31ESWYT-118	39.88	87.55	44.03	29.63	54.03	75.33	15.1	34.87	64.33	7.8
31ESWYT-107	26.47	83.87	42.43	29.37	53.03	73.33	15.43	35.3	65.87	7.5
31ESWYT-110	43.71	69.15	34.9	30.23	53.73	76	15.5	37.5	62.73	7.73
31ESWYT-120	63.84	85.63	42.37	30.9	45.27	77	13.47	31.37	64.83	7.7
31ESWYT-121	42.14	77.48	23.9	30.07	52.77	72.33	15.17	35.63	64	7.6
31ESWYT-123	64.11	68.81	38	30.83	52	73	14.27	33.4	65.6	7.73
31ESWYT-125	57.32	76.14	36.33	30.57	52.47	74.33	14.63	34.2	64.73	7.6
31ESWYT-126	52.45	78.64	40.77	30.33	53.5	75.67	14.53	34.5	65.07	7.63
31ESWYT-127	50.52	83.4	37.03	30.7	53.13	73.67	14.3	33.37	64.33	8.3
31ESWYT-131	45.24	77.96	25.87	29.4	54.57	75.33	15.17	34.53	62.27	8.17
31ESWYT-132	37.06	81.97	36.17	29.97	55.77	77.33	15.37	35.63	66.87	7.87
31ESWYT-134	55.93	84.43	38.77	30.1	45.53	77.67	14.3	33.13	66.87	7.67
Mean	**41.19**	**79.32**	**38.56**	**30.08**	**50.63**	**74.82**	**14.69**	**34.42**	**64.65**	**7.78**

ABSTRACT

The present investigation entitled “Screening of stable wheat genotypes for morpho-physiological and quality attributes under different environments” was carried out under Wheat Improvement Project at Seed Breeding Farm, Department of Plant Breeding & Genetics, J.N.K.V.V. Jabalpur during *Rabi* season 2012-13 and 2013-14. The experimental material comprised of 30 promising genotypes of bread wheat (*Triticum aestivum*) planted in randomized completely block design with three replications under three different sowing conditions (timely, late and very late sown). High GCV and PCV were recorded in number of effective tillers plant^{-1}, number of ineffective tillers plant^{-1} and number of grains plant^{-1}, under timely sown conditions (E1 & E4), whereas under late sown conditions (E2 & E5), the GCV and PCV was reported high for number of in-effective tillers plant^{-1}, yield plant^{-1} (g), number of effective tillers plant^{-1}. High GCV and PCV were observed by the traits *viz.,* number of effective tillers plant^{-1}, harvest index (%), number of ears plant^{-1} and number of grains plant^{-1} under very late sown conditions **(**E3 & E6). GCV and PCV estimates were also found high for the traits *viz.,* number of effective tillers plant^{-1}, number of ineffective tillers plant^{-1}, number of ears plant^{-1} and number of grains plant^{-1} in pooled analysis. High heritability coupled with high genetic advance (as percentage of mean) were recorded in timely sown condition (E1 & E4) for the traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, ear weight, peduncle length, yield plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, harvest index, sedimentation value, wet gluten, protein and sedimentation value. In late sown condition (E2 & E5), traits *viz.,* number of grains ear^{-1}, ear weight, number of leaves plant^{-1}, 1000 grain weight and sedimentation value reported high heritability coupled with high genetic advance. Number of grains ear^{-1}, number of grains plant^{-1}, number of leaves plant^{-1}, 1000 grain weight, biological yield plant^{-1} and sedimentation value were the traits reported high heritability coupled with high genetic advance under very late sown condition **(**E3 & E6). The correlation analysis reported that grain yield plant^{-1} shared positive significant association with numbers of grains plant^{-1}, harvest index ,

numbers of effective tillers plant^{-1}, biological yield plant^{-1}, ear weight, numbers of spikelet ear^{-1}, numbers of tillers plant^{-1}. So it could be possible to bring about gene upgradation in one character by selection of the other pair. However, grain yield plant^{-1} reported significant negative association with relative water content, protein % and wet gluten %, this indicates that simultaneous improvement in both the traits were not possible.Path coefficient analysis revealed that sedimentation value, wet gluten %, hectoliter weight, biological yield plant-^{1}, moisture %, starch %, number of grains ear^{-1}, harvest index and number of tillers plant^{-1}, exhibited high direct positive effect on grain yield plant^{-1}. Whereas, number of grains plant^{-1}, 1000 grain weight, days to 50% flowering, ear head length, days to maturity, plant height, relative water content of flag leaf, and protein % showed direct negative effect on grain yield plant^{-1}. The positive high direct effect of traits on grain yield suggests that selection based on these traits would improve the grain yield. The multiple regression analysis revealed that, maximum variation in grain yield plant^{-1} mainly reported by the traits *viz.,* number of grains ear^{-1}, number of grains plant^{-1}, ear weight, 1000 grain weight, biological yield plant^{-1} and harvest index. Stability analysis revealed that genotypes 31ESWYT-123, 31ESWYT-126, 31ESWYT-134, 31ESWYT-123 and 31ESWYT-126 were stable for timely sown situation. In late sown, genotypes 31ESWYT-123, 31ESWYT-126, 31ESWYT-123, 31ESWYT-126 and 31ESWYT-132, reported stable performance with high mean grain yield. Whereas, in very late sowing conditions, stability in yield were showed by the genotypes LOK-1, JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123, 31ESWYT-126, 31ESWYT-132, JW-3211, JW-3336, MP-3324/MP-3092/MP-322, 31ESWYT-123 and 31ESWYT-126. Although, genotypes 31ESWYT-123 and 31ESWYT-126 possessing regression coefficient near unity and also minimum deviation from regression with high mean yield over all the trails for the two years and are considered most stable genotypes in the present study. These genotypes might be released as a variety suitable for wide range of environmental condition besides this, it may be used as donor parent in further breeding programme.

ABSTRACT

Title of the thesis	:	**"**Screening of stable wheat genotypes for morpho-physiological and quality attributes under different environments**"**
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Degree to be awarded	:	**Ph.D. (Ag.) Plant Breeding & Genetics**
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Signature of Advisor	Signature of Head of Department	Signature of Student
(Dr. P.K. Moitra)	**(Dr. D.K. Mishra)**	**(Monika Singh)**

VITA

The author of the thesis **Mrs. Monika Singh** D/o Late Dr. S.S. Thakur was born on 4th september, 1986 at Jabalpur (M.P.).

She passed her High School in the year 2002 from kendriya vidyalaya khandwa with 65.8 per cent marks. After that she passed Higher Secondary in the year 2004 acquiring 61 per cent marks from kendriya vidyalaya khandwa.

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During the entire period of his education, from schooling to post graduation she was very sincere and honest towards her studies.

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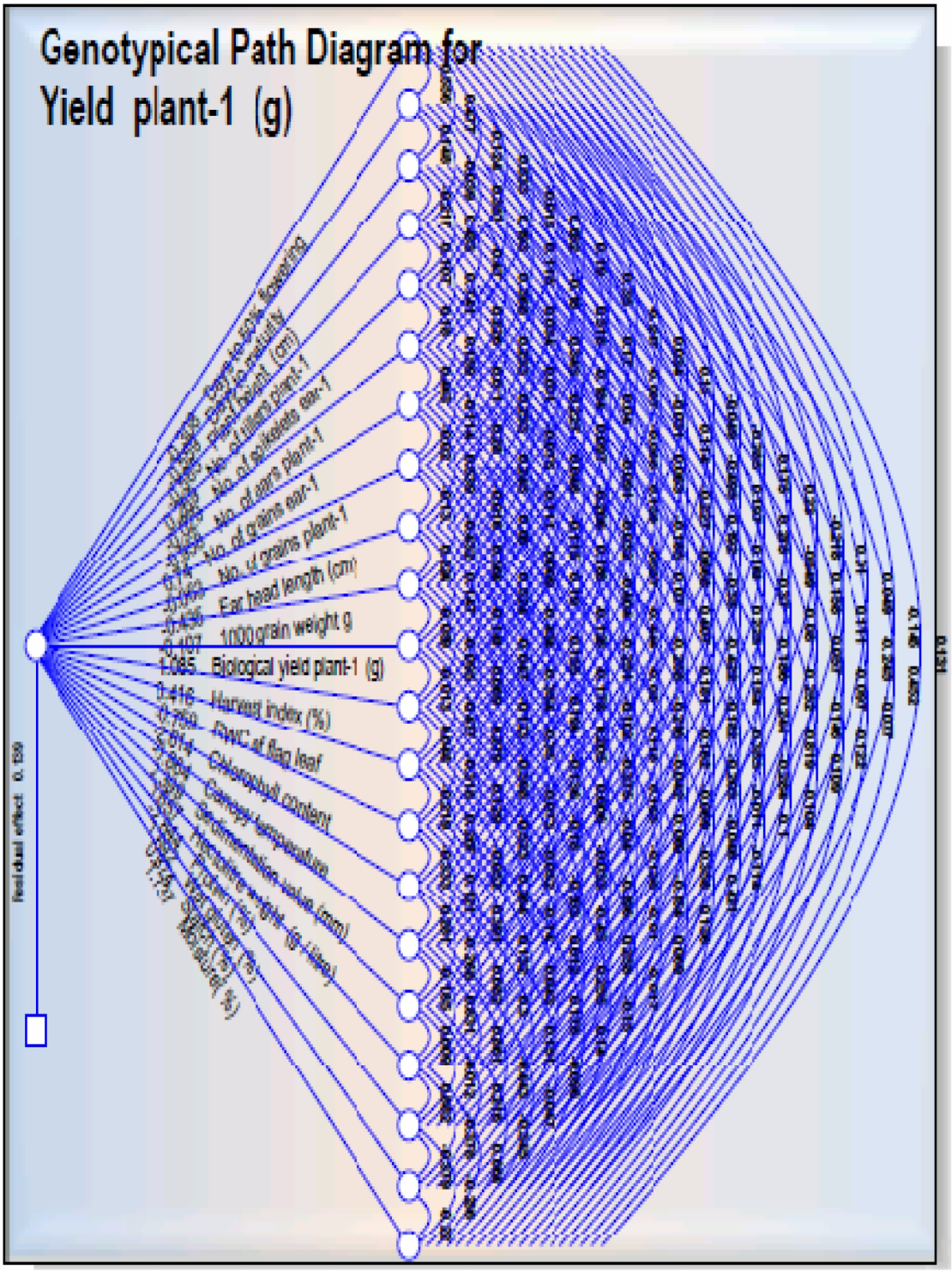


Fig. 4.4.1 : Genotypical path diagram for yield plant^{-1} (g)

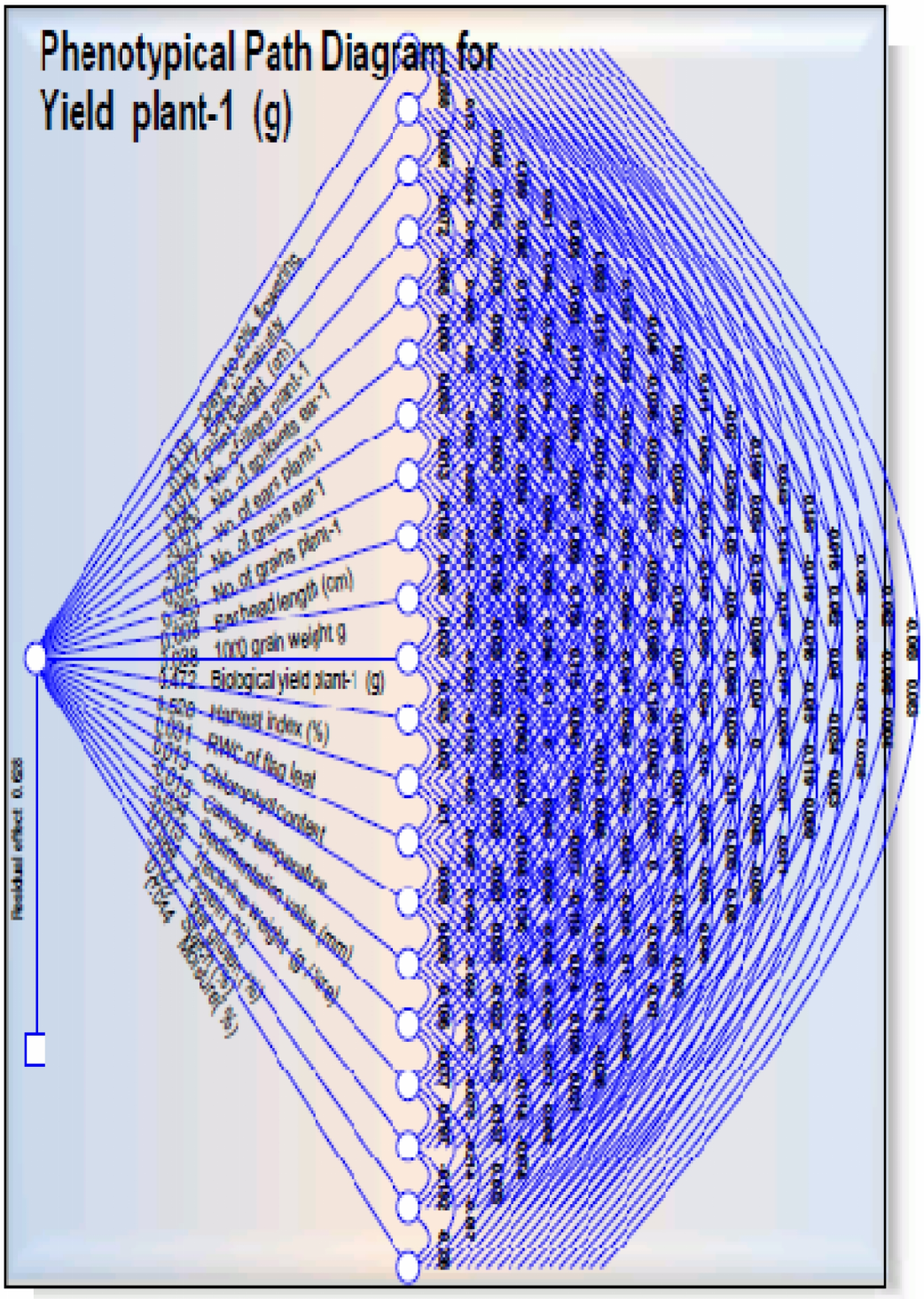
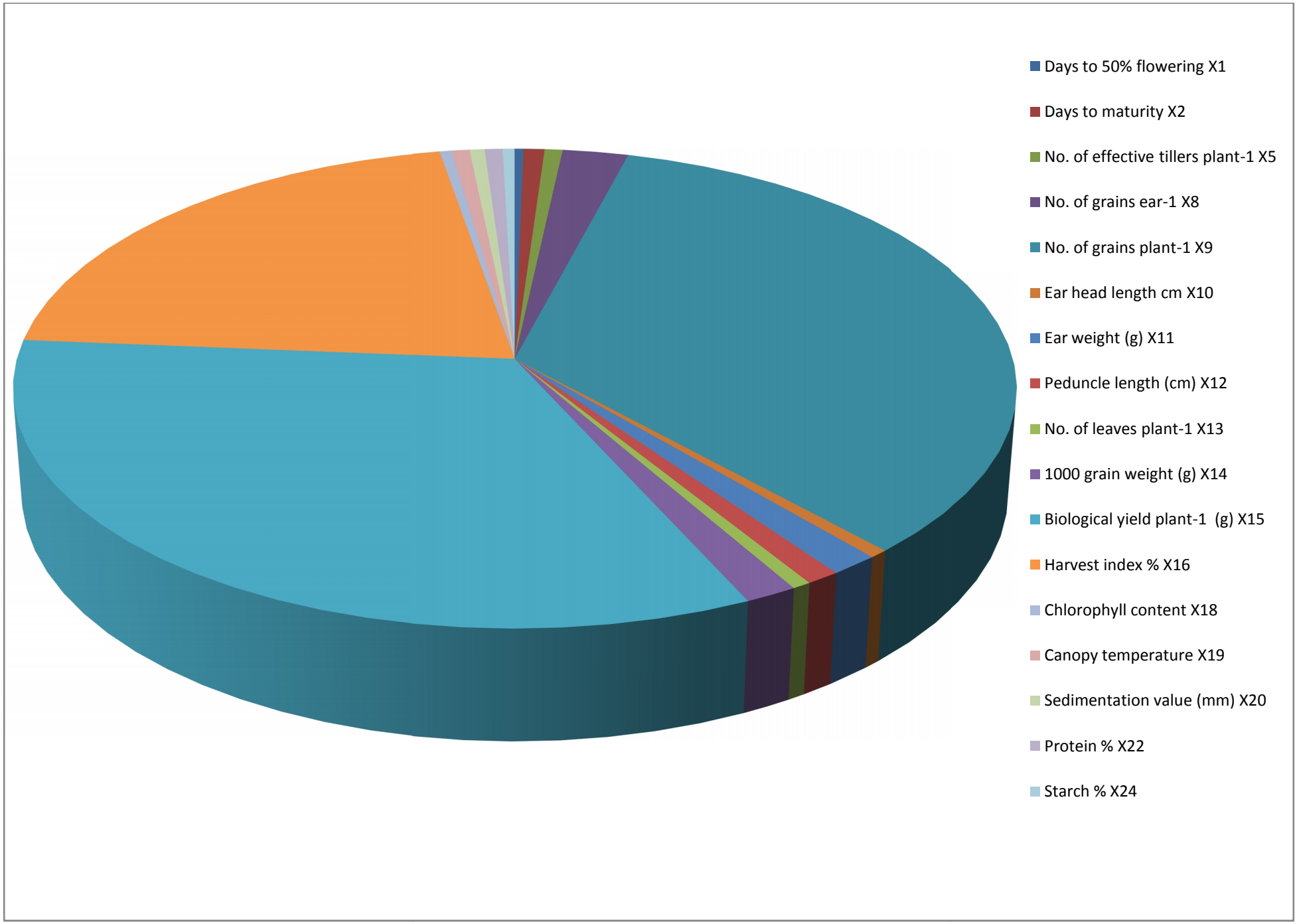


Fig. 4.4.2 : Phenotypical path diagram for yield plant^{-1} (g)


Days to 50% flowering X1
Days to maturity X2
No. of effective tillers plant-1 X5
No. of grains ear-1 X8
No. of grains plant-1 X9
Ear head length cm X10
Ear weight (g) X11
Peduncle length (cm) X12
No. of leaves plant-1 X13
1000 grain weight (g) X14
Biological yield plant-1 (g) X15
Harvest index % X16
Chlorophyll content X18
Canopy temperature X19
Sedimentation value (mm) X20
Protein % X22
Starch % X24