G X E INTERACTION FOR MORPHO-PHYSIOLOGICAL ASPECTS IN BREAD WHEAT [*Triticum aestivum* , (L.)]

A thesis submitted

to

Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722

Dist. Ahmednagar (M.S.), India

by

Patil Jitendra Madhukar
(Reg. No. 12/18)

In partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

AGRICULTURAL BOTANY

(GENETICS AND PLANT BREEDING)

DEPARTMENT OF AGRICULTURAL BOTANY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI – 413 722
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2016

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part there of has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

Place : MPKV, Rahuri **(Jitendra M. Patil)**

Date: / /2016

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CERTIFICATE

This is to certify that the thesis entitled **"G X E INTERACTION FOR MORPHO-PHYSIOLOGICAL ASPECTS IN BREAD WHEAT [*Triticum aestivum,* (L.)]"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar, M. S. for the award of the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **GENETICS AND PLANT BREEDING**, embodies the results of a bonafide research carried out by **MR. JITENDRA MADHUKAR PATIL ,** under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and help received during the course of this investigation have been acknowledged.

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Date: / /2016 Research Guide

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Place : MPKV, Rahuri **(B. R. Ulmek)**

Date: / /2016 Associate Dean

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Place: MPKV, Rahuri
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List of Abbreviations

%	Per cent
°C	Degree Celsius
ANOVA	Analysis of variance
C. D.	Critical difference
cm	Centimeter
C. V.	Coefficient of variation
d.f.	Degree of freedom
e.g.	For example
et al.	et allii :and others
etc.	Etcetera
g	Gram
G x E	Genotype x Environment
TSI	Timely sown irrigated
LSI	Late sown irrigated
ha	Hectare
hrs	Hours
i.e.	That is
Kg	kilogram
Max.	Maximum
MPKV	Mahatma Phule Krishi Vidyapeeth
MSS	mean sum of square
Min.	Minimum
Max	Maximum
ml	Millilitre
No.	Number
S. E	Standard Error
Sr.	Serial
viz.	Namely
PH	Plant height
Till/m	Tillers per meter
SL	Spike length
Gr./Sp	Grains per spike
TGW	Thousands grain weight
PR	Photosynthetic rate

TR	Transpiration rate
PAR	Photosynthetically active radiation
SC	Stomatal conductance
SR	Stomatal resistance
CT	Canopy temperature
MII	Membrane Injury Index
Prot.	Protein
SV	Sedimentation Value
HW	Hectoliter weight
WGC	Wet gluten content
GY	Grain yield

ABSTRACT

G X E INTERACTION FOR MORPHO-PHYSIOLOGICAL ASPECTS IN BREAD WHEAT [*Triticum aestivum,* (L.)]

By

PATIL JITENDRA MADHUKAR

A

Candidate for the Degree

Of

DOCTOR OF PHYLOSOPHY (AGRICULTURE)

in

GENETICS AND PLANT BREEDING

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Research Guide	**:**	**Dr. D.V. Kusalkar**
Major Descipline	**:**	**Genetics and Plant Breeding**

The present investigation on "G x E Interaction for Morpho-Physiological Aspects In Bread Wheat [*Triticum aestivum,* (L.)]" was undertaken at three locations *viz*. Niphad, Rahuri and Savalvihir under timely sown irrigated (TSI) and late sown irrigated (LSI) conditions during *Rabi*-2013-14. The experimental material consist of twenty new bread wheat genotypes developed at Agricultural Research Station , Niphad and three check varieties. Experimental material was grown in a randomized block design with three replications over six environments.

The mean sum of squares due to genotypes were significant for all the nineteen characters studied across the environments, which indicated the presence of substantial variation in the material studied. The analysis also indicated significant variation among the environments for all the characters. The values of G x E interaction were significant for all nineteen characters which indicated that genotypes interacted differently with environmental variation for the said characters. Highly significant values of mean squares due to environments (linear) for all the characters indicated that the linear responses of genotypes to environment differed significantly for the said characters; while mean square values due to G x E (pooled error) were also significant for all the characters.

TSI environments were better for tillers per plant, grain yield, spike length, grains per spike, plant height and thousand grain weight. LSI environments were rich for quality characters like protein per cent and wet gluten content.

The genotypes *viz*. NIAW 1994 , NIAW 2268, NIAW 2275 , NIAW 2279, NIAW 2313, NIAW 2349 and check NIAW 917 had average stability and well adaption to all types of environment for grain yield. NIAW 2351 showed above average stability and well adapted to poor environment, similarly NIAW 1885 would have below average stability and specifically adapted to favorable environment. These six genotypes viz., NIAW 1994, NIAW 2279, NIAW 2275, NIAW 2349, NIAW 2351 and NIAW 917 had also exhibited their stable performance for more than one yield contributing , physiological and quality traits.

The estimates of phenotypic coefficient of variance (PCV) were higher in respect of all the nineteen characters studied in all environments than the corresponding genotypic coefficient of variance (GCV). The characters spike length, number of tillers per meter, the number of grains per spike, membrane injury index, photosynthetic rate, stomatal conductance, transpiration rate, stomatal resistance, sedimentation value, wet gluten content and grain yield exhibited larger amount of variability both at phenotypic level and genotypic level in most of the environments suggesting that selection can be practiced for the above traits so as to exploit this variability.

All the characters exhibited high heritability in all the individual environments at both the locations. Characters *viz*, spike length, number of grains per spike, days to 50 per cent flowering, membrane injury index, photosynthetic rate, stomatal conductance, transpiration rate, stomatal resistance, sedimentation value and wet gluten content exhibited high heritability coupled with high GAM. It indicates that these characters are under the influence of additive gene effects and the selection may be effective.

Grain yield showed positive and significant correlation coefficient on overall basis with days to 50 per cent flowering, plant height, days to maturity, tillers per meter , spike length, grains per spike, stomatal conductance, photosynthetic rate, sedimentation value and hectoliter weight. Whereas, grains per spike, tillers per meter, plant height and stomatal conductance recorded significant positive direct effect on grain yield.

Pages 1 to 210

Affectionately Dedicated

To

My Beloved

Late Mother

Jitu.....

1. INTRODUCTION

Wheat belongs to family *Poaceae* (*Gramineae*). The chromosome number for wheat are diploids 14 (n=7), tetraploids 28 (n=14) and the hexaploids 42 (n=21). There are 50 wild species of wheat, out of which four species *viz. Triticum aestivum, Triticum durum, Triticum diccocum* and *Triticum sphaerococcum* are under cultivation in India. *Triticum aestivum* is the most important species occupying more than 90 per cent of the total wheat area in country followed by *Triticum durum* (8-9%) and *Triticum dicocum* (< 1%). *Triticum sphaerococcum* has now practically not been cultivated because of its low productivity and high susceptibility to diseases. Nearly 344 wheat varieties (291 *T. aestivum*, 46 *T. durum*, 4 *T. dicoccum* and 3 *T. triticale*) have been released so far in India.

In India wheat is grown in almost all states. The important wheat growing states are Bihar, Jharkhand, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, Uttrakhand and West Bengal. In India the area under wheat is 31.34 million hectares producing about 95.91 million tonnes with an average productivity of 3061 kg ha^{-1} (Anonymous, 2013-14a). Area under cultivation in Maharashtra is 10.96 lakhs hectares having production of 16.023 lakh metric tonnes and productivity of 1461 kg ha^{-1} (Anonymous, 2013-14b).

This crop is being increasingly grown in areas where the ambient temperatures exceed the optimum temperature. Heat stress at late growth stages is a problem in 40 per cent of wheat areas in the temperate environments (Blum, 1983). The ideal genotype for high temperature stress conditions must combine a reasonably high yield potential with specific physiological characters which could buffer yield against severe temperature stress (Kumar, 2002).

Temperature is one of the most important climatic factors which affect the growth, development and yield of wheat. It has been predicted by the middle of the next century, increase in concentration of green house gases will result in rise in mean temperature of about 2^0C (Kattenberg *et al*., 1995). The Inter- governmental Panel on Climate Change (IPCC, 2007) announced that the world temperatures could rise by between 1.1 and 6.4 ^{0}C (2.0 and 11.5 ^{0}F) during the 21st century. Many reports have concluded that the increase of average global temperature would cause significant change on ecosystems. In wheat, rate of grain filling can be decreased by high temperature (> 31^0C) after anthesis (Stone *et al*., 1995; Wardlaw and Moncur, 1995).

For the germination of wheat, the optimum temperature requirement is between 20^0C-22^0C whereas, the *base* temperature is 4^0C. During grain development, the mean maximum temperature between 25^0C and 32^0C are considered moderately high temperatures and 35-45^0C are considered very high temperature (Stone *et al*., 1995).

Even if there is increase in the yield potential by wheat breeding, the success of the future depends on the cooperation between wheat breeders and crop physiologists (Jackson *et al*., 1996). In recent years, researchers showed that some physiological criteria such as stomatal conductance (Bahar *et al*., 2009), photosynthetic rate (Koc *et al.,* 2003), membrane thermal stability (Yıldırım *et al*., 2009), canopy temperature depression (Bahar *et al*., 2008), and cholorophyll content (Yıldırım *et al*., 2011) provide a gain in wheat production. However, yield and yield components are still been used as most effective screening criteria in wheat under heat stressed conditions (Ozkan *et al*., 1998 and Mohammadi *et al*., 2004). Physiological researches showed that photosynthetic rate of flag leaf, stomatal conductance, and ash content were the complementary selection criteria for heat stress tolerance under Mediterranean conditions (Koc *et al*., 2008).

Manifestation of wheat yield fluctuates widely as a result of its interaction with environment because grain yield is a complicated quantitative charecter and is the product of several contributing factors affecting grain yield directly or indirectly. Wheat production can be increased through development of productive genotypes/varieties for various agro-climatic conditions and stresses. Selection for grain yield improvement can only be effective if sufficient genetic variability is present in the genetic material (Ali *et al*., 2008). Genotypic and phenotypic correlations are important in determining the degree of association of various yield contributing parameters with grain yield with knowledge of their direct positive and negative effects in genotypes for adopting suitable selection strategy. Correlation among different traits is generally due to the presence of linkage and pleotropic effect of different genes. Environment plays an important role in the development of phenotypic correlation (Ali *et al*., 2009). Phenotypic correlation is the net result of genetic and environmental correlation. The dual nature of phenotypic correlation makes it clear that the magnitude of genetic correlation can not be determined from phenotypic correlation.

Any breeding programme aims to develop high yielding varieties with good quality attributes, showing good response and stability under different environmental conditions. Information on impact of sowing dates is thus very important to adjust the genotypes for their stability in wide range of environments. The phenotypic expression of a character is not always same under all the environments and different genotypes may respond differently to any specified environments .This response of genotypes to environmental fluctuations is due to genotype x environment interaction, which is less defined and non predictable. G x E interactions may offer opportunities especially in the selection and adaption of genotypes showed positive interaction with location and its prevailing environmental conditions (exploitation of yield stability). Improvement of end use quality in bread wheat depends on thorough understanding of current wheat quality and the influence of genotypes, environments and genotype x environment interactions on quality traits (Singh *et al.*, 2003). Moreover, stability of quality characters is also important in increasing selection efficiency for breeders in breeding programmes (Korkut *et al.,* 2007).

Considering the G x E as one of the major factors to determine yield, yield attributes, physiological and quality traits as well as environment effects inter-relationship among the traits simultaneously in same direction or some time in different directions. Therefore, the present investigation was undertaken with the following objectives.

1. To estimate the G x E interaction for yield, yield contributing traits, physiological and quality aspects of newly developed bread wheat genotypes.
2. To estimate the correlations and undertake path analysis for yield and yield contributing traits over the environments.

2. REVIEW OF LITERATURE

Stability performance of wheat cultivars for different agro climatic zones and cultivation with respect to grain yield ability over fluctuations of environment conditions caused by climatic changes effects is necessarily desirable. For this, identifications of adaptive traits to be incorporated into genotypes are needed. Traits like earliness, number of tillers, grains per spike, test weight, photosynthesis rate, transpiration rate *etc* are importance. for higher yield along with stability performance. Sufficient biomass production by the genotype is necessary for metabolite production for grain yield and quality.

The volume of work done in improvement of wheat for this particular objective is not sufficient and literature available in this line is fairly scanty. However, attempts have been made to review the work done in the past and collect the various suggestions put forward for this purpose.

2.1 G x E interaction

The stability was defined as adaptation of varieties to unpredictable and transient environmental conditions and the technique has been used to select stable genotypes unaffected by environmental changes (Allard and Bradshaw, 1964). A number of stability studies have been carried out on different crop plants as well as on bread wheat. The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions (Ali *et al*., 2003). Some genotypes may perform well in certain environments, but fail in several others. Genotype environment (G x E) interactions were extremely important in the development and evaluation of plant varieties because they reduce the genotypic stability values under diverse environments (Hebert *et al*., 1995). Genotype x environment interactions complicates the identification of superior genotypes (Allard and Bradshaw, 1964) but their interpretation can be facilitated by the use of several statistical modeling methods. The most widely used is the joint regression including regression coefficient (bi) and variance of deviations from regression (S^2di) (Eberhart and Russell, 1966).

2.1.1 G x E interaction for yield and yield components

Stability analysis is a statistical technique in plant breeding research (Eberhart and Russell, 1996), where the yield of a variety is regressed on the location-year mean yield of all genotypes providing an indication of varietal behavior across changing environments. Yield stability is the result of a crop's buffering capacity *i.e.*, its ability to perform reliably well over a range of years and locations.

Sandhu *et al*. (1980) observed that significant G x E interaction was exist for all the characters such as grain yield, 1000 grain weight, spikelets per spike, productive tillers, spike length, grain number per spike, days to heading and plant height. The heterogeneity of regression was significant for all the characters except for spikelet number. The deviations from regression were significant for all the characters except for 1000 grain weight and grain yield.

Chaubey and Sastry (1981) studied stability parameters of 14 Indian and 14 Mexican genotypes of wheat over four artificially created environments. The result indicated that none was stable for all the traits, but most of them were stable for days to flowering and number of spikes. Medium height genotypes were stable for grain yield per plant and such Indian genotypes were stable for yield components and gave higher grain yield. Further, they reported that number of spikes was the most influential yield component and breeding for stability for this trait might result in stable high yields.

Moneim (1987) had studied genotypic stability of yield and yield related traits in wheat-Agropyron derivatives under varying water regime for two years. The result indicated that differences among environments, genotypes and their interactions were highly significant for grain yield, tiller number per plant, spikelet number per main spike, number of grains per spike, 1000-grain weight, biological yield, plant height and harvest index. The G x E linear responses were significant for number of spikelets per main spike and grain number per main spike. No significant linear responses were detected for grain yield or the yield related traits studied. Deviations from linear responses were highly significant for all traits studied. Grain yield stability was not associated with the stability of yield components.

Gebeyuhu *et al.* (1988) evaluated six and eight varieties of wheat for grain yield stability at 37 and 23 sites, respectively. The result indicated that G x E interaction was highly significant. Regression analysis suggested that the high yielding varieties were more suitable under favourable growing conditions compared to low yielding .

Mondal and Das (1989) evaluated 19 genotypes of bread wheat for stability analysis in tarai soils of West Bengal under four different environments. The results indicated significant differences among genotypes (G), environments (E), the linear component (L) and also G x E interactions were observed for the yield per plant, days to 50 per cent maturity and plant height, but not for 1000-grain weight.

Xhuveli and Collaku (1989) studied 32 genotypes of bread wheat for yield stability at nine sites and grouped them into three on the basis of coefficient of regression of means for yield on environment (bi) as (1) those with bi=1 (with high stability in 7 different environments), which are recommended for commercial cultivation, (2) those bi>1, performing well in favourable environments and (3) those with bi<1 performing better over unfavourable environments.

Borghi and Perenzin (1990) evaluated 15 hybrids bread wheat with their parental varieties over 8 locations. They found that for yield of the hybrid, bi and S^2di were close to those of the parental varieties. The grain yield of the hybrids correlated with the performance of the parental varieties. They concluded that the best performing genotypes (either hybrids or varieties) were those which responded linearly and in predictable way under increased fertility.

More *et al*. (1990) studied 28 genotypes at 7 locations for grain yield. They found a significant G x E interaction and suggested that the stability parameters are governed by an independent genetic system.

Geleta *et al*. (1992) tested eight bread wheat genotypes for stability of yield and harvest index at nine locations under rainfed conditions. They found a significant difference between cultivar and location for grain yield and biological yield and harvest index. However, cultivar x location interactions were highly significant for grain yield and biomass yield only.

Maloo *et al*. (1993) evaluated 40 different wheat varieties for G x E interaction on grain yield, biological yield and harvest index at nine environments. They found G x E interaction was significant for all the traits studied. Both linear and non linear portion of G x E interaction were significant for biological yield with predominance of linear component. Non linear component was significant for grain yield and harvest index. The mean performance appeared to be associated with linear response and stability of grain yield.

Kheiralla and Ismail (1995) conducted stability analysis of 10 wheat genotypes for grain yield and some useful traits related to drought resistance over 12 environments. The result revealed that G x E interaction was highly significant for days to heading, leaf water loss percentage and grain yield. The major component of differences in stability was due to the linear regression for the traits studied. The regression coefficient was positively correlated with the mean performance, indicating that low yielding genotypes were generally stable and high yielding ones were rather responsive.

Deswal *et al*. (1996a) evaluated 35 genotypes of bread wheat and three macaroni wheat for stability analysis of harvest index and some yield components over locations. The result indicated that G x E interactions was significant for plant height, number of tillers per 30 cm and grain weight per spike. Both predictable and non predictable components shared the G x E interaction for plant height and number of tillers per 30 cm. However, for grain weight per spike, the non linear component was predominant. In spite of non-significant G x E interactions, the linear component was significant for 1000-grain weight. They found significant G x E interaction for 1000-grain weight and harvest index. The majority of genotypes were stable for different traits.

Shahid and Kabir (1996) studied 21 promising bread wheat breeding lines at six different sowing dates over a wide range of environments for yield. The result indicated that genotypes differed significantly for yield and G x E interaction was highly significant.

Menon *et al*. (1997) tested 55 genotypes of hexaploid wheat for phenotypic stability, days to maturity, plant height, tiller number, 1000 grain weight, harvest index and yield. They found that environmental linear component was highly significant only for grain yield, tiller number and plant height.

Mehta *et al*. (2000) reported that HD 2329, DL 153-2 and DL 803-3 to be highest yielding with mean performance over all fertility levels. However, two genotypes viz., HD2329, and DL 153-2 (Kundan) had attributes of responsiveness to high yielding environments as evidenced by unit linear regression coefficient (bi=1) of the stability analysis. The deviation (S^2di) from regression was the highest for HD 2329 and this variety is suited especially to high yielding environments whereas, Kundan showed the minimal S^2di indicating that varietal performance was stable even at lower fertility level.

Madariya *et al*. (2001) studied 50 genotypes of bread wheat with three simulated environments for stability parameters in respect of grain yield and its component. The result revealed that G x E interaction was significant for all the characters. Both linear and non linear components of G x E interaction for grain yield, number of spikelets per spike, number of grains per main spike and 1000 grain weight whereas, for number of effective tillers per plant only linear component was significant. They reported that number of effective tillers per plant, number of spikelets per spike, number of grains per main spike and 1000-grain weight were the major component of yield, varied in compensatory fashion to impart stability to the final and complex yield.

Sial *et al*. (2000) studied the stability for yield performance and G x E interaction in 12 bread wheat genotypes under 13 contrasting locations. The combined analysis of variance revealed a highly significant ($P \leq 0.01$) difference for genotypes, environments and G x E interaction. They found that genotype SI-90157 produced the highest mean yield over all environments showing wide adaptation and stability.

Babu and Kumar (2001) reported that G x E interaction was notable for grain yield and its attributes, suggesting that some of the genotypes were unable to maintain consistent performance under various environments.

Mondal and Khajuria (2002) studied 10 bread wheat genotypes for stability in Jammu and Kashmir. They found significant genetic variation in terms of G x E interaction for yield and other characters.

Amin *et al.* (2005) evaluated 10 promising wheat genotypes for grain yield stability under varied environments at 9 locations in the North West Frontier Province, Pakistan. The interaction between genotypes and environments (G x E) was found significant in this study. In this study, deviations from regression (S^2di) and average grain yields were used to identify the superior genotypes. Above average grain yields were observed in genotypes, CT-99022, SAW-98063, CT-99155 and Saleem-2000. Although cultivar Saleem-2000 produced high yield, on the basis of high S^2di value seemed to be sensitive upon environmental changes. Based on grain yield performance, low deviation from regression and bi values the genotype CT-99022 is more suitable for favourable and CT-99155 for unfavourable environments. Stable performance was expressed by SAW-98063 because of higher grain yield, regression coefficient (bi = 0.983) and low deviation from regression ($S^2di = 0.065$).

Aycicek and Yildirim (2006) conducted trials on the 20 bread wheat genotypes trials across two locations for two years. . All the genotypes were found stable for their traits of plant density and days to heading. There were differences in stability performances among the genotypes for the traits of plant height, days to heading, grain numbers per spike , grain weight per spike , 1000 grain weight and grain yield.

Banerjii *et al.* (2006) reported, significant mean squares for all the genotypes and genotype x environment for all the traits studied. The linear component of G x E interactions was also found to be significant for number of grains per spike, 1000-grain weight and grain yield per plot indicating the presence of both predictable and non-predictable components.

Gowda (2009) and Gowda *et al.* (2010) reported stability of 49 genotypes for different morpho-physiological and quality parameters. The 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 which showed distinctly differential effect of the different sowing conditions. The variance for genotypic effect was also highly significant for all the traits indicating thereby differential response of all the genotypes selected for the 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.

Kota (2010) and Kota *et al.* (2013) studied 23 new plant type wheat derivatives with three checks were evaluated for grain yield and stability under timely (TSI) and late-sown irrigated environments (LSI). Analysis of variance of stability for grain yield through Eberhart and Russell's model and AMMI analysis revealed highly significant differences among genotypes and environments and significant genotype x environment (G x E) interaction (GEI). Highly significant mean squares due to environment + genotype x environment interactions (E + G x E) in the Eberhart and Russell model revealed that genotype interacted considerably with environmental conditions that existed under TSI and LSI condition. Further partitioning of E + G x E effects indicated that E (linear), G x E (linear) component, and pooled deviation were highly significant for grain yield. Genotypes DL 893, DL 901, DL 966 and PBW 343 exhibited high *per se* performance under TSI, whereas DL 880, DL 882, DL 886, DL 892, DL 893, DL 901 and DL 927 recorded high *per se* performance under LSI at both locations. Based on *per se* performance, regression coefficient, and deviations from regression as well as AMMI analysis, genotypes DL 886, DL 901, DL 924, DL 927, DL 966 and DL 960 were found to be stable and are adaptable to both TSI and LSI.

Parveen *et al.* (2010) evaluated 13 wheat cultivars for 2-years at 5 diverse locations of North West Frontier Pakistan for stability analysis of tillers per meter square, 1000-grain weight and grain yield. Combined analysis of variance revealed significant differences among locations, years and location × year interactions for these wheat traits. Cultivar × year interaction was highly significant (p=0.01) for 1000-grain weight and grain yield, while cultivar × location interaction was highly significant only for productive tillers per meter square. Maximum number of productive tillers of 410 per meter square were produced by wheat cultivar Dirk, followed by Fakhre Sarhad (396 tillers per meter square) and Nowshera-96 (395 tillers per meter square). Cultivars Dirk and Nowshera-96 excelled in 1000-grain weight (43 g). Maximum grain yield of 4259 kg ha^{-1} was produced by cultivar Nowshera-96 followed by Fakhre Sarhad (4183 kg ha^{-1}). Wide range of stability statistics was observed among cultivars for all the three parameters. Though none of the wheat cultivar had bi- value equal to unity for tillers per meter square, 1000-grain weight or grain yield, but Pirsabak-85, Bakhtawar-92, Nowshera-96 and Fakhre Sarhad were the stable cultivars on the basis of overall mean yields and stability parameters *viz.*, regression coefficients and minimum deviations from regression.

Arain *et al.* (2011) studied G x E interaction in 12 (nine advance genotypes and three checks) wheat genotypes evaluated at various locations having different agro-climatic conditions in Sindh province of Pakistan over two years. Pooled analysis of variance revealed highly significant ($p<0.01$) difference for genotypes, environments and genotype x environment (G x E) interaction. A joint regression analysis showed that genotype MSH-14 produced the highest mean yield (5090 kg ha^{-1}) in all environments averaged for two years, and had regression coefficient (bi) close to unity (0.86) and S^2di close to zero (0.7923). This indicated wide adaptation and stability of performance of MSH-14 in all environments. Other high yielding genotypes MSH-03 and MSH-05 ranked 2nd and 3rd showing regression coefficient (bi=0.78 and 0.69 respectively) and deviation from regression (S^2di = 1.076 and 1.29, respectively) indicating specific adaptability of these genotypes to harsh (unfavorable) environments. These findings suggested that both the genotypes could be used as stress tolerant genotypes under stressed environments (such as drought, heat and salinity stress).

Anwar *et al.* (2011) were studied stability performance for 20 advanced lines wheat including two check varieties was sown under two different sowing times throughout the Punjab province at 18 different locations. The pooled analysis of variance showed significant differences among environments and genotypes for grain yield demonstrating the presence of considerable variations ($p<0.01$) among genotypes as well as diversity of growing environments at various locations for both normal and late sown wheat crops.. Under both normal and late sowing, none of the varieties exceeded the check Seher-2006, however, the check was followed by the advanced lines V-04022 and V-05066 for normal sown crop and Shafaq-2006, V-05066 and V-04022 under delayed sowing. All the genotypes revealed decline in grain yield for late sown wheat crop. The analysis of stability based on mean grain yield, regression coefficient and deviation from regression advocated that the cultivars V-05066 and V-03BT007 were most stable and adapted to diverse environmental conditions of Punjab. These cultivars revealed unit regression and non-significant deviations from regression. The check variety Seher-2006 produced maximum yield for both sowing times that suggested its consistent and stable performance across the environments.

Bhoite *et al.* (2011) studied six genotypes under four environments , on the examination of individual parameters of stability for grain yield reported two varieties stable for average cultivation under rainfed situation.

Karimizadeh *et al.* (2012) evaluated 18 durum wheat genotypes at two locations for two years in Iran. Seed yield and its components are affected by plant genotype and environmental conditions. Significant differences among years or between conditions were obtained in terms of all traits. Genotypes x environment interactions at all the traits *viz.* grain yield, thousand grain weight, spike length and grains per spike were highly significant. According to the stability parameters, G6 and G12 genotypes were stable for grain yield. Genotypes, GA//2*CHEN/ ALTAR84 and SHAG_26/SNITAN were considered as having high adaptability to both rainfed and irrigated conditions while OUASERL -1(G5) and OSSL-1/4/MRBSH/3/RABI//GS/CR/5/ HNA (G8) were considered as having low adaptability to both rainfed and irrigated conditions.

Ranjana and Kumar (2013a) tested 20 varieties of wheat for 11 quantitative traits in three environments of extended dates of sowing. Highly significant variations due to genotypes against pooled deviation revealed the presence of genetic variability for all the traits under study except for biological yield per plant and harvest index. The genotypes PBW 343, PBW 527, PBW 233, PBW 502, UP 2425, UP 2565, C 306 has high mean values for grain yield and non-significant regression coefficient (bi) approaching unity with non-significant deviation from regression were more stable across three environments. Parameters in respects to yield attributing traits revealed that the variety UP 2565 was stable for grain yield per plant and biological yield per plant. While variety PBW 396 had average stability for productive tillers per meter, spike length and UP 2382 has similar response of test weight and days to maturity.

Yadav *et al.* (2013) evaluated 49 bread wheat genotypes in three environments to study G x E interaction. Highly significant differences were detected among the environment and genotypes for all the traits except number of tillers per meter, grain weight per spike and hectoliter weight. Both genotype and environment had significant effect on yield and quality traits. The genotype UP 2572 was found to be the highest yielder and was the most stable genotype PBW 396 and UP 2731 has been stable for grain yield in addition to spikelet's per ear , days to maturity and plant height ,while HD 2967 was found stable for yield long with ear length, spiklets per spike , thousands grain weight and harvest index. UP 2338 was the only genotype showed stability for sedimentation value.

Kant *et al.* (2014) studied 42 bread wheat genotypes were grown in four different test environment to identify the stable genotypes under different environments. The genotypes WH 711, DBW 17, PBW 343, UP 2338, WH 542, HD 2687, PBW 550, WH 416 and were promising for grain yield. A major portion of G x E was accounted by non-linear component for days to heading, days to maturity and biological yield per plant. However, the linear portion was higher for number of grains per spike, effective tillers per plant and protein (per cent).

Meena *et al.* (2014) studied the G x E interaction for 47 genotypes of bread wheat under four environments. The variance for genotypic effect was highly significant for all traits indicating thereby differential response of all the genotypes. Varieties K 9107, UP 2382 and PBW 443 were found to be stable across the environments for grain yield and NW 1076 was the highest yielding stable variety in which superior yield was resulted from high mean values of six contributing traits, while variety LOK 1 was the only variety showed stable performance for all 12 traits. The varieties HD 2824, UP 2382, NW 1076, DBW 16, DBW 39, GW 173, HUW 234, NIAW 917, LOK 1, HD 2851 and PBW 154 have shown higher mean values, desirable regression coefficient and non-significant deviation from the regression coefficient for yield and its contributing traits.

2.1.2 G x E interaction for physiological traits

Gowda *et al.* (2011) had assessed the relationship of physiological parameters with grain yield under hot environment. From the analysis of normal, late and very late sowing date it is evident that all the characters showed sufficient amount of variability in all three environments among all the 49 bread wheat genotypes. All the characters *viz.* grain yield, membrane injury percent and relative water content expressed significant interaction with environments, indicate that all the characters respond to high temperature in different ways in different genotypes.

Ghobadi *et al.* (2011) conducted experiment to study of water relations and chlorophyll in 21 wheat genotypes and their correlations with grain and biological yields. The results showed that relative water deficit, relative water loss, excised leaf water retention, cell membrane stability, chlorophyll-a, chlorophyll-b, total chlorophyll, grain yield and biological yield were different significantly among wheat genotypes, but SPAD-chlorophyll index, relative water content and chlorophyll florescence were not.

Tripura *et al.* (2011) 36 diverse wheat genotypes and three sowing conditions to assess the stability of genotypes for yield and physiological parameters. The pooled analysis of variance with respect to all the traits indicated that the variance due to environment was significant for all the traits *viz.* grain yield, membrane injury index and relative water content except canopy temperature depression at anthesis which showed the distinctly differential effect of the different sowing conditions in the name of environment. The variance for genotypic effect was also highly significant for all the traits under study indicating thereby differential response of all the genotypes selected for the study. The varieties BACANORA T 88, BHRIKUTI, BL 1804, CHIRIYA 3, CHIRIYA 7, CNO 79/PRULLA, GW 273, GW 326, HD 2189, HD 2819, KANCHAN, HD 2781, MP 4010, NEPAL 1, NL 623, HD 2987, C 306 and PBW reported stable varieties .

Li *et al.* (2012) characterized grain yield and three physiological traits for 30 spring wheat genotypes. These field experiments with three irrigation regimes were conducted in 2009 and 2010 seasons. Study revealed that Feekes 11.2 is the optimal stage to evaluate flag leaf senescence (FLS) and canopy temperature (CT) when making selections for high grain yield and drought resistance among wheat genotypes. Flag leaf carbon isotope discrimination (CID) was positively correlated with grain yield, whereas FLS and CT were negatively correlated with grain yield. The three traits together explained 92 per cent of the total phenotypic variation of grain yield. Selected genotypes were classified into four groups based on yield performance across irrigation regimes. High yield genotypes IDO599, 'Alturas', and IDO702 produced high grain yield across different water conditions; drought-resistant genotypes 'Agawam', 'McNeal', and 'Alpowa' produced higher grain yield under the non irrigated regime. High yield of those genotypes was contributed by good performance of physiological traits such as late FLS, great CID, or low CT or combinations of these traits. Preliminary results indicate that using physiological traits to estimate yield performance can be effective, and selecting suitable genotypes for different water environments may be crucial for improving yield productivity

2.1.3 G x E interaction for quality traits:

Atli (1999) and Hailu *et al.* (2007) clearly showed that there are certain differences in grain protein content of genotypes among environments due to climatic conditions.

Grausgruber *et al*. (2000) reported that zeleny sedimentation value depends more on the qualitative variation of storage proteins than on their quantity and is mainly affected by the genotypic and environmental effects .

Baric *et al.* (2004) was evaluated for four cultivars grown in 12 environments in different parts of Croatia to study the G x E interaction. The cultivars Kuna and Banica showed high performance for most quality traits and were also identified as stable for the majority of them. The cultivar Žitarka was stable for four farinogram traits showing high level of performance only for dough development time, while Marija showed stability for only three traits but with unfavorable mean values for all of them. The largest contribution of genotype by environment effects in the total sum of variance components was found for the farinogram traits stability and dough development time, while the lowest, but similar to each other for protein content and wet gluten content.

Tahir *et al.* (2006) concluded that high temperature influences both grain yield and end use quality of wheat. Fifteen bread wheat genotypes in 2000/2001 and 18 genotypes in 2002/2003 were evaluated under the optimum and late sown environment of the irrigated hot environment of the irrigated hot environment of Gezira Research Form Wad Medani Sudan showed that high temperature significantly decreased grain yield by decreasing grain weight. Although genotypes exhibited variation in magnitude of response ,results indicated that high temperature during grain filling increased both soluble and insoluble protein contents, SDS sedimentation values, and hence gluten strength. Variation among genotypes suggest that grain end use quality could be improved under high temperature conditions utilizing the available variability.

Oury and Godin (2007) studied the relationship between grain yield (GY) and grain protein concentration (GPC) in bread wheat for about 11 years of series of trials. The correlations between the two characters appeared highly variable due to high genotype x environment interaction for GY and GPC. Using the well assessed relationship obtained, grain protein deviations were defined as the standardized residuals of the regression of GPC on GY.

Majid *et al* (2007) reported variance due to variety × environment showed significant linear interaction for the characters grain yield, protein per cent, hectoliter weight, and sedimentation value showing differential response to the varieties with different environments .

Zeki Mut *et al.* (2010) carried out an experiment at seven environmental conditions during 2 growing periods (2003-2004 and 2004-2005) in randomized complete block design with four replicates. The ANOVA showed that out of the total sum of squares, 48.4, 28.0 and 23.6 per cent for TGW, 71.4, 14.9 and

13.7 per cent for HW, 54.4, 23.0 and 22.6 per cent for GPC, 44.7, 41.7 and 13.6 per cent for ZSV was attributable to E, G and G x E interaction effects, respectively. Thousand grain weight, hectoliter weight, grain protein content and zeleny sedimentation volume of genotypes changed from 34.5 to 41.4 g, from 76.5 to 80.4 kg, from 11.49 to 13.37 per cent and from 22.1 to 46.0 ml, respectively. The study of genotypic stability showed that Bezostaya and advanced lines numbered 11 and 24 had high stability for quality traits and proved to be the best within the pool of the studied genotypes. Also, 8 and 17 numbered genotypes demonstrated high stability for TGW, HW, GPC, & ZSV, respectively.

Dencic *et al.* (2011) studied 140 wheat genotypes originated from 28 countries were grown in 2000, 2001, 2002 and 2003. Data of 9 bread making quality traits, protein content (PC), wet gluten content (WG), farinograph absorption (FA), farinograph dough development time (FD), farinograph quality number (FQU), resistance to extension (ER), falling number (FN), loaf volume (LV), and baking score (BS), were used to evaluate the effects of cultivar, environment and their interaction. Both cultivar and cultivar by environment interaction had significant effects on all quality traits.

Castillo *et al.* (2012) evaluated the 13 spring wheat cultivars sown in six environments in the central-south and southern zones of Chile during two seasons to asses G x E interaction for grain yield, sedimentation, and wet gluten content of the data were analyzed by regression analysis, additive main effects and multiplicative interaction (AMMI), and the sites regression (SREG) model. By this was thus established that SREG analysis is the most efficient for this type of study since, in addition to analyzing stability, adaptability, and effect (G×E), it allows identifying the best cultivar. In this case, ‘Pandora-INIA’ stands out by exhibiting the best yield (7.38 t ha^{-1}), high sedimentation (36.95 ml), and wet gluten (41.54per cent) indices in all the environments, and this positions it as a variety having both high yield and quality.

2.2 Genetic variability and inter-relationship studies

First hand information on the nature and extent of variability in bread wheat genotypes grown under different environments are essential to understand status of the grain yield potential and contribution of yield components to the grain yield.

Chaturvedi and Gupta (1995) found that phenotypic variation was higher than genotypic variation; heritability estimates were high for protein content, spike length and plant height, moderate for seed hardness, flowering time, time to maturity, 1000 grain weight and grain weight per spike and low for the other traits.

Bahadur and Lodhi (1995) reported high GCV and PCV for plant height, grains per ear and grain yield per plant while tillers per plant had low heritability. Plant height, days to heading, grains per ear and grain yield per plant and high genetic advance.

Raut *et al.* (1995) analyzed the selection criteria in wheat and concluded that grain yield 1000 grain weight, tillers per meter row length and peduncle length exhibited high heritability along with high genetic advance. Characters 1000 grain weight, biological yield per plant, harvest index, plant height and grains per spike had high GCV and high heritability along with high genetic advance.

Sharma *et al.* (1995) studied 42 population of winter x spring crosses and found that 1000 grain weight, biological yield/plant, harvest index, plant height, grains per spike had high GCV, high heritability and high genetic advance.

Deswal *et al.* (1996b) concluded that due to additive gene effects 1000 grain weight, total biomass per plant, grains per spike and grain yield per spike had the high heritability and high genetic advance.

Shimpiger *et al.* (1996) studied the genetic variability in 324 durum lines and concluded that biological yield per m^2 and harvest index had moderate variation, heritability and genetic advance. All other characters had low variation and high heritability except for the number of productive tillers and grain yield. The highest genotypic coefficients of variation were observed for grains per spike followed by

1000 grain weight, grain yield per plant and spikes per plant. Days to heading, 1000 grain weight and days to maturity exhibited high broad sense heritability.

Uddin *et al.*(1997) reported that heritability value was moderate for grains per spike and low for the rest of the characters Genetic advance in percentage of mean was high for 1000 grain weight, grains per spike, days to heading, grain yield per plant and plant height .

Moyghaddam *et al.* (1998) analyzed genetic variation for agronomic traits in landraces of bread wheat and found highly significant differences among the genotypes for all the traits considered. However, genetic coefficient of variation was relatively low for the developmental characters and plant height. Compared with the modern cultivars, the landrace genotypes were, on average, later, taller and produced more spikes per plant but had lower values for number of grains per spike, 1000 grain weight, grain yield per plant, and harvest index. Intermediate to moderate estimates of heritability and genetic advance were observed for grains per spike, 1000 grain weight and grain yield.

Khumkar *et al.* (2001) evaluated 49 wheat genotypes for genetic variability and found that total tillers per meter row length and grain yield per plot had high genetic advance and heritability. Based on genetic coefficient of variation, heritability coupled with genetic advance, the characters viz., numbers of total tillers per meter and grain yield per 100 tillers were identified as selection criteria for yield improvement in late sown wheat.

Prakash and Pandey (2001) assessed the genetic diversity in 42 genetic stocks of *T. durum* on the basis of 10 quantitative characters. Days to heading, plant height, productive tillers per plant, 1000 grain weight, protein content and sedimentation value showed high heritability value which means that these characters are likely to respond to direct selection.

Satyavari *et al.* (2002) found maximum heritability for ear length followed by number of grains per ear and peduncle length, whereas genetic advance was higher for plant height, peduncle length and ear length.

Gupta *et al.* (2004a) found the high heritability estimates for number of tillers per plant, plant height, number of spikes per plant and yield per plant. Low to medium heritability was observed for test weight, number of spikelets per spike, number of grains per plant, length of the main ear per plant, number of tillers per plant and yield per plant. High genetic advance was observed for number of spikes per plant, number of tillers per plant and yield per plant. Low to medium genetic advance was observed for plant height, test weight, main ear length per plant, number of grains per spike and number of spikelets per spike.

Yadav *et al.* (2006) revealed that a close proximity between GCV and PCV could also be noticed for characters *viz.* grain weight per spike, yield per plant and that per meter square, number of grains per spike, grain protein per cent and thousand grain weight indicating them to be less influenced by environment.

Kumar *et al.* (2009) reported considerable genetic variability for grain yield and it's component characters in bread wheat.

Shankarrao *et al.* (2010) and Hokrani *et al.* (2013) reported high genotypic and phenotypic coefficient of variation for number of productive tillers and grain yield per plant .

Ranjana and Kumar (2013b) revealed that high phenotypic and genotypic coefficient of variation was observed for grain yield per plant, grain yield per plot, productive tillers per meter, grains per spike, biological yield per plant, harvest index and moderate for plant height, flag leaf length, width and test weight. The high heritability coupled with high genetic advance was observed for the characters plant height, productive tillers, spike length and test weight in all three dates of sowing. Thus these traits could be used effectively for the improvement of high yielding varieties of wheat for early, timely and late sown conditions.

2.3 Correlation studies

Grain yield in wheat, as in other crops, is a complex character and is greatly influenced by environmental factors. Adequate knowledge of inter-relationship of factors influencing such complex traits is essential for designing an effective plant breeding programmes. Various studies have been conducted by several workers in relation to the correlation of various attributes to the yield and the literature regarding these studies is cited below:

Significant positive correlation between stomatal conductance and photosynthetic rate with grain yield were observed by Shimshi and Ephart (1975), Delgado *et al.* (1994), Reynolds *et al.* (1994) and X .Chen *et al.* (2012).

The rise in crop canopy temperature adversely affect the grain yield were reported by Das *et al.* (1993), Chakrborty (1994), Onyiibe *et al.* (2003), Tyagi *et al.* (2003), Bahar *et al.* (2011) and Basu *et al.* (2014).

Thousand grain weight showed negative and highly significant association with grain yield indicating the practical difficulty of simultaneous improvement of these characters due to lack of closely linked genes that cause co-variation in the traits (Falconer, 1989). These results are in agreement with the result of Sarkar *et al.* (2002) , Khaliq *et al.* (2004) and Degewione *et al.* (2013)

Mohan *et al.* (1993) reported that correlation studies indicated that grain yield was positively correlated with biological yield, effective tiller per meter, length of ear, number of grains per ear, grain weight per ear and nutrient uptake ability.

Singh and Sharma (1994) showed that grain yield was significant and positively associated with tiller number, biological yield and grains per ear but harvest index was negatively correlated with biological yield in wheat. In peninsular India, high temperature stress has a strong influence on wheat growth and yield. The stress intensity is severe under late sowing causing the reduction in the duration of GS_2 and GS_3 growth phases. The genetic variability and association analyses indicated grain test weight, spikelet's per spike and grains per spike under hot (normal sowing) environment and spike length and spike per m^2 under very hot (late sowing) environment may serve as valuable selection criteria (Hanchinal *et al.,*1994).

Mann *et al.* (1994) concluded the results of two experiments in Thailand , found that phenotypic correlations of early vigour were highly significant with grain yield, biomass, heads per meter, days to anthesis, days to maturity and plant height.

Chaturvedi and Gupta (1995) studied selection parameters in wheat, found that economic yield was significantly correlated to biological yield, seed hardness and tillers per plant.

Kaushik *et al.* (1996) found that genotypic coefficients of variation were higher than phenotypic coefficients in two crosses of wheat. In sub populations of WH 416 x UNC 1, 1000-grain weight was significantly and positively correlated with grain yield per plant and biological yield per plant.

Radmehr *et al.* (1996) reported that higher temperatures following the January sowings accelerated the growth and development of plants, but shortened the duration of other development stages and resulted in a decrease in plant height. Reductions in the 1000-grain weight and number of grains per spike were the most important, whilst number of spikes/$m^2$was the least affected.

Rahman *et al.* (1997) grew 11 wheat genotypes under late sowing conditions with high temperatures at the end of February/beginning of March. Grain yield was positively associated with biomass, harvest index, grain production rate, 1000-grain weight and chlorophyll content, and negatively correlated with days to anthesis.

Singh *et al.* (1997) elucidated that coefficients of correlation of grain yield showed significant positive relationship with effective ear number, biological yield and 1000-grain weight, indicating their involvement in heat tolerance of wheat under late-sown conditions.

Uddin *et al.* (1997) found that grain yield per plant was positively and significantly correlated with spikes per plant, spikelets per plant and 1000-grain weight and a high direct effect was observed in spikelets per spike and spikes per plant. They also revealed that grain yield per plant, spikes per plant and 1000 grain weight gave the highest relative efficiency over straight selection for grain yield per plant.

Fischer *et al*. (1998) reported that wheat yield progress is associated with higher stomatal conductance, photosynthetic rate and cooler canopies .

Dokuyncu and Akkaya (1999) analyzed the wheat genotypes for association between agronomic traits and found positive and significant correlations between grain yield and number of heads per m^2, number of grains per head, grain weight per head and test weight.

Khan *et al.* (1999) studied the correlation coefficients in eight wheat genotypes and their crosses. The phenotypic and genotypic correlation coefficients between plant height with grain yield per plant were positive and highly significant. The genotypic correlations were significant for grain yield in a positive direction with days to 50per cent flowering and negative with 1000-grain weight.

Siddique *et al.* (2000) observed the canopy temperature between 23.89 and 29.18°C at anthesis. They also reported that plants under drought stress showed higher canopy temperature than non-stressed (well-watered) plants at both vegetative and anthesis stages.

Esmail (2001) reported that grain yield per plant in wheat was positively correlated with number of spikes per plant, plant height and days to heading but negatively correlated with grain weight per spike. The largest negative phenotypic and genotypic correlation was obtained between number of spikes per plant and grain weight per spike.

Jedynski (2001) reported that number of ears per plant had the highest positive correlation with grain yield. Association of number of grains per ear with plant yield was much lower but significant. There was no significant relationship between 1000-grain weight and grain yield per plant. Correlations between yield components were very low. Negative correlation was found between number of ears per plant and 1000 grain weight in one cross. Results of this study indicated that number of grains per ear was the most important character in selection for high grain yield in wheat.

Prasad and Pandey (2001) found low correlation between 1000 grain weight and yield which indicated that the role of 1000 grain weight in enhancing yield appeared to be limited in case of durum wheat and these two traits were behaving independently. Low negative correlation of yield with protein (-0.18) and no correlation with sedimentation value indicated the possibility of evolving varieties with high yield along with high protein content and strong gluten strength.

Munjal and Rana (2003) reported that cooler canopy and high stomatal conductance at grain filling period would be assumed as the basic morpho-physiological criteria for higher grain yield under heat stressed conditions.

Munjal and Dhanda (2004) studied 43 wheat genotypes under normal (first week of November) and late (last week of December) sowing conditions. In correlation analysis showed that grain yield was positively correlated with tillers per plot and photosynthetic rate under normal conditions, while it was positively correlated with 1000 grain weight with grain yield.

Bhagat *et al.* (2004) concluded that estimates of genotypic correlation coefficients were generally higher than those of phenotypic correlation coefficients for most of the characters. There was a significant positive correlation between grain yield and number of tillers per meter. Plant height was negatively correlated with grain yield. The number of tillers per meter showed significant negative correlation with weight of five tillers and 1000 grain weight. Plant height showed a negative correlation with yield, number of tillers per meter and weight of five tillers and showed a positive correlation with 1000 grain weight.

Khaliq *et al.* (2004) studied the correlation among the ten characters in five wheat genotypes and found that grain yield had a highly significant and positive phenotypic correlation with plant height, number of tillers per plant, spike length, number of spikelets per spike and 1000 grain weight, whereas it had a significant and positive genotypic correlation with all the characters.

Sahu *et al.* (2005) studied the extent of variation and degree of association among yield traits with grain yield under late sown conditions and reported that number of spikes per plant and 1000-grain weight were positively and significantly correlated with the yield.

Aycicek and Yeldrim (2006) revealed that positive and significant correlation was found between yield and plant density, plant height, grain number per spike, grain weight per spike and 1000-grain weight. Grain yield was significantly negatively correlated with time to heading.

Akram *et al.* (2008) results revealed positive correlation in case of number of spikelet's per spike, number of grains per spike and 1000 grain weight with grain yield at both genotypic and phenotypic levels. However, number of tillers per m^2 and spike length contributed negatively towards grain yield at both levels. Plant height was positively correlated with grain yield at genotypic level, whereas negatively correlated at phenotypic levels.

Anjum *et al* (2008) found positive non-significant correlations between grain yield and stomatal conductance.

Balota *et al.* (2008) reported that wheat cultivars with high CTD showed a trend of higher yield under heat and drought stress. He also reported durum wheat stayed cooler than bread wheat genotypes under heat stress conditions.

Anwar *et al.* (2009) concluded that grain yield per plant was positively and significantly correlated with number of tillers per plant and days to maturity at genotypic level but non-significantly correlated at phenotypic level. Days to maturity had positive genotypic correlation with grain yield per plant, number of tillers per plant and 1000-grain weight.

Bahar *et al.* (2009) and Bahar *et al.* (2011) have reported that stomatal conductance values have shown positive correlations with grain yield at early milky maturity stage when the genotypes have been classified according to their phonologies at an thesis as earlier or later group.

Khan and Dar (2010) evaluated 37 wheat genotypes and three check varieties were studied for correlation and path coefficient analysis. Seed yield was significantly and positively associated with number of spikelets per plant, followed by number of effective tillers and 1000-seed weight at both phenotypic and genotypic levels. Seed yield showed a significant negative association with number of seeds per spikelet at genotypic level. Among the significant inter-relationships, the association of days to 75 per cent spike emergence with days to maturity and 1000-seed weight were significant and positive, but were negative and significantly associated with number of seeds per spikelet and number of grains per spike. Similarly, the associations of spike length with number of seeds per spikelet, and number of spikelets per plant and number of effective tillers were negative and significant. The association of number of spikelets per plant with number of effective tillers was also positive and highly significant.

Mollasadeghi *et al.* (2011) studied relationship between grain weight per main spike with main spike weight, secondary spike weight, number of grain per main spike and number of grain per secondary spikes was significant and positive, but it was negative and significant with plant height. The relationship between number of grain per main spike with number of grain secondary spike and weight of grain per main spike was significantly positive, but it was negative and significant with one-thousand grain weight per main spike and 1000 weight per secondary spikes. Correlation between biological yields with straw yield was significant and positive and correlation between straw yield and harvest index was significant and negative.

Tripathi *et al.* (2011) revealed that the correlation coefficient between grain yield per plant and other quantitative attributing to yield showed that grain yield was positively associated with plant height spike length, number grains per spike and test weight and biological yield.

Abderrahmane *et al.* (2013) reported that total biomass, number of spikes per plant, number of grains per spike are positively correlated with grain yield.

Mohammadi *et al.* (2012) reported that grain yield was positively correlated with plant height, spike length, days to physiological maturity, agronomic score and test weight.

Ashraf *et al.* (2014) showed that significant and positive correlation estimates were detected between grain yield per plant and each of number of number of tillers per plant, number of spikelet's per spike, number of grains per spike, 1000-grain weight and harvest index. On the other hand, days to 50 per cent heading and plant height showed negative association with grain yield per plant.

Ata *et al.* (2014) reported canopy temperature had positive genotypic association with spike density while had maximum significant negative genotypic association with number of grains per spike, number of spikelets per spike and plant height.

2.4 Path coefficient analysis

Information on the correlation of agronomic and morphological characters with yield is helpful in identification of the components of this complex character, yet these do not provide precise information on their relative importance. With increasing number of variables, it becomes necessary to measure the contribution of these variables to the observed correlation and hence partition the correlation coefficients into unidirectional and alternate pathways. The path coefficient analysis permits a critical examination of specific factors that produce a given correlation and could be successfully employed in formulating an effective selection strategy.

Wright (1921) suggested path coefficient analysis to understand the influence of one variable upon another and permit the partitioning of correlation coefficients into components of direct and indirect effects.

Dewey and Lu (1959) discussed the utility of path coefficient analysis and employed this technique to establish the relative importance of seed size, spikelets per spike, fertility and plant size as determiners of seed yield in crested wheat grain. Fertility and plant size had a strong direct and indirect influence upon seed yield.

Chowdhury and Mandal (1991) worked on three yield characters of wheat and reported that days to maturity showed the highest direct effect on yield and suggested that for improved yield, selection could be followed for larger number of tiller per plant, spikelets per spike, height and grains per ear. Correlation and path analysis on 14 wheat cultivars revealed grain number and weight of the main spike, 1000-grain weight and fertile spikelets, but not plant height, spikes per plant and spike length were significantly correlated with grain yield per plant. It was also shown that the direct contribution of grain weight on the main spike to grain yield per plant was highest, followed by spikes per plant.

Qayyum *et al*. (1991) reported that multiple correlation and regression studies on bread wheat showed that numbers of tillers per plant and kernel weight per spike are the effective yield components as they showed significant contributions towards yield per plant.

Shelembi *et al.* (1992) showed that grains per spike exerted the greatest direct influence on grain yield, but also had a negative indirect influence which reduced the coefficients between grain weight and spikes per meter row with yield, even though there was strong direct contributions by both traits. Since the 3 variables recorded negative correlations and opposite effects to yield, they suggested that the breeder needs to compromise between the three in order to maximize grain yield.

Bahadur *et al.* (1993) showed that estimate of path coefficients revealed that direct contribution towards grain yield was maximum through 1000 grain weight followed by tiller number, number of seeds per ear, number of spikelets and ear length. Plant height had negative direct contribution. It was also reported that indirect effects of tiller number, spikelet number and number of seeds per ear were higher when compared with indirect effects via other variables and these variables also had high direct effects and correlations on grain yield as compared to other variables. Therefore, they suggested that tiller number, spikelet number, number of seeds per ear and 1000 grain weight appeared to be major component of grain yield and should be given utmost consideration in selection for breeding for high grain yield in wheat.

Kumar and Singh (1993) reported spike length had the greatest positive direct effect on grain yield.

Akanda and Mundt (1996) stated that path analysis of yield components in winter wheat revealed that components with the highest correlations to yield also had the largest direct effects on yield. The direct effects of number of seeds per spike and weight of individual seed were similar, although number of seeds per spike was more important in the absence of rust than in its presence.

Mondal *et al.* (1997) stated that grains per ear, 1000 grain weight and tillers per plant had a positive direct effect on grain yield while height and maturity had a negative direct effect on yield. It was suggested that selection should be based on 1000-grain weight and tillers per plant.

Kumar and Hunshal (1998) revealed that harvest index, total dry matter, effective tillers, grains per ear and grain weight per ear were the most important components of grain yield of durum wheat. Indirect effects of other characters on grain yield through harvest index and total dry matter were higher.

Moyghaddam *et al*. (1998) found that direct effect of days to anthesis on grain yield was negligible, whereas that of plant height spikes per plant, grains per spike, and grain weight was moderate to high. The negative correlation between plant height and grain yield was due to indirect negative effects mainly via number of grains per spike and to some extent, grain weight. Spikes per plant, grains per spike and grain weight each had large indirect negative effects on grain yield via the other two traits. It appeared that, for the short term, improvement of concerned wheat land races might be possible through simultaneous indirect selection for fewer spikes per plant but greater number of grains per spike and heavier grains. They also stated that direct selection for yield per se might also be effective.

Khan *et al.* (1999) concluded that harvest index, grains per panicle and plant height are the important characters in order of magnitude. These characters influenced the grain yield of wheat directly; therefore, are the desired characters for selection in wheat.

Dokuyucu and Akkaya (1999) concluded that both direct effects of number of spikes/m^2 and grain weight per spike and indirect effect of number of grains per spike by grain weight per spike and an indirect effect of number of grains per spike by grain weight per spike, were significant and positive. Therefore, number of spikes per meter square, grain weight per spike, and number of grains per spike may be used as selection criteria in breeding programmes to develop high yielding bread wheat varieties.

Narwal *et al.* (1999) stated that tillers per plant, grains per spike and spike length had positive and large direct effects on grain yield.

Tarnman *et al.* (2000) reported that grain yield was affected directly by number of spikes per plant, number of kernels per spike and 1000-kernel weight in both phenotypic and genotypic correlations. Also, it was affected indirectly by biological yield via effects on number of spikes per plant, number of kernels per spike, 1000 kernel weight and days to heading.

Esmail (2001) studied the correlation and path coefficient in bread wheat and reported that the number of spikes per plant had the highest direct effect on grain yield per plant followed by grain weight per spike and plant height in the parents, F_1 and F_2 populations except plant height, which had negative direct effect in the parental lines only at the genotypic level. Number of spikes per plant and grain weight per spike had the highest contribution to grain yield, either through its direct effects and/or its indirect effects with other traits.

Bhagat *et al.* (2004) found that the number of tillers had the largest direct effect. Regression analysis also showed that the number of tillers and grain size were major yield components. There was a high positive indirect genotypic effect of weight of five tillers and 1000-grain weight *via* the number of tillers per meter. The weight of five tillers had a negative direct effect on grain yield and a negative indirect effect on number of tillers per meter, but had high positive indirect effect on 1000-grain weight and height. The weight of 1000-grain showed high negative genotypic direct effect and high positive indirect effect on grain yield. He also reported that, plant height has negative association with grain yield.

Gupta *et al.* (2004b) revealed from path coefficient analysis that number of spikelets per spike and length of main ear per plant showed the highest positive direct effect on seed yield. The number of tillers per plant, number of grains per spike, plant height, seed hardness, sedimentation value and protein content showed negative direct effect on seed yield.

Khaliq *et al.* (2004) stated that direct contribution of spike length to grain yield was the highest (4.43), whereas the number of spikelets per spike had the maximum direct effect (-4.22) on grain yield. Plant height, spike length, spike density, number of tillers per plant, peduncle length and number of grains per spike along with their indirect causal factors should be considered simultaneously as effective selection criteria evolving high yielding cultivars because of their direct positive contribution to grain yield.

Okuyama *et al.* (2004) studied the path coefficient analysis which revealed that positive direct effect and moderate correlation of number of spikes per m2 and number of grains per spike with grain yield. These results indicated that the number of spikes per m2 and the number of grains per spike were the traits related to higher grain yield, under irrigated and late season water stress conditions.

Naserian *et al*. (2007) and Kotal *et al*. (2010) findings led to conclude that grains per spike as a reliable criterion for getting high yield in wheat plants.

Khayatnejada *et al*. (2010) reported that 1000-grain weight had a positive direct effect on yield.

Mollasadeghi *et al* (2011) revealed from path coefficient analysis that the grain yield has a direct and positive effect (0.527) over harvest index, while the straw yield has a direct and negative effect over it (-0.366). Of effective traits to grain yield, four traits including number of grain per spike (0.212), grain weight (0.408), 1000-grain weight (0.093) and biological yield (0.853) had the most direct and positive effect on grain yield. Three traits including spike length, spike weight and biological yield had the most direct effect to straw yield (respectively with 0.029 - 0.191 and 0.891).

Khan and Naqvi (2012) obtained results that , the selection on the basis of number of spikes, number of spikelet's and number of grains in this material would likely to be most useful for increasing grain yield because of their direct positive contribution to grain yield under irrigated condition.

Ata *et al.* (2014) revealed in normal and stress environments that number of grains per spike and spike length could be used for direct selection for the yield. Plant height, 1000-grian weight and relative water contents also contributed for the grain yield in positive way. Canopy temperature could also be used as differentiating trait for the selection of best surviving genotype under drought conditions.

In wheat, studies on correlation and path analysis are extensive. Since the correlation coefficients like other genetical estimates vary from environment to environment and depending on the material used, the genetic association has to be determined for the material in hand under the given set of environmental conditions before planning a pragmatic breeding programme.

3. MATERIAL AND METHODS

The materials used and methods adopted in present investigation are presented in detail below.

3.1 Experimental Material

The experiment was for morpho-physiolgical and quality traits as well as interrelationship studies carried out at multi-location. The experimental material consisted of twenty new bread wheat genotypes developed at Agricultural Research Station, Niphad and three check varieties. The list of the material is given in the Table 3.1.1.

Table 3.1.1 List of the experimental material

SL	Genotypes	Pedigree
1	NIAW 1885	ALTR84/AEGILPOS SQUARROSSA (TAUS)//OPATA/3/…
2	NIAW 1951	HD 2781/NIAW 301
3	NIAW 1994	NIAW 34/ PBW 435
4	NIAW 2065	HD 2781 X NIAW 301
5	NIAW 2073	IC 1296487 X NIAW 34
6	NIAW 2248	NIAW 34 X WH 423
7	NIAW 2255	NIAW 301 X LOK BOLD
8	NIAW 2268	NIAW 301 X K 0221
9	NIAW 2275	GIANI 3 X KYZO 117
10	NIAW 2279	(NIAW 301 X NIAW 34) X (HD 2428 X RAJ 4037)
11	NIAW 2300	HD 2781 X RAJ 4037
12	NIAW 2303	(NIAW 301 X NIAW 34) X (HD 2428 X RAJ 4037)
13	NIAW 2304	NIAW 917 X LOK 45
14	NIAW 2310	NIAW 301 X LOK BOLD
15	NIAW 2313	LOK 45 X WR 1006
16	NIAW 2345	CROC 1/ AE.SQUARROSA (205)//KAUZ/3/SASIA/4/TROST
17	NIAW 2346	ESDA//ALTAR 84/ AE.SQUARROSA (211)/3/ESDA/4CHOIX/5WAXWING
18	NIAW 2348	WHEAR*2/PBW 343*2/TUKURU
19	NIAW 2349	WHEAR/TUKRU/WHEAR
20	NIAW 2351	PFAU/BOW//VEE 9/3/WBLI
21	NIAW 1415 ©	GW 9506/PRL//PRL
22	NIAW 917 ©	GW 244/BOB WHTIE
23	NIAW 34 ©	CNO 79/PRL “S”

3.2 Field experimental methodology

The experiments were conducted at three locations under two sowing conditions. There details are as under

No.	Location	Sowing condition	Sowing date
1	A. R. S., Niphad	Timely Sown Irrigated (TSI)	11.11.2013
		Late Sown Irrigated (LSI)	3.12.2013
2.	P.G.I., M.P.K.V., Rahuri	Timely Sown Irrigated (TSI)	12.11.2013
		Late Sown Irrigated (LSI)	4.12.2013
3.	A.R.S., Savalvihir	Timely Sown Irrigated (TSI)	15.11.2013
		Late Sown Irrigated (LSI)	7.12.2013

At all locations, the experiment was laid out in Randomized Block Design with three replications. Each entry was plotted in four rows of 2.5 meter length. The rows were spaced 20 cm apart and the plant to plant distance was maintained around 5 cm by thinning. The standard cultivation practices prescribed for wheat under irrigated conditions were followed precisely. The field observations were recorded in crop growing season. The material was harvested manually and was brought to Wheat Quality Lab, Department of Food Science and Technology, MPKV, Rahuri where laboratory test on quality traits was carried out.

3.3 Field observations

The field observations were recorded in crop growing season. The data were recorded on 10 plants from each plot for most of the traits. The observation on days to 50 per cent flowering and maturity was recorded on plot basis. The observations were recorded as per the details given below.

3.3.1 Days to 50 per cent flowering:

The data on heading was recorded when 50 per cent of the tillers extruded awns out of the flag leaves. The number of days from sowing to 50 per cent heading over a plot was taken as days to heading.

3.3.2 Days to maturity:

The physiological maturity was considered when plants turned pale yellow due to senescence. Number of days from sowing to senescence was taken for this purpose.

3.3.3 Plant height (cm):

Height of the plant from ground level to the top of the main spike, excluding awns, was recorded at maturity by taking average of ten plants per plot

3.3.4. Spike length (cm):

Spike length was measured from base of the spike to the top of the spike, excluding awns and was recorded at maturity by taking average of ten plants per plot.

3.3.5 Number of productive tillers per meter:

Total number of effective tillers of one meter marked row with bamboo pegs, was counted from a randomly taken row in each plot.

3.3.6 Number of grains per spike:

A random sample of 10 spikes was taken and threshed separately. The number of grains was counted and data was used to get the average grains per spike.

3.3.7 Thousand grain weight (g):

1000-grains at random were counted from the threshed material and weighed on electronic balance.

3.3.8 Grain yield per plot (kg):

The grain yield per plot was taken after harvesting and threshing of the individual plot. The cleaned grains were weighed and thus grain yield was recorded for each plot.

3.4 Physiological parameters:

3.4.1 Photosynthetic rate, transpiration rate, stomatal conductance, stomatal resistance, photosynthetically active radiation and canopy temperature.

The photosynthetic rate (μ mol m^{-2} s^{-1}), transpiration rate (m mol m^{-2} s^{-1}), stomatal conductance (μ mol m^{-2} s^{-1}), stomatal resistance (μ mol m^{-2} s^{-1}), photosynthetically active radiation (μ mol m^{-2} s^{-1}) and canopy temperature (^{0}C) were measured using Infra-Red Gas Analyzer (IRGA; Model Portable Photosynthesis System LI 6400, LI-COR® Inc, Lincoln, Nebraska, USA). The transpiration rate and stomatal conductance were measured continuously monitoring H_2O of the air entering and exhausting in the IRGA headspace chamber and the measurements were made at mid day, between 11:30 and 12:00 eastern day time (1400–1800 m mol m^{-2} s^{-1} PPFD), on fully open flag leaf. The flow-rate of air in the sample line was adjusted to 500 μ mol s^{-1}. The stomatal resistance of leaf surface was calculated as inverse of stomatal conductance.

3.4.2 Estimation of membrane injury index:

To estimate temperature tolerance, conductivity tests were carried out by the method given by Onwueme (1979). Fresh leaf material (100 mg) weighed and placed in a test tube containing 10ml of double distilled deionized water. Three replicates were prepared for each treatment. These tubes were incubated at 45°C (T_1) for half an hour in a water bath (York Scientific Industries). Electrical conductivity (C_1) of this solution was measured with the help of conductivity bridge of ELICO Pvt. Ltd. (CM 82T). These test tubes were kept in boiling water at 100°C (T_2) for 10 minutes and cooled at room temperature and conductivity (C_2) was measured again. The method was standardized by repeated observations for uniform results. Per cent conductivity was determined by the following way:

$$\text{Membrane injury index} = 1 - \left\{ \frac{1 - \dfrac{T_1}{T_2}}{1 - \dfrac{C_1}{C_2}} \right\} \times 100$$

Where,

T= Temperature (^{0}C) and C = conductivity in m hos.

3.5 Quality parameters

3.5.1. Estimation of total protein content of wheat grains

The protein content in the grain samples were determined by Kjeldahl method using the Autokjeltech system 3100 from Foss, Tecator, USA. The following reagents from Merck, India were used for the estimation.

1. Concentrated sulphuric acid (H_2SO_4):
2. Hydrogen peroxide 30-35 per cent (freshly prepared)
3. Sodium Hydroxide Solution (35-40per cent)
4. Digestion Mixture was prepared by adding Potassium Sulphate (K_2SO_4) and Copper Sulphate ($CuSO_4$) in the ratio 50:1.
5. Sodium Thiosulphate Solution was prepared by dissolving 300g of $Na_2S_2O_3$ H_2 O in a liter of water or 60 g in one liter of the alkali
6. Boric acid 1 per cent with bromocresol green per methyl red indicator solution was prepared by dissolving 100 g of Boric acid in 10 litre distilled water. To this 100 ml bromocresol green solution (100 mg in 100 ml methanol) and 70 ml methyl red solution (100 mg in 100 ml methanol) was added.
7. 0.1 N HCl.

Protocol

1. Grain sample was grind with Cyclotech mill of Foss Tecator, USA and 0.2 g of flour sample was weighed.
2. 10 ml concentrated H_2SO_4 and 4.5 g of catalyst mixture was added to the sample. The samples were digested at 450^0C for 30-45 minutes till contents were clear.
3. After cooling, 70 ml distilled water was added to the digestion tubes.

4. The digested contents were distilled with the distillation system. Multiplication factor of 5.7 and exactly normality of the HCl along with the weight of the sample were fed in the machine. The protein values were obtained by multiplying with a factor of 5.7.

3.5.2. SDS- sedimentation test

This test was based on method of Misra *et al.*, 1998. The following reagents were prepared and used for the sedimentation test.

1. **Lactic acid –** Lactic acid was diluted by adding one part of lactic acid to eight parts of water. 20 ml lactic acid was taken and added to 160 ml of water.
2. **Sodium Dodecyl Sulphate solution (2per cent) –** 40 gm SDS was dissolved in 2 liters of water.
3. **SDS – Lactic acid solution -** To each 50 ml SDS solution, 1 ml of diluted lactic acid was added. *i.e.*, 40 ml lactic acid was added to 2 liters of SDS solution.

Protocol:

This test was carried for four samples at a time. 50 ml of distilled water was taken in each of the four measuring cylinders with stoppers. 5 gm of the flour was added into first cylinder and stop clock was started. 15 seconds of shaking was given to first cylinder. The same protocol was repeated for other three samples also. The times for commencement of the other operations are given, in minute in the table 3.5.2.1

Table 3.5.2.1 SDS Sedimentation test- operation time commencement (minutes)

Cylinder no	15sec shake in water	15sec shake in water	15sec shake in water 50 ml SDS invert 4X	Invert 4X	Invert 4X	Invert 4X	Read sedimentation volume	
							Whole Meal	Flour
1	0	2.0	4.0	6.0	8.0	10.0	30.0	50.0
2	0.5	2.5	4.5	6.5	8.5	10.5	30.5	50.5
3	1.0	3.0	5.0	7.0	9.0	11.0	31.0	51.0
4	1.5	3.5	5.5	7.5	9.5	11.5	31.5	51.5

3.5.3. Hectoliter weight

Hectoliter weight determines the plumpyness of the grain. Flour yield increases and flour ash decrease with the increase in test weight. A flour yield up to 70 per cent and flour ash of 4per cent would be normal for wheat with 75kg hectoliter weight.

Protocol:

1. Fill the cleaned grains into the funnel of the hectoliter (designed by DWR, Karnal) keeping its outlet closed and level it.
2. Keep the hectoliter below the outlet allow the grains to free fall into it till it is completely filled. Level it by sliding the shutter.

3. Take the weight of the sample contained in the hectoliter. The hectoliter weight is the expressed as kg/hectoliter.

3.5.4 Wet gluten content

The gluten content in wheat flour was determined as per the method described by Misra *et al.* (1998).

Procedure

The wheat flour (10g) was taken in a beaker and 7 ml distilled water was added to it and dough was prepared in around 2 min. After proper mixing it was made into small ball and immersed in a beaker containing water. The ball was left in water for 30 min. The dough was washed gently under running water till a chewing gum type cohesive mass separated out. To ensure complete removal of bran; the extracted gluten was washed with excess of water by stretching inside with the fingers. To check whether whole of the starch was washed out or not, iodine in KI was added to the last extract. The absence of violet color indicated complete removal of starch. The adhered water was squeezed out from the extracted gluten and weighed. This was recorded as the weight of wet gluten. It is expressed in percentage.

3.6 STATISTICAL ANALYSIS

3.6.1 Analysis of variance

Differences between genotypes for different characters were tested for significance by usinganalysis of variance technique (Panse and Sukhatme, 1954). Analysis of variance was done on the basis of following model:

Yij = b + gi +rj + eij

Where:

Yij = Phenotypic observation on the ith genotype in jth replication

B = General mean

gi = Effect of i^{th} genotype

rj = Effect of j^th^ replication

eij = Random error associated with i^th^ genotype and j^th^ replication.

The structure of the analysis of variance (ANOVA) was as follows:

ANOVA

Source	d.f.	MSS	Expected MSS	'f' value
Replication	r-1	Mr	$\sigma e^2 + g\sigma r^2$	
Treatment	g-1	Mg	$\sigma e^2 + r\sigma g^2$	Mg/Me
Error	(r-1)(g-1)	Me	$\sigma^2 e$	
Total	(rg-1)			

Where,

r = number of replication

g = number of genotypes

Mr, Mg and Me = Mean sum of squares due to replication, genotype and error respectively

$\sigma^2 e$ = Error variance

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

MSS due to genotypes were tested against the error variance using F test of P = 0.05 or P = 0.01 with V_1 and V_2 degree of freedom, where V_1 is the degree of freedom for highest value of variance and V_2 is the degree of freedom for lower value of variance.

3.6.2 Estimation of mean, standard error and critical difference

Mean value for each character was worked out by dividing the total values with corresponding number of observations. Standard error of mean and critical difference was calculated as follows:

Standard error of mean (SEM) = $\sqrt{EMSS/r}$

Critical difference for mean = SEM x t value at 5per cent level of significance

3.6.3 Phenotypic and genotypic coefficient of variance

Phenotypic and genotypic coefficient of variation was calculated by using the formula suggested by Burton (1952).

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sigma p}{X} \times 100$$

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sigma g}{X} \times 100$$

Where,

σg = Genotypic standard deviation

σp = Phenotypic standard deviation and X = General mean.

3.6.4 Heritability

Heritability (broad sense) was calculated as the ratio between genotypic variance to total or phenotypic variance and expressed as percentage (Allard, 1960)

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

Where,

$h^2(bs)$ = heritability in broad sense

$\sigma^2 g$ = genotypic variance and $\sigma^2 p$ = phenotypic variance

As suggested by Johnson *et al.* (1955) heritability estimates were categorized as:

Low - 0-30 per cent,

Medium - 31-60 per cent,

High – 61 per cent and above

3.6.5 Genetic advance as per cent mean (GAM)

Genetic advance estimated as percent of mean of the population and is estimated as follows:

$$GAM = \frac{GA}{X} \times 100$$

Where,

GA = Expected genetic advance;

X = Grand mean

- **Expected genetic advance**

The expected genetic advance is obtained as the difference between the mean of the progeny of selected individuals and base population, was estimated with the formula as suggested by Johnson *et al*. (1955)

$$GA = K \times \sigma p \times h^2 (bs)$$

Where,

GA = Expected genetic advance

K = Selection differential, the value is 2.06 at 5per cent selection intensity

σp= Phenotypic standard deviation and

h^2 (bs) = Heritability in broad sense

The range of genetic advance as percent of mean was classified as suggested by Johnson *et al* (1955).

Low - less than 10 per cent

Moderate - 10-20 per cent

High - More than 20 per cent

3.6.6 Estimation of correlation coefficient

Correlation coefficients were computed to determine the association among all the yield contributing characters. The correlation coefficients at genotypic and phenotypic levels were estimated from the analysis of variance and covariance as suggested by Falconer (1964).

❖ **Genotypic correlation between character x and y**

$$r\,(x,y)_g = \frac{Cov\,(x,y)_g}{\sqrt{V(x)_g\,V\,(y)_g}}$$

$Cov(x,y)_g$ = Genotypic covariance between character x and y

$Var\,(x)_g$ = Genotypic variance of character x

$Var\,(y)_g$ = Genotypic variance of character y

❖ **Phenotypic correlation between character x and y**

$$r\,(x,y)_p = \frac{Cov\,(x,y)_p}{\sqrt{V(x)_p\,V\,(y)_p}}$$

$Cov\,(x,y)_p$ = Phenotypic covariance between character x and y

$Var\,(x)_p$ = Phenotypic variance of character x

$Var\,(y)_p$ = Phenotypic variance of character y

The significance of correlation coefficient (r) was tested by comparing the calculated value of t with table‘t’ value at (nr-2) d.f. (Snedecor and Cochran, 1967).

3.6.7 Path coefficient analysis

The direct and indirect contributions of various characters to yield were calculated through path coefficient analysis as suggested by Dewey and Lu (1959).

The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects

$$r_{1y} = P_{1Y} + r_{12} P_{2Y} + r_{13} P_{3Y} + \ldots.. + r_{1k} P_{kY}$$

$$r_{2y} = r_{21} P_{1Y} + P_{2Y} + r_{23} P_{3Y} + \ldots.. + r_{2k} P_{kY}$$

$$r_{iy} = r_{i1} P_{1Y} + r_{i2} P_{2Y} + r_{i3} P_{3Y} + \ldots.. + r_{ik} P_{kY}$$

$$r_{ky} = r_{k1} P_{1Y} + r_{k2} P_{2Y} + r_{k3} P_{3Y} + \ldots.. + P_{kY}$$

Where,

r_{1y} to r_{ky} = coefficients of correlation between causal factor 1 to k and dependant factor y.

r_{12} to $r_{(k-1),\, k}$ = coefficient of correlation among causal factors.

P_{1Y} to P_{kY} = Direct effects of characters 1 to k on character y.

The above equations were written in a matrix form as under.

$$\begin{pmatrix} r_{1y} \\ r_{2y} \\ . \\ . \\ . \\ r_{ky} \end{pmatrix} \begin{pmatrix} 1 & r_{12} & r_{13} & . & . & . & r_{1} \\ r_{21} & 1 & r_{2\,3} & . & . & . & r_{2} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ r_{k1} & r_{k2} & r_{k3} & . & . & . & 1 \end{pmatrix} \begin{pmatrix} P_{1y} \\ P_{2y} \\ . \\ . \\ . \\ P_{ky} \end{pmatrix}$$

Then B = $(C)^{-1}$ A

$$\begin{pmatrix} C_{11} & C_{12} & . & . & . & C_{1k} \\ C_{21} & C_{22} & . & . & . & C_{2k} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ C_{k1} & C_{k2} & . & . & . & C_{kk} \end{pmatrix}$$

Then direct effects were calculated as follows:

$$P_{1Y} = \sum_{i=1}^{k} C_{11}\, r1_{iy}$$

$$P_{2Y} = \sum_{i=1}^{k} C_{21}\, r1_{iy}$$

$$P_{kY} = \sum_{i=1}^{k} C_{k1}\, r1_{iy}$$

Besides the direct and indirect effects the residual effects which measures the contribution of the charecters and considered in the casual scheme was obtained as

$$\text{Residual effect } (Pr_y) = \sqrt{1 - R^2}$$

Where ,

$R^2 = P_{1y}\ r_{1y} + P_{2y}\ r_{2y} + \ldots.. P_{iy}\ r_{iy}$

Pr_y = residual effect, Pi_y = direct effect x_i on y

r_{iy} = correlation coefficient of x_1 and y

3.6.8 Stability analysis

(A) Analysis of G x E interaction

Phenotypic stability of a genotype for yield and different morphological characters was estimated by regression analysis according to Eberhart and Russell (1966).

Eberhart and Russell (1966) model provides estimates of stability parameters by calculating the regression of each variety/cross in the experiment on an environmental index, and a function of the squared deviation from this regression. According to this model, a desirable variety with good stability should have high mean (μ), unit regression coefficient (bi=1) and the minimum deviation i.e. equal to zero from regression ($S^2di=0$).

The sum of squares due to environments and genotypes x environments interaction were partitioned into environments (linear), genotypes x environments (linear) and deviation from linearity of regression model (pooled deviation).

Analysis of variance for estimation of the stability parameters

Sources of variation	**d.f.**	**Sum of squares**	**M.S.**
Genotypes (g)	(g-1)	$\frac{1}{e}\sum_{i=1}^{g} Y_{i.}^2 - \frac{(\Sigma Y_{ij})^2}{eg}$	Mg
Environments (e)	(e-1)	$\frac{1}{e}\sum_{j=1}^{e} Y_{.j}^2 - \frac{(\Sigma Y_{ij})^2}{eg}$	-
G x E	(g-1) (e-1)	$\sum_{i=1}^{g}\sum_{j=1}^{e} Y_{ij}^2 + \frac{(\Sigma Y_{ij})^2}{eg}$ - (Envi. SS - Geno.SS)	-
Environment (E) + (G x E)	g(e-1)	$\sum_{i=1}^{g}\sum_{j=1}^{e} Y_{ij}^2 - \frac{1}{e}\Sigma Y^2{}_{i.}$	-
Environment (linear)	1	$\frac{\frac{1}{g}(\sum_{j=1}^{e} Y_{.j} I_j)^2}{\sum_{j=1}^{e} I_j^2}$	-
G x E (linear)	(g-1)	$\sum_{j=1}^{g}\left[\frac{(\sum_{j=1}^{e} Y_{.j} I_j)^2}{\sum_{j=1}^{e} I_j^2}\right] - Environment\ (linear)\ SS$	Mge
Pooled deviations	g(e-2)	$\sum_{i=1}^{g}\sum_{j=1}^{e} \delta_{ij}^2$	Mpd
Pooled deviation due to Genotype-1	(e-2)	$\left[\sum_{i=1}^{g} Y_{ij}^2 - \frac{(Yi.)^2}{e}\right] - \frac{(\sum_{j=1}^{e} Y_{ij} I_j)^2}{\sum_{j=1}^{e} I_j^2} = \sum_{j=1}^{e} \delta_{ij}^2$	
Pooled error	e (g-1) (r-1)	$\sum_{i=1}^{g}\sum_{j=1}^{e} e_{ij}^2$	Me

Where,

δ_e^2 = Mean square for pooled error

r = Number of replications

g = Number of genotypes

e = Number of environments

Significance of the estimates was tested as follows:

1. The pooled deviation mean square was tested against the pooled error mean square. The "F" test would be as Mpd/Me.

2. Appropriate denominator to test the significance of mean square due to genotypes, would be pooled deviation mean square (if it is significant). The null hypothesis used for the test of significance among genotypes means was as under:

   $H_0: \mu_1 = \mu_2 = \ldots = \mu_g$. $\mu_1, \mu_2, \ldots, \mu_g$ denote the mean performance of genotypes 1, 2, 3,……, g, respectively.

   $$\text{Thus, } F = \frac{Mg}{Mpd}$$

   Here, we assume that deviations are homogenous over all the genotypes.

3. The hypothesis that there are non-significant differences among regression coefficients was tested by

   $$F = \frac{Mge}{Mpd} \text{ (if Mpd is significant)}$$

   If the mean square for linear component of genotypes x environments interaction found to be significant, conclusion was drawn that variation in the performance of genotypes was due to regression of genotypes on environments, and hence the performance would be predictable in nature.

4. Individual deviation of each variety/genotype from linear regression was tested by

   $$F = \left[\left(\sum_j \delta_{ij}^2\right) / (e-2)\right] / Me$$

   Where, n= Number of treatments

This significance was used for testing the deviation of individual variety from its regression.

(B) Stability parameters

The stability parameters for different genotypes were based on the mathematical model of Eberhart and Russell (1966).

$$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$$

(i = 1, 2, ….. g and j = 1, 2, ….. e)

Where,

Y_{ij} = Mean of i^{th} genotype in j^{th} environment

μ_i = Mean of i^{th} genotype overall environments

β_i = The regression coefficient of the i^{th} genotype on the environmental index, which measures the linear response of this genotype to varying environments.

I_j = An environmental index, which is defined as the deviation of the mean of all the genotypes at the j^{th} environment from the overall mean (with $\sum_i I_j = 0$)

δ_{ij} = The deviation from regression of i^{th} genotype at j^{th} environment.

The three main stability parameters are (i) mean yield of genotype over all the environments (μi), (ii) regression coefficient (bi) and (iii) deviation from regression (S^2di). The mean yield of genotype over all the environments provides comparative measure of performance of an individual genotype. The regression coefficient (b_i) is the regression of the performance of each genotype under different environments on the environmental index. The regression coefficient was regarded as a measure of response of particular genotype to environments, and the deviation from regression as the measure of stability. These were estimated as:

(1) Mean (μ_i)

The mean value of i^{th} genotype overall environments.

$$\mu_i = \sum_j Yij / e$$

(2) Environmental index (I_j)

Environmental index obtained as the mean of all the genotypes at j^{th} environment minus grand mean.

Thereby, $$I_j = \left[\sum_i Y_{ij} / e\right] - \left[\sum_i \sum_j Y_{ij} / ge\right]$$

Where, $\sum I_j = 0$ i = 1, 2, 3, ……., 'g' genotypes

j = 1, 2, 3, ……., 'e' environments

(3) Regression coefficient (bi)

$$b_i = \left[\sum_{j=1}^{n} Y_{ij} I_j\right] / \left[\sum_{j=1}^{n} I_j^2\right]$$

Where, I_j = Environmental index

Y_{ij} = Mean value of i^{th} genotype in j^{th} environment

bi = Regression coefficient

(4) Squared deviation from regression (S^2di)

(Non-linear component of genotype-environment interaction):

$$(S^2di) = \left[\frac{\sum_j \delta^2_{ij}}{(e-2)}\right] - \left[\frac{\hat{\sigma}^2 e}{r}\right]$$

δ_{ij} = The deviation of i^{th} variety in j^{th} environment from regression, and was obtained as $\delta_{ij} = Y_{ij} - \hat{Y}_{ij}$;

Where,

$\hat{Y}_{ij}$ = Expected value of i^{th} genotype in j^{th} environment, and predicted as $\hat{Y}_{ij} = \overline{X}_i + b_i I_j$ and $\Sigma\delta^2_{ij}$ was calculated as

$$\sum_j \delta^2 ij = \left[\sum Y^2{}_{ij} - \frac{Y^2{}_{i.}}{g}\right] - \left[\frac{(\sum_j Y_{ij}\, I_j)^2}{\sum I^2{}_j}\right] \text{and}$$

Where, $\hat{\sigma}^2 e$ = The estimate of pooled error.

The pooled error mean square was calculated as pooled error m.s.

$$\frac{1}{er}(\sigma^2_{e_1} + \sigma^2_{e_2} + ... + \sigma^2_{e_j})$$

Where, $\sigma^2_{e_j}$ = Error variance corresponding to j^{th} environment, and

r = Number of replications within each environment

The hypothesis that regression coefficient (b_i) do not differ from zero and unity was tested by appropriate 't' test.

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

Calculated 't' values > 1.96 and 2.56, those were considered * and ** at 0.05 and 0.01 level of probability, respectively. Significance of 't' test suggest that the 'b' value significantly differed from zero. If 'bi' significant, it's significant deviation from unity was tested as

$$t = \frac{|b_i - 1|}{S.E.(b_i)}$$

Calculated 't' values > 1.96 and 2.56, those were considered * and ** at 0.05 and 0.01 level of probability, respectively. Significance of 't' test suggest that the 'b' value significantly differed from unity.

Where,

$$S.E.(b_i) = \sqrt{\left[\frac{\sum_j \delta_{ij}^{2} / n-2}{\sum I_j^{2}}\right]}$$

Significance of the deviation of each genotype from its regression (S^2di) could be tested by an appropriate 'F' test, thus,

$$F = \frac{\left[\frac{\sum_{j=1}^{n} \delta_{ij}^{2}}{(e-2)}\right]}{Me}$$

Where, Me = Pooled error mean square

The calculated ‘F’ value of each genotype was compared with the table values of ‘F’ at (e-2) and pooled error degree of freedom.

A stable variety would be one which would have bi=1, S^2di=0, and mean value higher than population mean.

4. RESULTS

In the present investigation, material comprised of 20 bread wheat genotypes along with three checks for stability analysis across the locations. Data was collected on various characters like yield, yield components, physiological traits and quality parameters across the locations. Based on the study, the results are presented under the following heading:

4.1 Analysis of variance and mean performance

4.2 Stability analysis

4.3 Variability parameters

4.4 Character association and correlations

4.5 Path coefficient analysis

4.1 Analysis of variance and mean performance of genotypes of bread wheat for morpho- physiological and quality traits.

All the characters studied showed significant variation in respect of the genotypes under the present investigation. This was apparent from the significant to highly significant mean squares (MS) values under each environment .While, in pooled analysis of variance mean squares (MS) values in interaction of location into genotypes over the six environments for all traits were significant. It is presented in Table no 4.1.1 and 4.1.2.

The mean performance of genotypes at different locations for all nineteen characters has been presented in Table 4.1.3 results are furnished as under.

4.1.1. Grain yield (kg/plot)

At Niphad, the mean grain yield of 1.085 kg/plot with range between 0.750 kg/plot (NIAW 2300) and 1.275 kg/plot (NIAW 1885) was recorded under TSI. While , the mean grain yield of 0.952 kg/plot with range between 0.663 kg/plot (NIAW 2304) and 1.165 kg/plot (NIAW 2345) was recorded under LSI.

At Rahuri, the mean grain yield of 1.079 kg/plot with range between 0.680 kg/plot (NIAW 2304) and 1.337 kg/plot (NIAW 2268) was recorded under TSI. While, the mean grain yield of 0.855 kg/plot with range between 0.587 kg/plot (NIAW 2073) and 1.070 kg/plot (NIAW 2348) was recorded under LSI.

At Savalvihir, the mean grain yield of 0.944 kg/plot with range between 0.555 kg/plot (NIAW 2304) and 1.252 kg/plot (NIAW 2349) was recorded under TSI. While, the mean grain yield of 0.823 kg/plot with range between 0.549 kg/plot (NIAW 2304) and 0.988 kg/plot (NIAW 2349) was recorded under LSI. The mean grain yield across locations ranged between 0.684 kg/plot (NIAW 2304) and 1.134 kg/plot (NIAW 2349) with an overall mean of 0.956 kg/plot.

The environmental indices for grain yield varied from -0.134 (Savalvihir, TSI) to 0.129 (Niphad, TSI). Under TSI, Niphad (0.129) and Rahuri (0.122) observed better environments than others.

4.1.2. Days to 50 per cent flowering

At Niphad, the mean days to 50 per cent flowering of 60 .03 days with range between 50.67 days (NIAW 2279) and 72.33 days (NIAW 2351) was recorded under TSI. While, the mean days to 50 per cent flowering of 57.49 days with range between 51.67 days (NIAW 2304) and 64.33 days (NIAW 1415) was recorded under LSI. At Rahuri, the mean days to 50 per cent flowering of 57.30 days with range between 46.33 days (NIAW 2304) and 70.33 days (NIAW 2351) were recorded under TSI. While, the mean days to 50 per cent flowering of 55.54 days with range between 50.33 days (NIAW 2279) and 62.67 days (NIAW 2351) was recorded under LSI. At Savalvihir, the mean days to 50 per cent flowering of 56.38 days with range between 48 days (NIAW 2304) and 65.67 days (NIAW 2351) were recorded under TSI. While, the mean days to 50 per cent flowering of 53.33 days with range between 44.33 days (NIAW 2310) and 62.33 days (NIAW 1415) was recorded under LSI. The mean days to 50 per cent flowering across locations ranged between 48.78 days (NIAW 2304) and 65.5 days (NIAW 2351) with an overall mean of 56.68 days.

The environmental indices for days to 50 per cent flowering varied from -3.345 (Savalvihir, LSI) to 3.35 (Niphad, TSI). At Savalvihir, for both conditions (TSI: -0.302, LSI:-3.345) and Rahuri LSI (-1.143) showed negative signs for environmental indices which indicated earliness for flowering, hence these environments favourable than others.

4.1.3. Days to maturity

At Niphad, the mean days to maturity of 114.52 days with range between 101 days (NIAW 2304) and 125.33 days (NIAW 2351) were recorded under TSI. While, the mean days to maturity of 110.12 days with range between 98.33 days (NIAW 2304) and 119.67 days (NIAW 917) were recorded under LSI. At Rahuri, the mean days to maturity of 111.9 days with range between 99.67 days (NIAW 2304) and 122.67 days (NIAW 917) were recorded under TSI. While, the mean days to maturity of 105.62 days with range between 98 days (NIAW 2275) and 114.33 days (NIAW 917) was recorded under LSI. At Savalvihir, the mean days to maturity of 110.54 days with range between 98.67 days (NIAW 2275) and 122.33 days (NIAW 917) were recorded under TSI. While, the mean days to maturity of 104.52 days with range between 98.33 days (NIAW 2279) and 114.33 days (NIAW 917) were recorded under LSI. The mean days to maturity across locations ranged between 99.5 days (NIAW 2304) and 119.78 days (NIAW 917) with a mean value of 109.5 days.

The environmental indices for maturity varied from -5.014 (Savalvihir, LSI) to 4.986 (Niphad, TSI). Under LSI conditions for both locations *viz*. Savalvihir (-5.014) and Rahuri (-3.913) showed negative signs for environmental indices which indicates earliness for maturity, hence these environments good for this trait than others.

4.1.4. Plant height (cm)

The height of genotypes ranged from 74.87 cm (NIAW 2065) to 108.70 cm (NIAW 2255) with a mean height of 93.09 cm and from 73.8 cm (NIAW 2065) to 104.49 cm (NIAW 2255) with a mean height of 86.81 cm under

TSI and LSI at Niphad. At Rahuri, the height of genotypes ranged from 82.53 cm (NIAW 2304) to 113.0 cm (NIAW 2255) with a mean height of 93.79 cm and from 73.37 cm (NIAW 2304) to 96.3 cm (NIAW 2255) with a mean height of 82.61 cm under TSI and LSI, respectively. At Savalvihir, the height of genotypes ranged from 74.80 cm (NIAW 2304) to 104.07 cm (NIAW 2255) with a mean height of 86.95 cm and from 75.8 cm (NIAW 34) to 93.47 cm (NIAW 2268) with a mean height of 84.02 cm under TSI and LSI, respectively. The mean plant height across locations ranged between 77.14 cm (NIAW 2304) and 103.34 cm (NIAW 2255) with a mean value of 87.88 cm.

For plant height, environmental indices varied from Rahuri, LSI (-5.269) to Niphad, TSI (5.211). Except, TSI conditions at both locations *viz.*, Niphad and Rahuri, remaining centers recorded negative environmental indices.

4.1.5. Number of tillers per meter

The highest number of tillers per meter was recorded for NIAW 2279 (79.92) and lowest for NIAW 34 (57.58) with mean value of 67.49 under TSI, while it was maximum for NIAW 2275 (73.33) and minimum for NIAW 1885 (54.67) with a mean value of 61.23 under LSI at Niphad. At Rahuri, the highest number of tiller per meter was recorded for NIAW 2279 (80.42) and lowest for NIAW 2304 (55.92) with mean value of 70.77 under TSI, while it was maximum for NIAW 2275 (74.33) and minimum for NIAW 2346 (51.17) with a mean value of 63.42 under LSI. At Savalvihir, it ranged between 53.67 (NIAW 2304) and 80.08 (NIAW 2275) with a mean value of 71.20 and between 42.17 (NIAW 2346) and 71.08 (NIAW 2349) with a mean value of 61.27 under TSI and LSI, respectively. The mean number of tillers per meter across locations ranged between 55.06 (NIAW 2304) and 75.26 (NIAW 2275) with a grand mean value of 65.9.

The environmental indices for tillers per meter varied from -4.623 (Savalvihir, LSI) to 4.873 (Rahuri, TSI). Under TSI conditions for all locations *viz.*, Niphad (1.59), Rahuri (4.873) Savalvihir (5.301) shows positive signs for environmental indices which indicate favorable situations than other environments.

4.1.6. Spike length (cm)

The spike length of genotypes ranged from 7.12 cm (NIAW 2300) to 10.15 (NIAW 2348) with a mean spike length of 8.63 cm and from 6.11 cm (NIAW 2275) to 9.79 (NIAW 2348) with a mean spike length of 8.19 cm under TSI and LSI at Niphad. At Rahuri, the spike length of genotypes ranged from 6.59 cm (NIAW 1951) to 9.56 (NIAW 2348) with a mean spike length of 8.17 cm and from 6.63 cm (NIAW 2275) to 9.45 (NIAW 2349) with a mean spike length of 7.76 cm under TSI and LSI, respectively. At Savalvihir, the spike length of genotypes ranged from 6.62 cm (NIAW 2304) to 11.37 (NIAW 2348) with a mean height of 8.84 cm and from 6.88 cm (NIAW 1951) to 9.56 cm (NIAW 2348) with a mean spike length of 7.91 cm under TSI and LSI, respectively. The mean spike length across locations ranged between 6.98 cm (NIAW 1951) and 9.76 cm (NIAW 2255) with a mean value of 8.25 cm.

For spike length, environmental indices varied from Rahuri, LSI (-0.487) to Savalvihir, TSI (0.588). Under TSI, both locations *viz*., Niphad (0.377) and Savalvihir (0.588) are better environments than others.

4.1.7. Number grains per spike

The highest number of grains per spike was recorded for NIAW 1415 (72.33) and lowest for NIAW 2300 (30.33) with mean value of 49.80 under TSI, while it was maximum for NIAW 1415 (70.0) and minimum for NIAW 2300 (32.67) with a mean value of 43.20 under LSI at Niphad. At Rahuri, the highest number of grains per spike was recorded for NIAW 1415 (63.67) and lowest for NIAW 2304 (32.67) with mean value of 44.3 under TSI, while it was maximum for NIAW 1415 (64.0) and minimum for NIAW 2346 (3.33) with a mean value of 43.83 under LSI. At Savalvihir, it ranged between 30.67 (NIAW 2300) and 69.0 (NIAW 1415) with a mean value of 47.62 and between 34.67 (NIAW 2304) and 53 (NIAW 1415) with a mean value of 42.68 under TSI and LSI, respectively. The mean number of grains per spike across locations ranged between 32.44 (NIAW 2300) and 65.33 (NIAW 1415) with a grand mean value of 45.24.

The environmental indices for grains per spike varied from -2.558 (Savalvihir, LSI) to 4.558 (Rahuri, TSI). Under TSI, both locations *viz.* Niphad (4.558) and Savalvihir (2.384) were better environments than others

4.1.8 Thousand grain weight (g)

The mean thousand grain weight of 44.81 g and 44.07 g with a range of 38.07 g (NIAW 2351) to 53.67 g (NIAW 2310) and 36.53 g (NIAW 1415) to 52.13 g (NIAW 2300) was recorded under TSI and LSI , respectively at Niphad. While , it ranged from 36.17 g (NIAW 917) to 50.73 g (NIAW 2300) and 35.07 g (NIAW 2313) and 47.0 g (NIAW 2300) with a mean value of 42.05 g and 40.44 g under TSI and LSI respectively at Rahuri. At Savalvihir, the mean thousands grain weight of 44.82 g and 44.0 g with a range of 37.13 g (NIAW 2351) to 55.07 g (NIAW 2300) and 37.23 g (NIAW 2345) to 52.27 g (NIAW 2300) was recorded under TSI and LSI, respectively. The mean thousands grain weight across locations ranged between 37.79 g (NIAW 2351) and 51.52 g (NIAW 2300) with a mean value of 43.36 g.

For thousand grain weight, environmental indices varied from Rahuri, LSI (-2.984) to Savalvihir, TSI (1.453). At Niphad, for both conditions (TSI: 1.443, LSI: 0.709) and Savalvihir, TSI (1.453) were favorable environments than others.

4.1.9 Photosynthetic rate (µ mol m^{-2} s^{-1})

At Niphad, the mean photosynthetic rate of 20.22 µ mol m^{-2} s^{-1} with range between 16.91 µ mol m^{-2} s^{-1} (NIAW 1885) and 25.17 µ mol m^{-2} s^{-1} (NIAW 2268) were recorded under TSI. While, the mean photosynthetic rate of 17.49 µmol m^{-2} s^{-1} with range between 13.14 µ mol m^{-2} s^{-1} (NIAW 2303) and 23.24 µ mol m^{-2} s^{-1} (NIAW 2345) was recorded under LSI. At Rahuri, the mean photosynthetic rate of 23.13 µ mol m^{-2} s^{-1} with range between 15.61 µ mol m^{-2}

s^{-1} (NIAW 2304) and 29.55 μ mol m^{-2} s^{-1} (NIAW 2248) were recorded under TSI. While, the mean photosynthetic rate of 16.43 μ mol m^{-2} s^{-1} with range between 13.25 μ mol m^{-2} s^{-1} (NIAW 2303) and 20.98 μ mol m^{-2} s^{-1} (NIAW 2300) was recorded under LSI. At Savalvihir, the mean photosynthetic rate of 23.51 μ mol m^{-2} s^{-1} with range between 17.42 μ mol m^{-2} s^{-1} (NIAW 2346) and 28.64 μ mol m^{-2} s^{-1} (NIAW 2275) were recorded under TSI. While, the mean photosynthetic rate of 16.29 μ mol m^{-2} s^{-1} with range between 11.02 μ mol m^{-2} s^{-1} (NIAW 2346) and 20.92 μ mol m^{-2} s^{-1} (NIAW 1885) was recorded under LSI. The mean photosynthetic rate across locations ranged between 15.86 μ mol m^{-2} s^{-1} (NIAW 2303) and 22.59 μ mol m^{-2} s^{-1} (NIAW 34) with a grand mean value of 19.54 μmol m^{-2} s^{-1} .

The environmental indices for photosynthetic rate varied from -3.253 (Savalvihir, LSI) to 3.966 (Savalvihir, TSI). Under TSI conditions for all locations *viz*., Niphad (0.674), Rahuri (3.783) and Savalvihir (3.966) shows positive signs for environmental indices which indicates favorable situations than other environments.

4.1.10 Transpiration rate (m mol m^{-2} s^{-1})

At Niphad, the mean transpiration rate of 4.31 m mol m^{-2} s^{-1} with range between 3.04 m mol m^{-2} s^{-1} (NIAW 2065) and 5.42 m mol m^{-2} s^{-1} (NIAW 2351) were recorded under TSI. While, the mean transpiration rate of 3.31 m mol m^{-2} s^{-1} with range between 2.02 m mol m^{-2} s^{-1} (NIAW 1885) and 5.51 m mol m^{-2} s^{-1} (NIAW 2351) was recorded under LSI.

At Rahuri, the mean transpiration rate of 3.33 m mol m^{-2} s^{-1} with range between 2.22 m mol m^{-2} s^{-1} (NIAW 2073) and 4.41m mol m^{-2} s^{-1} (NIAW 2351) were recorded under TSI. While, the mean transpiration rate of 4.13 m mol m^{-2} s^{-1} with range between 3.16 m mol m^{-2} s^{-1} (NIAW 2310) and 5.40 m mol m^{-2} s^{-1} (NIAW 2351) was recorded under LSI. At Savalvihir, the mean transpiration rate of 3.53 m mol m^{-2} s^{-1} with range between 2.0 m mol m^{-2} s^{-1} (NIAW 2073) and 4.89 m mol m^{-2} s^{-1} (NIAW 34) were recorded under TSI. While, the mean transpiration rate of 3.62 m mol m^{-2} s^{-1} with range between

2.19 m mol m^{-2} s^{-1} (NIAW 2310) and 5.13 m mol m^{-2} s^{-1} (NIAW 2351) was recorded under LSI. The mean transpiration rate across locations ranged between 2.98 m mol m^{-2} s^{-1} (NIAW 1994) and 5.11 m mol m^{-2} s^{-1} (NIAW 2351) with a grand mean value of 3.70 m mol m^{-2} s^{-1}.

For transpiration rate, environmental indices ranged from Niphad, LSI (-0.398) to Niphad, TSI (0.61). Except, TSI conditions both locations viz. Niphad and Rahuri, remaining centers recorded negative environmental indices.

4.1.11 Photosynthetically active radiation (μ mol m^{-2} s^{-1})

At Niphad, the mean photosynthetically active radiation of 1509.4 μ mol m^{-2} s^{-1} with range between 1235.14 μ mol m^{-2} s^{-1} (NIAW 2248) and 1669.53 μ mol m^{-2} s^{-1} (NIAW 2346) were recorded under TSI. While, the mean photosynthetically active radiation of 1477.7 μ mol m^{-2} s^{-1} with range between 1207.1 μ mol m^{-2} s^{-1} (NIAW 2349) and 1620.67 μ mol m^{-2} s^{-1} (NIAW 34) was recorded under LSI, respectively. At Rahuri, the mean photosynthetically active radiation of 1319.8 μ mol m^{-2} s^{-1} with range between 1210.63 μ mol m^{-2} s^{-1} (NIAW 2275) and 1542.5 μ mol m^{-2} s^{-1} (NIAW 1415) were recorded under TSI. While, the mean photosynthetically active radiation of 1482.6 μ mol m^{-2} s^{-1} with range between 1187.0 μ mol m^{-2} s^{-1} (NIAW 1885) and 1623 μ mol m^{-2} s^{-1} (NIAW 2346) was recorded under LSI, respectively. At Savalvihir, the mean photosynthetic active radiation of 1492.9 μ mol m^{-2} s^{-1} with range between 1225.07 μ mol m^{-2} s^{-1} (NIAW 1951) and 1641.17 μ mol m^{-2} s^{-1} (NIAW 917) were recorded under TSI. While, the mean photosynthetically active radiation of 1385.7 μ mol m^{-2} s^{-1} with range between 1110.73 μ mol m^{-2} s^{-1} (NIAW 2073) and 1638 μ mol m^{-2} s^{-1} (NIAW 2351) was recorded under LSI, respectively. The mean photosynthetic active radiation across locations ranged between 1292.7 μ mol m^{-2} s^{-1} (NIAW 1885) and 1597.7 μ mol m^{-2} s^{-1} (NIAW 1415) with an overall mean of 1385.7 μ mol m^{-2} s^{-1}.

The environmental indices for photosynthetically active radiation varied from -124.87 (Rahuri, TSI) to 64.76 (Niphad, TSI). At Rahuri, TSI, (-124.87) and Savalvihir , LSI (-58.984) shows negative signs for environmental indices which indicate poor situations than other environments.

4.1.12 Stomatal conductance (μ mol m^{-2} s^{-1})

At Niphad, the mean stomatal conductance of 0.604 μ mol m^{-2} s^{-1} with range between 0.38 μ mol m^{-2} s^{-1} (NIAW 2303) and 0.85 μ mol m^{-2} s^{-1} (NIAW 2065) were recorded under TSI. While, the mean stomatal conductance of 0.428 μ mol m^{-2} s^{-1} with range between 0.267 μ mol m^{-2} s^{-1} (NIAW 2248) and 0.83 μ mol m^{-2} s^{-1} (NIAW 1885) was recorded under LSI. At Rahuri, the mean stomatal conductance of 0.584 μ mol m^{-2} s^{-1} with range between 0.347 μ mol m^{-2} s^{-1} (NIAW 2345) and 0.797 m mol m^{-2} s^{-1} (NIAW 2348) were recorded under TSI. While, the mean stomatal conductance of 0.471 μ mol m^{-2} s^{-1} with range between 0.297 μ mol m^{-2} s^{-1} (NIAW 2346) and 0.69 μ mol m^{-2} s^{-1} (NIAW 2300) was recorded under LSI. At Savalvihir, the mean stomatal conductance of 0.569 m mol m^{-2} s^{-1} with range between 0.383 μ mol m^{-2} s^{-1} (NIAW 2303) and 0.793 μ mol m^{-2} s^{-1} (NIAW 2275) were recorded under TSI. While, the mean stomatal conductance of 0.471 μ mol m^{-2} s^{-1} with range between 0.273 μ mol m^{-2} s^{-1} (NIAW 2310) and 0.727 μ mol m^{-2} s^{-1} (NIAW 1885) was recorded under LSI. The mean stomatal conductance across locations ranged between 0.377 μ mol m^{-2} s^{-1} (NIAW 2303) and 0.631 μ mol m^{-2} s^{-1} (NIAW 1885) with a grand mean value of 0.513 μ mol m^{-2} s^{-1}.

In case of stomatal conductance, environmental indices ranged from Savalvihir, LSI –0.092) to Niphad, TSI (0.091). Under TSI conditions for all locations *viz*. Niphad (0.091), Rahuri (0.072) and Savalvihir (0.056) shows positive signs for environmental indices which indicated better situations than other environments.

4.1.13 Stomatal resistance (μ mol m^{-2} s^{-1})

At Niphad, the mean stomatal resistance of 1.748 μ mol m^{-2} s^{-1} with range between 1.176 μ mol m^{-2} s^{-1} (NIAW 2065) and 2.632 μ mol m^{-2} s^{-1}

(NIAW 2303) were recorded under TSI. While, the mean stomatal resistance of 2.495 μ mol m^{-2} s^{-1} with range between 1.205 μ mol m^{-2} s^{-1} (NIAW 1885) and 3.745 μ mol m^{-2} s^{-1} (NIAW 2248) was recorded under LSI. At Rahuri, the mean stomatal resistance of 1.806 m mol m^{-2} s^{-1} with range between 1.255 m mol m^{-2} s^{-1} (NIAW 2348) and 2.882 μ mol m^{-2} s^{-1} (NIAW 2345) were recorded under TSI. While, the mean stomatal resistance of 2.219 μ mol m^{-2} s^{-1} with range between 1.449 μ mol m^{-2} s^{-1} (NIAW 2300) and 3.367 μ mol m^{-2} s^{-1} (NIAW 2346) was recorded under LSI. At Savalvihir, the mean stomatal resistance of 1.815 μ mol m^{-2} s^{-1} with range between 2.261 μ mol m^{-2} s^{-1} (NIAW 2275) and 2.611 μ mol m^{-2} s^{-1} (NIAW 2303) were recorded under TSI. While, the mean Stomatal Resistance of 2.537 μ mol m^{-2} s^{-1} with range between 1.376 μ mol m^{-2} s^{-1}(NIAW 1885) and 3.663 μ mol m^{-2} s^{-1} (NIAW 2310) was recorded under LSI. The mean stomatal resistance across locations ranged between 1.585 μ mol m^{-2} s^{-1} (NIAW 1885) and 2.653 μ mol m^{-2} s^{-1} (NIAW 2303) with a grand mean value of 1.985 μ mol m^{-2} s^{-1} .

Environmental indices for stomatal resistance, varied from Niphad, TSI (–0.35) to Savalvihir, LSI (0.43). Under LSI conditions for all locations *viz.* Niphad (0.389), Rahuri (0.113) and Savalvihir (0.43) shows positive signs for environmental indices which indicated more resistance which was unfavorable situations for crop growth than other environments.

4.1.14 Canopy temperature (^{0}C)

At Niphad, the mean canopy temperature of 29.16^{0}C with range between 26.80^{0}C (NIAW 1885) and 32.77^{0}C (NIAW 2348) were recorded under TSI. While, the mean canopy temperature of 30.42^{0}C with range between 27.77 ^{0}C (NIAW 2073) and 32.2^{0}C (NIAW 2304) was recorded under LSI. At Rahuri, the mean canopy temperature of 29.61^{0}C with range between 27.77^{0}C (NIAW 2255) and 31.10^{0}C (NIAW 1415) were recorded under TSI. While, the mean canopy temperature of 31.06^{0}C with range between 29.63^{0}C (NIAW 917) and 32.17^{0}C (NIAW 2268) was recorded under LSI. At Savalvihir, the mean canopy temperature of 30.86^{0}C with range between 29.2^{0}C (NIAW 2073) and

32.03^{0}C (NIAW 2304) were recorded under TSI. While, the mean canopy temperature of 32.12^{0}C with range between 29.17^{0}C (NIAW 1885) and 33.53^{0}C (NIAW 2310) was recorded under LSI. The mean Canopy temperature cross locations ranged between 29.18^{0}C (NIAW 2073) and 31.50^{0}C (NIAW 1415) with a grand mean value of 30.54^{0}C.

For canopy temperature, environmental indices ranged from Niphad, TSI (-1.376) to Savalvihir, LSI (1.578). At Niphad, for both conditions (TSI: -1.376, LSI: -0.116) and Rahuri, TSI (-0.934) shows positive signs for environmental indices which indicated cooler canopy situations i.e. better environments than others.

4.1.15 Membrane injury index (%)

The mean membrane injury index of 48.25 per cent and 48.56 per cent with a range of 27.74 per cent (NIAW 2349) to 78.53 per cent (NIAW 2304) and 25.83 per cent (NIAW 2351) to 79.56 per cent (NIAW 2304) was recorded under TSI and LSI, respectively at Niphad. While, it ranged from 24.93 per cent (NIAW 2345) to 79.30 per cent (NIAW 2303) and 25.29 per cent (NIAW 2349) and 76.79 per cent (NIAW 2304) with a mean value of 48.34 per cent and 48.83 per cent under TSI and LSI respectively at Rahuri. At Savalvihir, the mean membrane injury index of 48.43 per cent and 48.34 per cent with a range of 25.61 per cent (NIAW 2351) to 79.96 per cent (NIAW 2304) and 25.41 per cent (NIAW 2351) to 79.41 per cent (NIAW 2303) was recorded under TSI and LSI, respectively. The mean membrane injury index across locations ranged between 26.38 per cent (NIAW 2351) and 77.60 per cent (NIAW 2304) with a grand mean value of 48.46 per cent.

Environmental indices for membrane injury index, ranged from Niphad, TSI (–0.205) to Rahuri, LSI (0.371). Under LSI conditions for both locations *viz.* Niphad (0.105) and Rahuri (0.371) shows positive signs for environmental indices which indicates more membrane injury level which is unfavorable situations for crop growth than other environments.

4.1.16. Protein (%)

Protein per cent ranged from 8.91 (NIAW 2346) and 13.37 (NIAW 1885) to 9.99 (NIAW 2345) and 13.38 (NIAW 1951) with a mean value of 10.84 and 11.73 under TSI and LSI respectively at Niphad. The protein per cent at Rahuri ranged from 7.94 (NIAW 2348) and 13.25 (NIAW 1951) to 9.41 (NIAW 2345) and 13.32 (NIAW 1415) with a mean value of 10.68 and 11.29 under TSI and LSI , respectively. At Savalvihir the protein per cent ranged from 8.66 (NIAW 2300) and 13.12 (NIAW 1415) to 8.79 (NIAW 2345) and 13.40 (NIAW 1415) with a mean value of 11.00 and 11.87 under TSI and LSI , respectively. The mean protein per cent across locations ranged between 9.43per cent (NIAW 2345) and 13.21per cent (NIAW 1415) with a grand mean value of 11.23per cent.

In case of protein, environmental indices varied from Savalvihir, LSI (0.637) to Rahuri, TSI (0.555). Under LSI conditions for all locations *viz.* Niphad (0.496), Rahuri (0.052) and Savalvihir (0.637) showed positive signs for environmental indices which indicated better situations than other environments.

4.1.17. Sedimentation value (ml)

The highest and lowest sedimentation value were recorded for NIAW 2346 (52.67 ml) and NIAW 2348 (38.33 ml) respectively, with a mean value of 45.62 ml under TSI and it was highest for NIAW 2348 (47.67 ml) and lowest for NIAW 2255 (35.33 ml) with a mean value of 44.97 ml under LSI. Similarly, the values at Rahuri were range in of 37.67 ml (NIAW 1885) and 56.33 ml (NIAW 2073) with a mean value 46.57 ml under TSI. Under LSI, the values range between 39.33 ml (NIAW 2268) and 54.67 ml (NIAW 2348) with a mean value of 44.97 ml. At Savalvihir the values were range in 38.67 ml (NIAW 1994) and 54.0 ml (NIAW 2348) with a mean value 46.38 ml under TSI. Under LSI, the values range between 36.0 ml (NIAW 2303) and 50.67 ml (NIAW 2348) with a mean value of 44.41 ml. The mean sedimentation value across locations ranged between 40.39 ml (NIAW 1415) and 50.67 ml (NIAW 2073) with a grand mean value of 45.17 ml.

Environmental indices for sedimentation value, ranged from Niphad, LSI (–2.072) to Rahuri, TSI (1.391). Under TSI conditions for all locations *viz.* Niphad (0.449) Rahuri (1.391) and Savalvihir (1.203) showed positive signs for environmental indices which indicates more better situations than other environments.

4.1.18. Hectoliter weight (kg/hl)

Hectoliter weight ranged from 79.45 kg/hl (NIAW 2345) and 84.10 kg/hl (NIAW 2065) to 78.79 kg/hl (NIAW 2345) and 84.72 kg/hl (NIAW 2248) with a mean value of 82.6 kg/hl and 82.33 kg/hl under TSI and LSI respectively at Niphad . The hectoliter weight at Rahuri ranged from 77.61 kg/hl (NIAW 2345) and 82.67 kg/hl (NIAW 2268) to 74.51 kg/hl (NIAW 2345) and 83.04 kg/hl (NIAW 2065) with a mean value of 80.75 kg/hl and 79.04 kg/hl under TSI and LSI, respectively. At Savalvihir the hectoliter weight ranged from 77.01 kg/hl (NIAW 2345) and 84.31 kg/hl (NIAW 2065) to 75.35 kg/hl (NIAW 2345) and 83.34 kg/hl (NIAW 2065) with a mean value of 81.86 kg/hl and 81.04 kg/hl under TSI and LSI, respectively. The hectoliter weight across locations ranged between 77.12 kg/hl (NIAW 2345) and 83.31 kg/hl (NIAW 2065) with a grand mean value of 81.25 kg/hl.

For hectoliter weight, environmental indices varied from Rahuri, LSI (-2.205) to Niphad, TSI (1.212). At Niphad, for both conditions (TSI: 1.212, LSI: 1.085) and Savalvihir, TSI (-0.617) showed positive signs for environmental indices which indicated better environments than others.

4.1.19. Wet gluten content (%)

At Niphad, highest wet gluten content was recorded for NIAW 2255 (55.54%) while it was lowest for NIAW 2349 (24.85%) with a mean value of 41.01 per cent under TSI. Under LSI, the highest and lowest wet gluten content was 42.18 per cent (NIAW 2348) and 56.5 per cent (NIAW 1885) with a mean value of 50.70 per cent.At Rahuri, highest wet gluten content was recorded for NIAW 917 (55.25%) while it was lowest for NIAW 2345 (37.74%) with a mean value of 44.11 per cent under TSI. Under LSI, the highest and lowest wet gluten content was 35.26 per cent (NIAW 2348) and 53.01 per cent (NIAW 917) with a mean value of 44.82 per cent. At Savalvihir, highest wet gluten content was recorded for NIAW 2255 (62.29per cent) while it was lowest for NIAW 2345 (42.27%) with a mean value of 50.51 per cent under TSI. Under LSI, the highest and lowest wet gluten content was 42.14 per cent (NIAW 2346) and 60.62per cent (NIAW 2248) with a mean value of 50.69 per cent. The mean wet gluten content across locations ranged between 39.68 per cent (NIAW 2349) and 55.71 per cent (NIAW 2255) with a grand mean value of 46.97 per cent

In case of wet gluten content, environmental indices varied from Niphad, TSI (-5.962) to Niphad, LSI (3.730). At Savalvihir, for both conditions (TSI: 3.536, LSI: 3.715) and Niphad, LSI (3.73) showed positive signs for environmental indices which indicated good environments than others.

4.2 Stability analysis

4.2.1 Pooled analysis of variance for stability

In order to study the performance of genotypes across the locations (Niphad, Rahuri and Savalvihir) in different environments (TSI and LSI) the analysis for stability of twenty wheat genotypes along with three zonal checks was carried out after pooling the data across environments as per Eberhart and Russell (1966) model. Pooled analysis of variance over locations revealed significant G x E interactions with respect to all the nineteen characters studied (Table 4.2.1.1). Further, analysis of variance for stability revealed that the mean squares due to G x E interaction were highly significant for all the characters when tested against pooled error. Further, highly significant mean squares due to environment plus G x E was observed for the all characters studied. The environment (linear) for all the characters studied was significant. G x E interaction (linear) was significant for all the characters studied were significant when tested against pooled error. Pooled deviation was significantly different with respect to all the characters except grain yield tested against the pooled error.

4.2.2 Stability parameters for morpho-physiological and quality traits

Stability parameters *viz.*, mean performance of the new genotypes, regression coefficient (bi) and deviation from regression (S^2di) for all the nineteen characters are presented in the Table 4.2.2.1

4. 2.2.1 Grain yield (kg/plot)

For grain yield, six genotypes namely NIAW 2073, NIAW 2300, NIAW 2304, NIAW 2345, NIAW 2346 and NIAW 2348 have shown significantly higher S^2d values. The rest of the 17 genotypes showed non significant S^{-2}di values. The linear regression (bi) values were significant for NIAW 1885, NIAW 2248 and NIAW 2351. The rest of the genotypes showed non-significant values for bi. None of the variety showed negative value for the linear regression (bi). The genotypes NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2313, NIAW 2349, NIAW 199 and NIAW 2351 showed higher mean values which were more than the population mean of 0.956 kg/plot. Based on the mean performance, linear regression and S^{-2}di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.2 Days to 50 per cent flowering

For the character days to 50 per cent flowering nineteen genotypes namely NIAW 1885 NIAW 2065 NIAW 2073, NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2300, NIAW 2303, NIAW 2304, NIAW 2310, NIAW 2313, NIAW 2345, NIAW 2346, NIAW 2348, NIAW 2349 , NIAW 2351, NIAW 1415, NIAW 917 and NIAW 34 showed significantly superior S^2di values. The linear regression values were significant for the genotypes NIAW 1994, NIAW 2255 and NIAW 2275. None of the variety showed the negative value for the linear regression. The genotypes NIAW 1951, NIAW 1994 and NIAW 2255 have shown the lower mean than the population means 56.68 days, but only NIAW 1951 was said to be stable based on these parameters, these varieties are said to be stable in their performance across the locations

4. 2.2.3 Days to maturity

Genotypes NIAW 2310, NIAW 2345, NIAW 2346 and NIAW 34 showed significant S^2di values for days to maturity. NIAW 2073, NIAW 2275, NIAW 2279, NIAW 2300, NIAW 2304, NIAW 2310,NIAW 2313, NIAW 2345, NIAW 2349, NIAW 2351, NIAW 1415 and NIAW 917 showed significantly superior linear regression values. None of the genotypes out of 23 have shown negative value for the linear regression (bi). Based on the mean performance over the performance of the population, linear regression values (bi) and S^2di values, the NIAW 1951, NIAW 2065, NIAW 2255, NIAW 2268, NIAW 2349, NIAW 2248, NIAW 2275, NIAW 2279, NIAW 2300, NIAW 2304 and NIAW 2348 are performing in a very stable manner for the trait number of days to maturity over all locations .

4. 2.2.4 Plant height (cm)

For plant height, six genotypes namely NIAW 2065, NIAW 2255, NIAW 2300, NIAW 2310, NIAW 2345 and NIAW 34 have shown significantly higher S^2di values. The rest of the 17 genotypes showed non significant $S^{-2}di$ values. The linear regression (bi) values were significant for NIAW 1885, NIAW 2073, NIAW 2255, NIAW 2275, NIAW 2300, NIAW 2304 NIAW 2310, and NIAW 2348. The rest of the varieties showed non-significant values for bi. None of the variety showed negative value for the linear regression (bi). The varieties seven genotypes viz. NIAW 1951, NIAW 1994, NIAW 2248 ,NIAW 2300, NIAW 2304, NIAW 1415, and NIAW 917 recorded lower plant height than the population mean of plant height 87.88 cm. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.5 Number of tillers per meter

Genotypes NIAW 1885, NIAW 1951, NIAW 2073, NIAW 2248, NIAW 2255, NIAW 2268, NIAW 2345, NIAW 2346, NIAW 2348 and NIAW 34 showed significantly superior S^2di values for number of tillers per meter. NIAW1994, NIAW2065, NIAW2248, NIAW2255, NIAW2275, NIAW2279,

NIAW 2303, NIAW 2304, NIAW 2310, NIAW 2313, NIAW 2346, NIAW 2348, NIAW 2349, NIAW 1415 NIAW 917 and NIAW 34 showed significantly superior linear regression values. None of the varieties out of 23 have shown negative value for the linear regression (bi). Based on the mean performance over the performance of the population, linear regression values (bi) and S^2di values, NIAW 2279 , NIAW 917 ,NIAW 1994 ,NIAW 2065 , NIAW 2275, NIAW 2349 and NIAW 2351 recorded higher number of tillers per meter than the population mean of tillers per meter (65.9). Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.6 Spike length (cm)

For spike length, eight genotypes namely NIAW 2073, NIAW 2275, NIAW 2279, NIAW 2313, NIAW 2346, NIAW 2348, NIAW 1415 and NIAW 917 have shown significantly higher S^2di values. The rest of the 15 genotypes showed non significant S^{-2}di values. The linear regression (bi) values were significant for NIAW 2268, NIAW 2303, NIAW 2304, and NIAW 2349. The rest of the varieties showed non-significant values for bi. The six genotypes viz., NIAW 1885, NIAW 1994, NIAW 2310, NIAW 2345 , NIAW 2349 and NIAW 2351 recorded higher spike length than the population mean of spike length 8.25 cm. Based on the mean performance, linear regression and S^2di values, the above varieties can be said stable as per the criteria of the stability analysis.

4. 2.2.7 Number grains per spike

Significantly superior values for S^2di were expressed by 11 genotypes *viz.* NIAW 1951, NIAW 2065, NIAW 2275, NIAW 2279, NIAW 2304, NIAW 2345, NIAW 2346, NIAW 2349, NIAW 2351, NIAW 1415 and NIAW 917 for the character number of grains per spike. Genotypes NIAW 1885, NIAW 1994, NIAW 2073, NIAW 2248, NIAW 2255, NIAW 2268, NIAW 2279, NIAW 2300, NIAW 2304, NIAW 2310, NIAW 2313, NIAW 2345, NIAW 2348, NIAW 2349 and NIAW 34 expressed significantly superior values of linear regression (bi). Four genotypes showing superior mean performance over the base population were NIAW 1994, NIAW 2313 and NIAW 2348. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.8 Thousand grain weight (g)

For thousand grain weight, 20 genotypes have shown significantly higher S^2di values except NIAW 2255, NIAW 2279 and NIAW 2346. The linear regression (bi) values were significant for NIAW 2303, NIAW 2346 and NIAW 2348. The rest of the 20 genotypes showed non-significant values for bi. The genotypes NIAW 2275 and NIAW 2279 recorded higher thousand grain weight than the population mean of thousand grain weight 43.36 g. Based on the mean performance, linear regression and S^2di values, the above varieties can be said stable as per the criteria of the stability analysis.

4. 2.2.9 Photosynthetic rate (µ mol m^{-2} s^{-1})

For photosynthetic rate, 20 genotypes have shown significantly higher S^2di values except NIAW 1951, NIAW 1994 and NIAW 2279. The linear regression (bi) values were significant for NIAW 1885, NIAW 1951 NIAW 2073, NIAW 2248, NIAW 2268, NIAW 2275, NIAW 2279 NIAW 2304 and NIAW 1415. Higher photosynthetic rate recorded by NIAW 1994 and NIAW 2279 than the base population mean. Based on the mean performance, linear regression and S^2di values, these two genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.10 Transpiration rate (m mol m^{-2} s^{-1})

For transpiration rate, 21 genotypes have shown significantly higher S^2di values except NIAW 1951 and NIAW 2248. NIAW 34 expressed significantly superior values of linear regression (bi). Better transpiration rate recorded by NIAW 1951 and NIAW 2248 than the base population mean. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.11 Photosynthetically active radiation (μ mol m^{-2} s^{-1})

For photosynthetic active radiation, except NIAW 2255 remaining 22 genotypes have shown significantly higher S^2di values. All tested genotypes expressed significantly superior values of linear regression (bi). Better photosynthetic active radiation recorded by NIAW 2255 than the base population mean. Based on the mean performance, linear regression and S^2di values, the above genotype can be said stable as per the criteria of the stability analysis.

4. 2.2.12 Stomatal conductance (μ mol m^{-2} s^{-1})

All tested genotypes for stomatal conductance have shown significantly higher S^2di values. The linear regression (bi) values were significant for NIAW 1885, NIAW 2248, NIAW 2268, NIAW 2303, NIAW 2310, NIAW 2351 and NIAW 34. None of the genotype recorded better performance for stomatal conductance than the base population mean.

4. 2.2.13 Stomatal resistance (μ mol m^{-2} s^{-1})

For stomatal resistance, except NIAW 34 remaining 22 genotypes have shown significantly higher S^2di values. The linear regression (bi) values were significant for NIAW 1885, NIAW 2248, NIAW 2279, NIAW 2303, NIAW 2310, and NIAW 2351and NIAW 1415. Better stomatal resistance recorded by NIAW 34 than the base population mean. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.14 Canopy temperature (^{0}C)

For canopy temperature all genotypes have shown significantly higher S^2di values. Hence none of the genotype satisfies the criteria of the stability analysis**.** The linear regression (bi) value was significant only for NIAW 34.

4. 2.2.15 Membrane injury index (%)

Significantly superior values for S^2di were expressed by 13 genotypes *viz.* NIAW 1885, NIAW 2065, NIAW 2073, NIAW 2268, NIAW 2275,

NIAW 2300, NIAW 2304, NIAW 2310 , NIAW 2345 , NIAW 2348, NIAW 2349 ,NIAW 2351, NIAW 1415 and NIAW 917 for the character membrane injury index. Genotypes NIAW 1951, NIAW 1994, NIAW 2255, and NIAW 2346 expressed significantly superior values of linear regression (bi). Five genotypes showing superior mean performance over the base population were NIAW 1994, NIAW 2279, NIAW 2313, NIAW 917 and NIAW 34. Based on the mean performance, linear regression and S^2di values, the above varieties can be said stable as per the criteria of the stability analysis.

4. 2.2.16 Protein (%)

Out of 23 genotypes 17 genotypes showed significantly superior values for S^2di. Genotypes NIAW 1994, NIAW 2065, NIAW 2348, NIAW 2349, NIAW 1415 and NIAW 917 expressed significantly superior values of linear regression (bi). The four genotypes NIAW 1994, NIAW 1415, NIAW 917 and NIAW 34 recorded higher protein content than the population mean of protein 11.23 per cent are recording in a very stable manner for the trait protein content over all locations. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.17 Sedimentation value (ml)

For sedimentation value, eleven genotypes *viz.*, NIAW 1885, NIAW 2065, NIAW 2073, NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2303, NIAW 2310, NIAW 2348, NIAW 2349 and NIAW 917 have shown significantly higher S^2di values. The rest of the 12 genotypes showed non significant S^{-2}di values. The linear regression (bi) values were significant for NIAW 1885, NIAW 1994, NIAW 2073, NIAW 2255, NIAW 2275, NIAW 2279, NIAW 2300, NIAW 2304, NIAW 2310, NIAW 2313, NIAW 2348, NIAW 2349, NIAW 917 and NIAW 34. Eight genotypes showing superior mean performance over the base population *viz.*, NIAW 1951, NIAW 1994, NIAW 2248 ,NIAW 2255, NIAW 2304, NIAW 2345, NIAW 1415 and NIAW 34 .

Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4. 2.2.18 Hectoliter weight (kg/hl)

Out of 23 genotypes 12 genotypes showed significantly superior values for S^2di. Only NIAW 1951 expressed significantly superior values of linear regression (bi). The eight genotypes NIAW 1885, NIAW 1951 , NIAW 1994, NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2313 , NIAW 2351 NIAW 1415, NIAW 917 and NIAW 34 recorded higher hectoliter weight than the population mean .Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis

4. 2.2.19 Wet gluten content (%)

Out of 23 genotypes 20 genotypes showed significantly superior values for S^2di. NIAW 1885, NIAW 2255, NIAW 2268 and 2300 expressed significantly superior values of linear regression (bi). NIAW 1885 and NIAW 1951 recorded higher wet gluten content than population mean. Based on the mean performance, linear regression and S^2di values, the above genotypes can be said stable as per the criteria of the stability analysis.

4.3 Variability parameters

The analysis of yield, physiological and quality traits at different locations as well as pooled over environments showed significant differences among genotypes for all the characters studied indicating a high degree of variably in the material (Table 4.3.1).The genotypic and phenotypic coefficient of variation (GCV and PCV) for all the nineteen characters were obtained and the heritable portion of variability i.e. heritable and genetic advance as percent mean (GAM) were estimated from genotypic and phenotypic coefficient of variation ,the results of PCV, GCV heritability and genetic advance as per cent mean are given in the Table 4.3.1. It is revealed from Table 4.3.1 .that coefficient of variation at phenotypic level was higher for all the characters in all individual environments as well as pooled environments than the coefficient of variation at the genotypic level.

4.3.1 Phenotypic coefficient of variation

At Niphad under TSI, PCV of 36.07, 26.88, 24.81 and 18.41 were observed membrane injury index, stomatal resistance, stomatal conductance and grains per spike. While, under LSI, PCV of membrane injury index (36.67), stomatal conductance (30.89), transpiration rate (30.03), grains per spike (19.96) and grain yield (17.09) were recorded.

Similarly, at Rahuri under TSI, PCV of observed membrane injury index (36.12), stomatal resistance (26.36), stomatal conductance (22.87), transpiration rate (22.22) and photosynthetic rate (18.02) were observed. Under LSI, PCV of membrane injury index (36.40), stomatal resistance (26.45), stomatal conductance (21.34), grains per spike (17.28) and grain yield (17.26) was observed.

At Savalvihir under TSI, PCV of 37.41 (membrane injury index), 26.42 (transpiration rate) 25.90 (stomatal resistance), 24.83 (stomatal conductance) and 20.41 (grain yield) was recorded. While under LSI, PCV of 36.57 (membrane injury index), 35.83 (stomatal resistance), 29.69 (stomatal conductance), 24.33 (transpiration rate) and 22.70 (photosynthetic rate) was observed. For rest of the characters in all environment and locations, lower phenotypic coefficient was observed.

4.4.2 Genotypic coefficient of variation

At Niphad under TSI, GCV of 36.00, 23.85, 23.28 and 17.66 were observed for membrane injury index, stomatal resistance, stomatal conductance and grains per spike. While under LSI, PCV of membrane injury index (36.65), stomatal conductance (30.59), transpiration rate (29.30), and grains per spike (17.66) were recorded.

Similarly, at Rahuri under TSI, GCV of observed for membrane injury index (36.65), stomatal conductance (30.59), transpiration rate (29.30), stomatal resistance (23.69) and grains per spike (18.30) were observed. Under LSI, GCV of membrane injury index (36.37), stomatal resistance (24.60) and stomatal conductance (21.08), grains per spike (17.28) was observed.

At Savalvihir under TSI, GCV of 37.38 (membrane injury index), 24.60 (stomatal resistance), 23.29 (stomatal conductance), 21.31 (transpiration rate) and 19.09 (grains per spike) was recorded. While under LSI, GCV of 36.70 (membrane injury index), 34.46 (stomatal conductance), 26.65 (stomatal resistance) and 24.61 (transpiration rate) was observed. For rest of the characters particularly hectoliter weight, flowering, maturity, canopy temperature, sedimentation value exhibited lower GCV values across all environment.

Table 4.3.1: Estimates of Variability (PCV & GCV), heritability (per cent), genetic advance as percent of mean (GAM) for nineteen characters under different environments.

Character	Locations	Conditions	PCV	GCV	h^2 (bs)	GAM
Grain yield (kg/plot)	Niphad	TSI	12.69	9.31	53.70	14.05
		LSI	17.09	9.63	31.70	11.16
	Rahuri	TSI	17.40	12.96	55.5	19.90
		LSI	17.26	12.22	50.1	17.83
	Savalvihir	TSI	20.41	17.41	72.8	30.59
		LSI	19.02	14.66	59.3	23.25
Pooled over environments			20.27	11.41	31.7	13.23
Days to 50 per cent Flowering	Niphad	TSI	10.92	10.65	95.2	21.42
		LSI	6.99	6.81	94.9	13.66
	Rahuri	TSI	12.17	11.94	96.3	24.14
		LSI	7.80	7.62	95.3	15.31
	Savalvihir	TSI	10.09	9.91	96.5	20.05
		LSI	11.14	11.03	98.1	22.50
Pooled over environments			10.63	6.87	41.8	11.72
Days to Maturity	Niphad	TSI	6.22	5.82	87.5	11.21
		LSI	6.04	5.75	90.5	11.26
	Rahuri	TSI	6.07	5.74	89.2	11.16
		LSI	4.59	4.18	82.9	7.84
	Savalvihir	TSI	6.04	5.82	92.8	11.54
		LSI	4.46	4.12	85.5	7.84
Pooled over environments			6.51	3.82	34.4	5.92
Plant Height (cm)	Niphad	TSI	8.81	8.20	86.8	15.70
		LSI	10.05	9.27	85.1	17.61
	Rahuri	TSI	7.62	6.96	83.6	13.12
		LSI	7.13	5.96	70.0	10.27
	Savalvihir	TSI	8.02	7.46	86.6	14.59
		LSI	6.63	5.06	58.2	7.95
Pooled over environments			9.45	5.21	29.8	7.52
Spike length (cm)	Niphad	TSI	10.95	9.02	67.8	15.30
		LSI	12.77	11.30	78.4	20.62
	Rahuri	TSI	10.89	9.91	82.9	18.58
		LSI	9.38	8.59	84.0	16.22
	Savalvihir	TSI	12.46	11.19	80.6	20.70
		LSI	8.88	7.12	62.6	11.59
Pooled over environments			12.05	7.27	36.5	9.05

Table contd.

Character	Locations	Condition	PCV	GCV	h^2 (bs)	GAM
No. of Tillers per meter	Niphad	TSI	11.36	8.80	59.9	14.02
		LSI	10.83	8.54	62.2	13.88
	Rahuri	TSI	9.32	8.02	73.9	14.19
		LSI	11.12	10.22	84.4	19.33
	Savalvihir	TSI	10.96	9.12	69.2	15.63
		LSI	12.84	10.74	70.0	18.51
Pooled over environments			12.76	7.16	31.5	8.28
No. of grains per spike	Niphad	TSI	18.41	17.66	92.0	34.90
		LSI	19.96	18.30	84.1	34.57
	Rahuri	TSI	17.50	16.11	82.3	30.11
		LSI	17.28	15.98	85.5	30.43
	Savalvihir	TSI	20.31	19.09	88.4	36.97
		LSI	14.36	11.36	62.6	18.52
Pooled over environments			19.12	10.93	32.7	12.86
Thousand grain weight (g)	Niphad	TSI	8.78	8.63	78.2	17.46
		LSI	9.00	8.83	96.2	17.84
	Rahuri	TSI	7.93	7.69	94.2	15.39
		LSI	7.81	7.51	92.5	14.88
	Savalvihir	TSI	10.77	10.54	95.8	21.26
		LSI	8.06	7.77	93.0	15.44
Pooled over environments			9.61	6.50	45.8	9.07
Photosynthetic rate (μ mol m^{-2} s^{-1})	Niphad	TSI	12.22	11.34	86.2	21.68
		LSI	16.77	16.16	92.8	32.07
	Rahuri	TSI	18.02	17.72	96.6	35.88
		LSI	13.76	12.76	86.0	24.39
	Savalvihir	TSI	14.87	10.98	54.6	16.72
		LSI	15.93	15.35	92.9	30.49
Pooled over environments			22.20	16.00	51.9	23.76
Transpiration rate (m mol m^{-2} s^{-1})	Niphad	TSI	14.30	13.05	83.3	24.53
		LSI	30.03	29.30	95.2	58.91
	Rahuri	TSI	22.22	21.75	95.8	43.84
		LSI	15.49	12.79	68.2	21.76
	Savalvihir	TSI	26.42	21.31	65.1	35.42
		LSI	24.76	24.61	99.0	50.42
Pooled over environments			24.33	13.95	32.9	16.47

Table contd.

Character	Locations	Condition	PCV	GCV	h^2 (bs)	GAM
Photosynthetic - ally active radiation ($\mu mol\ m^{-2}\ s^{-1}$)	Niphad	TSI	7.83	7.23	85.3	13.76
		LSI	7.26	7.10	95.5	14.29
	Rahuri	TSI	7.00	6.46	85.2	12.29
		LSI	8.43	8.31	97.1	16.87
	Savalvihir	TSI	8.68	7.37	72.2	12.91
		LSI	9.18	9.12	98.8	18.67
Pooled over environments			9.44	6.04	41.0	7.96
Stomatal couductance ($\mu mol\ m^{-2}\ s^{-1}$)	Niphad	TSI	24.81	23.28	92.7	46.19
		LSI	30.89	30.59	98.1	62.41
	Rahuri	TSI	22.87	21.69	90.1	42.41
		LSI	21.34	21.08	97.5	42.87
	Savalvihir	TSI	24.83	23.29	87.9	44.99
		LSI	34.89	34.46	97.5	70.08
Pooled over environments			29.69	15.84	28.5	17.41
Stomatal resistance ($\mu mol\ m^{-2}\ s^{-1}$)	Niphad	TSI	26.88	23.85	78.8	43.62
		LSI	24.23	23.69	97.8	48.30
	Rahuri	TSI	26.36	25.11	90.7	49.26
		LSI	22.45	22.00	96.1	44.34
	Savalvihir	TSI	55.90	54.60	95.4	53.62
		LSI	29.87	26.65	98.6	60.66
Pooled over environments			35.83	18.31	26.1	19.27
Canopy temperature (^0C)	Niphad	TSI	5.47	5.36	96.0	10.82
		LSI	3.44	3.36	95.3	6.75
	Rahuri	TSI	3.06	2.90	90.3	5.68
		LSI	2.31	2.20	91.3	4.33
	Savalvihir	TSI	2.40	2.20	83.9	4.15
		LSI	3.86	3.56	84.9	6.76
Pooled over environments			4.79	3.99	69.3	6.48
Membrane injury index (%)	Niphad	TSI	36.07	36.0	99.5	74.13
		LSI	36.67	36.65	99.8	75.43
	Rahuri	TSI	36.12	36.08	99.7	74.14
		LSI	36.40	36.37	99.8	74.86
	Savalvihir	TSI	37.41	37.38	99.8	76.95
		LSI	36.73	36.70	99.2	75.55
Pooled over environments			36.57	19.49	28.4	21.39

Table contd.

Character	Locations	Condition	PCV	GCV	h^2 (bs)	GAM
Protein (%)	Niphad	TSI	13.26	12.78	92.9	25.38
		LSI	7.44	6.90	85.9	13.17
	Rahuri	TSI	14.70	14.12	92.3	27.95
		LSI	9.11	8.7	91.2	17.11
	Savalvihir	TSI	11.91	10.60	89.6	20.66
		LSI	8.22	7.49	83.2	14.08
Pooled over environments			11.43	6.44	31.8	7.49
Sedimentation value (ml)	Niphad	TSI	11.14	10.12	82.5	18.93
		LSI	7.67	6.78	78.0	12.34
	Rahuri	TSI	11.46	10.87	89.9	21.22
		LSI	9.69	8.87	83.6	16.71
	Savalvihir	TSI	9.83	9.20	87.5	17.72
		LSI	11.53	7.79	45.7	10.86
Pooled over environments			10.66	4.66	19.1	4.20
Hectoliter weight (kg/hl)	Niphad	TSI	1.42	1.29	80.9	2.38
		LSI	1.99	1.84	84.8	3.48
	Rahuri	TSI	1.46	1.36	86.2	2.59
		LSI	2.14	2.05	91.1	4.02
	Savalvihir	TSI	2.05	1.96	91.1	3.85
		LSI	2.12	1.99	88.4	3.85
Pooled over environments			2.39	1.75	53.5	2.63
Wet gluten content (%)	Niphad	TSI	14.79	14.34	94.6	28.73
		LSI	9.46	8.67	83.9	16.35
	Rahuri	TSI	11.15	10.38	86.7	19.91
		LSI	13.47	12.02	79.5	22.08
	Savalvihir	TSI	9.85	8.72	78.4	15.91
		LSI	10.78	10.49	94.6	21.01
Pooled over environments			14.16	9.43	44.3	12.93

4.3.3 Heritability and genetic advance as per cent of mean (GAM)

All the characters in the present study showed high heritability in all individual environments. With respect to genetic advance as per cent of mean (GAM) at Niphad under TSI, GAM of membrane injury index (74.13), stomatal conductance (46.69), stomatal resistance (43.62), grains per spike (34.90) and transpiration rate (24.53) was observed. While under LSI, GAM of 75.43 (membrane injury index), 62.41(stomatal conductance), 58.91 (transpiration rate) and 34.57 (grains per spike) was recorded.

At Rahuri under TSI, GAM of 74.14, 49.26, 43.84, 42.41 and 35.88 were observed for membrane injury index, stomatal resistance, transpiration rate, stomatal conductance and photosynthetic rate. While under LSI, GAM of 74.86 (membrane injury index), 44.34 (stomatal resistance), 42.87 (stomatal conductance) 30.43 (grains per spike) and 24.39 (photosynthetic rate) was recorded.

Similarly, at Savalvihir under TSI, GAM for membrane injury index (76.95), stomatal resistance (53.62), stomatal conductance (44.99) grains per spike (36.97) and transpiration rate (35.42) were observed. Under LSI, GAM of membrane injury index (75.35), stomatal conductance (70.08), stomatal resistance (60.66) and transpiration rate (50.42) was observed.

4.4 Character association and correlation

The genotypic and phenotypic correlation coefficients among nineteen characters were studied in each environment separately as well as pooled over environments.

4.4.1 Correlation analysis of morpho-physiological and quality traits at Niphad under TSI condition

The genotypic correlations coefficients among nineteen characters under TSI at Niphad are presented in Table 4.4.1.1.

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.5571), spike length (0.6792), grains per spike (0.7301), transpiration rate (0.3346) and grain yield (0.5587).Significant negative relationship was observed with thousand grain weight (-0.8234), stomatal resistance (-0.3058), membrane injury index (-0.4852), hectoliter weight (-0.3319)and wet gluten content (-0.3319).

Days to maturity possessed significant positive correlation with plant height (0.3091), grains per spike (0.4159), spike length (0.4143) , protein (0.3075) and grain yield (0.5393) and significant negative relationship with thousand grain weight (-0.3009) and membrane injury index (-0.3411).

Plant height possessed significant positive correlation with spike length (0.318), transpiration rate (0.3015) and grain yield (0.2786) and no significant negative relationship with other character was observed.

Tillers per meter possessed significant positive correlation with spike length (0.3732) and significant negative relationship was observed with canopy temperature (-0.4013).

Spike length showed significant positive correlation with grains per spike (0.6786) ,canopy temperature (0.3265) and grain yield (0.551) and significant negative relationship were observed with thousand grain weight (-0.5453), membrane injury index (-0.5392),protein (-03207), hectoliter weight (-0.5262) and wet gluten content (0.3156).

Grains per spike possessed significant positive correlation with canopy temperature (0.3537) and grain yield (0.5551).Significant negative relationship with thousand grain weight (-0.7113), membrane injury index (-0.4746), hectoliter weight (-0.3907) and wet gluten content (-0.3156).

Thousand grain weight possessed significant positive correlation with membrane injury index (0.4498) and significant negative relationship were observed with canopy temperature (-0.3003) and grain yield (-0.5611).

Photosynthetic rate possessed significant positive correlation with stomatal conductance (0.7339) and hectoliter weight (0.4142) and significant negative relationship with stomatal resistance (-0.714).

Transpiration rate showed significant negative correlation with membrane injury index (-0.4039). Photosynthetically active radiation shows significant positive correlation with canopy temperature (0.4187).

Stomatal conductance possessed significant positive correlation with hectoliter weight (0.4388) and significant negative relationship with stomatal resistance (-0.9753) and membrane injury index (-0.3168).

Stomatal resistance possessed significant positive correlation with membrane injury index (0.4151) and significant negative relationship with hectoliter weight (-0.3631) .

Canopy temperature did not observed significant positive correlation with any other characters, however it shows significant negative correlation with membrane injury index (-0.469), hectoliter weight (-0.4188) and wet gluten content (-0.3911).

Membrane injury index possessed significant positive correlation with gluten content (0.4295) and significant negative relationship with grain yield (-0.3907).

Protein content possessed significant positive correlation with hectoliter weight (0.3014) and gluten content (0.5237) and significant negative relationship with sedimentation value (-0.5134). Sedimentation value did not show significant either positive or negative relationship with other traits. Hectoliter weight possessed significant positive relationship with wet gluten content (0.4777) and significant negative relationship with grain yield (-0.4621). Wet gluten content possessed significant negative correlation with grain yield (-0.2944).

The phenotypic correlation coefficients among nineteen characters under TSI at Niphad are presented in Table 4.4.1.2

. Days to 50 per cent flowering were significantly positively correlated with maturity (0.4903), grains per spike (0.6772), spike length (0.5553), transpiration rate (0.3119) and grain yield (0.4156). It was significantly negatively correlated with thousands grain weight (-0.7765), membrane injury index (-0.4717) and wet gluten (-0.3195).

Days to maturity were significantly positively correlated with plant height (0.2941), spike length (0.3620), grains per spike (0.3692), protein (0.287) and grain yield (0.287). Whereas, it is significantly negatively correlated with membrane injury index (-0.3168).

Number of tillers per meter was significantly positively correlated with spike length (0.2784) and significantly negatively correlated with canopy temperature (-0.3228).

Spikelet length significantly positively correlated with grains per spike (0.5544) and grain yield (0.4467). It was significantly negatively correlated with thousand grain weight (-0.4385), hectoliter weight (-0.3928), membrane injury index (-0.4448) and wet gluten content (-0.4635).

Grains per spike were significantly positively correlated with grain yield (0.3772). It had significantly negatively correlate with thousand grain weight (-0.6428), membrane injury index (-0.4515), hectoliter weight (-0.286) and wet gluten (-0.2909).

Thousand grain weights was significantly positively correlated with membrane injury index (0.4398) and significantly negatively correlated with grain yield (-0.4114).

Photosynthetic rate was significantly positively correlated with stomatal conductance (0.6775) and hectoliter weight (0.3532). It had significantly negatively correlation with stomatal resistance (-0.5947).

Transpiration rate was significantly positively correlated with canopy temperature (0.2937) and significantly negatively correlated with membrane injury index (-0.3677).

Stomatal conductance was significantly positively associated with hectolitre weight (0.3724) whereas; it was significantly negatively correlated with stomatal resistance (-0.9413) and membrane injury index (-0.3054). Stomatal resistance significantly positively correlated with (0.3696).

Canopy temperature was significantly negatively correlated with membrane injury index (-0.4555), protein (-0.2488), hectoliter weight (-0.3897) and wet gluten (-0.3649).

Membrane injury index was significantly positively correlated with wet gluten (0.4154) and significantly negatively correlated with grain yield (-0.2895).

Protein content was significantly positively correlated with wet gluten (-0.4854) and significantly negatively correlated with sedimentation value (-0.4309).

4.4.2 Correlation analysis of morpho-physiological and quality traits at Niphad under LSI condition

The genotypic correlations coefficient among nineteen characters under LSI at Niphad are presented in Table 4.4.2.1.

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.462), spike length (0.5675), grains per spike (0.808), photosynthetic rate (0.45) transpiration rate (0.3168) and grain yield (0.602).Significant negative relationship was observed with thousand grain weight (-0.784) , photosynthetic active radiation (-0.333),canopy temperature (-0.608), membrane injury index (-0.4026) and hectoliter weight (-0.416).

Days to maturity possessed significant positive correlation with spike length (0.447), photosynthetic rate (0.45), transpiration rate (0.3189) and grain yield (0.4016). Significant negative relationship with thousand grain weight (-0.3258), stomatal resistance (-0.3612), canopy temperature (-0.489) and hectoliter weight (-0.509).

Plant height possessed significant positive correlation with grain yield (0.3852) and no significant negative relationship with other character was observed.

Tillers per meter possessed significant positive correlation with hectoliter weight (0.363) and grain yield (0.4799). Significant negative relationship was observed with spike length (-0.4917) and photosynthetically active radiation (-0.354).

Spike length showed significant positive correlation with grains per spike (0.653), sedimentation value (0.3522) and grain yield (0.498). Significant negative relationships were observed with thousand grain weight (-0.37), photosynthetic active radiation (-0.447), canopy temperature (-0.4081), hectoliter weight (-0.759) and wet gluten content (-0.405)

Grains per spike possessed significant positive correlation with photosynthetic rate (0.403), transpiration rate (0.541) and grain yield (0.3141).Significant negative relationships with thousand grain weight (-0.827), canopy temperature (-0.5981), membrane injury index (-0.5186)and hectoliter weight (-0.594) .

Thousand grain weight possessed significant positive correlation with photosynthetically active radiation (0.3231), canopy temperature (0.407) , membrane injury index (0.466), stomatal resistance (0.286) and hectoliter weight (0.3476).Significant negative relationships were observed with photosynthetic rate (-0.492), transpiration rate (-0.435), stomatal conductance (-0.2788) and grain yield (-0.4893).

Photosynthetic rate possessed significant positive correlation with transpiration rate (0.447), stomatal conductance (0.761) and grain yield (0.3993) . Significant negative relationship with stomatal resistance (-0.7666) , membrane injury index (-0.4962) and sedimentation value (-0.3397).

Transpiration rate not showed significant positive correlation with other traits and significant negative relationship with membrane injury index (-0.3997).

Photosynthetically active radiation showed significant positive correlation with canopy temperature (0.3645) and wet gluten content (0.566). Significant negative relationship with sedimentation value (-0.2954) and grain yield (-0.8394).

Stomatal conductance not showed significant positive correlation with other traits, however significant negative relationship with stomatal resistance

(-0.939). Stomatal resistance not possessed significant positive or negative relationship with other traits.

Canopy temperature does not show significant positive correlation with any other characters, however it shows significant negative correlation with grain yield (-0.3288).

Membrane injury index does not show significant positive correlation with any other characters, however it possessed significant negative relationship with grain yield (-0.7178).

Protein does not show significant positive correlation with any other characters, however significant negative relationship with sedimentation value (-0.404) and grain yield (-0.3097) .Sedimentation value does not show significant positive correlation with other traits, however negative relationship was observed with hectoliter weight (-0.3658) and wet gluten content (-0.497). Hectoliter weight possessed significant positive relationship with wet gluten content (0.3412) and no significant negative relationship with other traits. Wet gluten content did not show significant positive correlation with other trait. Significant negative correlation with grain yield (-0.3301)

The phenotypic correlation coefficients among nineteen characters under LSI at Niphad are presented in Table 4.4.2.2

Days to 50 per cent flowering were significantly positively correlated with maturity (0.4145), spike length (0.4797), photosynthetic rate (28.46), grains per spike (0.7032) and grain yield (0.3442). Whereas, it is significantly negatively correlated with thousand grain weight (-0.7449), transpiration rate (-0.3108), canopy temperature (-0.571), membrane injury index (-0.3909) and hectoliter weight (-0.3677).

Plant height was significantly positively correlated with grain yield (0.3362).

Number of tillers per meter were significantly positively correlated with hectolitre weight (0.3087) and grain yield (0.2588) whereas it was significantly negatively correlated with spike length (-0.311) and protein per cent (-0.347).

Spike length has positively correlated with grains per spike (0.5669) and grain yield (0.2816). It had negatively correlated with thousand grain weight (-0.3005) photosynthetically active radiation (-0.389), canopy temperature (-0.349), hectolitre litre (-0.5774) and wet gluten content (-0.326).

Grains per spike were significantly positively correlated with photosynthetic rate (0.3518), transpiration rate (0.4863) and grain yield (0.237) whereas, it is negatively correlated with thousand grain weight positively (-0.7537), stomatal resistance (-0.2539), membrane injury index (-0.4052), canopy temperature (-0.519) and hectoliter weight (-0.5463).

Thousand grain weight was positively correlated with photosynthetically active radiation (0.3006), canopy temperature (0.375) and membrane injury index (0.4541). Whereas, significantly negatively correlated with photosynthetic rate (-0.4094), transpiration rate (-0.419) and spike length (-0.271).

Photosynthetic rate was significantly positively correlated with transpiration rate (0.4299), stomatal conductance (0.719) and grain yield (0.2723) whereas, significantly negatively correlated with stomatal resistance (-0.728), membrane injury index (-0.4786) and sedimentation value (-0.2725).

In case of transpiration rate it was significantly negatively correlated with stomatal resistance (-0.309), membrane injury index (-0.3902) and hectolitre weight (-0.3506).

Photosynthetically active radiation significantly correlated with canopy temperature (0.348) and wet gluten (0.4931). Whereas, it was significantly negatively correlated with grain yield (-0.4675).

Stomatal conductance significantly negatively correlated with stomatal resistance (-0.938). Stomatal resistance was significantly positively correlated with membrane injury index (0.2431) and hectolitre weight (-0.293).

Canopy temperature was significantly positively correlated with hectolitre weight (0.2556). Whereas, membrane injury index positively correlated with grain yield (0.4079).

Protein was significantly negatively correlated with sedimentation value (-0.308). Sedimentation value is significantly negatively correlated with hectolitre weight (-0.3021) and wet gluten content (-0.391). Whereas, hectoliter weight was significantly positively correlated with wet gluten content (0.288).

4.4.3 Correlation analysis of morpho-physiological and quality traits at Rahuri under TSI condition

The genotypic correlation coefficients among nineteen characters under TSI at Rahuri are presented in Table 4.4.3.1

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.576), spike length (0.5054), grains per spike (0.7819), transpiration rate (0.2841) canopy temperature (0.4054) and grain yield (0.4877).Significant negative relationship was observed with thousand grain weight (-0.7175)and membrane injury index (-0.4753).

Days to maturity possessed significant positive correlation with grains per spike (0.4442), spike length (0.4594), stomatal resistance (0.4082), canopy temperature (0.3198) wet gluten content (0.4253) and significant negative relationship with thousand grain weight (-0.3953) and stomatal resistance (-0.4274). Plant height possessed significant positive correlation with thousand grain weight (0.3145) and grain yield (0.328) and no significant negative relationship with other character was observed.

Tillers per meter possessed significant positive correlation photosynthetic rate (0.7133), stomatal conductance (0.5058), hectoliter weight (0.4237) and grain yield (0.5647). Significant negative relationship was observed with spike length (-0.3773), stomatal resistance (-0.5089) and membrane injury index (0.2819).

Spike length showed significant positive correlation with grains per spike (0.65), canopy temperature (0.4801), photosynthetic active radiation (0.3584) and stomatal resistance (0.5111). Significant negative relationship were observed with thousand grain weight (-0.2813), photosynthetic rate (-0.3818), stomatal conductance (-0.4758) membrane injury index (-0.5249), protein (-0.3137) and hectoliter weight (-0.485) .

Grains per spike possessed significant positive correlation with transpiration rate (0.4011), canopy temperature (0.4733)and grain yield (0.3671).Significant negative relationship with thousand grain weight (-0.6237) and membrane injury index (-0.5245) .

Thousand grain weight possessed significant positive correlation with stomatal counductance (0.3083), membrane injury index (0.2989) and hectoliter weigh (0.2745) Significant negative relationship were observed with photosynthetic active radiation (-0.433) and canopy temperature (-0.4171) .

Photosynthetic rate possessed significant positive correlation with stomatal conductance (0.7372) and grain yield (0.6514) and significant negative relationship with stomatal resistance (-0.6699).

Transpiration rate showed significant positive correlation with canopy temperature (0.5481) and significant negative relationship with membrane injury index (-0.314).

Photosynthetically active radiation showed significant positive correlation with stomatal resistance (0.3036) and canopy temperature (0.5361). Significant negative relationship with membrane injury index (-0.3734) and sedimentation value (0.3121).

Stomatal conductance possessed significant positive correlation with hectoliter weight (0.6501) and grain yield (0.3458). Significant negative relationship with stomatal resistance (-0.9775).

Stomatal resistance possessed significant negative relationship with hectoliter weight (-0.6815) and grain yield (-0.3175). Canopy temperature did not observed significant positive correlation with any other characters, however it shows significant negative correlation with membrane injury index (-0.6328) and hectoliter weight (-0.2865).

Membrane injury index possessed significant positive correlation with gluten content (0.3694) and significant negative relationship with grain yield (-0.5776).

Protein content possessed significant positive correlation with gluten content (0.5912) and significant negative relationship with sedimentation value (-0.7743). Sedimentation value did not showed significant positive correlation with other traits, however negative relationship was observed with wet gluten content (0.3213). Hectoliter weight possessed significant positive relationship with grain yield (0.4956) and no significant negative relationship with other traits. Wet gluten content possessed significant negative correlation with grain yield (-0.4642).

The phenotypic correlation coefficients among nineteen characters under TSI at Rahuri are presented in Table 4.4.3.2

Days to 50 per cent flowering was significantly associated with maturity (0.5334), grains per spike (0.7132), canopy temperature (0.3740), spike length (0.4540), transpiration rate (0.2871) and grain yield (0.397). Whereas, significantly negatively correlated with thousand grain weight (-0.6882) and membrane injury index (-0.4669).

Days to maturity was significantly positively correlated with spike length (0.3735), stomatal resistance (0.3870), grains per spike (0.3865), canopy temperature (0.2814) and wet gluten (0.3628). It has significantly negatively correlated with thousand grain weight (-0.3470) and stomatal conductance (-0.3999).

Plant height was significantly positively associated with thousand grain weight (0.2844). Number of tillers per meter was significantly positively correlated with photosynthetic rate (0.6136), stomatal conductance (0.4422), hectolitre weight (0.3828) and grain yield (0.4717). It had significantly negatively associated with spike length (-0.2643), stomatal resistance (-0.4351) and membrane injury index (-0.2401).

Spike length was significantly positively correlated with grains per spike (0.5349), stomatal resistance (0.4147) and photosynthetically active radiation (0.3205). It had significantly negatively correlated with photosynthetic rate (-0.3543), stomatal conductance (-0.3843), membrane injury index (-0.4763), protein (-0.274) and hectoliter weight (-0.406).

Grains per spike were significantly positively associated with transpiration rate (0.398), canopy temperature (0.4141), photosynthetic active radiation (0.3027) and grain yield (0.3715). It had significantly negatively correlated with thousand grain weight (-0.5475) and membrane injury index (-0.4777).

Thousand grain weight significantly positively correlated with stomatal conductance (0.2957), membrane injury index (0.2885), sedimentation value (0.3316) and hectolitre weight (0.2372). Whereas, it was significantly negatively correlated with stomatal resistance (-0.2899) and photosynthetically active radiation (-0.3731).

Photosynthetic rate was significantly positively correlated with stomatal conductance (0.6603), hectolitre weight (0.4680) and grain yield (0.492) whereas, it was significantly negatively correlated with stomatal resistance (-0.6010).

Transpiration rate had significantly positively correlated with canopy temperature (0.5178) and hectoliter weight (0.2384) whereas significantly negatively correlated with membrane injury index (-0.3042).

Photosynthetically active radiation was significantly positively correlated with stomatal resistance (0.2382) and canopy temperature (0.3458) whereas it was significantly negatively correlated with membrane injury index (-0.3458) and sedimentation value (-0.2969).

Stomatal conductance was significantly negatively correlated with stomatal resistance (-0.9725) and hectolitre weight (-0.5781). Whereas stomatal resistance was significantly negatively correlated with hectolitre weight (-0.606), canopy temperature is significantly negatively correlated with membrane injury index (-0.5999) and wet gluten (-0.2895).

Membrane injury index was significantly positively correlated with wet gluten (0.3437) and significantly negatively correlated with grain yield (-0.429).

Protein was significantly positively correlated with wet gluten (0.5344) and significantly negatively correlated with sedimentation value (-0.712) and grain yield (-0.1299).

4.4.4 Correlation analysis of morpho- physiological and quality traits at Rahuri under LSI condition

The genotypic correlation coefficients among nineteen characters under LSI at Rahuri are presented in Table 4.4.4.1

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.357), tillers per meter (0.3168), spike length (0.655), grains per spike (0.7255), transpiration rate (0.7628), sedimentation value (0.385) and grain yield (0.408).Significant negative relationship was observed with thousand grain weight (-0.4371), membrane injury index (-0.398), protein content (-0.2855) and wet gluten content (-0.47).

Days to maturity possessed significant positive correlation with photosynthetic rate (0.4964), transpiration rate (0.375) and stomatal conductance (0.536). Significant negative relationship with photosynthetic active radiation (-0.3245) , stomatal resistance (-0.5421) and canopy temperature (-0.3865).

Plant height possessed significant positive correlation with wet gluten content (0.3555) and no significant negative relationship with other characters.

Tillers per meter possessed significant positive correlation grains per spike (0.3758), photosynthetic rate (0.446), stomatal conductance (0.3383) and grain yield (0.7903). Significant negative relationship was observed with stomatal resistance (-0.3994) , membrane injury index (-0.656) and wet gluten content (-0.41).

Spike length showed significant positive correlation with grains per spike (0.578), sedimentation value (0.356) and grain yield (0.3968). Significant negative relationship were observed with thousand grain weight (-0.5059), membrane injury index (-0.442), and wet hectoliter weight (-0.44)

Grains per spike possessed significant positive correlation with photosynthetic rate (0.3068), transpiration rate (0.4128) and grain yield (0.549).Significant negative relationship with stomatal resistance (-0.3036) and membrane injury index (-0.488)

Thousand grain weight possessed significant positive correlation with hectoliter weight (0.353).Significant negative relationship were observed with transpiration rate (-0.4332).

Photosynthetic rate possessed significant positive correlation with stomatal conductance (0.8709) and grain yield (0.6543). Significant negative relationship with stomatal resistance (-0.8227) and membrane injury index (-0.649) .

Transpiration rate showed significant positive correlation with stomatal conductance (0.3984) and significant negative relationship with stomatal resistance (-0.4125), canopy temperature (-0.433) and wet gluten content(-0.37).

Photosynthetically active radiation not showed significant positive or negative correlation with other traits.

Stomatal conductance showed significant positive correlation with grain yield (0.3269), however significant negative relationship with stomatal resistance (-0.973), canopy temperature (-0.433) and membrane injury (-0.411) .

Stomatal resistance showed significant positive correlation with canopy temperature (0.3237), and membrane injury (0.448) .Significant negative relationship with protein content (-0.3026) and grain yield (-0.3756) .

Canopy temperature not shows significant positive or negative correlation with any other characters.

Membrane injury index does not show significant positive correlation with any other characters, however it possessed significant negative relationship with grain yield (-0.9154).

Protein content show significant positive correlation with wet gluten content (0.312) and significant negative relationship with sedimentation value (-0.427).Sedimentation value, hectoliter weight and wet gluten content did not show significant positive or negative correlation with other traits.

The phenotypic correlations coefficients among nineteen characters under LSI at Rahuri are presented in Table 4.4.4.2.

Days to 50 per cent flowering was significantly positively correlated with maturity (0.304), spike length (0.576), grain per spike (0.674), transpiration rate (0.631), sedimentation value (0.337) and grain yield (0.3007). It had significantly negatively correlated with thousand grain wight (0.4071), protein (0.3867) and wet gluten (0.429).

Days to maturity was significantly positively correlated with spike length (0.2379), photosynthetic rate (0.412) and stomatal conductance (0.479). It had significantly negatively correlated with photosynthetic active radiation (-0.292), stomatal resistance (-0.475) and canopy temperature (-0.338).

Plant height did not significant positive or negative correlated with other traits.

Number of tillers per meter were significantly positively correlated with grains per spike (0.325), photosynthetic rate (0.377), stomatal conductance (0.311) and grain yield (0.5381). Whereas, it was significantly negatively correlated with membrane injury index (-0.6023) and wet gluten content (-0.346).

Spike length has significantly positively correlated with grains per spike (0.509). It has significantly negatively correlated with thousand grain weight (-0.4474), membrane injury index (-0.4066), hectoliter weight (-0.374) and wet gluten (-0.425).

Grains per spike were significantly positively correlated with transpiration rate (0.2924) and grain yield (0.3926). It has significantly negatively correlated with thousand grain weight (-0.4678), membrane injury index (-0.4498) and wet gluten (-0.358).

Thousand grain weight was significantly positively correlated with hectoliter weight (0.3032) and significantly negatively correlated with transpiration rate (-0.352).

Photosynthetic rate was significantly positively correlated with stomatal conductance (0.804) and grain yield (0.3822). It has significantly negatively correlated with stomatal resistance (-0.751) and membrane injury index (-0.6036).

Transpiration rate had significantly positively correlated with stomatal conductance (0.2913) and significantly negatively correlated with stomatal resistance (-0.291) and canopy temperature (-0.2986).

Stomatal conductance had significantly negatively correlated with stomatal resistance (-0.966) and membrane injury index (-0.4054). Stomatal resistance is significantly positively correlated with canopy temperature (0.308) and membrane injury index (0.4394) and significantly negatively correlated with protein (-0.273).

Canopy temperature was significantly negatively correlated with wet gluten (-0.332). Membrane injury index was significantly negatively correlated with sedimentation value (-0.245), wet gluten (-0.2787) and grain yield (-0.651).

Protein content was significantly positively correlated with wet gluten (0.263) and significantly negatively associated with sedimentation value (-0.363).

4.4.5 Correlation analysis of morpho- physiological and quality traits at Savalvihir under TSI condition

The genotypic correlation coefficients among nineteen characters under TSI at Savalvihir are presented in Table 4.4.5.1.

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.5065), tillers per meter (0.3843), spike length (0.5526), grains per spike (0.8919), transpiration rate (0.321) and grain yield (0.5023). Significant negative relationship was observed with thousand grain weight (-0.8782) and membrane injury index (-0.5209).

Days to maturity possessed significant positive correlation with spike length (0.4594), stomatal resistance (0.3619) and grains per spike (0.5172) . Significant negative relationship with thousand grain weight (-0.3328) and stomatal conductance (-0.245) and canopy temperature (-0.3272).

Plant height possessed significant positive correlation with thousand grain weight (0.3145) and grain yield (0.328) and no significant negative relationship with other character was observed.

Tillers per meter possessed significant positive correlation spike length (0.5679), transpiration rate (0.2944) and grain yield (0.4159). No Significant negative relationship was observed with other traits.

Spike length showed significant positive correlation with grains per spike (0.5694), stomatal conductance (0.3189) and grain yield (0.7603). Significant negative relationship were observed with thousand grain weight (-0.4669), stomatal resistance (-0.3822) and membrane injury index (-0.5211).

Grains per spike possessed significant positive correlation with transpiration rate (0.4024) and grain yield (0.5569). Significant negative relationship with thousand grain weight (-0.8209) and membrane injury index (-0.5186).

Thousand grain weight possessed significant positive correlation with membrane injury index (0.5261) and significant negative relationship was observed grain yield (-0.4546).

Photosynthetic rate possessed significant positive correlation with stomatal conductance (0.9303) , hectoliter weight (0.5822) and grain yield (0.4404) . Significant negative relationship with stomatal resistance (-0.9277) and membrane injury index (-0.5394).

Transpiration rate showed significant positive correlation with photosynthetic active radiation (0.5997) and significant negative relationship with membrane injury index (-0.4475).

Photosynthetically active radiation not showed significant positive correlation with other traits, however significant negative relationship with membrane injury index (-0.2484).

Stomatal conductance possessed significant positive correlation with hectoliter weight (0.3891) and grain yield (0.4463).Significant negative relationship with stomatal resistance (-0.9755) .

Stomatal resistance possessed significant positive relationship with membrane injury index (0.4288). Significant negative relationship with hectoliter weight (-0.4614) and grain yield (-0.5346).

Canopy temperature did not shows significant positive correlation with any other characters, however it shows significant negative correlation with hectoliter weight (-0.3487).

Membrane injury index did not shows significant positive correlation with any other characters, however it possessed significant negative relationship with grain yield (-0.5334).

Protein content possessed significant positive correlation with hectoliter weight (0.3446) and wet gluten content (0.4005) and significant negative relationship with sedimentation value (-0.4909). Sedimentation value did not show significant positive correlation with other traits, however negative relationship was observed with wet gluten content (-0.4013). Hectoliter weight possessed significant positive relationship with wet gluten content (0.5533) grain yield (0.4956) and no significant negative relationship with other traits.

The phenotypic correlations coefficients among nineteen characters under TSI at Savalvihir are presented in Table 4.4.5.2

Days to 50 per cent flowering was significantly positively correlated with maturity (0.4732), spike length (0.2844), tillers per meter (0.501), grains per spike (0.801) and grain yield (0.3996). It had significantly negatively correlated with thousand grain weight (-0.8047) and membrane injury index (-0.5069).

Days to maturity was significantly positively correlated with tillers per meter (0.2866) and grains per spike (0.4508). Whereas, it is significantly negatively correlated with thousand grain weight (-0.3127), stomatal conductance (-0.299), canopy temperature (-0.2852) and sedimentation value (-0.2383).

Plant height was significantly positively correlated with tillers per meter (0.4856) and grain yield (0.3707).

Number of tillers per meter was significantly positively associated with spike length (0.3693), photosynthetic rate (0.541), stomatal conductance (0.5198), hectoliter wet (0.3733) and grain yield (0.5825). It had significantly negatively correlated with membrane injury index (-0.415) and thousand grain weight (-0.2449).

Spike length had significantly positive correlation with grains per spike (0.4967) and stomatal conductance (0.2618) and grain yield (0.5458). It was significantly negatively correlated with thousand grain weight (-0.413) and membrane injury index (-0.4738).

Grains per spike were significantly positively correlated with transpiration rate (0.2687) and grain yield (0.4442). It has significantly negatively associated with thousands grain weight (-0.7727) and membrane injury index (-0.4879).

Thousand grain weight was significantly positively correlated with membrane injury index (0.5129) and significantly negatively correlated with grain yield (-0.3771).

Photosynthetic rate was significantly positively associated with stomatal conductance (0.6268), hectolitre weight (0.3997) and grain yield (0.3007). It has significantly negatively correlated with stomatal resistance (-0.649) and membrane injury index (-0.2479).

Transpiration rate was significantly positively correlated with photosynthetically active radiation (0.3198) and significantly negatively correlated with membrane injury index (-0.3630).

Stomatal conductance was significantly positively correlated with hectolitre weight (0.3234) and grain yield (0.3137). It has significantly negatively correlated with stomatal resistance (-0.9679) and membrane injury index (-0.3039).

Stomatal resistance was significantly positively correlated with membrane injury index (0.3967) and it was significantly negatively correlated with hectoliter weight (-0.3993) and grain yield (-0.3967).

Canopy temperature was significantly negatively correlated with hectoliter weight (0.2931). Membrane injury index is significantly negatively correlated with grain yield (-0.4544).

Protein per cent was significantly positively correlated with wet gluten (0.3296) and hectoliter weight (0.3109). It has significantly negatively correlated with sedimentation value (0.4371). Sedimentation value was significantly negatively correlated with wet gluten (0.3408), hectolitre weight was significantly positively correlated with wet gluten content (0.3796) and grain yield (0.2903).

4.4.6 Correlation analysis of morpho- physiological and quality traits at Savalvihir under LSI condition

The genotypic correlation coefficients among nineteen characters under LSI at Savalvihir are presented in Table 4.4.6.1

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.486), tillers per meter (0.454), spike length (0.595), grains per spike (0.794), photosynthetic rate (0.525), transpiration rate (0.3817), stomatal conductance (0.463) and grain yield (0.661). Significant negative relationship was observed with thousand grain weight (-0.66) and membrane injury index (-0.4032) .

Days to maturity possessed significant positive correlation with spike length (0.2859) photosynthetic rate (0.439), transpiration rate (0.3358) , stomatal conductance (0.5257) and grain yield (0.2871) . Significant negative relationship with thousand grain weight (-0.377), stomatal resistance (-0.5266), membrane injury index (-0.2868) and sedimentation value (0.2893).

Plant height possessed significant positive correlation with stomatal conductance (0.36) and grain yield (0.317) and no significant negative relationship with other character was observed.

Tillers per meter possessed significant positive correlation photosynthetic rate (0.497), stomatal conductance (0.3522), hectoliter weight (0.403), wet gluten content (0.299) and grain yield (0.8139). Significant negative relationship was observed with stomatal resistance (-0.4102), canopy temperature (-0.3084) and membrane injury index (-0.3432).

Spike length shows significant positive correlation with photosynthetic rate (0.421), stomatal conductance (0.3421), sedimentation value (0.487) and grain yield (0.6771). Significant negative relationship were observed with thousand grain weight (-0.402), stomatal resistance (-0.3384), membrane injury index (-0.6914), and wet gluten content (-0.394).

Grains per spike possessed significant positive correlation with grain yield (0.6884).Significant negative relationship with thousand grain weight (-0.526) and membrane injury index (-0.5185)

Thousand grain weight possessed significant positive correlation with stomatal resistance (0.4292), membrane injury index (0.4292) and hectoliter weight (0.421).Significant negative relationship were observed with photosynthetic rate (-0.593), stomatal conductance (-0.3928) and grain yield (-0.3972).

Photosynthetic rate possessed significant positive correlation with transpiration rate (0.614), stomatal conductance (0.861) and grain yield (0.5913). Significant negative relationship with stomatal resistance (-0.8334) and membrane injury index (-0.5064).

Transpiration rate showed significant positive correlation with photosynthetic active radiation (0.2722), stomatal conductance (0.554), hectoliter weight (0.2735) and grain yield (0.3078). Significant negative relationship with stomatal resistance (-0.5865).

Photosynthetically active radiation showed significant positive correlation with canopy temperature (0.3441). Whereas significant negative correlation with membrane injury index (-0.3767).

Stomatal conductance showed significant positive correlation with grain yield (0.4897) ,however significant negative relationship with stomatal resistance (-0.9631) and canopy temperature (-0.2825) . Stomatal resistance showed significant positive correlation with membrane injury (0.2939) and significant negative relationship with grain yield (-0.4915) .

Canopy temperature did not show significant positive correlation with any other characters and significant negative relationship with hectoliter weight (-0.312) .

Membrane injury index did not show significant positive correlation with any other characters, however it possessed significant negative relationship with grain yield (-0.6055).

Protein content showed significant positive correlation with hectoliter weight (0.462) and wet gluten content (0.2775) and no significant negative relationship with other traits.

Sedimentation value did not show significant positive correlation with any other characters, however it possessed significant negative relationship with wet gluten content (-0.716).

Hectoliter weight show significant positive correlation with wet gluten content (0.2978) and grain yield (0.3116) and no significant negative relationship with other traits. Wet gluten content did not shows significant positive or negative correlation with other traits.

The phenotypic correlation coefficients among nineteen characters under LSI at Savalvihir are presented in Table 4.4.6.2.

. Days to 50 per cent flowering were significantly positively correlated with maturity (0.443), spike length (0.436), tillers per meter (0.363), grains per spike (0.623), transpiration rate (0.368) and grain yield (0.4997). It had significantly negatively correlated with thousands grain weight (0.635), stomatal resistance (0.506) and membrane injury index (0.3993).

Days to maturity is significantly positively correlated with photosynthetic rate (0.407), transpiration rate (0.307) and stomatal conductance (0.473). Whereas, it is significantly negatively correlated with thousand grain wet (0.319) and stomatal resistance (0.473) .

Plant height was significantly positively correlated with and grain yield (0.2951).

Number of tillers per meter was significantly positively associated with photosynthetic rate (0.389), stomatal conductance (0.2918) and grain yield (0.5357). It had significantly negative correlation with stomatal resistance (-0.342) and membrane injury index (-0.415).

Spike length had significantly positively correlated with grains per spike (0.4967) and stomatal conductance (0.2618) and grain yield (0.5458). It had significantly negative correlation with thousand grain weight (-0.413) and membrane injury index (-0.4738).

Grains per spike were significantly positively correlated with grains per spike (0.477), photosynthetic rate (0.31) and grain yield (0.461). It had significantly negatively associated with thousand grain weight (-0.296) ,stomatal resistance (-0.26), membrane injury index (-0.55) and wet gluten (-0.292).

Thousand grain weight was significantly positively correlated with stomatal resistance (0.417), membrane injury index (0.4122) and grain yield (0.256). It had significantly negatively associated with photosynthetic rate (-0.547) and stomatal conductance (-0.376).

Photosynthetic rate was significantly positively associated with transpiration rate (0.585), stomatal conductance (0.815) and grain yield (0.0.4425). It has significantly negatively correlated with stomatal resistance (-0.853) and membrane injury index (-0.4874).

Transpiration rate was significantly positively correlated with stomatal conductance (0.537) and hectoliter weight (0.2472). Whereas,it is significantly negatively correlated with stomatal resistance (-0.569).

Photosynthetically active radiation was significantly negatively associated with membrane injury index (-0.3751).

Stomatal conductance was significantly positively correlated with grain yield (0.3922). It has significantly negatively associated with stomatal resistance (-0.961). Stomatal resistance was significantly positively correlated with membrane injury index (0.2898) and it was significantly negatively correlated with grain yield (-0.3881).

Canopy temperature was significantly negatively correlated with hectolitre weight (-0.295) and wet gluten (-0.321). Membrane injury index was significantly negatively correlated with grain yield (-0.4633).

Sedimentation value was significantly negatively correlated with wet gluten (-0.469), hectoliter weight was significantly positively associated with grain yield (0.2827).

4.4.7 Pooled correlation analysis over environments for morpho-physiological and quality traits.

The genotypic correlations pooled over environments is presented in Table 4.4.7.1

Days to 50 per cent flowering possessed significant positive correlation with days to maturity (0.815), spike length (0.6768), grains per spike (0.906), transpiration rate (0.397), stomatal conductance (0.3406) and grain yield (0.7265).Significant negative relationship was observed with thousand grain weight (-0.5717), stomatal resistance (-0.3992), canopy temperature (-0.3044) , membrane injury index (-0.4032) and wet gluten content (-0.369) .

Days to maturity possessed significant positive correlation with plant height (0.5273), tillers per meter (0.4226), spike length (0.6577), grains per spike (0.763), photosynthetic rate (0.6074), stomatal conductance (0.7239) hectoliter weight (0.3289) and grain yield (0.8532). Significant negative relationship was observed with stomatal resistance (-0.732), canopy temperature (-0.649), membrane injury index (-0.4525) and wet gluten content (-0.369).

Plant height possessed significant positive correlation with tillers per meter (0.551), spike length (0.363), photosynthetic rate (0.5824), stomatal conductance (0.5761), sedimentation value (0.502), hectoliter weight (0.376) and grain yield (0.8043) and significant negative relationship with stomatal resistance (-0.5095), canopy temperature (-0.649), and wet gluten content (-0.538).

Tillers per meter possessed significant positive correlation with spike length (0.2774), photosynthetic rate (0.8414), stomatal conductance (0.7736), sedimentation value (0.402), hectoliter weight (0.4439), and grain yield (0.6275). Significant negative relationship was observed with stomatal resistance (-0.7682) , canopy temperature (-0.6939) and protein (-0.283).

Spike length showed significant positive correlation with grains per spike (0.821), photosynthetic rate (0.5119), photosynthetic active radiation (0.2897), stomatal conductance (0.4613), sedimentation value (0.476) and grain yield (0.6131). Significant negative relationship was observed with stomatal resistance (-0.4613), membrane injury index (-0.6302), protein content (-0.338) and wet gluten content (-0.289).

Grains per spike possessed significant positive correlation with photosynthetic rate (0.3203), transpiration rate (0.5275), stomatal conductance (0.4581), and grain yield (0.6411). Significant negative relationships was observed with thousand grain weight (-0.5682), stomatal resistance (-0.506), membrane injury index (-0.849) and wet gluten content (-0.4041).

Thousand grain weight possessed significant positive correlation with membrane injury index (0.732) and hectoliter weight (0.5898).Significant negative relationship was observed with transpiration rate (-0.344) .

Photosynthetic rate possessed significant positive correlation with stomatal conductance (0.8607), sedimentation value (0.5362) and grain yield (0.6827). Significant negative relationship was observed with stomatal resistance (-0.8595), canopy temperature (-0.5105) and protein content (-0.416) .

Transpiration rate showed significant positive correlation with photosynthetic active radiation (0.4623) and significant negative relationship with membrane injury index (-0.54), hectoliter weight (-0.2864) and wet gluten content (-0.4813).

Photosynthetically active radiation did not showed significant positive or negative correlation with other traits.

Stomatal conductance show significant positive correlation with sedimentation value (0.5651) and grain yield (0.771), however significant negative relationship with stomatal resistance (-0.9897), canopy temperature (-0.7468), protein content (-0.386) and wet gluten content (0.473) .

Stomatal resistance show significant positive correlation with canopy temperature (0.6953), protein content (0.3553) and wet gluten content (0.4362). Significant negative relationship observed with sedimentation value (-0.5515) and grain yield (-0.7509).

Canopy temperature shows significant positive correlation with protein content (0.2842) and gluten content (0.415). Significant negative relationship observed with sedimentation value (-0.2836), hectoliter weight (-0.401) and grain yield (-0.7532) .

Membrane injury index showed significant positive correlation with hectoliter weight (0.3325) however possessed significant negative relationship with grain yield (-0.2797).

Protein content showed significant positive correlation with wet gluten content (0.717) and significant negative relationship with sedimentation value (-0.2838), hectoliter weight (-0.401) and grain yield (-0.7532).

Sedimentation value showed significant positive correlation with grain yield (0.3752) and significant negative relationship with sedimentation value (-0.7714) and grain yield (-0.478).

Hectoliter weight showed significant positive correlation with wet gluten content (0.302) and grain yield (0.3378) and no significant negative relationship with other traits.

Wet gluten content did not show significant positive correlation with other traits and significant negative relationship with grain yield (-0.6118).

The phenotypic correlation pooled values are presented in Table 4.4.7.2.

Days to 50 per cent flowering were significantly positively correlated with maturity (0.531), spike length (0.501), grains per spike (0.695), transpiration rate (0.315) and grain yield (0.47). It had significantly negatively correlated with thousands grain wet (-0.56), stomatal resistance (-0.263) and membrane injury index (-0.4121).

Days to maturity was significantly positively correlated with spike length (0.294), and grain yield (0.4509). Whereas, it was significantly negatively correlation with stomatal resistance (-0.3133) and canopy temperature (-0.3573).

Plant height was significantly positively correlated with spike length (0.294) and grain yield (0.4509).

Number of tillers per meter were significantly positively associated with photosynthetic rate (0.531), stomatal conductance (0.396) and grain yield (0.4924). It had significantly negatively associated with stomatal resistance (-0.4253).

Spike length had significantly positively correlated with grains per spike (0.563) and grain yield (0.4112). It had significantly negatively associated with stomatal resistance (-0.2139) and membrane injury index (-0.3869).

Grains per spike were significantly positively correlated with grain yield (0.3968). It has significantly negatively associated with thousand grain weight (0.487) and membrane injury index (-0.4253) .

Thousand grain weight was significantly positively correlated with membrane injury index (0.3637) and hectoliter weight (0.3783). No significant negative association was observed with other traits .

Photosynthetic rate was significantly positively associated with stomatal conductance (0.737) and grain yield (0.4555). It had significantly negatively correlation with stomatal resistance (-0.7258) and membrane injury index (-0.2458) and canopy temperature (-0.3191).

Transpiration rate was significantly negatively correlated with stomatal resistance (-0.2907).

Photosynthetically active radiation was significantly positively associated with canopy temperature (0.1512) and significantly negatively associated with sedimentation value (-0.101).

Stomatal conductance was significantly positively correlated with grain yield (0.3854). It has significantly negatively associated with stomatal resistance (-0.952) and canopy temperature (-0.384) .

Stomatal resistance was significantly positively correlated with canopy temperature (0.366) and membrane injury index (0.245) and it was significantly negatively correlated with grain yield (-0.3729).

Canopy temperature was significantly negatively correlated grain yield (-0.3849).

Membrane injury index was significantly negatively correlated with grain yield (-0.3854). Protein content was significantly positively associated with wet gluten (0.4387) and negatively associated with sedimentation value (-0.452). Sedimentation value was significantly negatively correlated with wet gluten (0.305). Wet gluten was significantly negatively correlated with grain yield (0.2889).

4.5 Path coefficient analysis

Among the nineteen characters in the present study, grain yield was considered as dependent variable, while remaining eighteen characters were considered as independent variables for path coefficient. The genotypic and phenotypic path analysis among nineteen characters are studied in each environment separately as well as pooled over environments are presented in Table 4.5.1.1 to 4.5.7.2.

4.5.1 Path coefficient analysis on grain yield at Niphad under TSI condition

The genotypic path analysis under TSI at Niphad is presented in Table 4.5.1.1.

At this location the maximum positive direct effect on grain yield was due to transpiration rate (1.4864) followed by sedimentation value (1.3306), spike length (0.7312) and stomatal conductance (0.6294) .Whereas , maximum negative direct effect was due to hectoliter weight (-1.4308) followed by days to flowering (-0.9933), photosynthetically active radiation (-0.9340), thousand grain weight (-0.6399) and tillers per meter (-0.5270).

The phenotypic path analysis under TSI is presented in Table 4.5.1.2. The maximum positive direct effect on grain yield was due to stomatal conductance (0.6567) followed by stomatal resistance (0.517) and transpiration rate (0.3636). Whereas maximum negative direct effect was due to hectoliter weight (-0.4135) followed by thousand grain weight (-0.4297), canopy temperature (-0.3975) and days to 50 per cent flowering (-0.3597).

4.5.2 Path coefficient analysis on grain yield at Niphad under LSI condition

The genotypic path analysis under LSI under Niphad is presented in Table 4.5.2.1.

Grain yield had maximum positive direct effect by photosynthetic rate (0.7714) followed by grains per spike (0.4362) and canopy temperature (0.3554). While maximum negative direct effect was due to photosynthetic active radiation (-0.9361) followed by transpiration rate (-0.6912), membrane injury index (-0.4911), protein (-0.4314) hectoliter weight (-0.3916) and spike length (-0.3639),

The phenotypic path analysis under LSI at Niphad is presented in Table 4.5.2.2.

Grain yield has maximum positive direct effect by stomatal resistance (0.6876) followed by 1000 grain weight (0.4605), stomatal conductance (0.4151) and grains per spike (0.309). Whereas, negative direct effect was due to photosynthetic active radiation (-0.3331) followed by membrane injury index (-0.2005).

4.5.3 Path coefficient analysis on grain yield at Rahuri under TSI condition

The genotypic path analysis under TSI at Rahuri is presented in Table 4.5.3.1.

At this location grain yield has maximum positive direct effect by hectoliter weight (0.8548) followed by plant height (0.8068) days to flowering (0.7876) and stomatal resistance (0.6243). It had negative direct effect by transpiration rate (-0.8607) followed by photosynthetic rate (-0.6999), membrane injury index (-0.6151), spike length (-0.6062) and photosynthetically active radiation (-0.5493).

The phenotypic path analysis under TSI at Rahuri is presented in Table 4.5.3.2.

Grain yield had maximum direct positive effect due to hectoliter weight (0.3931) followed by tillers per meter (0.2918) and grains per spike (0.2066) whereas negative direct effect was due to photosynthetic active radiation (-0.2345), protein content (-0.1505), sedimentation value (-0.325) and membrane injury index (-0.1371).

4.5.4 Path coefficient analysis on grain yield at Rahuri under LSI condition

The genotypic path analysis under LSI at Rahuri is presented in Table 4.5.4.1.

At this location grain yield had maximum direct positive effect due to days to flowering (0.9631) followed by hectolitre weight (0.9495), spike length (0.9418), wet gluten (0.8764), photosynthetic active radiation (0.8563) grains per spike (0.7178) and thousand grain weight (0.4907). Whereas negative direct effect was due to stomatal resistance (-0.9492) followed by photosynthetic rate

(0.8402), plant height (0.8292) and membrane injury index (-0.765), transpiration rate (-0.7234) and protein content (-0.6951).

The phenotypic path analysis under LSI at Rahuri is presented in Table 4.5.4.2.

The grain yield had maximum positive direct effect due to tillers per meter (0.3341) followed by plant height (0.2375) and grains per spike (0.2096). Whereas negative direct effect was due to membrane injury index (-0.4646) followed by thousand grain weight (-0.3427) and spike length (-0.201).

4.5.5 Path coefficient analysis on grain yield at Savalvihir under TSI condition

The genotypic path analysis under TSI at Savalvihir is presented in Table 4.5.5.1.

At this location grain yield had maximum positive direct effect due to hectolitre weight (1.0113) followed by membrane injury index (0.6029), canopy temperature (0.5696) and spike length. Whereas, negative direct effect was due to wet gluten (-1.2367) followed by thousand grain weight (-0.9685), stomatal resistance (-0.6842) and grains per spike (-0.637).

The phenotypic path analysis under TSI at Savalvihir is presented in Table 4.5.5.2.

Grain yield had positive direct effect due to tillers per meter (0.4103) followed by plant height (0.2695) and grains per spike (0.2667) .While, negative direct effect was due to stomatal conductance (-0.3142) followed by photosynthetic active radiation (-0.1749) followed by maturity (-0.1358).

4.5.6 Path coefficient analysis on grain yield at Savalvihir at LSI condition

The genotypic path analysis under LSI at Savalvihir is presented in Table 4.5.6.1.

Grain yield had maximum direct positive effect due to wet gluten content (0.9661) followed by stomatal conductance (0.7332), tillers per meter (0.6493), canopy temperature (0.644) and spike length (0.4014). Whereas, negative direct effect was due to photosynthetic rate (-0.9704) followed by days to 50 per cent flowering (-0.9216), stomatal resistance (-0.8378) and days to maturity (-0.8305) .

The phenotypic path analysis under LSI at Savalvihir is presented in Table 4.5.6.2 .

Grain yield had maximum direct positive effect due to stomatal conductance (0.665) followed by hectoliter weight (0.3874), plant height (0.2876) and tillers per meter (0.2803). While negative direct effect was due to membrane injury index (-0.2821) followed by protein (-0.1724) and thousand grain weight (-0.163).

4.5.7 Path coefficient analysis on grain yield pooled over environments.

The genotypic path analysis pooled over location is presented in Table 4.5.7.1.

Across the locations, grain yield had positive direct effect due to photosynthetic rate (0.6822), stomatal conductance (0.5854), stomatal resistance (0.5811), grains per spike (0.2844) and plant height (0.2511). It had negative direct effect due to canopy temperature (-0.4765), wet gluten (-0.3039), membrane injury index (-0.2322) and days to 50 per cent flowering (-0.1242).

The phenotypic path analysis pooled over location is presented in Table 4.5.7.2.

Across the location grain yield had maximum direct positive effect due to plant height (0.2851) followed by tillers per meter (0.1727), stomatal resistance (0.157) and hectoliter weight (0.1464) whereas, maximum direct negative effect was due to membrane injury index (-0.2418) followed by canopy temperature (-0.183) and wet gluten content (-0.1313).

Table 4.1.1: Analysis of variance (ANOVA) for nineteen characters under different locations.

Character	Source of variance	d. f.	Niphad		Rahuri		Savalvihir	
			TSI	LSI	TSI	LSI	TSI	LSI
			Mean sum of squares					
Grain yield (kg/plot)	Replication	2	0.0266	0.0215	0.0006	0.0094	0.0174	0.0171
	Treatment	22	0.0393**	0.0432**	0.0743**	0.0436**	0.0912**	0.0536**
	Error	44	0.0088	0.0181	0.0157	0.0109	0.0101	0.0100
Days to 50 % flowering	Replication	2	3.884	0.710	5.391	2.797	4.101	2.275
	Treatment	22	124.755**	46.784**	142.391**	54.568**	94.858**	104.515**
	Error	44	2.217	0.922	2.073	0.888	1.480	0.760
Days to maturity	Replication	2	2.913	0.754	1.145	0.232	1.841	7.957
	Treatment	22	139.570**	124.321**	128.559**	62.494**	127.265**	58.752**
	Error	44	6.337	4.193	4.993	4.020	3.219	3.153
Plant height (cm)	Replication	2	31.644	27.853	19.848	0.967	10.265	15.879
	Treatment	22	183.778**	205.489**	136.333**	83.152**	132.733**	67.118**
	Error	44	12.181	11.325	8.366	10.404	6.527	12.975
Spike length (cm)	Replication	2	0.4422	0.7881	0.2529	0.1817	0.3960	0.2881
	Treatment	22	2.1032**	2.8062**	2.1019**	1.4197**	3.1689**	1.1395**
	Error	44	0.2872	0.2501	0.1356	0.0850	0.2348	0.1891
Number of tillers per meter	Replication	2	3.930	10.063	15.642	15.152	39.272	32.747
	Treatment	22	129.259**	98.688**	107.869**	133.848**	145.192**	148.449**
	Error	44	23.572	16.596	11.364	7.787	18.726	18.562

Table contd….

Character	Source of variance	d.f.	Niphad		Rahuri		Savalvihir	
			TSI	LSI	TSI	LSI	TSI	LSI
			Mean sum of squares					
Number of grains per spike	Replication	2	23.580	0.754	5.783	10.478	15.014	16.710
	Treatment	22	238.871**	199.325**	163.664**	155.390**	258.858**	84.560**
	Error	44	8.337	11.829	10.919	8.327	10.893	14.028
Thousand grain weight (g)	Replication	2	1.8132	0.8794	0.3843	0.4819	0.9265	1.0737
	Treatment	22	45.3442**	46.0224**	32.0729**	28.4409**	67.9575**	35.9554**
	Error	44	0.6883	0.6646	0.6450	0.7505	0.9723	0.9780
Photosynthetic rate (μ mol m^{-2} s^{-1})	Replication	2	0.2167	0.68616	1.7865	1.4797	1.7326	0.2223
	Treatment	22	16.6137**	24.58531**	51.8661**	13.9130**	25.5532**	19.2501**
	Error	44	0.8442	0.62039	0.7131	0.7146	5.5456	0.4773
Transpiration rate (m mol m^{-2} s^{-1})	Replication	2	0.0302	0.0618	0.0497	0.3602	0.2649	0.0213
	Treatment	22	1.0149**	2.8648**	1.5971**	0.9655**	2.0036**	2.3888**
	Error	44	0.0637	0.0471	0.0301	0.1299	0.3040	0.0183
Photosynthetically active radiation (μ mol m^{-2} s^{-1})	Replication	2	4514.53	262.66	2674.21	1317.14	5848.01	190.32
	Treatment	22	37804.85**	33537.69**	23093.45**	45986.99**	41034.17**	48113.06**
	Error	44	2060.09	522.54	1361.60	448.67	4663.04	191.92
Stomatal conductance (μ mol m^{-2} s^{-1})	Replication	2	0.0025	0.0002	0.0002	0.0016	0.0073	0.0001
	Treatment	22	0.0608**	0.0465**	0.0500**	0.0298**	0.0310**	0.0400**
	Error	44	0.0016	0.0004	0.0018	0.0003	0.0023	0.0004

Table contd..

Character	Source of variance	d.f.	Niphad		Rahuri		Savalvihir	
			TSI	LSI	TSI	LSI	TSI	LSI
			Mean sum of squares					
Stomatal resistance (μ mol m^{-2} s^{-1})	Replication	2	0.0424	0.0073	0.0114	0.0474	0.0926	0.0059
	Treatment	22	0.5746**	1.0851**	0.6431**	0.7272**	0.3553**	1.1889**
	Error	44	0.0472	0.0134	0.0211	0.0098	0.0175	0.0105
Canopy temperature (^{0}C)	Replication	2	0.3093	0.1665	0.2165	0.1005	0.1377	0.7379
	Treatment	22	7.4391**	3.1786**	2.2941**	1.4488**	1.4725**	4.1569**
	Error	44	0.1250	0.0655	0.0794	0.0447	0.0884	0.2321
Membrane injury index (%)	Replication	2	0.5276	0.1026	1.4532	1.0083	0.8035	0.7107
	Treatment	22	907.5661**	950.4779**	913.1112**	946.6850**	983.6206**	944.7460**
	Error	44	0.7505	0.4755	0.6662	0.5165	0.5140	0.4881
Protein content (%)	Replication	2	0.0807	0.2257	0.1201	0.0624	0.2334	0.5395
	Treatment	22	5.9034**	2.0737**	7.0132**	2.9850**	4.2318**	2.5375**
	Error	44	0.1468	0.1167	0.1891	0.0934	0.1570	0.1605
Sedimentation Value (ml)	Replication	2	3.058	9.101	6.043	9.145	6.797	30.841
	Treatment	22	68.494**	28.013**	79.710**	50.846**	57.191**	50.211**
	Error	44	4.528	2.859	2.892	3.115	2.600	14.235
Hectoliter weight (g)	Replication	2	0.204	0.882	0.273	0.080	0.608	0.305
	Treatment	22	3.632**	7.270**	3.790**	8.100**	7.948**	8.130**
	Error	44	0.296	0.412	0.192	0.258	0.365	0.397
Wet gluten content (%)	Replication	2	0.623	10.101	5.586	5.979	0.081	4.418
	Treatment	22	105.771**	61.637**	66.102**	94.498**	63.578**	82.705**
	Error	44	1.987	4.032	3.226	7.474	5.354	2.375

**Significant at 5% level, ** Significant at 1% level*

Table 4.1.2: Analysis of variance (ANOVA) for nineteen characters pooled over environments

Source of variance	d. f.	M.S.S.									
		GY	Flow.	Matu.	Pl. Ht.	SL	Till/m	Gr/Sp	TGW	PR	TR
Location (L)	5	0.275	114.418	332.325	491.5	3.903	476.75	184.038	70.781	253.018	4.068
Treatment (T)	22	0.0769	166.938	196.829	228.86	3.175	168.579	307.673	73.464	19.58	1.575
L x T	110	0.00762**	4.47**	3.359**	8.136**	0.2149**	17.164**	11.84**	2.359**	6.203**	0.407**
Error	264	0.0041	0.4633	1.4397	3.432	0.06565	5.367	3.574	0.261	0.4952	0.0329

Source of variance	d.f.	M.S.S.								
		PAR	SC	SR	CT	MII	Prot	SV	HW	WGC
Location (L)	5	129200.9	0.1566	2.952	25.99	1.018	5.406	39.16	37.7	407.5
Treatment (T)	22	380712.7	0.0271	0.5429	2.397	1877.54	5.638	65.93	10.8	95.46
L x T	110	7691.05**	0.0117**	0.1923**	0.8521**	0.8937**	0.5213**	9.11**	0.4329**	12.52**
Error	264	513.76	0.0003	0.0354	0.0352	0.1892	0.04797	1.67	0.1066	1.358

** Significant at 5% level, ** Significant at 1% level*

GY-Grain yield , Flow.- Days to 50% flowering, Matu.-Days to maturity ,Pl.Ht: Plant height , Till/m-Tillers per meter, SL-Spike length , Gr./Sp ,- Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR-Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content

Table 4.1.3: Mean Performance of new bread wheat genotypes for nineteen characters at different locations.

Sr. No	Genotype	Grain yield (kg/plot)							Days to 50% flowering						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	1.275	1.028	1.228	0.837	1.094	0.970	1.072	61.67	58.33	61.33	57.33	61.00	56.33	59.33
2	NIAW 1951	0.985	0.893	1.028	0.708	0.727	0.725	0.845	54.67	53.00	51.00	52.00	52.33	49.67	52.11
3	NIAW 1994	1.186	1.058	1.107	0.963	1.045	0.987	1.058	55.67	55.67	52.67	53.67	54.00	52.67	54.06
4	NIAW 2065	0.975	0.892	1.078	0.93	0.823	0.819	0.920	59.33	56.33	58.67	54.33	54.67	53.33	56.11
5	NIAW 2073	1.052	1.030	0.950	0.587	0.845	0.735	0.866	61.00	60.33	61.00	62.00	56.33	61.67	60.39
6	NIAW 2248	1.053	0.937	1.067	0.873	0.941	0.849	0.953	60.67	60.00	58.33	55.67	56.67	54.33	57.61
7	NIAW 2255	1.025	0.927	1.027	0.717	1.047	0.829	0.929	56.67	55.00	53.00	53.33	53.00	52.33	53.89
8	NIAW 2268	1.148	1.008	1.337	0.873	0.975	0.806	1.025	61.00	60.33	60.00	53.67	57.33	54.33	57.78
9	NIAW 2275	1.082	0.888	1.195	0.858	0.993	0.934	0.992	62.00	55.67	53.67	53.33	55.67	50.00	55.06
10	NIAW 2279	1.133	1.097	1.258	0.942	1.22	0.952	1.100	50.67	52.33	48.67	50.33	48.67	47.33	49.67
11	NIAW 2300	0.750	0.741	1.03	0.833	0.925	0.799	0.846	52.33	52.33	50.33	51.33	49.33	46.33	50.33
12	NIAW 2303	1.047	0.830	0.825	0.768	0.746	0.614	0.805	53.00	53.00	48.33	50.67	48.67	45.33	49.83
13	NIAW 2304	0.980	0.663	0.680	0.678	0.555	0.549	0.684	51.00	51.67	46.33	51.00	48.00	44.67	48.78
14	NIAW 2310	1.075	0.912	1.098	0.808	0.807	0.685	0.898	54.67	52.33	49.00	51.67	50.67	44.33	50.44
15	NIAW 2313	1.187	0.940	1.233	0.948	1.053	0.935	1.049	71.67	61.33	68.00	61.00	63.67	58.00	63.94
16	NIAW 2345	1.225	1.165	1.187	1.020	0.854	0.808	1.043	69.33	62.00	67.00	61.00	64.33	59.00	63.78
17	NIAW 2346	1.162	0.933	0.867	0.697	0.808	0.631	0.850	54.67	57.00	53.33	53.33	54.67	46.33	53.22
18	NIAW 2348	1.007	1.005	1.155	1.070	1.201	0.955	1.065	63.67	64.33	60.67	61.67	58.33	59.67	61.39
19	NIAW 2349	1.153	1.142	1.300	0.97	1.252	0.988	1.134	66.00	59.33	62.00	60.67	64.00	60.33	62.06
20	NIAW 2351	1.178	1.090	1.155	0.953	1.104	0.966	1.074	72.33	60.00	70.33	62.67	65.67	62.00	65.50
21	NIAW 1415 ©	1.083	0.862	0.988	0.850	0.943	0.880	0.934	68.67	64.33	64.33	60.67	65.33	62.33	64.28
22	NIAW 917©	1.212	0.928	0.976	0.950	0.999	0.875	0.990	62.67	61.00	63.67	54.00	60.00	55.00	59.39
23	NIAW 34 ©	0.977	0.918	1.038	0.830	0.753	0.629	0.858	57.33	56.67	56.33	52.00	54.33	51.33	54.67
	Env. Index	0.129	-0.004	0.122	-0.101	-0.012	-0.134	-	3.35	0.814	0.626	-1.143	-0.302	-3.345	-
	Grand Mean	1.085	0.952	1.079	0.855	0.944	0.823	0.9561	60.03	57.49	57.30	55.54	56.38	53.33	56.68
	S. Ed.±	0.076	0.11	0.102	0.085	0.082	0.081	0.0356	1.216	0.784	1.176	0.769	0.993	0.712	0.863
	CD at 5%	0.154	0.221	0.206	0.171	0.165	0.164	0.0099	2.45	1.58	2.369	1.551	2.002	1.435	2.41
	Range	0.750 - 1.275	0.663 - 1.165	0.680 - 1.337	0.587 - 1.07	0.555 - 1.252	0.549 - 0.988	0.684 - 1.134	50.67 - 72.33	51.67 - 64.33	46.33 - 70.33	50.33 - 62.67	48.00 - 65.67	44.33 - 62.33	48.78 - 65.5
	C.V. (%)	8.63	14.13	11.61	12.18	10.65	12.13	-	2.48	1.67	2.51	1.70	2.16	1.64	-

Table contd..

Sr. No	Genotype	Days to maturity							Plant height (cm)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	118.00	111.67	114.67	108.33	114.00	107.33	112.33	96.23	88.85	91.00	86.67	93.57	86.98	90.55
2	NIAW 1951	113.33	107.67	110.00	104.67	110.33	101.67	107.94	92.00	83.31	89.23	78.60	81.80	82.53	84.58
3	NIAW 1994	118.33	112.67	116.33	109.67	113.33	108.33	113.11	88.37	77.58	87.20	78.53	82.20	80.20	82.35
4	NIAW 2065	112.00	110.67	109.33	104.33	110.33	103.67	108.39	74.87	73.80	85.97	75.97	77.57	78.40	77.76
5	NIAW 2073	120.67	115.67	119.33	110.33	117.00	107.33	115.06	97.37	90.34	93.90	84.17	87.97	86.40	90.02
6	NIAW 2248	107.33	100.67	106.00	99.33	103.33	100.33	102.83	90.93	77.90	92.43	80.23	83.87	79.30	84.11
7	NIAW 2255	113.00	108.33	112.67	104.67	110.33	104.00	108.83	108.70	104.49	113.00	96.30	104.07	93.47	103.34
8	NIAW 2268	111.00	109.67	110.33	104.67	108.33	100.67	107.44	99.20	97.47	101.37	85.77	94.23	90.60	94.77
9	NIAW 2275	102.67	98.67	101.67	98.00	98.67	99.33	99.83	93.03	85.25	93.47	79.97	85.87	82.93	86.75
10	NIAW 2279	105.67	102.67	100.67	100.67	100.33	98.33	101.39	93.07	92.34	92.80	83.33	86.43	84.37	88.72
11	NIAW 2300	110.67	110.33	111.00	107.67	111.00	104.00	109.11	86.30	86.08	93.23	85.53	83.90	83.50	86.42
12	NIAW 2303	119.67	112.33	116.67	110.33	116.33	107.33	113.78	104.17	88.05	95.57	87.47	85.17	87.10	91.25
13	NIAW 2304	101.00	98.33	99.67	98.67	99.33	100.00	99.50	78.97	77.37	82.53	73.37	74.80	75.80	77.14
14	NIAW 2310	120.33	116.00	115.67	106.33	111.33	104.67	112.39	105.17	101.84	108.00	89.87	99.40	89.37	98.94
15	NIAW 2313	121.00	116.33	116.67	110.33	117.00	109.67	115.17	93.20	89.53	92.83	84.40	84.40	84.93	88.22
16	NIAW 2345	122.33	119.67	118.00	108.67	115.67	108.33	115.45	95.40	89.27	92.53	82.80	85.13	84.60	88.29
17	NIAW 2346	109.67	108.33	105.67	100.33	103.67	99.67	104.56	87.13	81.38	92.27	76.43	90.87	78.83	84.49
18	NIAW 2348	112.33	108.67	107.67	102.33	105.33	102.00	106.39	98.93	93.65	100.03	83.93	92.60	91.37	93.42
19	NIAW 2349	112.67	106.67	109.67	102.00	108.67	100.67	106.72	96.83	91.06	95.97	85.13	89.73	84.43	90.53
20	NIAW 2351	123.33	118.00	119.00	110.33	119.00	111.33	116.83	95.70	92.45	93.73	85.13	87.73	86.10	90.14
21	NIAW 1415 ©	122.67	117.33	121.67	110.33	117.67	109.67	116.56	86.70	76.85	87.07	74.07	81.40	80.50	81.10
22	NIAW 917©	125.33	119.67	122.67	114.33	122.33	114.33	119.78	89.57	79.65	90.70	80.80	83.53	84.93	84.86
23	NIAW 34 ©	111.00	102.67	108.67	103.00	109.00	101.33	105.95	89.20	77.99	92.43	81.53	83.57	75.80	83.42
	Env. Index	4.986	0.580	2.362	-3.913	1.000	-5.014	-	5.211	-1.072	5.917	-5.269	-0.929	-3.858	-
	Grand Mean	114.52	110.12	111.90	105.62	110.54	104.52	109.5	93.09	86.81	93.79	82.61	86.95	84.02	87.88
	S. Ed.±	2.055	1.672	1.825	1.637	1.465	1.450	0.748	2.85	2.748	2.362	2.634	2.086	2.941	1.1645
	CD at 5%	4.143	3.370	3.677	3.299	2.953	2.922	2.096	5.743	5.538	4.76	5.308	4.204	5.927	3.263
	Range	101.00 - 125.33	98.33 - 119.67	99.67 - 122.67	98.00 - 114.33	98.67 - 122.33	98.33 - 114.33	99.5 - 119.78	74.87 - 108.70	73.80 - 104.49	82.53 - 113.00	73.37 - 96.30	74.80 - 104.07	75.80 - 93.47	77.14 - 103.34
	C.V. (%)	2.20	1.86	2.00	1.90	1.62	1.70	-	3.75	3.88	3.08	3.91	2.94	4.29	-

Table contd...

Sr. No	Genotype	Number of tillers per meter							Spike length (cm)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	78.33	54.67	67.92	67.42	66.00	66.17	66.75	9.08	8.30	8.04	8.29	9.83	8.22	8.63
2	NIAW 1951	63.67	61.92	76.58	56.75	65.00	57.00	63.49	7.70	7.07	6.59	6.71	6.93	6.88	6.98
3	NIAW 1994	62.50	57.25	70.17	69.33	71.42	68.92	66.60	8.73	8.61	8.48	7.80	9.74	8.22	8.60
4	NIAW 2065	75.25	70.17	78.00	73.83	77.17	69.58	74.00	8.20	7.40	7.54	7.23	8.42	7.80	7.77
5	NIAW 2073	76.67	63.00	74.75	58.08	73.50	66.08	68.68	8.78	9.19	8.32	7.90	8.92	7.70	8.47
6	NIAW 2248	66.50	66.17	76.58	59.75	76.58	63.67	68.21	8.37	7.18	7.21	7.19	8.18	7.18	7.55
7	NIAW 2255	71.42	57.33	70.75	53.92	72.83	56.92	63.86	7.92	7.82	8.01	7.18	9.20	7.63	7.96
8	NIAW 2268	69.25	66.08	69.67	65.67	78.08	59.17	67.99	8.77	7.90	7.57	7.34	9.80	7.27	8.11
9	NIAW 2275	75.75	73.33	77.50	74.33	80.08	70.58	75.26	8.17	6.11	7.20	6.63	8.09	7.32	7.25
10	NIAW 2279	79.92	65.92	80.42	66.75	78.00	68.58	73.26	9.32	7.57	7.97	7.96	8.39	8.29	8.25
11	NIAW 2300	63.83	59.67	72.42	65.58	71.33	60.25	65.51	7.12	7.48	7.52	6.89	8.00	7.66	7.45
12	NIAW 2303	61.67	54.75	61.08	55.83	58.58	57.17	58.18	8.17	8.34	8.09	8.02	8.10	7.66	8.06
13	NIAW 2304	58.33	55.83	55.92	53.67	53.67	52.92	55.06	7.13	7.83	7.46	7.55	6.62	7.18	7.30
14	NIAW 2310	63.58	57.58	63.33	63.17	66.50	57.67	61.97	8.52	8.63	8.50	7.83	9.21	7.58	8.38
15	NIAW 2313	63.33	55.67	72.83	61.92	67.58	55.08	62.74	9.90	9.41	8.88	8.12	9.40	8.16	8.98
16	NIAW 2345	65.42	65.00	69.67	68.33	72.92	57.33	66.44	9.72	9.24	9.38	8.70	9.74	8.13	9.15
17	NIAW 2346	59.00	57.33	64.58	51.17	62.75	42.17	56.17	9.17	8.85	8.86	7.88	8.42	8.20	8.56
18	NIAW 2348	72.00	55.17	67.67	64.33	75.00	58.42	65.43	10.15	9.79	9.56	8.10	11.37	9.56	9.76
19	NIAW 2349	67.83	67.92	72.83	73.08	77.58	71.08	71.72	9.49	9.48	9.51	9.45	9.47	8.93	9.39
20	NIAW 2351	72.17	70.00	71.42	71.08	76.33	69.08	71.68	9.18	8.14	8.31	8.10	9.12	8.49	8.56
21	NIAW 1415 ©	63.58	55.50	64.08	63.42	66.25	64.58	62.90	8.92	9.47	9.51	8.89	8.56	8.45	8.97
22	NIAW 917©	64.58	59.83	75.17	58.67	79.67	61.08	66.50	8.50	7.45	8.27	7.41	9.49	7.95	8.18
23	NIAW 34 ©	57.58	58.17	74.33	62.60	70.67	55.75	63.18	7.38	7.05	7.13	7.34	8.21	7.46	7.43
	Env. Index	1.59	-4.667	4.873	-2.474	5.301	-4.623	-	0.377	-0.061	-0.079	-0.487	0.588	-0.338	-
	Grand Mean	67.49	61.23	70.77	63.42	71.20	61.27	65.90	8.63	8.19	8.17	7.76	8.84	7.91	8.25
	S. Ed.±	3.964	3.326	2.752	2.279	3.533	3.518	1.691	0.438	0.408	0.301	0.238	0.396	0.355	0.189
	CD at 5%	7.989	6.704	5.547	4.592	7.121	7.09	4.524	0.882	0.823	0.606	0.48	0.797	0.716	0.5304
	Range	57.58 - 79.92	54.67 - 73.33	55.92 - 80.42	51.17 - 74.33	53.67 - 80.08	42.17 - 71.08	55.06 - 75.26	7.12 - 10.15	6.11 - 9.79	6.59 - 9.56	6.63 - 9.45	6.62 - 11.37	6.88 - 9.56	6.98 - 9.76
	C.V. (%)	7.19	6.65	4.76	4.40	6.08	7.03	-	6.21	6.11	4.51	3.76	5.48	5.50	-

Table contd...

Sr. No	Genotype	Number of grains per spike							Thousand grain weight (g)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	53.00	42.33	46.33	42.00	48.00	38.67	45.06	43.00	40.67	39.93	40.33	41.70	41.20	41.14
2	NIAW 1951	45.67	42.33	36.67	43.33	46.67	40.67	42.56	45.53	44.60	43.67	39.20	45.47	44.50	43.83
3	NIAW 1994	55.67	40.67	45.33	45.00	49.00	45.00	46.78	47.47	47.53	43.40	42.90	46.43	44.47	45.37
4	NIAW 2065	51.33	35.33	44.33	42.67	36.67	38.67	41.50	42.73	42.70	40.43	40.83	43.47	43.73	42.32
5	NIAW 2073	48.00	44.00	40.00	41.00	44.00	45.00	43.67	48.93	47.60	42.40	44.20	48.13	46.93	46.37
6	NIAW 2248	46.00	39.33	43.67	42.00	45.00	45.33	43.56	44.67	44.27	40.60	40.57	45.53	43.00	43.11
7	NIAW 2255	50.33	39.00	40.67	40.33	46.67	39.00	42.67	45.53	45.67	43.77	42.47	46.27	46.53	45.04
8	NIAW 2268	50.00	40.00	46.00	43.67	49.00	41.00	44.94	45.13	45.27	41.67	41.67	45.20	45.87	44.13
9	NIAW 2275	48.33	37.00	45.33	47.33	44.67	43.00	44.28	44.33	45.07	45.20	44.37	47.13	44.27	45.06
10	NIAW 2279	38.67	40.33	35.33	35.33	41.67	40.67	38.67	46.60	47.30	43.77	42.17	47.67	47.40	45.82
11	NIAW 2300	30.33	32.67	32.67	33.33	30.67	35.00	32.44	51.93	52.13	50.73	47.00	55.07	52.27	51.52
12	NIAW 2303	43.00	34.00	39.00	38.00	43.33	36.00	38.89	47.93	47.63	41.37	39.17	50.80	47.30	45.70
13	NIAW 2304	41.33	40.67	38.67	39.67	32.33	34.67	37.89	46.47	45.67	42.70	37.13	47.03	41.63	43.44
14	NIAW 2310	42.33	36.00	39.67	37.00	39.00	37.00	38.50	53.67	49.87	48.70	44.83	54.03	49.50	50.10
15	NIAW 2313	53.00	52.33	53.33	50.33	58.00	53.00	53.33	40.13	40.83	41.20	35.07	39.60	41.73	39.76
16	NIAW 2345	57.00	49.67	51.00	50.33	55.67	40.33	50.67	41.37	41.40	38.43	37.87	38.50	37.23	39.13
17	NIAW 2346	47.33	41.67	34.67	35.00	45.33	44.67	41.44	47.80	46.07	43.83	40.90	46.83	46.30	45.29
18	NIAW 2348	63.00	53.67	56.00	53.00	57.00	49.00	55.28	41.87	39.60	40.93	40.90	39.97	41.63	40.82
19	NIAW 2349	63.67	47.67	49.00	55.33	56.33	51.00	53.83	41.07	39.93	41.23	36.77	39.40	41.83	40.04
20	NIAW 2351	52.33	49.33	51.00	45.33	61.33	45.33	50.78	38.07	38.70	37.67	36.17	37.13	39.00	37.79
21	NIAW 1415 ©	72.33	70.00	63.67	64.00	69.00	53.00	65.33	40.27	36.53	39.17	38.07	40.03	40.93	39.17
22	NIAW 917©	49.33	47.00	44.67	45.33	55.33	44.67	47.72	40.13	39.20	36.17	36.67	40.37	41.17	38.95
23	NIAW 34 ©	43.33	38.67	42.00	38.67	40.67	41.00	40.72	45.93	45.47	40.07	40.90	45.03	43.63	43.51
	Env. Index	4.558	-2.036	-0.935	-1.413	2.384	-2.558	-	1.443	0.709	-1.32	-2.924	1.453	0.638	-
	Grand Mean	49.80	43.20	44.30	43.83	47.62	42.68	45.24	44.81	44.07	42.05	40.44	44.82	44.00	43.36
	S. Ed.±	2.358	2.808	2.698	2.356	2.695	3.058	1.404	0.677	0.666	0.656	0.707	0.805	0.807	0.627
	CD at 5%	4.751	5.66	5.438	4.748	5.431	6.163	3.936	1.365	1.341	1.322	1.426	1.623	1.627	1.757
	Range	30.33 - 72.33	32.67 - 70.00	32.67 - 63.67	33.33 - 64.00	30.67 - 69.00	34.67 - 53.00	32.44 - 65.33	38.07 - 53.67	36.53 - 52.13	36.17 - 50.73	35.07 - 47.00	37.13 - 55.07	37.23 - 52.27	37.79 - 51.52
	C.V. (%)	5.80	7.96	7.46	6.58	6.93	8.78	-	1.85	1.85	1.91	2.14	2.20	2.25	-

Table contd...

Sr. No	Genotype	Photosynthetic rate (μ mol m^{-2} s^{-1})							Transpiration rate (m mol m^{-2} s^{-1})						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	16.91	23.10	20.44	17.68	21.97	20.92	20.17	3.77	2.02	4.28	3.03	2.69	4.69	3.41
2	NIAW 1951	20.20	16.29	22.81	14.14	22.92	12.58	18.16	4.20	2.44	3.98	2.78	2.55	3.35	3.22
3	NIAW 1994	22.10	18.68	22.77	18.05	24.73	17.04	20.56	3.94	2.83	3.83	2.65	2.44	2.21	2.98
4	NIAW 2065	22.31	17.66	28.53	16.73	24.79	19.82	21.64	3.04	2.48	4.35	2.79	2.24	4.65	3.26
5	NIAW 2073	19.42	14.51	22.38	13.48	22.29	12.83	17.49	3.34	2.48	5.35	2.22	2.00	3.08	3.08
6	NIAW 2248	23.13	13.43	29.55	14.32	24.90	14.80	20.02	4.31	2.47	3.70	3.09	2.78	3.21	3.26
7	NIAW 2255	17.47	18.54	20.73	17.16	22.55	15.38	18.64	4.52	2.20	3.98	3.46	3.96	3.43	3.59
8	NIAW 2268	25.17	14.87	28.14	14.36	27.45	15.26	20.88	4.89	3.06	3.65	3.18	3.87	4.16	3.80
9	NIAW 2275	17.73	16.36	27.46	15.30	28.64	15.95	20.24	5.37	2.85	3.62	4.34	4.12	3.34	3.94
10	NIAW 2279	20.69	16.01	27.01	16.32	26.54	15.23	20.30	4.59	2.33	3.45	2.60	3.49	3.26	3.29
11	NIAW 2300	17.75	16.13	25.74	20.98	27.71	16.15	20.74	4.33	2.97	4.15	3.56	3.81	4.29	3.85
12	NIAW 2303	17.93	13.14	18.05	13.25	18.59	14.20	15.86	3.45	2.92	3.42	4.30	3.49	3.93	3.58
13	NIAW 2304	17.82	16.39	15.61	13.44	18.91	15.68	16.31	3.79	4.60	4.54	2.24	3.02	2.81	3.50
14	NIAW 2310	21.54	16.65	26.23	15.83	21.41	13.52	19.20	4.75	3.28	3.16	3.18	3.86	2.19	3.40
15	NIAW 2313	21.12	21.16	26.35	16.86	25.49	19.06	21.67	4.43	4.17	4.42	3.85	3.44	4.27	4.10
16	NIAW 2345	17.44	23.24	24.17	17.88	23.96	17.77	20.74	4.27	4.31	4.26	2.53	3.42	2.79	3.60
17	NIAW 2346	22.33	15.90	16.32	13.84	17.42	11.02	16.14	4.24	3.57	3.46	2.55	4.03	2.36	3.37
18	NIAW 2348	20.25	15.69	24.43	16.89	23.03	16.64	19.49	4.35	2.76	4.39	4.27	3.49	4.89	4.02
19	NIAW 2349	20.49	15.70	20.28	16.39	21.85	16.93	18.61	4.28	3.23	4.70	3.21	4.58	2.50	3.75
20	NIAW 2351	19.98	22.15	21.95	18.29	25.09	19.21	21.11	5.42	5.51	5.40	4.41	4.80	5.13	5.11
21	NIAW 1415 ©	18.29	19.37	17.42	19.63	21.01	19.79	19.25	4.60	5.01	4.29	3.96	4.68	4.36	4.48
22	NIAW 917©	20.32	17.36	21.21	19.31	23.55	16.58	19.72	4.80	4.04	4.34	4.20	3.56	4.17	4.18
23	NIAW 34 ©	24.66	19.88	28.97	17.78	25.93	18.35	22.59	4.56	4.55	4.18	4.21	4.89	4.18	4.43
	Env. Index	0.674	-2.057	3.783	-3.114	3.966	-3.253	-	0.61	-0.398	0.421	-0.374	-0.173	-0.086	-
	Grand Mean	20.22	17.49	23.33	16.43	23.51	16.29	19.54	4.31	3.31	4.13	3.33	3.53	3.62	3.70
	S. Ed.±	0.75	0.643	0.689	0.69	1.923	0.564	1.0168	0.206	0.177	0.294	0.142	0.45	0.111	0.2606
	CD at 5%	1.512	1.296	1.39	1.391	3.875	1.137	2.849	0.415	0.357	0.593	0.286	0.907	0.223	0.7304
	Range	16.91 - 25.17	13.14 - 23.24	15.61 - 29.55	13.25 - 20.98	17.42 - 28.64	11.02 - 20.92	15.86 - 22.59	3.04 - 5.42	2.02 - 5.51	3.16 - 5.40	2.22 - 4.41	2.00 - 4.89	2.19 - 5.13	2.98 - 5.11
	C.V. (%)	4.54	4.50	3.62	5.15	6.02	4.24	-	5.85	6.56	8.73	5.21	9.61	3.74	-

Table contd...

Sr. No	Genotype	Photosynthetically active radiation (µ mol m^{-2} s^{-1})							Stomatal conductance (µ mol m^{-2} s^{-1})						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	1420.1	1423.8	1275.8	1187.0	1264.7	1184.9	1292.7	0.537	0.830	0.520	0.543	0.630	0.727	0.631
2	NIAW 1951	1508.8	1405.6	1231.1	1258.1	1225.1	1508.3	1356.2	0.490	0.350	0.627	0.467	0.570	0.307	0.468
3	NIAW 1994	1319.0	1451.7	1251.4	1407.8	1326.2	1326.4	1347.1	0.810	0.457	0.633	0.523	0.613	0.513	0.592
4	NIAW 2065	1546.7	1445.6	1314.3	1457.2	1490.5	1278.0	1422.0	0.850	0.373	0.693	0.423	0.590	0.503	0.572
5	NIAW 2073	1364.2	1360.2	1260.9	1208.2	1524.5	1110.7	1304.8	0.603	0.353	0.560	0.380	0.443	0.373	0.452
6	NIAW 2248	1235.1	1528.2	1243.2	1587.2	1491.4	1277.4	1393.7	0.730	0.267	0.723	0.333	0.607	0.313	0.496
7	NIAW 2255	1602.1	1479.2	1344.5	1513.0	1567.8	1413.5	1486.7	0.427	0.417	0.440	0.547	0.577	0.323	0.455
8	NIAW 2268	1476.8	1516.5	1276.3	1451.7	1473.9	1295.8	1415.2	0.827	0.300	0.723	0.337	0.747	0.380	0.552
9	NIAW 2275	1391.5	1520.7	1210.6	1517.4	1487.3	1406.1	1422.3	0.560	0.427	0.690	0.483	0.793	0.393	0.558
10	NIAW 2279	1606.3	1562.9	1465.9	1554.0	1530.6	1375.7	1515.9	0.563	0.313	0.707	0.377	0.627	0.310	0.483
11	NIAW 2300	1586.8	1568.5	1228.8	1622.2	1428.7	1520.7	1492.6	0.530	0.583	0.747	0.690	0.600	0.533	0.614
12	NIAW 2303	1581.3	1595.9	1322.1	1594.6	1500.2	1377.4	1495.3	0.380	0.367	0.360	0.423	0.383	0.350	0.377
13	NIAW 2304	1557.3	1609.7	1340.7	1612.1	1557.8	1355.2	1505.5	0.393	0.447	0.540	0.377	0.393	0.383	0.422
14	NIAW 2310	1487.3	1532.5	1247.9	1410.8	1533.6	1462.1	1445.7	0.777	0.347	0.630	0.420	0.537	0.273	0.497
15	NIAW 2313	1526.1	1553.6	1240.0	1441.2	1276.7	1291.8	1388.2	0.800	0.487	0.580	0.450	0.547	0.573	0.573
16	NIAW 2345	1568.0	1412.8	1354.2	1463.5	1576.9	1414.4	1465.0	0.527	0.610	0.347	0.513	0.690	0.473	0.527
17	NIAW 2346	1669.5	1359.6	1350.9	1623.3	1529.2	1364.3	1482.8	0.560	0.317	0.447	0.297	0.443	0.277	0.390
18	NIAW 2348	1506.3	1361.7	1408.1	1556.0	1610.8	1515.8	1493.1	0.497	0.340	0.797	0.423	0.603	0.400	0.510
19	NIAW 2349	1354.2	1207.1	1278.8	1489.8	1489.3	1231.4	1341.8	0.450	0.457	0.460	0.517	0.563	0.367	0.469
20	NIAW 2351	1611.3	1339.1	1417.3	1569.1	1621.7	1522.1	1513.4	0.620	0.510	0.513	0.610	0.523	0.523	0.550
21	NIAW 1415 ©	1608.5	1587.0	1542.5	1580.7	1629.7	1638.9	1597.9	0.643	0.507	0.410	0.547	0.480	0.590	0.529
22	NIAW 917©	1587.3	1543.4	1295.9	1495.8	1641.2	1479.2	1507.1	0.600	0.383	0.633	0.610	0.497	0.367	0.515
23	NIAW 34 ©	1602.7	1620.7	1454.6	1498.1	1560.2	1521.0	1542.9	0.713	0.397	0.660	0.543	0.630	0.420	0.561
	Env. Index	64.76	32.969	-124.87	37.867	48.258	-58.984	-	0.091	-0.085	0.072	-0.042	0.056	-0.092	-
	Grand Mean	1509.4	1477.7	1319.8	1482.6	1492.9	1385.7	1444.7	0.604	0.428	0.584	0.471	0.569	0.421	0.513
	S. Ed.±	37.06	18.66	30.13	17.30	55.76	11.31	35.80	0.032	0.016	0.034	0.013	0.039	0.017	0.0043
	CD at 5%	74.69	37.62	60.72	34.86	112.37	22.80	100.339	0.065	0.032	0.069	0.026	0.078	0.035	0.124
	Range	1235.14 - 1669.53	1207.10 - 1620.67	1210.63 - 1542.50	1187.00 - 1623.30	1225.07 - 1641.17	1110.73 - 1638.90	1292.7 - 1597.9	0.380 - 0.850	0.267 - 0.830	0.347 - 0.797	0.297 - 0.690	0.383 - 0.793	0.273 - 0.727	0.377 - 0.631
	C.V. (%)	3.01	1.55	2.80	1.43	4.57	1.09	-	6.53	4.62	7.21	3.37	8.37	4.99	-

Table contd...

Sr. No	Genotype	Stomatal resistance (μ mol m^{-2} s^{-1})							Canopy temperature (^{0}C)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	1.862	1.205	1.923	1.842	1.587	1.376	1.585	26.80	30.57	28.60	31.13	29.70	29.17	29.33
2	NIAW 1951	2.041	2.857	1.595	2.141	1.754	3.257	2.137	27.80	29.30	28.97	31.33	31.23	29.77	29.73
3	NIAW 1994	1.235	2.188	1.580	1.912	1.631	1.949	1.689	27.40	30.27	29.23	31.37	30.73	30.90	29.98
4	NIAW 2065	1.176	2.681	1.443	2.364	1.695	1.988	1.748	27.60	30.87	28.97	31.07	29.20	31.17	29.81
5	NIAW 2073	1.658	2.833	1.786	2.632	2.257	2.681	2.212	26.87	27.77	28.67	30.37	30.57	30.87	29.18
6	NIAW 2248	1.370	3.745	1.383	3.003	1.647	3.195	2.016	28.43	30.70	28.83	31.30	30.30	32.20	30.29
7	NIAW 2255	2.342	2.398	2.273	1.828	1.733	3.096	2.198	28.03	30.80	27.77	30.43	31.37	31.73	30.02
8	NIAW 2268	1.209	3.333	1.383	2.967	1.339	2.632	1.812	27.63	31.20	29.03	32.17	30.70	32.33	30.51
9	NIAW 2275	1.786	2.342	1.449	2.070	1.261	2.545	1.792	27.97	31.37	29.23	30.30	31.50	32.23	30.43
10	NIAW 2279	1.776	3.195	1.414	2.653	1.595	3.226	2.070	29.10	31.63	29.17	31.50	31.33	32.67	30.90
11	NIAW 2300	1.887	1.715	1.339	1.449	1.667	1.876	1.629	29.47	31.43	29.23	31.23	30.50	33.07	30.82
12	NIAW 2303	2.632	2.725	2.778	2.364	2.611	2.857	2.653	29.37	32.20	29.93	30.77	29.83	33.37	30.91
13	NIAW 2304	2.545	2.237	1.852	2.653	2.545	2.611	2.370	29.33	31.53	29.23	31.37	32.03	33.20	31.12
14	NIAW 2310	1.287	2.882	1.587	2.381	1.862	3.663	2.012	29.50	31.13	29.83	31.97	31.07	33.53	31.17
15	NIAW 2313	1.250	2.053	1.724	2.222	1.828	1.745	1.745	29.40	29.27	29.80	30.50	31.33	33.03	30.56
16	NIAW 2345	1.898	1.639	2.882	1.949	1.449	2.114	1.898	28.97	30.37	29.73	30.43	31.23	32.03	30.46
17	NIAW 2346	1.786	3.155	2.237	3.367	2.257	3.610	2.564	30.70	29.87	30.13	31.13	31.03	33.27	31.02
18	NIAW 2348	2.012	2.941	1.255	2.364	1.658	2.500	1.961	32.77	29.50	30.20	31.43	31.43	32.57	31.32
19	NIAW 2349	2.222	2.188	2.174	1.934	1.776	2.725	2.132	31.27	31.20	30.53	32.03	30.97	32.43	31.41
20	NIAW 2351	1.613	1.961	1.949	1.639	1.912	1.912	1.818	29.77	29.53	30.97	29.83	29.80	33.03	30.49
21	NIAW 1415 ©	1.555	1.972	2.439	1.828	2.083	1.695	1.890	31.63	29.40	31.10	32.13	31.57	33.17	31.50
22	NIAW 917©	1.667	2.611	1.580	1.639	2.012	2.725	1.942	31.03	29.60	30.83	29.63	31.33	32.17	30.77
23	NIAW 34 ©	1.403	2.519	1.515	1.842	1.587	2.381	1.783	29.93	30.23	30.93	31.03	31.07	30.80	30.67
	Env. Index	-0.35	0.389	-0.296	0.113	-0.287	0.43	-	-1.376	-0.116	-0.934	0.524	0.323	1.578	-
	Grand Mean	1.748	2.495	1.806	2.219	1.815	2.537	1.985	29.16	30.42	29.61	31.06	30.86	32.12	30.54
	S. Ed.±	0.177	0.095	0.119	0.081	0.108	0.084	0.181	0.289	0.209	0.23	0.173	0.243	0.393	0.377
	CD at 5%	0.357	0.191	0.239	0.163	0.218	0.169	0.507	0.582	0.421	0.464	0.348	0.489	0.793	1.0561
	Range	1.176 2.632	1.205 3.745	1.255 2.882	1.449 3.367	1.261 2.611	1.376 3.663	1.585 2.653	26.80 - 32.77	27.77 - 32.20	27.77 - 31.10	29.63 - 32.17	29.20 - 32.03	29.17 - 33.53	29.18 - 31.5
	C.V. (%)	9.34	4.64	8.02	4.45	7.26	4.03	-	1.21	0.84	0.95	0.68	0.96	1.50	-

Table contd...

Sr. No	Genotype	Membrane injury index (%)							Protein (%)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	58.36	59.26	56.50	57.64	57.43	58.35	57.92	13.37	12.34	12.13	11.99	11.15	12.38	12.23
2	NIAW 1951	63.84	65.80	63.21	66.44	64.21	64.54	64.67	13.12	13.38	13.25	11.77	12.25	12.21	12.66
3	NIAW 1994	28.43	27.51	29.31	26.66	28.35	28.85	28.19	12.19	12.01	12.11	12.01	12.58	12.05	12.16
4	NIAW 2065	40.67	42.40	43.00	41.93	41.68	42.00	41.95	11.10	11.68	11.96	11.65	11.16	11.11	11.45
5	NIAW 2073	73.50	72.76	71.55	73.53	74.88	73.43	73.28	9.76	11.43	9.30	10.09	8.97	11.67	10.20
6	NIAW 2248	68.68	68.38	69.38	69.93	68.17	68.61	68.86	11.48	11.00	10.36	10.32	12.20	10.40	10.96
7	NIAW 2255	66.84	67.22	66.41	68.85	67.18	67.02	67.25	12.10	12.87	11.93	11.69	10.75	12.38	11.95
8	NIAW 2268	64.81	64.06	65.74	65.53	65.45	64.13	64.95	9.85	11.46	10.36	11.35	10.60	11.92	10.92
9	NIAW 2275	45.61	44.29	45.16	46.36	45.12	45.71	45.38	9.12	11.05	9.00	12.02	10.08	12.29	10.59
10	NIAW 2279	36.61	36.52	35.84	37.33	36.55	35.64	36.42	10.48	11.60	11.07	11.33	11.65	11.98	11.35
11	NIAW 2300	58.57	60.69	60.08	58.28	60.95	59.80	59.73	10.04	10.73	9.24	9.79	8.66	10.95	9.90
12	NIAW 2303	74.21	75.59	79.30	76.32	76.42	79.41	76.88	10.64	11.37	9.18	10.77	11.05	11.78	10.80
13	NIAW 2304	78.53	79.56	75.25	76.79	79.96	75.48	77.60	10.17	11.88	10.70	11.70	10.45	12.37	11.21
14	NIAW 2310	39.45	40.00	38.12	42.17	38.04	39.10	39.48	11.02	12.35	11.72	12.43	11.61	12.43	11.93
15	NIAW 2313	42.02	43.28	42.81	43.37	43.03	42.26	42.80	11.05	11.11	9.78	11.18	11.17	12.15	11.07
16	NIAW 2345	28.44	28.80	24.93	26.99	26.98	27.76	27.32	10.16	9.99	9.35	9.41	8.86	8.79	9.43
17	NIAW 2346	54.11	56.15	54.30	56.48	55.22	55.04	55.22	8.91	10.87	10.41	10.11	11.58	11.25	10.52
18	NIAW 2348	30.65	29.53	31.97	28.74	29.44	29.75	30.01	9.04	11.98	7.94	9.87	9.82	11.85	10.08
19	NIAW 2349	27.74	29.85	28.28	30.59	28.63	30.54	29.27	9.09	11.99	8.97	11.05	10.28	12.21	10.60
20	NIAW 2351	28.27	25.83	27.84	25.29	25.61	25.41	26.38	9.23	10.84	9.09	11.03	10.82	12.33	10.56
21	NIAW 1415 ©	36.12	35.54	36.93	35.91	37.17	35.18	36.14	13.06	13.20	13.18	13.32	13.12	13.40	13.21
22	NIAW 917©	34.09	34.12	34.52	35.56	33.98	34.07	34.39	12.18	12.46	12.33	12.33	12.09	12.60	12.33
23	NIAW 34 ©	30.22	29.79	31.32	32.34	29.33	29.65	30.44	12.09	12.20	12.23	12.35	12.08	12.51	12.24
	Env. Index	-0.205	0.105	-0.12	0.371	-0.031	-0.12	-	-0.397	0.496	-0.555	0.052	-0.234	0.637	-
	Grand Mean	48.25	48.56	48.34	48.83	48.43	48.34	48.46	10.84	11.73	10.68	11.29	11.00	11.87	11.23
	S. Ed.±	0.707	0.563	0.666	0.587	0.585	0.570	0.385	0.313	0.279	0.355	0.249	0.324	0.327	0.294 -
	CD at 5%	1.426	1.135	1.343	1.183	1.180	1.150	1.081	0.63	0.562	0.716	0.503	0.652	0.659	0.826
	Range	27.74 - 78.53	25.83 - 79.56	24.93 - 79.30	25.29 - 76.79	25.61 - 79.96	25.41 - 79.41	26.38 - 77.60	8.91 - 13.37	9.99 - 13.38	7.94 - 13.25	9.41 - 13.32	8.66 - 13.12	8.79 - 13.40	9.43 - 13.21
	C.V. (%)	1.80	1.42	1.69	1.47	1.48	1.45	-	3.54	2.91	4.07	2.71	3.60	3.38	-

Table contd...

Sr. No	Genotype	Sedimentation value (ml)							Hectoliter weight (kg/hl)						
		Niphad		Rahuri		Savalvihir		Pooled Mean	Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	43.33	41.33	37.67	39.67	43.67	43.00	41.44	82.19	82.44	81.19	79.29	82.45	81.57	81.52
2	NIAW 1951	44.00	41.67	45.33	40.33	46.67	42.33	43.39	84.09	83.43	81.63	79.44	82.96	82.01	82.26
3	NIAW 1994	43.33	43.67	41.67	40.33	38.67	42.67	41.72	83.68	83.35	81.94	80.40	83.67	82.95	82.66
4	NIAW 2065	49.33	42.00	43.33	44.33	51.67	50.67	46.89	84.10	84.40	80.66	83.04	84.31	83.34	83.31
5	NIAW 2073	51.00	47.33	56.33	47.00	53.67	48.67	50.67	81.27	80.74	79.80	78.49	81.29	80.99	80.43
6	NIAW 2248	41.67	41.33	42.67	43.00	45.67	42.33	42.78	82.88	84.72	81.14	79.55	82.51	81.64	82.08
7	NIAW 2255	43.33	35.33	44.67	44.00	43.33	37.33	41.33	82.83	83.52	81.25	81.26	82.87	82.62	82.39
8	NIAW 2268	45.33	38.67	43.67	39.33	41.33	41.00	41.56	83.68	84.28	82.67	80.52	84.02	82.54	82.95
9	NIAW 2275	52.33	42.67	51.67	43.67	51.67	44.00	47.67	82.91	83.71	81.58	80.11	83.18	82.76	82.38
10	NIAW 2279	42.00	45.33	42.33	42.33	48.33	49.67	45.00	82.48	82.96	81.99	80.14	81.60	81.66	81.80
11	NIAW 2300	50.33	43.33	52.33	45.67	49.67	44.00	47.56	83.62	83.10	81.55	79.44	81.58	81.72	81.83
12	NIAW 2303	52.00	46.67	52.67	43.67	45.33	36.00	46.06	82.52	80.90	80.06	77.58	80.10	80.30	80.24
13	NIAW 2304	44.67	45.00	47.67	43.67	42.67	45.33	44.83	81.59	81.56	79.63	76.86	79.26	79.42	79.72
14	NIAW 2310	41.33	44.33	46.67	48.67	42.67	47.33	45.17	82.54	82.33	80.19	78.02	81.34	79.83	80.71
15	NIAW 2313	52.33	44.00	51.33	50.33	49.33	49.33	49.44	82.84	82.99	81.41	79.54	83.01	81.70	81.92
16	NIAW 2345	42.00	41.33	43.33	43.33	42.67	41.33	42.33	79.45	78.79	77.61	74.51	77.01	75.35	77.12
17	NIAW 2346	52.67	47.33	50.67	51.33	51.33	48.67	50.33	81.25	81.41	78.83	78.76	80.27	80.03	80.09
18	NIAW 2348	38.33	47.67	52.67	54.67	54.00	50.67	49.67	81.35	80.28	80.97	78.35	81.94	80.70	80.60
19	NIAW 2349	52.00	44.67	53.67	52.33	50.00	45.67	49.72	81.96	81.51	80.51	79.10	81.63	80.36	80.85
20	NIAW 2351	46.67	45.00	47.33	45.33	46.67	46.33	46.22	82.93	82.50	80.93	78.47	82.95	81.14	81.49
21	NIAW 1415 ©	40.67	38.33	41.33	41.33	41.33	39.33	40.39	81.57	79.86	80.48	78.59	81.38	80.08	80.33
22	NIAW 917©	39.33	43.00	42.33	45.67	43.67	42.33	42.72	81.69	81.19	79.75	78.04	81.70	80.26	80.44
23	NIAW 34 ©	41.33	41.33	39.67	44.33	42.67	43.33	42.11	83.12	83.66	81.36	78.47	81.83	80.96	81.57
	Env. Index	0.449	-2.072	1.391	-0.203	1.203	-0.768	-	1.212	1.085	-0.502	-2.205	0.617	-0.207	-
	Grand Mean	45.62	43.10	46.57	44.97	46.38	44.41	45.17	82.46	82.33	80.75	79.04	81.86	81.04	81.25
	S. Ed.±	1.737	1.381	1.389	1.441	1.317	3.081	1.23	0.444	0.524	0.358	0.414	0.493	0.514	0.268
	CD at 5%	3.501	2.782	2.798	2.904	2.653	6.208	3.45	0.895	1.056	0.721	0.835	0.994	1.036	0.752
	Range	38.33 - 52.67	35.33 - 47.67	37.67 - 56.33	39.33 - 54.67	38.67 - 54.00	36.00 - 50.67	40.39 - 50.67	79.45 - 84.10	78.79 - 84.72	77.61 - 82.67	74.51 - 83.04	77.01 - 84.31	75.35 - 83.34	77.12 - 83.31
	C.V. (%)	4.66	3.92	3.65	3.92	3.48	5.50	-	0.66	0.78	0.54	0.64	0.74	0.78	-

Table contd…

Sr. No	Genotype	Wet gluten content (%)						
		Niphad		Rahuri		Savalvihir		Pooled Mean
		TSI	LSI	TSI	LSI	TSI	LSI	
1	NIAW 1885	43.75	56.45	48.80	47.57	55.49	57.99	51.67
2	NIAW 1951	45.20	53.52	46.72	50.77	55.95	54.48	51.11
3	NIAW 1994	42.40	49.01	45.80	42.60	53.08	49.53	47.07
4	NIAW 2065	42.67	45.14	43.59	37.75	52.13	51.04	45.39
5	NIAW 2073	42.31	43.51	49.77	40.50	48.84	48.42	45.56
6	NIAW 2248	45.47	54.79	46.48	52.16	49.60	60.62	51.52
7	NIAW 2255	55.54	51.40	54.07	52.63	62.29	58.32	55.71
8	NIAW 2268	41.32	52.93	41.16	41.56	51.29	53.28	46.92
9	NIAW 2275	41.89	56.15	38.57	47.77	50.54	48.25	47.20
10	NIAW 2279	37.28	47.76	40.06	46.19	48.41	43.99	43.95
11	NIAW 2300	43.41	47.13	43.45	42.55	49.77	48.28	45.77
12	NIAW 2303	41.37	54.28	43.18	46.06	43.67	52.44	46.83
13	NIAW 2304	37.94	47.65	45.24	44.08	52.29	46.17	45.56
14	NIAW 2310	40.56	53.05	43.69	51.37	51.56	53.32	48.92
15	NIAW 2313	35.60	56.50	42.47	51.70	46.75	42.39	45.90
16	NIAW 2345	30.08	46.40	37.74	40.96	42.27	44.82	40.38
17	NIAW 2346	42.21	48.80	39.83	41.94	45.13	42.14	43.34
18	NIAW 2348	34.70	42.18	39.99	35.26	48.57	43.42	40.69
19	NIAW 2349	24.85	44.16	38.26	36.41	44.00	50.39	39.68
20	NIAW 2351	42.23	50.89	40.46	42.31	48.06	54.27	46.37
21	NIAW 1415 ©	43.48	55.99	46.63	36.62	52.31	55.46	48.41
22	NIAW 917©	44.91	53.56	55.25	53.01	54.81	54.49	52.67
23	NIAW 34 ©	44.03	54.83	43.22	48.96	54.83	52.26	49.69
	Env. Index	-5.962	3.73	-2.865	-2.155	3.536	3.715	-
	Grand Mean	41.01	50.70	44.11	44.82	50.51	50.69	46.97
	S. Ed.±	1.151	1.64	1.466	2.232	1.889	1.258	1.444
	CD at 5%	2.319	3.304	2.955	4.499	3.808	2.536	4.049
	Range	24.85 - 55.54	42.18 - 56.50	37.74 - 55.25	35.26 - 53.01	42.27 - 62.29	42.14 - 60.62	39.68 - 55.71
	C.V. (%)	3.10	4.41	3.95	6.01	5.09	3.39	-

Table 4.2.1.1: Analysis of Variance of yield and yield contributing traits under different environments

Source of variation	d. f.	Mean Squares									
		Grain Yield (kg/hplot)	Days to 50% flowering	Days to maturity	Plant Height	Number of tillers per meter	Spike length (cm)	Grains/spike	Thousand Grains weight(g)	Photosynthetic rate (µmol m^{-2} s^{-1}):	Transpiration Rate (m mol m^{-2} s^{-1}):
Rep within Env.	12	0.00514	1.06441	0.82448	5.9142	6.48919	0.1305	4.01771	0.30882	0.34021	0.04378
Varieties	22	0.07691^{++**}	166.94774^{++**}	196.8612^{++**}	228.82388^{++**}	168.59799^{++**}	3.17253^{++**}	307.69593^{++**}	73.4659^{++**}	19.5797^{++**}	1.57447^{++**}
Env. + (Var x Env)	115	0.01926^{++**}	9.2475^{++**}	17.6583^{++**}	29.15202^{++**}	37.1505^{++**}	0.37519^{++**}	19.3277^{++**}	5.33588^{++**}	16.93357^{++**}	0.56664**
Environments	5	0.27494^{++**}	114.38656^{++**}	332.2827^{++**}	491.36635^{++**}	476.77879^{++**}	3.90401^{++**}	184.08433^{++**}	70.80534^{++**}	253.00966^{++**}	4.06938^{++**}
Var. x Env.	110	0.00763*	4.46845**	3.35719^{++**}	8.14228**	17.16739**	0.21479^{+**}	11.83876**	2.35999^{+**}	6.20284^{++**}	0.40742^{++**}
Env. (Linear)	1	1.37472^{++**}	571.93281^{++**}	1661.414^{++**}	2456.8317^{++**}	2383.8939^{++**}	19.5201^{++**}	920.4217^{++**}	354.0267^{++**}	1265.048^{++**}	20.347^{++**}
Var. x Env. (Lin)	22	0.00733**	5.3240**	8.71926^{++**}	8.68399**	22.495^{+**}	0.43491*	16.259**	5.2456**	15.97831^{+**}	0.29286**
Pooled Deviation	92	0.00737	4.06958**	1.92899*	7.65873**	15.1469**	0.15282**	10.267**	1.567**	3.5956**	0.4171**
Pooled Error	264	0.00408	0.4634	1.4398	3.43211	5.36707	0.06565	3.57411	0.26104	0.49529	0.03295
Total	137	0.02851	34.57163	46.43543	61.21615	58.25886	0.8244	65.63502	16.27647	17.3585	0.72848

$^{+,++}$ *Significant at 5% and 1% level tested against pooled deviation, respectively and *, ** Significant at 5% and 1% level tested against pooled error , respectively*

Table 4.2.1.1 Table contd..

Source of variation	d. f.	Mean Squares								
		PAR (μ mol m^{-2} s^{-1})	Stomatal conductance (μ mol m^{-2} s^{-1})	Stomatal resistance (μ mol m^{-2} s^{-1})	Canopy temperature (°C)	Membrane injury per cent	Protein percent	Sedimentation value (ml)	Hectoliter weight (kg/hl)	Wet gluten content (%)
Rep within Env.	12	822.60404	0.00066	0.0115	0.0927**	0.25588	0.07009	3.6103*	0.1306	1.48817
Varieties	22	38079.89^{++**}	0.0271^{++**}	0.5429^{++**}	2.4013^{++**}	1877.59^{++**}	5.6378^{++**}	65.918^{++**}	10.7829^{++**}	95.449^{++**}
Env. + (Var x Env)	115	12977.458^{+**}	0.01809^{++**}	0.3162^{++**}	1.945^{++**}	0.8997^{+**}	0.7345^{++**}	10.4199**	2.0529^{++**}	29.70744^{++**}
Environments	5	129330.75^{++**}	0.15662^{++**}	2.95219^{++**}	25.9747^{++**}	1.0168^{++**}	5.4075^{++**}	39.1478^{++**}	37.644**	407.617^{++**}
Var. x Env.	110	7688.67**	0.01179^{++**}	0.19636^{++**}	0.85243**	0.8945^{+**}	0.5221^{++**}	9.1142**	0.4351**	12.5298**
Env. (Linear)	1	646653.77^{++**}	0.78308^{++**}	14.76095^{++**}	129.8734^{++**}	5.0838^{++**}	27.0376^{++**}	195.7388^{++**}	188.221^{++**}	2038.084^{++**}
Var. x Env. (Lin)	22	4466.012**	0.03196^{++**}	0.5891^{++**}	0.9286**	1.7099^{++**}	1.346^{++**}	11.651**	0.5248**	11.89**
Pooled Deviation	92	8125.02**	0.0065**	0.0939**	0.7972**	0.6604**	0.3023**	8.1112**	0.3948**	12.1379**
Pooled Error	264	513.77041	0.00037	0.00664	0.03528	0.18948	0.04797	1.67933	0.1066	1.35823
Total	137	17008.504	0.01953	0.3526	2.01802	302.26713	1.52188	19.33206	3.4548	40.26456

$^{+,++}$ *Significant at 5% and 1% level tested against pooled deviation, respectively and *, ** Significant at 5% and 1% level tested against pooled error , respectively*

Table 4.2.2.1: Stability parameters of new wheat genotypes for morpho-physiological and quality traits characters.

Sr. No	Genotype	Grain yield (kg/plot)			Days to 50 % flowering			Days to maturity			Plant height (cm)			Number of tillers per meter		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	NIAW 1885	1.072	1.381*	0.0008	59.33	0.807	2.015 **	112.3	1.049	-0.8	90.55	0.613*	4.487	66.75	0.748	50.79 **
2	NIAW 1951	0.845	1.197	0.0001	52.11	0.677	0.312	107.9	1.084	-0.3	84.58	1.026	-0.125	63.49	1.217	22.16 **
3	NIAW 1994	1.058	0.698	-0.0031	54.06	0.44*	0.606	113.1	0.984	-0.7	82.35	0.877	1.331	66.60	0.604*	7.39
4	NIAW 2065	0.920	0.673	0.0012	56.11	0.979	1.038 *	108.4	0.873	0.2	77.76	0.42*	15.505 **	74.00	0.743*	-4.257
5	NIAW 2073	0.866	1.328	0.0105 **	60.39	-0.101*	4.804 **	115.1	1.351*	-0.4	90.02	1.007	-0.463	68.68	1.279	20.98**
6	NIAW 2248	0.953	0.820*	-0.004	57.61	1.05	0.404	102.8	0.767*	1.4	84.11	1.223*	4.662	68.21	1.292*	11.197 *
7	NIAW 2255	0.929	0.965	0.0039	53.89	0.634*	0.328	108.8	0.991	-0.3	103.34	1.482*	5.503 *	63.86	1.74*	9.851 *
8	NIAW 2268	1.025	1.661	0.0012	57.78	1.231	2.788 **	107.4	0.991	0.9	94.77	1.154	3.205	67.99	1.149	8.651 *
9	NIAW 2275	0.992	0.972	0.0021	55.06	1.673*	1.976 **	99.8	0.364*	0.6	86.75	1.174*	-3.278	75.26	0.677*	-3.5502
10	NIAW 2279	1.100	0.97	0.0037	49.67	0.492	2.004 **	101.4	0.519*	1.6	88.72	0.844	2.882	73.26	1.376*	4.5902
11	NIAW 2300	0.846	0.29	0.0103 **	50.33	0.839	1.632 **	109.1	0.638*	1.0	86.42	0.546*	4.051	65.51	1.093	0.2015
12	NIAW 2303	0.805	1.061	0.0043	49.83	1.074	3.494 **	113.8	1.159	0.6	91.25	1.291	18.029 **	58.18	0.466*	-1.2878
13	NIAW 2304	0.684	0.968	0.0126 **	48.78	0.793	6.028 **	99.5	0.108*	-0.5	77.14	0.64*	-0.993	55.06	0.113*	-0.6177
14	NIAW 2310	0.898	1.436	-0.0016	50.44	1.358	3.644 **	112.4	1.534*	2.2 *	98.94	1.566*	6.862 *	61.97	0.681*	-1.403
15	NIAW 2313	1.049	1.106	-0.0004	63.94	1.995	6.504 **	115.2	1.13*	-0.8	88.22	0.826*	0.1973	62.74	1.411*	1.749
16	NIAW 2345	1.043	1.28	0.0114 **	63.78	1.535	3.677 **	115.4	1.457*	2.3 *	88.29	1.004	0.3708	66.44	0.893	9.416 *
17	NIAW 2346	0.850	1.457	0.0086 *	53.22	1.225	6.659 **	104.6	0.975	2.4 *	84.49	1.137	15.607 **	56.17	1.467*	24.948 **
18	NIAW 2348	1.065	0.274	0.0062 *	61.39	0.641	3.644 **	106.4	0.98	1.0	93.42	1.182*	1.405	65.43	1.497*	10.422 *
19	NIAW 2349	1.134	0.961	0.0046	62.06	0.713	4.263 **	106.7	1.209*	-1.1	90.53	1.097	-1.526	71.72	0.46*	5.972
20	NIAW 2351	1.074	0.829*	-0.0032	65.50	1.461	16.389 **	116.8	1.293*	-0.2	90.14	0.861	0.760	71.68	0.439*	-2.434
21	NIAW 1415 ©	0.934	0.699	-0.0013	64.28	1.009	2.4794 **	116.6	1.426*	-0.3	81.10	1.012	2.8342	62.90	0.483*	6.2715
22	NIAW 917©	0.990	0.775	0.0039	59.39	1.433	6.830 ***	119.8	1.185*	-0.5	84.86	0.815	4.154	66.50	1.78*	8.2915
23	NIAW 34 ©	0.858	1.2	0.003	54.67	1.042	0.820 *	105.9	0.934	3.6 **	83.42	1.203	9.269 **	63.18	1.392*	17.459 **
	Popl. Mean	0.9561			56.68			109.5			87.88			65.90		
	SE $\pm$	0.0384			0.9022			0.60			1.2376			1.7405		
	SE $\pm$bi	0.3512			0.4045			0.20			0.2678			0.3823		

Table contd

Sr. No	Genotype	Spike length (cm)			No. of grains /Spike			Thousand grain weight (g)			Photosynthetic rate (µ mol m^{-2} s^{-1})			Transpiration Rate (m mol m^{-2} s^{-1})		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	NIAW 1885	8.63	1.465	0.0695	45.06	1.705*	0.0624	41.14	0.464	0.4337 *	20.17	0.096*	6.701 **	3.41	1.464	0.772 **
2	NIAW 1951	6.98	0.511	0.0671	42.56	0.841	5.6944 *	43.83	1.271	0.5440 *	18.16	1.316*	0.5177	3.22	1.69	0.0331
3	NIAW 1994	8.60	1.469	0.0029	46.78	1.666*	1.0682	45.37	0.997	1.162 **	20.56	0.892*	0.2819	2.98	1.45	0.1642**
4	NIAW 2065	7.77	0.989	-0.002	41.50	1.22	25.402**	42.32	0.667	0.3735 *	21.64	1.243	3.515 **	3.26	0.979	1.012 **
5	NIAW 2073	8.47	1.046	0.1383 *	43.67	0.591*	3.2453	46.37	1.239	1.823 **	17.49	1.320*	-0.1132	3.08	2.104	0.859 **
6	NIAW 2248	7.55	1.213	0.017	43.56	0.518*	1.5927	43.11	1.122	0.4999 *	20.02	1.923*	5.512 **	3.26	1.458	0.0414
7	NIAW 2255	7.96	1.423	0.0717	42.67	1.662*	-3.4353	45.04	0.851	0.1056	18.64	0.692	1.402 **	3.59	1.451	0.283 **
8	NIAW 2268	8.11	2.306*	0.0374	44.94	1.342*	-0.4101	44.13	0.998	0.5497 *	20.88	1.952*	3.241 **	3.80	1.228	0.205**
9	NIAW 2275	7.25	1.403	0.322 **	44.28	0.805	10.34 **	45.06	0.215	1.048 **	20.24	1.75*	4.116**	3.94	1.18	0.634 **
10	NIAW 2279	8.25	0.796	0.243 **	38.67	0.162*	5.6452 *	45.82	1.251	0.2815	20.30	1.602*	0.2436	3.29	1.658	0.144 **
11	NIAW 2300	7.45	0.463	0.08	32.44	-0.56*	-2.9447	51.52	1.359	1.316**	20.74	1.24	9.595 **	3.85	0.952	0.107 **
12	NIAW 2303	8.06	0.236*	-0.0175	38.89	1.195	-0.4593	45.70	2.458*	1.166**	15.86	0.721	0.7495 *	3.58	-0.185	0.241 **
13	NIAW 2304	7.30	-0.694*	0.0462	37.89	0.045*	12.54 **	43.44	1.912	3.325 **	16.31	0.354*	2.327 **	3.50	0.894	0.955 **
14	NIAW 2310	8.38	1.241	0.036	38.50	0.715*	-1.946	50.10	1.79	1.980 **	19.20	1.293	3.971 **	3.40	0.995	0.654 **
15	NIAW 2313	8.98	1.501	0.1135 *	53.33	0.418*	2.657	39.76	0.919	3.813 **	21.67	1.037	1.495 **	4.10	0.568	0.081 **
16	NIAW 2345	9.15	1.295	0.0691	50.67	1.735*	9.583 **	39.13	0.476	2.923**	20.74	0.672	7.375 **	3.60	1.021	0.539 **
17	NIAW 2346	8.56	0.652	0.1289 *	41.44	1.071	21.86 **	45.29	1.417*	-0.0678	16.14	0.623	12.06 **	3.37	0.871	0.535 **
18	NIAW 2348	9.76	2.337	0.167 **	55.28	1.529*	0.5985	40.82	-0.03*	0.7316 **	19.49	1.062	0.709 *	4.02	0.878	0.528 **
19	NIAW 2349	9.39	0.237*	-0.0169	53.83	1.824*	6.7847 *	40.04	0.625	2.442 **	18.61	0.706	0.926 *	3.75	1.243	0.628**
20	NIAW 2351	8.56	1.009	0.0041	50.78	1.415	20.20 **	37.79	0.375	0.5586 *	21.11	0.564	2.751 **	5.11	0.527	0.137 **
21	NIAW 1415 ©	8.97	-0.138	0.174 **	65.33	1.653	29.31 **	39.17	0.346	2.587 **	19.25	-0.07*	1.41**	4.48	-0.049	0.128 **
22	NIAW 917©	8.18	1.623	0.1208 *	47.72	1.025	7.2583 *	38.95	1.02	1.066 **	19.72	0.683	1.312**	4.18	0.681	0.0665 *
23	NIAW 34 ©	7.43	0.616	0.0648	40.72	0.424*	-1.1436	43.51	1.257	1.332**	22.59	1.33	1.360**	4.43	-0.058*	0.071 *
	Popl. Mean	8.25			45.24			43.36			19.54			3.70		
	SE ±	0.1748			1.433			0.5599			0.848			0.2888		
	SE ± bi	0.4243			0.5065			0.3191			0.2557			0.6866		

Table contd

Sr. No	Genotype	Photosynthetically active radiation (μ mol m^{-2} s^{-1})			Stomatal conductance (μ mol m^{-2} s^{-1})			Stomatal resistance (μ mol m^{-2} s^{-1})			Canopy temperature (^{0}C)			Membrane injury index (%)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	NIAW 1885	1292.7	0.558*	11605 **	0.631	-1.136*	0.0080 **	1.585	-0.635*	0.0366 **	29.33	0.855	1.9010 **	57.92	0.357	0.9313 **
2	NIAW 1951	1356.2	0.288*	21718.7 **	0.468	1.294	0.0044 **	2.137	1.662	0.0766 **	29.73	0.85	1.2726 **	64.67	5.216*	0.1677
3	NIAW 1994	1347.1	0.572*	3531.6 **	0.592	1.34	0.0041 **	1.689	0.852	0.0227 **	29.98	1.175	0.6714 **	28.19	-4.111*	0.0195
4	NIAW 2065	1422	1.26*	1899.5 **	0.572	1.893	0.0088 **	1.748	1.305	0.1192 **	29.81	1.117	0.8268 **	41.95	0.821	0.5256 **
5	NIAW 2073	1304.8	1.051*	17653.0 **	0.452	1.165	0.002 **	2.212	1.239	0.0497 **	29.18	1.338	0.8808 **	73.28	0.605	1.2722 **
6	NIAW 2248	1393.7	1.133*	22040.2 **	0.496	2.553*	0.0019 **	2.016	2.815*	0.0833 **	30.29	1.313	0.1306 **	68.86	1.679	0.2024
7	NIAW 2255	1486.7	1.217*	621.7	0.455	0.434	0.0088 **	2.198	0.75	0.1978 **	30.02	1.435	0.6948 **	67.25	3.655*	-0.0527
8	NIAW 2268	1415.2	1.278*	1089.1 *	0.552	2.775*	0.0046 **	1.812	2.427	0.167 **	30.51	1.605	0.5851 **	64.95	0.633	0.4579 *
9	NIAW 2275	1422.3	1.258*	5583.6 **	0.558	1.537	0.0102 **	1.792	1.285	0.0432 **	30.43	1.332	0.6564 **	45.38	0.892	0.3703 *
10	NIAW 2279	1515.9	0.856*	2875.0 **	0.483	1.945	0.0042 **	2.070	2.231*	0.0258 **	30.90	1.284	0.2470 **	36.42	2.126*	0.0181
11	NIAW 2300	1492.6	1.483*	10475.0 **	0.614	0.233	0.0087 **	1.629	0.155	0.0526 **	30.82	1.227	0.3473 **	59.73	-1.308	1.2161 **
12	NIAW 2303	1495.3	1.475*	2007.9 **	0.377	0.025*	0.0004	2.653	0.011*	0.0337 **	30.91	1.123	1.2371 **	76.88	2.642	0.2309
13	NIAW 2304	1505.5	1.522*	2535.3 **	0.422	0.223	0.0041 **	2.370	0.199	0.1037 **	31.12	1.395	0.2508 **	77.60	-3.537	0.7608 ***
14	NIAW 2310	1445.7	1.146*	4648.0 **	0.497	2.168*	0.0036 **	2.012	2.356*	0.0816 **	31.17	1.357	0.0643 *	39.48	5.949	0.7437 **
15	NIAW 2313	1388.2	1.252*	11673.2 **	0.573	0.944	0.0108 **	1.745	0.495	0.0903 **	30.56	1.165	0.6260 **	42.80	2.166	-0.0748
16	NIAW 2345	1465	0.964*	3112.5 **	0.527	-0.156	0.0167 **	1.898	-0.31	0.2831 **	30.46	0.967	0.1017 **	27.32	-1.364	0.3929 *
17	NIAW 2346	1482.8	1.389*	11755.6 **	0.390	1.266	0.0014 **	2.564	1.918	0.0922 **	31.02	0.887	0.6704 **	55.22	4.199*	-0.0212
18	NIAW 2348	1493.1	0.493*	8509.3 **	0.510	1.55	0.0141 **	1.961	1.46	0.1145 **	31.32	0.236	1.9437 **	30.01	-3.795	0.6310 **
19	NIAW 2349	1341.8	0.834*	14103.0 **	0.469	0.336	0.0042 **	2.132	0.486	0.0861 **	31.41	0.503	0.2219 **	29.27	3.366	0.6921 **
20	NIAW 2351	1513.4	0.69*	12151.2 **	0.550	0.165*	0.0026 **	1.818	0.119*	0.0231 **	30.49	0.727	1.4757 **	26.38	-1.935	0.8459 **
21	NIAW 1415 ©	1597.9	0.203*	754.7 *	0.529	-0.157	0.0079 **	1.890	-0.257*	0.1076 ***	31.50	0.605	1.3879 **	36.14	-0.714	0.5319 **
22	NIAW 917©	1507.1	1.439*	2729.4 **	0.515	1.06	0.0075 **	1.942	1.159	0.1028 **	30.77	0.266	1.1126 **	34.39	2.285	-0.0221
23	NIAW 34 ©	1542.9	0.636*	1677.0 **	0.561	1.543*	0.0006 *	1.783	1.277	0.0091	30.67	0.238*	0.1597 **	30.44	3.189	0.0260
	Popl. Mean	1444.7			0.513			1.985			30.54			48.46		
	SE ±	40.3			0.0359			0.137			0.3993			0.3634		
	SE ±bi	0.5			0.4353			0.3825			0.3757			1.7292		

Table contd

Sr. No	Genotype	Protein (%)			Sedimentation value (ml)			Hectoliter weight (kg/hl)			Wet glutent content (%)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	NIAW 1885	12.23	-0.004	0.5930 **	41.44	-0.275*	5.1687 **	81.52	0.911	0.0066	51.67	1.344*	-0.0866
2	NIAW 1951	12.66	-0.329	0.4811 **	43.39	1.401	1.1401	82.26	1.283*	-0.0729	51.11	0.984	0.9274
3	NIAW 1994	12.16	-0.199*	-0.0004	41.72	-0.882*	1.2174	82.66	0.965	0.0522	47.07	0.888	3.4740 **
4	NIAW 2065	11.45	-0.145*	0.1147 *	46.89	1.133	17.0401 **	83.31	0.571	1.6984 **	45.39	0.922	16.3982 **
5	NIAW 2073	10.20	2.127	0.1686 **	50.67	2.448*	2.9354 *	80.43	0.778	0.1581 *	45.56	0.37*	14.8757 **
6	NIAW 2248	10.96	-0.454	0.6138 **	42.78	0.718	0.1213	82.08	1.251	0.5062 ***	51.52	0.997	16.5082 **
7	NIAW 2255	11.95	0.809	0.3997 **	41.33	2.692*	2.3776	82.39	0.621	0.1912 *	55.71	0.33*	16.4572 **
8	NIAW 2268	10.92	1.476	0.0683	41.56	1.32	2.6239 *	82.95	1.047	0.0475	46.92	1.388*	3.2276 *
9	NIAW 2275	10.59	2.532	0.6007 **	47.67	3.109*	4.7212 **	82.38	0.966	0.1394	47.20	1.176	16.8408 **
10	NIAW 2279	11.35	0.814	0.1044 *	45.00	-0.562*	11.6203 **	81.80	0.679	0.1146	43.95	0.86	7.0098 **
11	NIAW 2300	9.90	1.43	0.3018 **	47.56	2.620*	0.8896	81.83	1.078	0.1836 *	45.77	0.634*	1.0954
12	NIAW 2303	10.80	1.541	0.2544 **	46.06	2.108	35.4710 **	80.24	1.14	0.4236 **	46.83	0.927	14.8019 **
13	NIAW 2304	11.21	1.675	0.1125 *	44.83	0.09*	1.8166	79.72	1.271	0.4386 **	45.56	0.941	6.6261 **
14	NIAW 2310	11.93	0.94	0.1045 *	45.17	-0.387*	8.1270 **	80.71	1.311	0.0321	48.92	1.136	6.7172 **
15	NIAW 2313	11.07	1.202	0.2377 **	49.44	1.76*	2.2376	81.92	1.04	-0.024	45.90	0.996	45.9055 **
16	NIAW 2345	9.43	-0.211	0.3351 **	42.33	0.503*	-1.2458	77.12	1.277	1.1676 **	40.38	1.279	5.6232 **
17	NIAW 2346	10.52	0.91	0.8497 **	50.33	1.176	0.1272	80.09	0.796	0.2113 *	43.34	0.474	6.1534 **
18	NIAW 2348	10.08	3.166*	0.1358 **	49.67	0.782	43.4907 **	80.60	0.75	0.6561 **	40.69	1.049	8.6439 **
19	NIAW 2349	10.60	2.823*	0.0518	49.72	2.339*	4.0072 *	80.85	0.817	-0.0451	39.68	1.933*	12.3541 **
20	NIAW 2351	10.56	2.188	0.4023 **	46.22	0.577*	-1.4893	81.49	1.314	0.0546	46.37	1.157	7.5086 ***
21	NIAW 1415 ©	13.21	0.188*	-0.0388	40.39	0.876	-1.3721	80.33	0.667	0.4745 **	48.41	1.446	24.4941 **
22	NIAW 917©	12.33	0.300*	-0.0327	42.72	-0.212*	3.4978 *	80.44	1.073	0.0331	52.67	0.629	8.7915 **
23	NIAW 34 ©	12.24	0.219*	-0.0299	42.11	-0.336*	1.4779	81.57	1.39	0.1563 *	49.69	1.137	3.4550 **
	Popl. Mean	11.23			45.17			81.25			46.97		
	SE ±	0.2459			1.2737			0.281			1.5581		
	SE ±bi	0.5071			0.9762			0.2196			0.3701		

Table 4.4.1.1: Genotypic correlation coefficient among nineteen characters under timely sown irrigated conditions (TSI) at Niphad.

Char.	Flow.	Matu.	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.5571**	0.1146	0.196	0.6792**	0.7301**	-0.8234**	-0.0488	0.3346*	-0.0986	0.2257	-0.3058*	0.2394	-0.4852*	-0.0907	-0.0003	-0.3318*	-0.3319*	**0.5587****
Matu.		-	0.3091*	-0.0889	0.4143**	0.4159**	-0.3009*	-0.1366	-0.0109	0.1339	0.1876	-0.1891	0.1228	-0.3411*	0.3075*	-0.1531	-0.2537	-0.0093	**0.5393****
PH			-	0.2034	0.318*	0.0743	0.1389	-0.1592	0.3015*	-0.0971	-0.2522	0.2763	-0.0131	0.0931	-0.0786	-0.0851	-0.1504	0.0535	**0.2786***
Till/m				-	0.3732**	0.1437	-0.2156	-0.2372	-0.0003	-0.302	0.017	-0.139	-0.4013**	-0.0393	-0.1637	0.0118	0.0465	0.0377	**0.186**
SL					-	0.6786**	-0.5453**	0.0565	0.1183	-0.1169	0.164	-0.2436	0.3265*	-0.5392**	-0.3207*	-0.0798	-0.5262**	-0.6215**	**0.8829****
Gr/Sp						-	-0.7113**	-0.0548	0.0608	-0.154	0.0763	-0.1058	0.3537*	-0.4746**	0.1015	-0.2052	-0.3907**	-0.3156*	**0.5551****
TGW							-	0.0696	-0.2534	-0.0688	-0.0069	0.0593	-0.3003*	0.4498**	-0.056	0.1339	0.2234	0.2599	**-0.5611****
PR								-	0.0969	-0.1542	0.7339**	-0.714**	0.0192	-0.2069	-0.0509	-0.1156	0.4142**	-0.0174	**0.0801**
TR									-	0.1636	0.0934	-0.2305	0.3238*	-0.4039**	-0.1793	-0.2534	0.023	0.0459	**0.2057**
PAR										-	-0.2528	0.2503	0.4187**	-0.1252	-0.0313	-0.0543	-0.1594	0.1465	**-0.1798**
SC											-	-0.9753**	-0.2459	-0.3168*	0.1774	-0.0917	0.4388**	0.0978	**0.1879**
SR												-	0.1934	0.4151**	-0.1724	0.1531	-0.3637**	-0.1014	**-0.2538**
CT													-	-0.469**	-0.2774	-0.211	-0.4188**	-0.3911**	**-0.0582**
MII														-	0.0583	0.2845	0.1405	0.4295**	**-0.3907****
Prot.															-	-0.5134**	0.3014*	0.5237**	**0.0873**
SV																-	0.1678	-0.1861	**-0.1142**
HW																	-	0.4777**	**-0.4621****
WGC																		-	**-0.2944***

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50%flowering, Matu.-Days to maturity ,PH:Plant height , Till/m- Tillers per meter , SL-Spike length , Gr./Sp ,- Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.1.2 : Phenotypic correlation coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Niphad.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.4903 **	0.0823	0.1468	0.5553 **	0.6772 **	-0.7765 **	-0.0453	0.3119 *	-0.0946	0.211	-0.2590	0.2323	-0.4717 **	-0.0957	0.0143	-0.2593	-0.3195 *	**0.4156****
Matu.		-	0.2939 *	-0.0392	0.3620 *	0.3692 *	-0.2715	-0.108	-0.0121	0.1021	0.1788	-0.1873	0.0968	-0.3168 *	0.2870 *	-0.1236	-0.2324	-0.007	**0.2872***
PH			-	0.2147	0.2541	0.0593	0.1096	-0.1414	0.2398	-0.1044	-0.2161	0.2186	-0.0472	0.086	-0.0701	-0.0633	-0.1149	0.0387	**0.1908**
Till/m				-	0.2784 *	0.0509	-0.1729	-0.1651	0.0045	-0.1675	-0.0078	-0.0272	-0.3228 *	-0.0334	-0.0867	0.0571	0.0539	0.0031	**0.1971**
SL					-	0.5544 **	-0.4385 **	0.0656	0.1432	-0.0741	0.0848	-0.121	0.2714	-0.4448 **	-0.2161	0.0179	-0.3948 **	-0.4635 **	**0.4447****
Gr/Sp						-	-0.6428 **	-0.0524	0.0482	-0.1551	0.0767	-0.1094	0.3245 *	-0.4515 **	0.0658	-0.1599	-0.2860 *	-0.2909 *	**0.3772****
TGW							-	0.0567	-0.2223	-0.0636	-0.0187	0.0665	-0.2863 *	0.4398 **	-0.0429	0.1306	0.1951	0.2318	**-0.4114****
PR								-	0.1157	-0.1512	0.6775 **	-0.5947 **	0.0215	-0.1934	-0.0366	-0.0846	0.3532 **	0.0196	**0.0209**
TR									-	0.128	0.0699	-0.16	0.2937 *	-0.3677 **	-0.1567	-0.1622	0.0716	0.0326	**0.1879**
PAR										-	-0.2245	0.2047	0.3743 **	-0.1175	-0.0079	-0.0457	-0.1446	0.1237	**-0.1077**
SC											-	-0.9413 **	-0.231	-0.3054 *	0.1579	-0.0933	0.3724 **	0.1006	**0.127**
SR												-	0.1783	0.3696 **	-0.1354	0.154	-0.2718	-0.0988	**-0.1173**
CT													-	-0.4555 **	-0.2488 *	-0.1901	-0.3897 **	-0.3649 *	**-0.0387**
MII														-	0.0554	0.2558 *	0.125	0.4154 **	**-0.2895***
Prot.															-	-0.4509 **	0.2174	0.4954 **	**0.0485**
SV																-	0.1366	-0.1586	**-0.0873**
HW																	-	0.3942 **	**-0.2634**
WGC																		-	**-0.2307**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp –Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.2.1 : Genotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Niphad.

Char.	Fl.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.462**	-0.038	0.0382	0.5675**	0.808**	-0.784**	0.3004*	0.3168*	-0.333*	0.1227	-0.0881	-0.608**	-0.4026**	-0.0954	-0.0933	-0.416**	-0.0349	**0.602****
Matu.		-	0.1902	-0.2147	0.5794**	0.447**	-0.3258*	0.45**	0.3189*	-0.1899	0.3144	-0.3612*	-0.489**	-0.3248	-0.0259	0.0187	-0.509**	-0.0098	**0.4016****
PH			-	-0.0227	0.2652	-0.0927	0.1455	0.0105	-0.2429	-0.2355	-0.0029	0.0268	0.1137	0.0448	-0.0271	-0.0812	-0.0762	-0.0894	**0.3852****
Till/m				-	-0.4917**	-0.1973	-0.0765	-0.1103	-0.0829	-0.354*	-0.2087	0.1887	0.1511	-0.2217	-0.4155	-0.0662	0.363*	-0.1886	**0.4799****
SL					-	0.653**	-0.37*	0.1924	0.2272	-0.447**	0.1914	-0.219	-0.4081*	-0.2556	-0.0421	0.3522*	-0.759**	-0.405	**0.4987****
Gr/Sp						-	-0.827**	0.403**	0.541**	-0.1954	0.2096	-0.2652	-0.5981*	-0.4422**	0.2286	-0.094	-0.594**	0.0281	**0.3141***
TGW							-	-0.492**	-0.435**	0.3231*	-0.2788*	0.286	0.407*	0.466**	-0.188	0.1805	0.3476*	-0.1167	**-0.4893****
PR								-	0.447**	-0.0793	0.761**	-0.766**	-0.2597	-0.4962**	-0.0315	-0.3397*	-0.1705	0.2387	**0.3993****
TR									-	0.1622	0.1598	-0.3246	-0.2125	-0.3997**	-0.1464	0.0439	-0.397**	0.1642	**-0.1386**
PAR										-	-0.0919	0.0749	0.3645*	0.2379	0.095	-0.2954*	0.2258	0.566**	**-0.8394****
SC											-	-0.939**	0.0089	-0.1422	-0.0631	-0.2072	-0.2573	0.1447	**0.1426**
SR												-	0.0259	0.2486	0.0255	0.1692	0.3232	-0.0722	**-0.0505**
CT													-	0.1712	-0.1751	-0.1234	0.3034	0.092	**-0.3288***
MII														-	0.0335	-0.0671	0.1951	0.127	**-0.7178****
Prot.															-	-0.404**	0.0879	0.2737	**-0.3097***
SV																-	-0.3658*	-0.497**	**0.1042**
HW																	-	0.3412*	**-0.2405**
WGC																			**-0.3301***

* Significant at 5% level, ** Significant at 1% level

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp ,-Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table4.4.2.2 : Phenotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Niphad.

Char.	Fl.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.4145 **	-0.0097	0.0393	0.4797 **	0.7032 **	-0.7449 **	0.2846 *	0.3101 *	-0.324*	0.1129	-0.0777	-0.571**	-0.3909 **	-0.0886	-0.0964	-0.3677 *	-0.0362	**0.3442***
Matu.		-	0.1897	-0.1844	0.492 **	0.4082 **	-0.3053 *	0.4063 **	0.2936 *	-0.1806	0.3017 *	-0.347**	-0.446**	-0.3088 *	-0.0174	-0.0263	-0.4456 **	0.0157	**0.2400**
PH			-	0.0141	0.2404	-0.058	0.1651	0.013	-0.2093	-0.2192	-0.0028	0.0317	0.0849	0.0402	-0.0052	-0.0478	-0.0237	-0.0721	**0.3362***
Till/m				-	-0.311 *	-0.167	-0.0711	-0.0765	-0.0496	-0.2674	-0.1758	0.1762	0.0866	-0.1771	-0.347**	-0.0496	0.3087 *	-0.1524	**0.2588**
SL					-	0.5669 **	-0.3005 *	0.1718	0.1934	-0.389**	0.1609	-0.1895	-0.349**	-0.2291	-0.0413	0.2278	-0.5754 **	-0.326 **	**0.2816***
Gr/Sp						-	-0.7357 **	0.3518 **	0.4863 **	-0.1747	0.1967	-0.2539*	-0.519**	-0.4052 **	0.2015	-0.0824	-0.5463 **	0.0309	**0.2370**
TGW							-	-0.4494 **	-0.4190 **	0.3006 *	-0.2714	0.2782 *	0.375 **	0.4541 **	-0.1662	0.1481	0.3425 *	-0.1014	**-0.2099**
PR								-	0.4299 **	-0.0811	0.719**	-0.728**	-0.241*	-0.4786 **	-0.0224	-0.2725*	-0.1572	0.1738	**0.2723***
TR									-	0.1568	0.1582	-0.309**	-0.207	-0.3902 **	-0.1409	0.0114	-0.3506 *	0.1322	**-0.0216**
PAR										-	-0.0889	0.0689	0.348 **	0.2324	0.0883	-0.2333	0.202	0.4931 **	**-0.4675****
SC											-	-0.938**	-0.0026	-0.1394	-0.0736	-0.1832	-0.2272	0.1332	**0.0727**
SR												-	0.0325	0.2431 *	0.0378	0.1536	0.2930 *	-0.0673	**-0.0173**
CT													-	0.1643	-0.1319	-0.1094	0.2556 *	0.0795	**-0.2008**
MII														-	0.0288	-0.0506	0.1744	0.1154	**-0.4079****
Prot.															-	-0.308 *	0.0463	0.2062	**-0.0981**
SV																-	-0.3021 *	-0.391 **	**0.0176**
HW																	-	0.2880 *	**-0.1060**
WGC																		-	**-0.1930**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.3.1: Genotypic correlation coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Rahuri.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.576**	-0.0852	0.2184	0.5054**	0.7819**	-0.7175**	0.0812	0.2841*	0.1739	-0.1796	0.1766	0.4054**	-0.4753**	-0.184	-0.0645	-0.1768	-0.0539	**0.4877****
Matu.		-	0.095	-0.1048	0.4594**	0.4442**	-0.3953**	-0.2162	0.2543	0.0391	-0.4274**	0.4082**	0.3198**	-0.2491	0.1638	-0.0926	-0.2553	0.4253**	**0.0361**
PH			-	-0.0434	0.1418	-0.0845	0.3145*	0.1806	0.241	-0.0911	0.0018	0.0265	-0.239	0.0439	-0.1916	0.1969	0.1389	0.0851	**0.328***
Till/m				-	-0.3713*	-0.1097	-0.0692	0.7133**	0.0298	-0.2012	0.5058**	-0.5089**	-0.1835	-0.2819*	0.0501	-0.1036	0.4237**	0.0045	**0.5647****
SL					-	0.650**	-0.2813*	-0.3878**	0.0826	0.3584*	-0.4758**	0.5111**	0.4801**	-0.5249**	-0.3137*	0.2399	-0.485**	-0.2518	**0.1985**
Gr/Sp						-	-0.6237**	-0.0421	0.4184**	0.4011**	-0.1673	0.1969	0.4733**	-0.5245**	-0.083	-0.1404	-0.0622	-0.1505	**0.3671****
TGW							-	0.1596	-0.2236	-0.433**	0.3083*	-0.3105*	-0.4171**	0.2989*	-0.0949	0.3656	0.2745*	-0.1379	**-0.087**
PR								-	0.1146	-0.2387	0.7372**	-0.6699**	-0.1952	-0.2169	-0.0764	-0.183	0.4923**	-0.2473	**0.6514****
TR									-	0.2161	0.0893	-0.0432	0.5481**	-0.314*	-0.193	0.0967	0.2456	-0.0507	**0.1351**
PAR										-	-0.2656	0.3036*	0.5361**	-0.3734*	0.1645	-0.3121*	-0.148	-0.128	**-0.123**
SC											-	-0.9775**	-0.1721	-0.0469	-0.0406	-0.0529	0.6501**	-0.0482	**0.3458***
SR												-	0.1791	0.0354	-0.0526	0.0675	-0.6815**	-0.0371	**-0.3175***
CT													-	-0.6328*	-0.0791	0.0436	-0.2865*	-0.3072	**-0.0538**
MII														-	-0.0056	0.2151	0.0477	0.3694**	**-0.5776****
Prot.															-	-0.7743**	0.1693	0.5912**	**-0.1975**
SV																-	-0.193	-0.3213*	**-0.1652**
HW																	-	0.0306	**0.4956****
WGC																		-	**-0.4642****

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.3.2 : Phenotypic correlation coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Rahuri.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.5334 **	-0.0501	0.2114	0.4540 **	0.7132 **	-0.6881 **	0.0844	0.2871 *	0.172	-0.1914	0.1821	0.3740 **	-0.4669 **	-0.1783	-0.0885	-0.1461	-0.0449	**0.397****
Matu.			0.0863	-0.1007	0.3735 **	0.3865 **	-0.3470 **	-0.195	0.2368	0.025	-0.3999 **	0.3870 **	0.2814 *	-0.2355	0.1708	-0.0749	-0.2366	0.3628 **	**-0.0012**
PH				-0.0336	0.146	-0.0517	0.2844 *	0.1716	0.2091	-0.0968	-0.0182	0.0463	-0.174	0.0407	-0.177	0.1577	0.148	0.0406	**0.2335**
Till/m					-0.2643 *	-0.0652	-0.056	0.6136 **	0.05	-0.1498	0.4422 **	-0.4351 **	-0.1895	-0.2407 *	0.0493	-0.1405	0.3828 **	0.0425	**0.4717**
SL						0.5349 **	-0.2422	-0.3543 *	0.0601	0.3205 *	-0.3843 **	0.4147 **	0.4117 **	-0.4763 **	-0.2740 *	0.2154	-0.406 **	-0.1926	**0.1575**
Gr/Sp							-0.5425 **	-0.0152	0.3980 **	0.3027 *	-0.1902	0.2153	0.4141 **	-0.4773 **	-0.0676	-0.1142	-0.002	-0.0929	**0.3715***
TGW								0.1439	-0.229	-0.3731 **	0.2957 *	-0.2899 *	-0.4005 **	0.2885 *	-0.0706	0.3316 **	0.2372 *	-0.1355	**-0.0555**
PR									0.1199	-0.2247	0.6603 **	-0.6010 **	-0.1736	-0.2123	-0.0698	-0.1654	0.4680 **	-0.2009	**0.492****
TR										0.2031	0.0667	-0.0348	0.5178 **	-0.3042 *	-0.1725	0.0771	0.2384 *	-0.0105	**0.1251**
PAR											-0.2178	0.2382 *	0.4404 **	-0.3458 **	0.1441	-0.2969 *	-0.1432	-0.108	**-0.0947**
SC												-0.9725 **	-0.1844	-0.045	-0.01	-0.0409	0.5781 **	-0.0403	**0.218**
SR													0.189	0.0338	-0.0681	0.0573	-0.606 **	-0.0422	**-0.1915**
CT														-0.5999 **	-0.081	0.0289	-0.2421 *	-0.2895 *	**-0.0148**
MII															-0.0058	0.2083	0.0416	0.3437 **	**-0.429****
Prot.																-0.712 **	0.1593	0.5544 **	**-0.1299**
SV																	-0.1606	-0.2839 *	**-0.1608**
HW																		0.0729	**0.411****
WGC																			**-0.2781**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.4.1 : Genotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Rahuri.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.357*	0.0274	0.3168*	0.655**	0.7255**	-0.4371**	0.2263	0.7628**	-0.2016	0.1471	-0.1848	-0.1856	-0.398**	-0.2853*	0.385**	-0.2479	-0.47**	**0.408****
Matu.		-	0.2426	-0.0019	0.2919	0.2188	-0.2304	0.4964**	0.375**	-0.3245*	0.536**	-0.5421**	-0.3865**	-0.1999	0.1179	-0.12	-0.2224	0.0541	**0.1131**
PH			-	-0.0089	0.0706	-0.2582	0.2689	0.1068	-0.0808	-0.1798	0.2324	-0.2536	-0.1521	0.115	-0.1863	0.1293	0.0618	0.355*	**-0.0436**
Till/m				-	0.2071	0.3758**	0.0779	0.4467**	0.1867	-0.1105	0.3383*	-0.3994**	0.0868	-0.656**	0.0779	-0.0905	0.2667	-0.41**	**0.7903****
SL					-	0.578**	-0.5059**	0.1556	0.3518*	-0.0119	0.0366	-0.0909	0.2448	-0.442**	-0.0909	0.356*	-0.44**	-0.55**	**0.3968****
Gr/Sp						-	-0.5371**	0.3068*	0.4128**	-0.023	0.2068	-0.3036**	0.1418	-0.488**	0.2073	0.1328	-0.1496	-0.46**	**0.549****
TGW							-	-0.0047	-0.4332**	-0.106	-0.0463	0.0959	0.2054	0.2303	-0.1126	-0.1214	0.353**	0.0225	**-0.3214***
PR								-	0.2633	0.1281	0.8709**	-0.8227**	-0.1421	-0.649**	0.1956	-0.0383	0.0296	-0.116	**0.6543****
TR									-	-0.245	0.3984**	-0.4125**	-0.433**	-0.1886	-0.1623	0.2426	-0.1514	-0.37**	**0.0846**
PAR										-	-0.0029	0.1016	0.0472	-0.1089	-0.1624	0.2657	-0.1103	-0.156	**0.257**
SC											-	-0.973**	-0.3405*	-0.411**	0.2183	-0.1159	-0.0712	0.0501	**0.3269***
SR												-	0.3237*	0.448**	-0.3026*	0.1356	0.0713	-0.053	**-0.3756***
CT													-	0.0446	0.189	-0.0642	0.165	-0.364	**0.0263**
MII														-	-0.1505	-0.2674	0.0963	0.3142	**-0.9154***
Prot.															-	-0.427*	0.2832	0.312*	**-0.1185**
SV																-	-0.164	-0.249	**0.1952**
HW																	-	0.0573	**-0.0184**
WGC																		-	**-0.2927***

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.4.2 : Phenotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Rahuri.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.304*	0.0461	0.2625	0.576 **	0.674 **	-0.4071 **	0.2076	0.631 **	-0.1997	0.1348	-0.1686	-0.1675	-0.3867 **	-0.243 *	0.337*	-0.2156	-0.429**	**0.3007***
Matu.		-	0.1791	0.006	0.2379 *	0.1815	-0.2195	0.412**	0.2858	-0.292 *	0.479 **	-0.475**	-0.338*	-0.1812	0.0877	-0.1177	-0.1761	0.0082	**0.1293**
PH			-	-0.0297	-0.0009	-0.1926	0.2242	0.0579	-0.0772	-0.1631	0.1911	-0.2018	-0.1436	0.105	-0.1405	0.1522	0.0513	0.2469	**0.0575**
Till/m				-	0.1809	0.325 *	0.0616	0.377 **	0.1462	-0.09	0.311 **	-0.365*	0.0683	-0.6023 **	0.0971	-0.0485	0.2314	-0.346*	**0.5381****
SL					-	0.509**	-0.4474 **	0.1724	0.2348	0.0064	0.0373	-0.0702	0.2094	-0.4066 **	-0.071	0.2608	-0.374**	-0.425**	**0.2708**
Gr/Sp						-	-0.4678 **	0.258	0.2924 *	-0.0164	0.1875	-0.274*	0.0937	-0.4498 **	0.2054	0.1097	-0.1007	-0.358*	**0.3926****
TGW							-	-0.0269	-0.352*	-0.1069	-0.0509	0.0969	0.1949	0.2201	-0.0954	-0.0818	0.3032 *	0.0224	**-0.2572**
PR								-	0.1957	0.1202	0.804 **	-0.751**	-0.1169	-0.6036 **	0.1803	-0.0189	0.0206	-0.0733	**0.3822****
TR									-	-0.1795	0.2913 *	-0.291 *	-0.2986*	-0.1572	-0.1513	0.1385	-0.1493	-0.362*	**0.0035**
PAR										-	-0.0046	0.1012	0.0429	-0.1067	-0.1517	0.2162	-0.1021	-0.1368	**0.154**
SC											-	-0.966**	-0.325*	-0.4054 **	0.1993	-0.1063	-0.06	0.0527	**0.2139**
SR												-	0.308 *	0.4394 **	-0.273 *	0.1216	0.064	-0.0666	**-0.2406**
CT													-	0.0416	0.1571	-0.0344	0.1362	-0.332*	**-0.0168**
MII														-	-0.1435	-0.245 *	0.093	0.2787 *	**-0.651****
Prot.															-	-0.363**	0.2830 *	0.263*	**-0.0202**
SV																-	-0.1658	-0.23	**0.1478**
HW																	-	0.0314	**0.0123**
WGC																		-	**-0.2016**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.5.1 : Genotypic correlation coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Savalvihir.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.5065**	0.0509	0.3843**	0.5526**	0.8919**	-0.8782**	0.1135	0.321*	0.1198	0.1647	-0.2142	-0.0585	-0.5209**	0.0053	-0.0083	0.0266	-0.2296	**0.5023****
Matu.		-	0.0212	0.0124	0.3619*	0.5172**	-0.3328*	-0.1007	-0.004	-0.0095	-0.295*	0.2168	-0.3272*	-0.211	0.0737	-0.258	-0.0283	0.0131	**0.0554**
PH			-	0.2119	0.5679*	0.1118	0.118	-0.1145	0.2944*	0.0991	0.2169	-0.2529	0.0106	0.0126	-0.1584	-0.0093	0.1328	0.1893	**0.4159****
Till/m				-	0.4988**	0.2576	-0.3185*	0.8667**	0.1378	0.2404	0.7189**	-0.759**	-0.1482	-0.4969**	-0.1689	0.2911*	0.4904**	0.0301	**0.6894****
SL					-	0.5694**	-0.4669**	0.1556	0.0949	0.1461	0.3189*	-0.3822**	-0.0883	-0.5273**	-0.1909	0.0341	0.1366	-0.1341	**0.7603****
Gr/Sp						-	-0.8209**	-0.0583	0.4024**	0.1795	0.0224	-0.0688	0.1531	-0.5186**	0.235	-0.1016	0.046	-0.1973	**0.5569****
TGW							-	-0.0152	-0.1943	-0.1552	-0.1146	0.1598	-0.0371	0.5261**	-0.1106	0.0126	-0.0332	0.1266	**-0.4546****
PR								-	0.0165	-0.1325	0.9303**	-0.9277**	-0.1035	-0.3394**	-0.2166	0.0739	0.5822**	0.1607	**0.4404****
TR									-	0.5997**	0.0378	-0.0414	0.2954	-0.4475**	0.0636	-0.133	-0.13	-0.1239	**0.2764**
PAR										-	-0.2168	0.2452	0.2444	-0.2484*	-0.1312	0.0158	-0.4045**	-0.1546	**-0.0129**
SC											-	-0.9755**	0.0134	-0.3416*	-0.1667	-0.0378	0.3891**	0.1473	**0.4463****
SR												-	0.0173	0.4288*	0.0907	0.019	-0.4614**	-0.2135	**-0.5346****
CT													-	-0.0953	0.0297	-0.1295	-0.3487**	0.1215	**-0.069**
MII														-	-0.1731	0.04	-0.0542	0.1865	**-0.5334****
Prot.															-	-0.4909**	0.3446**	0.4005**	**-0.0747**
SV																-	0.1002	-0.4013**	**0.2203**
HW																	-	0.5533**	**0.4162****
WGC																		-	**-0.0985**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.5.2: Phenotypic correlation coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Savalvihir.

Char.	Fl.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.4732 **	0.0523	0.2844 *	0.5010 **	0.8114 **	-0.8407 **	0.0539	0.2399	0.0854	0.1482	-0.1956	-0.0426	-0.5069 **	-0.0137	0.0162	0.0391	-0.2309	0.3996**
Matu.		-	0.0174	0.0027	0.2866 *	0.4508 **	-0.3127 **	-0.1025	-0.0112	0.0043	-0.299 *	0.2322	-0.2852*	-0.2056	0.0692	-0.2383*	0.0003	0.0006	0.0563
PH			-	0.1342	0.4856 **	0.1327	0.0967	-0.01	0.2105	0.0781	0.1568	-0.2046	0.0106	0.0119	-0.1605	-0.0091	0.0973	0.1838	0.3707*
Till/m				-	0.3693 *	0.2087	-0.2449 *	0.541 **	0.0722	0.1831	0.5198 **	-0.5760 **	-0.1189	-0.4150 **	-0.1241	0.2002	0.3733 **	-0.0055	0.5825**
SL					-	0.4967 **	-0.4130 **	0.0913	0.056	0.104	0.2618 *	-0.3235 **	-0.0762	-0.4738 **	-0.1426	0.012	0.1117	-0.102	0.5458**
Gr/Sp						-	-0.7727 **	-0.037	0.2687 *	0.1544	0.0226	-0.0646	0.1496	-0.4879 **	0.203	-0.1142	0.0043	-0.1281	0.4442**
TGW							-	-0.0401	-0.1629	-0.1116	-0.1043	0.1495	-0.0263	0.5129 **	-0.0979	0.0004	-0.0287	0.1088	-0.3771**
PR								-	0.148	-0.1709	0.6268 **	-0.6490 **	-0.0253	-0.2479 *	-0.1052	0.0661	0.3997 **	0.0756	0.3007*
TR									-	0.3198 *	0.166	-0.1493	0.2647	-0.3630 *	0.0742	-0.1127	-0.0695	-0.1025	0.1511
PAR										-	-0.1889	0.2176	0.164	-0.2113	-0.1042	0.0108	-0.3357 *	-0.0963	0.0149
SC											-	-0.9679 **	0.0011	-0.3039 *	-0.1517	-0.0415	0.3234 *	0.0891	0.3137
SR												-	0.0208	0.3964 **	0.0946	0.0328	-0.3993**	-0.1576	-0.3967**
CT													-	-0.0887	0.0581	-0.1103	-0.2931 *	0.0951	0.0022
MII														-	-0.1622	0.0393	-0.048	0.1646	-0.4544**
Prot.															-	-0.4371 **	0.3109 *	0.3296 *	-0.0061
SV																-	0.0847	-0.3408 *	0.1897
HW																	-	0.3796 **	0.2903*
WGC																			-0.0563

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.6.1: Genotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Savalvihir.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.486 **	0.2435	0.454**	0.595**	0.794**	-0.66**	0.525**	0.3817*	-0.116	0.463*	-0.5201**	-0.2053	-0.4032*	-0.0012	0.0818	-0.119	0.1206	**0.661****
Matu.		-	0.2274	0.1364	0.2859*	0.2497	-0.377**	0.439**	0.3358*	0.142	0.5257*	-0.5266**	-0.0389	-0.2868*	0.1273	-0.2893*	-0.227	0.2028	**0.2831***
PH			-	0.1031	0.360**	-0.0302	0.1813	-0.1264	0.2118	-0.047	-0.0921	0.1212	0.0924	0.0417	0.1257	-0.075	0.0248	0.1769	**0.317***
Till/m				-	0.1983	0.2347	-0.1574	0.497**	0.1936	-0.2322	0.3522*	-0.4102*	-0.3084*	-0.3432*	0.145	0.0735	0.403**	0.2994*	**0.8139****
SL					-	0.6532	-0.402**	0.421**	0.2486	0.0814	0.3421*	-0.3383*	0.2023	-0.6914**	0.071	0.487**	-0.2384	-0.394**	**0.6771****
Gr/Sp						-	-0.526**	0.2564	0.1179	0.0207	0.2002	-0.2243	0.1146	-0.5185**	0.2496	0.2482	0.0276	-0.1583	**0.6886****
TGW							-	-0.593**	-0.2458	-0.0417	-0.3928*	0.441*	0.1592	0.4292**	0.0717	0.0086	0.421**	-0.0269	**-0.3972****
PR								-	0.614**	0.0885	0.861**	-0.8834**	-0.1987	-0.5064**	0.1531	-0.0267	0.0399	0.1621	**0.5913****
TR									-	0.2722*	0.554**	-0.5865**	-0.1003	-0.1208	0.2131	-0.014	0.2735*	0.2059	**0.3078***
PAR										-	-0.0338	0.0016	0.3441*	-0.3767**	0.2424	-0.2651	-0.1944	0.0522	**-0.0973**
SC											-	-0.9631**	-0.2825*	-0.2524	0.0794	-0.0159	0.068	0.0658	**0.4897****
SR												-	0.2375	0.2939*	-0.0364	0.0313	-0.0614	0.0002	**-0.4915****
CT													-	-0.0771	-0.0144	0.0751	-0.312*	-0.3625*	**-0.1673**
MII														-	-0.055	-0.355	0.1872	0.2247	**-0.6055****
Prot.															-	-0.1184	0.462**	0.2775*	**0.1404**
SV																-	0.1555	-0.716**	**0.2638**
HW																	-	0.2978*	**0.3116***
WGC																		-	**0.0585**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.6.2 : Phenotypic correlation coefficient among nineteen characters under late sown irrigated (LSI) conditions at Savalvihir.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.443 **	0.1696	0.363 *	0.456 **	0.623 **	-0.633**	0.501 **	0.368 *	-0.1099	0.445 **	-0.506**	-0.1931	-0.3993 **	0.0116	0.0747	-0.1052	0.104	**0.4997***
Matu.		-	0.166	0.1458	0.1871	0.2296	-0.319*	0.407 **	0.315 *	0.1282	0.473 **	-0.473**	0.0002	-0.2656	0.0755	-0.1401	-0.2016	0.1896	**0.1916**
PH			-	0.0049	0.1417	0.0456	0.1395	-0.0564	0.1528	-0.0405	-0.0685	0.0966	0.0399	0.039	0.0166	-0.2018	0.0723	0.0793	**0.2951***
Till/m				-	0.2045	0.1312	-0.1219	0.389 **	0.1578	-0.1927	0.2918 *	-0.342**	-0.2083	-0.2871 *	0.1308	0.0685	0.317 *	0.2574	**0.5357***
SL					-	0.477**	-0.296 *	0.310 *	0.1698	0.0716	0.2548	-0.260 *	0.173	-0.5500 **	0.0477	0.2341	-0.1567	-0.292 *	**0.461***
Gr/Sp						-	-0.366**	0.2124	0.0868	0.0071	0.141	-0.1744	0.1105	-0.4049 **	0.1814	0.2051	-0.0095	-0.111	**0.3874***
TGW							-	-0.547**	-0.2292	-0.0399	-0.376**	0.417 **	0.1348	0.4122 **	0.0559	0.029	0.355 *	-0.0292	**-0.2563**
PR								-	0.585 **	0.0829	0.815 **	-0.833**	-0.175	-0.4874 **	0.1096	0.0204	0.0513	0.1452	**0.4425***
TR									-	0.2611	0.537**	-0.569**	-0.0806	-0.1175	0.2012	0.0396	0.2472 *	0.2003	**0.2325**
PAR										-	-0.0291	-0.003	0.308*	-0.3751 **	0.2155	-0.191	-0.1786	0.0453	**-0.0789**
SC											-	-0.961**	-0.268	-0.2487	0.0774	-0.0353	0.0619	0.0711	**0.3922***
SR												-	0.2274	0.2898 *	-0.0386	0.0431	-0.0558	-0.0062	**-0.3881***
CT													-	-0.0703	-0.0061	0.1081	-0.295 *	-0.321**	**-0.1441**
MII														-	-0.0493	-0.2343	0.1734	0.2176	**-0.4633***
Prot.															-	0.0093	0.353 *	0.2326	**0.0402**
SV																-	0.0252	-0.469**	**0.0516**
HW																	-	0.2443	**0.2827***
WGC																		-	**0.0547**

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.7.1: Genotypic correlation coefficient among nineteen characters pooled over environments.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.815**	0.2797	0.2509	0.6768**	0.906**	-0.5717**	0.2444	0.3977**	0.2125	0.3406*	-0.3992**	-0.3044*	-0.7607**	0.0422	-0.0421	0.1111	-0.369*	**0.7265****
Matu.		-	0.5273**	0.4226*	0.6577**	0.763**	-0.2445	0.6074**	0.1415	0.0651	0.7239*	-0.732**	-0.5573**	-0.4525**	-0.0769	0.0263	0.3289*	-0.369	**0.8532****
PH			-	0.551**	0.3643*	0.1464	0.2753	0.5824**	-0.1356	-0.1703	0.5761**	-0.5095**	-0.649**	0.1873	-0.7186	0.502**	0.376*	-0.538**	**0.8083****
Till/m				-	0.2774*	0.202	0.0968	0.8414**	-0.2056	-0.2279	0.7736**	-0.7682**	-0.6939**	0.176	-0.2836*	0.402**	0.4439*	-0.045	**0.6275****
SL					-	0.821**	-0.1736	0.5119**	0.2252	0.2897*	0.4613**	-0.4921	-0.1578	-0.6302**	-0.338*	0.476**	0.0923	-0.289*	**0.6131****
Gr/Sp						-	-0.5682**	0.3203*	0.5275**	0.2175	0.4581**	-0.506**	-0.1869	-0.849**	-0.0211	0.1614	-0.0067	-0.4041	**0.6411***
TGW							-	0.0922	-0.344*	0.1182	0.0169	0.0784	-0.1142	0.732**	-0.2064	-0.0299	0.5898**	0.2218	**-0.1173**
PR								-	-0.2401	-0.2212	0.8607**	-0.8595**	-0.5105**	-0.0693	-0.416**	0.5362**	0.2373	-0.1789	**0.6827***
TR									-	0.4623*	0.0794	-0.1674	-0.0269	-0.54**	-0.0562	0.1263	-0.2864	-0.4813*	**0.1664**
PAR										-	-0.1259	0.0708	0.2092	-0.1092	-0.0425	-0.0338	0.0493	-0.0742	**-0.1093**
SC											-	-0.9897**	-0.7468**	-0.0347	-0.386**	0.5651**	0.1993	-0.473	**0.771****
SR												-	0.6953**	0.1373	0.3553*	-0.5515**	-0.1379	0.4362*	**-0.7509****
CT													-	-0.228	0.2842*	-0.2838*	-0.401**	0.415*	**-0.7532****
MII														-	-0.1762	-0.11	0.3325*	0.1813	**-0.2797***
Prot.															-	-0.7714**	0.1663	0.717**	**-0.478****
SV																-	-0.3797	-0.543**	**0.3752****
HW																	-	0.302*	**0.3378***
WGC																		-	**-0.6118****

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.4.7.2 : Phenotypic correlation coefficient among nineteen characters pooled environments.

Char.	Flow.	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	-	0.531 **	0.1722	0.2535	0.501 **	0.695**	-0.560 **	0.2060	0.315 *	0.0165	0.2283	-0.2638	-0.2146	-0.4121 **	-0.1705	0.0438	0.002	-0.2471	**0.4707****
Matu.		-	0.349 **	0.1341	0.419 **	0.412**	-0.1566	0.2827	0.1493	0.0234	0.2713	-0.3133 *	-0.3573 *	-0.2224	-0.014	-0.0549	0.0546	-0.088	**0.3492***
PH			-	0.2152	0.294 **	0.0844	0.1771	0.2641	0.0412	-0.1321	0.2077	-0.1943	-0.3252*	0.0405	-0.2101	0.0636	0.1709	-0.1297	**0.4509***
Till/m				-	0.2043	0.1717	-0.07	0.531 **	0.0367	-0.1118	0.396**	-0.4253 **	-0.2797	-0.2575	-0.1957	0.1330	0.2369	-0.1225	**0.4924****
SL					-	0.563 **	-0.1951	0.2258	0.1173	0.0693	0.1879	-0.2139 **	-0.0553	-0.3869 **	-0.1982	0.1745	-0.0252	-0.2302	**0.4112***
Gr/Sp						-	-0.487**	0.1794	0.306 *	0.0957	0.1932	-0.2334	-0.0521	-0.4253 **	0.03	0.0061	-0.0305	-0.2229	**0.3968****
TGW							-	-0.0108	-0.2414	0.0191	-0.0271	0.0852	-0.0353	0.3637 *	-0.0402	0.075	0.3783 **	0.0941	**-0.1624**
PR								-	0.0809	-0.1163	0.737 **	-0.7258 **	-0.3191 *	-0.2458	-0.2128	0.095	0.2385	-0.0726	**0.4555****
TR									-	0.2499	0.2276	-0.2907 *	-0.004	-0.2561	-0.0651	0.0065	-0.0735	-0.1822	**0.0873**
PAR										-	-0.0929	0.074	0.1512	-0.1321	0.0323	-0.1010 *	0.0058	0.0211	**-0.0871**
SC											-	-0.952 **	-0.386**	-0.2024	-0.1607	0.0535	0.1848	-0.1489	**0.3834****
SR												-	0.3660 *	0.245 **	0.1428	-0.0537	-0.120	0.1508	**-0.3729****
CT													-	-0.1342	0.1212	-0.1026	-0.2374	0.1670	**-0.3849****
MII														-	-0.0388	0.0025	0.0688	0.2129	**-0.3854****
Prot.															-	-0.452 **	0.1648	0.4387 **	**-0.1749**
SV																-	-0.0584	-0.305 *	**0.0746**
HW																	-	0.2063	**0.2378**
WGC																		-	**-0.2889***

*** Significant at 5% level, ** Significant at 1% level**

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.1.1: Genotypic path coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Niphad.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.9933**	0.6379	-0.0191	-0.1033	0.1758	-0.1184	0.1737	-0.0007	0.4974	0.0921	0.1421	0.0020	-0.1538	-0.0223	-0.0423	-0.0004	0.4748	-0.1835	**0.5587****
Matu.	-1.2247	**0.1450**	-0.0514	0.0468	0.7172	-0.0674	0.7944	-0.0019	-0.0162	-0.1251	0.1181	0.0013	-0.0789	-0.0157	0.1435	-0.2037	0.3630	-0.0051	**0.5393****
PH	-0.4575	0.3540	**-0.1663**	-0.1072	0.5505	-0.0121	-0.3666	-0.0022	0.4482	0.0907	-0.1587	-0.0018	0.0084	0.0043	-0.0367	-0.1132	0.2153	0.0296	**0.2786**
Till/m	-0.7826	-0.1018	-0.0338	**-0.5270**	0.6460	-0.0233	0.5690	-0.0033	-0.0005	0.2821	0.0107	0.0009	0.2578	-0.0018	-0.0764	0.0157	-0.0666	0.0208	**0.186**
SL	-1.7121	0.4743	-0.0529	-0.1967	**0.7312**	-0.1100	1.4396	0.0008	0.1759	0.1092	0.1032	0.0016	-0.2097	-0.0248	-0.1496	-0.1062	0.7529	-0.3437	**0.8829****
Gr/Sp	-0.9316	0.4762	-0.0124	-0.0757	0.1748	**-0.1621**	0.8778	-0.0008	0.0904	0.1438	0.0480	0.0007	-0.2272	-0.0218	0.0474	-0.2731	0.5591	-0.1745	**0.5551****
TGW	1.2882	-0.3446	-0.0231	0.1136	-0.9441	0.1153	**-0.6399**	0.0010	-0.3767	0.0642	-0.0044	-0.0004	0.1929	0.0207	-0.0262	0.1781	-0.3197	0.1437	**-0.5611****
PR	0.1950	-0.1564	0.0265	0.1250	0.0977	0.0089	-0.1838	**0.0141**	0.1440	0.1440	0.4619	0.0048	-0.0123	-0.0095	-0.0238	-0.1538	-0.5927	-0.0096	**0.0801**
TR	-1.3363	-0.0124	-0.0501	0.0002	0.2048	-0.0099	0.6690	0.0014	**1.4864**	-0.1528	0.0588	0.0015	-0.2080	-0.0186	-0.0836	-0.3372	-0.0329	0.0254	**0.2057**
PAR	0.3937	0.1533	0.0161	0.1591	-0.2023	0.0250	0.1816	-0.0022	0.2432	**-0.9340**	-0.1591	-0.0017	-0.2690	-0.0058	-0.0146	-0.0723	0.2280	0.0810	**-0.1798**
SC	-0.9013	0.2148	0.0419	-0.0090	0.2840	-0.0124	0.0183	0.0103	0.1388	0.2361	**0.6294**	0.0065	0.1580	-0.0146	0.0828	-0.1220	-0.6279	0.0541	**0.1879**
SR	1.2210	-0.2166	-0.0459	0.0732	-0.4216	0.0172	-0.1567	-0.0100	-0.3425	-0.2338	-0.6139	**-0.0067**	-0.1242	0.0191	-0.0805	0.2038	0.5204	-0.0561	**-0.2538**
CT	-0.9561	0.1406	0.0022	0.2115	0.5652	-0.0573	0.7926	0.0003	0.4812	-0.3911	-0.1548	-0.0013	**-0.6424**	-0.0216	-0.1294	-0.2808	0.5992	-0.2163	**-0.0582**
MII	1.9375	-0.3905	-0.0155	0.0207	-0.9334	0.0770	-1.1874	-0.0029	-0.6003	0.1169	-0.1994	-0.0028	0.3012	**0.0460**	0.0272	0.3785	-0.2010	0.2375	**-0.3907****
Prot.	0.3620	0.3521	0.0131	0.0863	-0.5552	-0.0165	0.1480	-0.0007	-0.2664	0.0292	0.1117	0.0012	0.1782	0.0027	**0.4666**	-0.6832	-0.4313	0.2897	**0.0873**
SV	0.0012	-0.1753	0.0141	-0.0062	-0.1382	0.0333	-0.3534	-0.0016	-0.3767	0.0508	-0.0577	-0.0010	0.1355	0.0131	-0.2396	**1.3306**	-0.2401	-0.1029	**-0.1142**
HW	1.3251	-0.2905	0.0250	-0.0245	-0.9110	0.0634	-0.5898	0.0058	0.0341	0.1489	0.2762	0.0024	0.2690	0.0065	0.1406	0.2233	**-1.4308**	0.2642	**-0.4621****
WGC	1.3252	-0.0106	-0.0089	-0.0199	-1.0759	0.0512	-0.6861	-0.0002	0.0682	-0.1368	0.0616	0.0007	0.2512	0.0197	0.2444	-0.2476	-0.6835	**0.5531**	**-0.2944****

Residual effect=0.2419

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.1.2: Phenotypic path coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Niphad.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.3597**	0.0531	0.0082	0.0067	0.0533	0.112	0.3337	-0.002	0.1134	0.0014	0.1385	-0.1339	-0.0923	0.0246	-0.0135	0.0012	0.1072	0.0637	**0.4156****
Matu.	-0.1764	**0.1083**	0.0292	-0.0018	0.0348	0.0611	0.1167	-0.0047	-0.0044	-0.0016	0.1174	-0.0969	-0.0385	0.0165	0.0406	-0.0106	0.0961	0.0014	**0.2872**
PH	-0.0296	0.0318	**0.0992**	0.0098	0.0244	0.0098	-0.0471	-0.0062	0.0872	0.0016	-0.1419	0.113	0.0188	-0.0045	-0.0099	-0.0054	0.0475	-0.0077	**0.1908**
Till/m	-0.0528	-0.0042	0.0213	**0.0458**	0.0267	0.0084	0.0743	-0.0072	0.0016	0.0026	-0.0051	-0.0141	0.1283	0.0017	-0.0123	0.0049	-0.0223	-0.0006	**0.1971**
SL	-0.1997	0.0392	0.0252	0.0128	**0.096**	0.0917	0.1884	0.0029	0.0521	0.0011	0.0557	-0.0625	-0.1079	0.0232	-0.0306	0.0015	0.1633	0.0924	**0.4447****
Gr/Sp	-0.2436	0.04	0.0059	0.0023	0.0532	**0.1654**	0.2762	-0.0023	0.0175	0.0024	0.0504	-0.0565	-0.129	0.0235	0.0093	-0.0137	0.1183	0.058	**0.3772****
TGW	0.2793	-0.0294	0.0109	-0.0079	-0.0421	-0.1063	**-0.4297**	0.0025	-0.0808	0.001	-0.0123	0.0344	0.1138	-0.0229	-0.0061	0.0112	-0.0807	-0.0462	**-0.4114****
PR	0.0163	-0.0117	-0.014	-0.0076	0.0063	-0.0087	-0.0244	**0.0437**	0.0421	0.0023	0.4449	-0.3074	-0.0085	0.0101	-0.0052	-0.0073	-0.1461	-0.0039	**0.0209**
TR	-0.1122	-0.0013	0.0238	0.0002	0.0137	0.008	0.0955	0.0051	**0.3636**	-0.0019	0.0459	-0.0827	-0.1168	0.0191	-0.0222	-0.0139	-0.0296	-0.0065	**0.1879**
PAR	0.034	0.0111	-0.0104	-0.0077	-0.0071	-0.0257	0.0273	-0.0066	0.0465	**-0.0152**	-0.1474	0.1058	-0.1488	0.0061	-0.0011	-0.0039	0.0598	-0.0246	**-0.1077**
SC	-0.0759	0.0194	-0.0214	-0.0004	0.0081	0.0127	0.008	0.0296	0.0254	0.0034	**0.6567**	-0.4866	0.0918	0.0159	0.0223	-0.008	-0.154	-0.02	**0.127**
SR	0.0932	-0.0203	0.0217	-0.0012	-0.0116	-0.0181	-0.0286	-0.026	-0.0582	-0.0031	-0.6181	**0.517**	-0.0709	-0.0192	-0.0191	0.0132	0.1124	0.0197	**-0.1173**
CT	-0.0835	0.0105	-0.0047	-0.0148	0.0261	0.0537	0.123	0.0009	0.1068	-0.0057	-0.1517	0.0922	**-0.3975**	0.0237	-0.0352	-0.0163	0.1612	0.0727	**-0.0387**
MII	0.1697	-0.0343	0.0085	-0.0015	-0.0427	-0.0747	-0.189	-0.0084	-0.1337	0.0018	-0.2005	0.1911	0.1811	**-0.0521**	0.0078	0.0219	-0.0517	-0.0828	**-0.2895***
Prot.	0.0344	0.0311	-0.007	-0.004	-0.0207	0.0109	0.0184	-0.0016	-0.057	0.0001	0.1037	-0.07	0.0989	-0.0029	**0.1414**	-0.0387	-0.0899	-0.0987	**0.0485**
SV	-0.0051	-0.0134	-0.0063	0.0026	0.0017	-0.0264	-0.0561	-0.0037	-0.059	0.0007	-0.0613	0.0796	0.0756	-0.0133	-0.0638	**0.0858**	-0.0565	0.0316	**-0.0873**
HW	0.0933	-0.0252	-0.0114	0.0025	-0.0379	-0.0473	-0.0839	0.0154	0.026	0.0022	0.2445	-0.1405	0.1549	-0.0065	0.0307	0.0117	**-0.4135**	-0.0785	**-0.2634**
WGC	0.1149	-0.0008	0.0038	0.0001	-0.0445	-0.0481	-0.0996	0.0009	0.0118	-0.0019	0.066	-0.0511	0.1451	-0.0216	0.07	-0.0136	-0.163	**-0.1992**	**-0.2307**

Residual effect=0.7282

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.2.1: Genotypic path coefficient among Nineteen characters under late sown irrigated (LSI) conditions at Niphad.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.1956**	0.0556	-0.0008	-0.0064	-0.2065	0.3523	-0.2115	0.2317	-0.2189	0.3112	-0.0473	-0.0312	-0.2159	0.1977	0.0413	0.0037	0.1627	-0.0113	**0.602****
Matu.	0.0904	**0.1202**	0.0042	0.0357	-0.2108	0.195	-0.0879	0.3542	-0.2204	0.1777	-0.1213	-0.1281	-0.1736	0.1595	0.0112	-0.0007	0.1993	-0.0032	**0.4016****
PH	-0.0074	0.0229	**0.0223**	0.0038	-0.0965	-0.0404	0.0392	0.0081	0.1679	0.2204	0.0011	0.0095	0.0404	-0.022	0.0117	0.0032	0.0298	-0.0289	**0.3852****
Till/m	0.0075	-0.0258	-0.0005	**-0.1662**	0.1789	-0.0861	-0.0206	-0.0851	0.0573	0.331	0.0805	0.0669	0.0537	0.1089	0.1801	0.0026	-0.1422	-0.061	**0.4799****
SL	0.111	0.0697	0.0059	0.0817	**-0.3639**	0.2849	-0.0998	0.1484	-0.157	0.418	-0.0738	-0.0777	-0.145	0.1255	0.0182	-0.014	0.2974	-0.131	**0.4987****
Gr/Sp	0.158	0.0537	-0.0021	0.0328	-0.2376	**0.4362**	-0.2231	0.3112	-0.374	0.1829	-0.0809	-0.094	-0.2125	0.2171	-0.0991	0.0037	0.2327	0.0091	**0.3141***
TGW	-0.1534	-0.0392	0.0032	0.0127	0.1346	-0.3609	**0.2697**	-0.3798	0.3009	-0.3024	0.1075	0.1014	0.1446	-0.2288	0.0815	-0.0072	-0.1361	-0.0377	**-0.4893****
PR	0.0588	0.0552	0.0002	0.0183	-0.07	0.176	-0.1328	**0.7714**	-0.3092	0.0742	-0.2935	-0.2717	-0.0923	0.2437	0.0137	0.0135	0.0668	0.0772	**0.3993****
TR	0.0619	0.0383	-0.0054	0.0138	-0.0827	0.2361	-0.1174	0.3451	**-0.6912**	-0.1519	-0.0616	-0.1151	-0.0755	0.1963	0.0634	-0.0017	0.1558	0.0531	**-0.1386**
PAR	-0.065	-0.0228	-0.0053	0.0588	0.1625	-0.0852	0.0871	-0.0611	-0.1121	**-0.9361**	0.0355	0.0265	0.1295	-0.1168	-0.0412	0.0117	-0.0884	0.183	**-0.8394****
SC	0.024	0.0378	-0.0001	0.0347	-0.0696	0.0914	-0.0752	0.5869	-0.1105	0.086	**-0.3857**	-0.3333	0.0032	0.0698	0.0273	0.0082	0.1008	0.0468	**0.1426**
SR	-0.0172	-0.0434	0.0006	-0.0313	0.0797	-0.1157	0.0771	-0.5911	0.2243	-0.0701	0.3625	**0.3546**	0.0092	-0.1221	-0.011	-0.0067	-0.1266	-0.0233	**-0.0505**
CT	-0.1188	-0.0587	0.0025	-0.0251	0.1485	-0.2609	0.1098	-0.2003	0.1468	-0.3412	-0.0035	0.0092	**0.3554**	-0.0841	0.0759	0.0049	-0.1188	0.0298	**-0.3288***
MII	-0.0787	-0.0391	0.001	0.0368	0.093	-0.1929	0.1257	-0.3828	0.2762	-0.2227	0.0549	0.0881	0.0608	**-0.4911**	-0.0145	0.0027	-0.0764	0.0411	**-0.7178****
Prot.	-0.0186	-0.0031	-0.0006	0.0691	0.0153	0.0997	-0.0507	-0.0243	0.1012	-0.089	0.0243	0.009	-0.0622	-0.0164	**-0.4334**	0.016	-0.0344	0.0885	**-0.3097***
SV	-0.0183	0.0022	-0.0018	0.011	-0.1282	-0.041	0.0487	-0.262	-0.0303	0.2765	0.0799	0.06	-0.0439	0.0329	0.1752	**-0.0396**	0.1433	-0.1606	**0.1042**
HW	-0.0813	-0.0612	-0.0017	-0.0603	0.2763	-0.2592	0.0937	-0.1315	0.275	-0.2113	0.0992	0.1146	0.1078	-0.0958	-0.0381	0.0145	**-0.3916**	0.1103	**-0.2405**
WGC	-0.0068	-0.0012	-0.002	0.0313	0.1474	0.0123	-0.0315	0.1841	-0.1135	-0.5299	-0.0558	-0.0256	0.0327	-0.0624	-0.1186	0.0197	-0.1336	**0.3233**	**-0.3301***

Residual effect=0.3285

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.2.2 : Phenotypic path coefficient among nineteen characters under late sown irrigated (LSI) conditions at Niphad.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.2696**	0.0273	-0.0015	0.009	-0.0144	0.2173	-0.343	0.1307	-0.0212	0.1081	0.0469	-0.0534	-0.1049	0.0784	-0.0099	-0.0078	0.0132	0.0001	**0.3442***
Matu.	0.1117	**0.0658**	0.0293	-0.0424	-0.0147	0.1261	-0.1406	0.1865	-0.02	0.0602	0.1252	-0.2389	-0.0819	0.0619	-0.0019	-0.0021	0.016	0.0002	**0.240***
PH	-0.0026	0.0125	**0.1545**	0.0032	-0.0072	-0.0179	0.076	0.0059	0.0143	0.073	-0.0012	0.0218	0.0156	-0.0081	-0.0006	-0.0039	0.0008	-0.0001	**0.3362***
Till/m	0.0106	-0.0121	0.0022	**0.2302**	0.0093	-0.0516	-0.0327	-0.0351	0.0034	0.0891	-0.073	0.1212	0.0159	0.0355	-0.0387	-0.004	-0.0111	-0.0002	**0.2588**
SL	0.1293	0.0324	0.0371	-0.0715	**-0.0299**	0.1751	-0.1384	0.0789	-0.0132	0.1296	0.0668	-0.1303	-0.0642	0.0459	-0.0046	0.0184	0.0206	-0.0004	**0.2816**
Gr/Sp	0.1895	0.0268	-0.009	-0.0384	-0.017	**0.309**	-0.3388	0.1615	-0.0332	0.0582	0.0817	-0.1746	-0.0954	0.0812	0.0225	-0.0067	0.0196	0.0001	**0.237**
TGW	-0.2008	-0.0201	0.0255	-0.0164	0.009	-0.2273	**0.4605**	-0.2063	0.0286	-0.1001	-0.1127	0.1913	0.0688	-0.091	-0.0186	0.012	-0.0123	-0.0001	**-0.2099**
PR	0.0767	0.0267	0.002	-0.0176	-0.0051	0.1087	-0.207	**0.459**	-0.0293	0.027	0.2987	-0.5006	-0.0442	0.096	-0.0025	-0.022	0.0056	0.0002	**0.2723**
TR	0.0836	0.0193	-0.0323	-0.0114	-0.0058	0.1503	-0.193	0.1973	**-0.0683**	-0.0522	0.0657	-0.2129	-0.038	0.0782	-0.0157	0.0009	0.0126	0.0002	**-0.0216**
PAR	-0.0875	-0.0119	-0.0339	-0.0616	0.0117	-0.054	0.1384	-0.0372	-0.0107	**-0.3331**	-0.0369	0.0474	0.0639	-0.0466	0.0099	-0.0188	-0.0072	0.0006	**-0.4675****
SC	0.0304	0.0198	-0.0004	-0.0405	-0.0048	0.0608	-0.125	0.3303	-0.0108	0.0296	**0.4151**	-0.6446	-0.0005	0.028	-0.0082	-0.0148	0.0081	0.0002	**0.0727**
SR	-0.0209	-0.0228	0.0049	0.0406	0.0057	-0.0785	0.1281	-0.3342	0.0211	-0.023	-0.3892	**0.6876**	0.006	-0.0487	0.0042	0.0124	-0.0105	-0.0001	**-0.0173**
CT	-0.154	-0.0293	0.0131	0.0199	0.0105	-0.1606	0.1727	-0.1105	0.0141	-0.116	-0.0011	0.0223	**0.1836**	-0.033	-0.0147	-0.0088	-0.0092	0.0001	**-0.2008**
MII	-0.1054	-0.0203	0.0062	-0.0408	0.0069	-0.1252	0.2091	-0.2197	0.0266	-0.0774	-0.0579	0.1672	0.0302	**-0.2005**	0.0032	-0.0041	-0.0062	0.0001	**-0.4079**
Prot.	-0.0239	-0.0011	-0.0008	-0.0799	0.0012	0.0622	-0.0766	-0.0103	0.0096	-0.0294	-0.0306	0.026	-0.0242	-0.0058	**0.1116**	-0.0249	-0.0017	0.0003	**-0.0981**
SV	-0.026	-0.0017	-0.0074	-0.0114	-0.0068	-0.0255	0.0682	-0.1251	-0.0008	0.0777	-0.0761	0.1056	-0.0201	0.0102	-0.0344	**0.0808**	0.0108	-0.0005	**0.0176**
HW	-0.0991	-0.0293	-0.0037	0.0711	0.0172	-0.1688	0.1577	-0.0722	0.0239	-0.0673	-0.0943	0.2015	0.0469	-0.035	0.0052	-0.0244	**-0.0358**	**0.0003**	**-0.106**
WGC	-0.0098	0.001	-0.0111	-0.0351	0.0098	0.0095	-0.0467	0.0798	-0.009	-0.1642	0.0553	-0.0463	0.0146	-0.0231	0.023	-0.0316	-0.0103	0.0012	**-0.193**

Residual effect=0.6873

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.3.1: Genotypic path coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Rahuri.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.7186**	-0.0487	-0.0688	0.0471	-0.3064	0.1684	0.0148	-0.0568	-0.2445	-0.0955	-0.4592	0.4633	0.1812	0.2924	0.0021	0.0119	-0.1517	0.0196	**0.4877****
Matu.	0.414	**-0.0846**	0.0767	-0.0226	-0.2785	0.0957	0.0081	0.1513	-0.2189	-0.0215	-1.0928	1.0713	0.1429	0.1532	-0.0019	0.0171	-0.2191	-0.1544	**0.0361**
PH	-0.0613	-0.008	**0.8068**	-0.0093	-0.086	-0.0182	-0.0065	-0.1264	-0.2074	0.05	0.0045	0.0695	-0.1068	-0.027	0.0022	-0.0364	0.1192	-0.0309	**0.328***
Till/m	0.157	0.0089	-0.035	**0.2155**	0.2251	-0.0236	0.0014	-0.4993	-0.0257	0.1105	1.2933	-1.3354	-0.082	0.1734	-0.0006	0.0192	0.3637	-0.0016	**0.5647****
SL	0.3632	-0.0389	0.1144	-0.08	**-0.6062**	0.14	0.0058	0.2715	-0.0711	-0.1969	-1.2163	1.3413	0.2145	0.3228	0.0036	-0.0444	-0.4163	0.0914	**0.1985**
Gr/Sp	0.5619	-0.0376	-0.0682	-0.0236	-0.394	**0.2153**	0.0128	0.0294	-0.3601	-0.2203	-0.4277	0.5168	0.2115	0.3226	0.0009	0.026	-0.0534	0.0547	**0.3671****
TGW	-0.5156	0.0334	0.2537	-0.0149	0.1705	-0.1343	**-0.0206**	-0.1117	0.1924	0.2378	0.7881	-0.8148	-0.1864	-0.1839	0.0011	-0.0676	0.2356	0.0501	**-0.087**
PR	0.0583	0.0183	0.1457	0.1537	0.2351	-0.0091	-0.0033	**-0.6999**	-0.0986	0.1311	1.8848	-1.758	-0.0872	0.1334	0.0009	0.0338	0.4226	0.0898	**0.6514****
TR	0.2042	-0.0215	0.1944	0.0064	-0.0501	0.0901	0.0046	-0.0802	**-0.8607**	-0.1187	0.2283	-0.1133	0.2449	0.1931	0.0022	-0.0179	0.2108	0.0184	**0.1351**
PAR	0.1249	-0.0033	-0.0735	-0.0434	-0.2172	0.0864	0.0089	0.167	-0.186	**-0.5493**	-0.6789	0.7968	0.2396	0.2297	-0.0019	0.0577	-0.127	0.0465	**-0.123**
SC	-0.1291	0.0361	0.0014	0.109	0.2884	-0.036	-0.0063	-0.516	-0.0768	0.1459	**0.5567**	0.5651	-0.0769	0.0289	0.0005	0.0098	0.558	0.0175	**0.3458***
SR	0.1269	-0.0345	0.0214	-0.1097	-0.3098	0.0424	0.0064	0.4689	0.0372	-0.1668	0.499	**0.6243**	0.08	-0.0217	0.0006	-0.0125	-0.5849	0.0135	**-0.3175**
CT	0.2913	-0.027	-0.1929	-0.0395	-0.291	0.1019	0.0086	0.1366	-0.4717	-0.2945	-0.4401	0.4699	**0.4469**	0.3893	0.0009	-0.0081	-0.2459	0.1115	**-0.0538**
MII	-0.3416	0.0211	0.0354	-0.0608	0.3182	-0.113	-0.0062	0.1518	0.2702	0.2051	-0.1199	0.0928	-0.2828	**-0.6151**	0.0001	-0.0398	0.041	-0.1341	**-0.5776****
Prot.	-0.1322	-0.0139	-0.1546	0.0108	0.1902	-0.0179	0.002	0.0535	0.1661	-0.0903	-0.1038	-0.138	-0.0354	0.0034	**-0.0114**	0.1432	0.1454	-0.2146	**-0.1975**
SV	-0.0464	0.0078	0.1588	-0.0223	-0.1454	-0.0302	-0.0075	0.1281	-0.0832	0.1715	-0.1353	0.177	0.0195	-0.1323	0.0089	**-0.185**	-0.1657	0.1166	**-0.1652**
HW	-0.127	0.0216	0.112	0.0913	0.294	-0.0134	-0.0056	-0.3446	-0.2114	0.0813	1.6621	-1.7883	-0.128	-0.0294	-0.0019	0.0357	**0.8583**	-0.0111	**0.4956****
WGC	-0.0387	-0.036	0.0686	0.001	0.1526	-0.0324	0.0028	0.1731	0.0437	0.0703	-0.1232	-0.0974	-0.1373	-0.2272	-0.0068	0.0594	0.0263	**-0.363**	**-0.4642****

Residual effect=0.3129

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.3.2: Phenotypic path coefficient among nineteen characters under timely sown (TSI) irrigated conditions at Rahuri.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.2521**	-0.0633	-0.0091	0.0617	0.0777	0.1474	-0.104	0.003	-0.0376	-0.0403	-0.0015	0.032	0.0086	0.0643	0.0268	0.0288	-0.0574	0.0075	**0.3965****
Matu.	0.1344	**-0.1187**	0.0157	-0.0294	0.0639	0.0799	-0.0524	-0.007	-0.031	-0.0059	-0.0031	0.068	0.0065	0.0324	-0.0257	0.0243	-0.093	-0.0603	**-0.0012**
PH	-0.0126	-0.0102	**0.1823**	-0.0098	0.025	-0.0107	0.043	0.0061	-0.0274	0.0227	-0.0001	0.0081	-0.004	-0.0056	0.0266	-0.0513	0.0582	-0.0067	**0.2335**
Till/m	0.0533	0.0119	-0.0061	**0.2918**	-0.0452	-0.0135	-0.0085	0.0219	-0.0066	0.0351	0.0034	-0.0764	-0.0044	0.0332	-0.0074	0.0457	0.1505	-0.0071	**0.4717****
SL	0.1144	-0.0443	0.0266	-0.0771	**0.171**	0.1105	-0.0366	-0.0127	-0.0079	-0.0752	-0.0029	0.0728	0.0095	0.0656	0.0412	-0.07	-0.1596	0.032	**0.1575**
Gr/Sp	0.1798	-0.0459	-0.0094	-0.019	0.0915	**0.2066**	-0.082	-0.0005	-0.0521	-0.071	-0.0015	0.0378	0.0095	0.0658	0.0102	0.0371	-0.0008	0.0154	**0.3715***
TGW	-0.1734	0.0412	0.0518	-0.0163	-0.0414	-0.1121	**0.1511**	0.0051	0.03	0.0875	0.0023	-0.0509	-0.0092	-0.0398	0.0106	-0.1078	0.0932	0.0225	**-0.0555**
PR	0.0213	0.0231	0.0313	0.179	-0.0606	-0.0031	0.0218	**0.0357**	-0.0157	0.0527	0.005	-0.1056	-0.004	0.0292	0.0105	0.0537	0.1839	0.0334	**0.4917****
TR	0.0724	-0.0281	0.0381	0.0146	0.0103	0.0823	-0.0346	0.0043	**-0.131**	-0.0476	0.0005	-0.0061	0.0119	0.0419	0.0259	-0.0251	0.0937	0.0017	**0.1251**
PAR	0.0434	-0.003	-0.0176	-0.0437	0.0548	0.0626	-0.0564	-0.008	-0.0266	**-0.2345**	-0.0017	0.0418	0.0101	0.0476	-0.0217	0.0965	-0.0563	0.0179	**-0.0947**
SC	-0.0482	0.0475	-0.0033	0.129	-0.0657	-0.0393	0.0447	0.0236	-0.0087	0.0511	**0.0076**	-0.1708	-0.0042	0.0062	0.0015	0.0133	0.2272	0.0067	**0.218**
SR	0.0459	-0.0459	0.0084	-0.127	0.0709	0.0445	-0.0438	-0.0215	0.0046	-0.0559	-0.0074	**0.1756**	0.0043	-0.0047	0.0102	-0.0186	-0.2383	0.007	**-0.1915**
CT	0.0943	-0.0334	-0.0317	-0.0553	0.0704	0.0856	-0.0605	-0.0062	-0.0678	-0.1033	-0.0014	0.0332	**0.023**	0.0827	0.0122	-0.0094	-0.0951	0.0481	**-0.0148**
MII	-0.1177	0.0279	0.0074	-0.0702	-0.0815	-0.0986	0.0436	-0.0076	0.0399	0.0811	-0.0003	0.0059	-0.0138	**-0.1378**	0.0009	-0.0677	0.0164	-0.0571	**-0.4292****
Prot.	-0.0449	-0.0203	-0.0323	0.0144	-0.0469	-0.014	-0.0107	-0.0025	0.0226	-0.0338	-0.0001	-0.012	-0.0019	0.0008	**-0.1505**	0.2314	0.0626	-0.0921	**-0.1299**
SV	-0.0223	0.0089	0.0287	-0.041	0.0368	-0.0236	0.0501	-0.0059	-0.0101	0.0696	-0.0003	0.0101	0.0007	-0.0287	0.1071	**-0.325**	-0.0631	0.0472	**-0.1608**
HW	-0.0368	0.0281	0.027	0.1117	-0.0694	-0.0004	0.0359	0.0167	-0.0312	0.0336	0.0044	-0.1065	-0.0056	-0.0057	-0.024	0.0522	**0.3931**	-0.0121	**0.4108****
WGC	-0.0113	-0.0431	0.0074	0.0124	-0.0329	-0.0192	-0.0205	-0.0072	0.0014	0.0253	-0.0003	-0.0074	-0.0067	-0.0474	-0.0834	0.0922	0.0286	**-0.1661**	**-0.2781***

Residual effect=0.5429

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.4.1 : Genotypic path coefficient among Nineteen characters under late sown (LSI) irrigated conditions at Rahuri.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.9631**	0.8228	-0.0501	-0.0359	0.8138	-0.8036	-0.2144	-0.1901	-0.5518	-0.213	-0.5176	1.0253	-0.1653	0.4047	0.4836	-0.171	-0.3097	-0.8827	**0.408****
Matu.	0.6287	**0.3443**	-0.4438	0.0002	0.3625	-0.2423	-0.113	-0.417	-0.2713	-0.3427	-0.8868	1.1085	-0.3442	0.1529	-0.1998	0.9533	-0.2779	0.1015	**0.1131**
PH	0.0482	0.0835	**-0.8292**	0.001	0.0877	0.286	0.132	-0.0897	0.0585	-0.1899	-0.8179	0.4071	-0.1354	-0.088	0.3158	-0.0574	0.0772	0.6669	**-0.0436**
Till/m	0.5585	-0.0006	0.0162	**-0.1133**	0.2572	-0.4163	0.0382	-0.3753	-0.1351	-0.1167	-0.1906	1.2165	0.0773	0.5024	-0.132	0.0402	0.3332	-0.7696	**0.7903****
SL	0.1554	0.4005	-0.1292	-0.0235	**0.9418**	-0.6402	-0.2482	-0.1307	-0.2545	-0.0126	-0.1288	0.5044	0.218	0.3381	0.1541	-0.1581	-0.5505	-0.0393	**0.3968****
Gr/Sp	0.2792	0.0753	0.4723	-0.0426	-0.1076	**0.7178**	-0.2635	-0.2577	-0.2986	-0.0243	-0.7279	1.685	0.1263	0.3739	-0.3513	-0.059	-0.187	-0.8613	**0.549****
TGW	-0.7706	-0.0793	-0.492	-0.0088	-0.6282	0.5949	**0.4907**	0.0039	0.3134	-0.1119	0.1629	-0.5323	0.1829	-0.1762	0.1909	0.0539	0.4421	0.0423	**-0.3214***
PR	0.399	0.1709	-0.1953	-0.0506	0.1932	-0.3398	-0.0023	**-0.8402**	-0.1904	0.1353	-0.065	1.5653	-0.1266	0.497	-0.3315	0.017	0.0369	-0.2186	**0.6543****
TR	1.345	0.1291	0.1478	-0.0212	0.4369	-0.4572	-0.2126	-0.2212	**-0.7234**	-0.2588	0.402	1.2888	-0.3856	0.1443	0.2751	-0.1077	-0.1892	-0.7035	**0.0846**
PAR	-0.3555	-0.1117	0.3289	0.0125	-0.0148	0.0255	-0.052	-0.1076	0.3773	**0.8563**	0.0102	-0.5637	0.042	0.0833	0.2753	-0.1179	-0.1379	-0.2933	**0.257**
SC	0.2593	0.1846	-0.4251	-0.0383	0.9454	-0.2291	-0.0227	-0.7317	-0.2882	-0.0031	**-0.5193**	1.4973	-0.3032	0.3146	-0.37	0.0514	-0.089	0.094	**0.3269***
SR	-0.3258	-0.1867	0.4638	0.0453	-0.8129	0.3363	0.0471	0.6912	0.2984	0.1073	0.423	**-0.9492**	0.2883	-0.3428	0.5129	-0.9602	0.0891	-0.1008	**-0.3756****
CT	-0.3272	-0.1331	0.2782	-0.0098	0.304	-0.1571	0.1008	0.1194	0.3133	0.0498	0.1984	-0.7964	**0.8906**	-0.0341	-0.3203	0.0285	0.2062	-0.6846	**0.0263**
MII	-0.7021	-0.0688	-0.2103	0.0744	-0.5488	0.5414	0.113	0.5458	0.1365	-0.1151	0.4471	-1.4867	0.0397	**-0.765**	0.255	0.1187	0.1204	0.5896	**-0.9154****
Prot.	-0.503	0.0406	0.3408	-0.0088	-0.1129	-0.2296	-0.0553	-0.1643	0.1174	-0.1716	-0.7682	0.6792	0.1683	0.1151	**-0.6951**	0.1895	0.3538	0.5855	**-0.1185**
SV	0.6795	-0.0413	-0.2365	0.0103	0.4424	-0.1471	-0.0596	0.0322	-0.1755	0.2807	0.408	-0.7524	-0.0572	0.2046	0.7238	**-0.4437**	-0.205	-0.4677	**0.1952**
HW	-0.437	-0.0766	-0.113	-0.0302	-0.5471	0.1657	0.1736	-0.0248	0.4095	-0.1166	0.2506	-0.3956	0.1469	-0.0737	-0.48	0.0728	**0.9495**	0.1075	**-0.0184**
WGC	-0.8294	0.7186	-0.6501	0.3465	-0.6878	0.5084	0.0111	0.0979	0.2712	-0.1651	-0.1763	0.298	-0.3249	-0.2404	-0.5289	0.1106	0.0716	**0.8764**	**-0.2927***

Residual effect=0.3358

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.4.2 : Phenotypic path coefficient among nineteen characters under late sown irrigated (LSI) conditions at Rahuri.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.078**	0.0333	0.0109	0.0877	-0.1157	0.1413	0.1395	0.0318	-0.1222	-0.0113	-0.0046	-0.0345	-0.0045	0.1797	0.0499	-0.0113	-0.0057	0.0145	**0.3007***
Matu.	-0.0237	**0.1093**	0.0425	0.002	-0.0478	0.0381	0.0752	0.0631	-0.0554	-0.0165	-0.0163	-0.0973	-0.009	0.0842	-0.018	0.0039	-0.0047	-0.0003	**0.1293**
PH	-0.0036	0.0196	**0.2375**	-0.0099	0.0002	-0.0404	-0.0769	0.0089	0.015	-0.0092	-0.0065	-0.0413	-0.0038	-0.0488	0.0288	-0.0051	0.0014	-0.0083	**0.0575**
Till/m	-0.0205	0.0007	-0.007	**0.3341**	-0.0363	0.0682	-0.0211	0.0578	-0.0283	-0.0051	-0.0106	-0.0749	0.0018	0.2798	-0.0199	0.0016	0.0062	0.0117	**0.5381****
SL	-0.0449	0.026	-0.0002	0.0604	**-0.201**	0.1067	0.1534	0.0264	-0.0455	0.0004	-0.0013	-0.0144	0.0056	0.1889	0.0146	-0.0087	-0.01	0.0144	**0.2708**
Gr/Sp	-0.0526	0.0198	-0.0457	0.1087	-0.1023	**0.2096**	0.1603	0.0395	-0.0567	-0.0009	-0.0064	-0.056	0.0025	0.2089	-0.0421	-0.0037	-0.0027	0.0121	**0.3926****
TGW	0.0318	-0.024	0.0533	0.0206	0.0899	-0.0981	**-0.3427**	-0.0041	0.0682	-0.0061	0.0017	0.0198	0.0052	-0.1023	0.0196	0.0027	0.0081	-0.0008	**-0.2572**
PR	-0.0162	0.045	0.0138	0.1259	-0.0346	0.0541	0.0092	**0.1533**	-0.0379	0.0068	-0.0274	-0.1538	-0.0031	0.2804	-0.037	0.0006	0.0005	0.0025	**0.3822****
TR	-0.0492	0.0312	-0.0183	0.0489	-0.0472	0.0613	0.1206	0.03	**-0.1938**	-0.0102	-0.0099	-0.0597	-0.008	0.073	0.031	-0.0046	-0.004	0.0122	**0.0035**
PAR	0.0156	-0.0319	-0.0387	-0.0301	-0.0013	-0.0034	0.0366	0.0184	0.0348	**0.0567**	0.0002	0.0207	0.0011	0.0495	0.0311	-0.0072	-0.0027	0.0046	**0.154**
SC	-0.0105	0.0524	0.0454	0.1038	-0.0075	0.0393	0.0175	0.1233	-0.0564	-0.0003	**-0.034**	-0.198	-0.0087	0.1883	-0.0409	0.0035	-0.0016	-0.0018	**0.2139**
SR	0.0132	-0.052	-0.0479	-0.1222	0.0141	-0.0573	-0.0332	-0.1151	0.0564	0.0057	0.0329	**0.2048**	0.0082	-0.2041	0.056	-0.0041	0.0017	0.0022	**-0.2406**
CT	0.0131	-0.037	-0.0341	0.0228	-0.0421	0.0196	-0.0668	-0.0179	0.0579	0.0024	0.0111	0.0631	**0.0267**	-0.0193	-0.0322	0.0011	0.0036	0.0112	**-0.0168**
MII	0.0302	-0.0198	0.0249	-0.2013	0.0817	-0.0943	-0.0754	-0.0925	0.0305	-0.006	0.0138	0.09	0.0011	**-0.4646**	0.0294	0.0082	0.0025	-0.0094	**-0.651****
Prot.	0.019	0.0096	-0.0334	0.0325	0.0143	0.0431	0.0327	0.0276	0.0293	-0.0086	-0.0068	-0.056	0.0042	0.0667	**-0.2052**	0.0121	0.0075	-0.0089	**-0.0202**
SV	-0.0263	-0.0129	0.0361	-0.0162	-0.0524	0.023	0.028	-0.0029	-0.0268	0.0122	0.0036	0.0249	-0.0009	0.1139	0.0745	**-0.0334**	-0.0044	0.0078	**0.1478**
HW	0.0168	-0.0193	0.0122	0.0773	0.0753	-0.0211	-0.1039	0.0032	0.0289	-0.0058	0.002	0.0131	0.0036	-0.0432	-0.0581	0.0055	**0.0266**	-0.0011	**0.0123**
WGC	0.0335	0.0009	0.0587	-0.1158	0.0855	-0.0751	-0.0077	-0.0112	0.0703	-0.0077	-0.0018	-0.0136	-0.0089	-0.1295	-0.0539	0.0077	0.0008	**-0.0338**	**-0.2016**

Residual effect=0.6176

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.5.1: Genotypic path coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Savalvihir.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.4336**	0.1358	0.0115	-0.0619	0.2807	-0.5681	0.8506	0.0285	0.1001	0.0194	-0.4019	0.5751	-0.0333	-0.314	0.0002	0.0023	0.0269	0.2839	**0.5023****
Matu.	-0.2196	**0.2681**	0.0048	-0.002	0.1838	-0.3294	0.3223	-0.0253	-0.0012	-0.0015	0.7198	-0.5819	-0.1864	-0.1272	0.0033	0.0728	-0.0287	-0.0161	**0.0554**
PH	-0.0221	0.0057	**0.2252**	-0.0341	0.2885	-0.0712	-0.1143	-0.0288	0.0918	0.016	-0.5293	0.6789	0.006	0.0076	-0.007	0.0026	0.1343	-0.2341	**0.4159****
Till/m	-0.1666	0.0033	0.0477	**-0.161**	0.2534	-0.1641	0.3085	0.218	0.043	0.0389	-0.7543	1.0374	-0.0844	-0.2996	-0.0075	-0.0821	0.4959	-0.0372	**0.6894****
SL	-0.2396	0.097	0.1279	-0.0803	**0.508**	-0.3627	0.4522	0.0391	0.0296	0.0236	-0.7783	1.0259	-0.0503	-0.3179	-0.0085	-0.0096	0.1382	0.1659	**0.7603****
Gr/Sp	-0.3867	0.1387	0.0252	-0.0415	0.2893	**-0.637**	0.7951	-0.0147	0.1255	0.029	-0.0548	0.1846	0.0872	-0.3126	0.0104	0.0287	0.0465	0.244	**0.5569****
TGW	0.3808	-0.0892	0.0266	0.0513	-0.2372	0.5229	**-0.9685**	-0.0038	-0.0606	-0.0251	0.2797	-0.4289	-0.0211	0.3172	-0.0049	-0.0036	-0.0335	-0.1566	**-0.4546****
PR	-0.0492	-0.027	-0.0258	-0.1396	0.0791	0.0371	0.0147	**0.2515**	0.0051	-0.0214	-0.2702	0.49	-0.059	-0.2046	-0.0096	-0.0208	0.5887	-0.1987	**0.4404****
TR	-0.1392	-0.0011	0.0663	-0.0222	0.0482	-0.2563	0.1882	0.0041	**0.3119**	0.0971	-0.0923	0.1111	0.1683	-0.2698	0.0028	0.0375	-0.1315	0.1532	**0.2764***
PAR	-0.052	-0.0026	0.0223	-0.0387	0.0742	-0.1143	0.1503	-0.0333	0.187	**0.1619**	0.5291	-0.6582	0.1392	-0.1498	-0.0058	-0.0045	-0.4091	0.1912	**-0.0129**
SC	-0.0714	-0.0791	0.0488	-0.1157	0.162	-0.0143	0.111	0.234	0.0118	-0.0351	**-0.4403**	0.6183	0.0076	-0.206	-0.0074	0.0107	0.3935	-0.1822	**0.4463****
SR	0.0929	0.0581	-0.057	0.1222	-0.1942	0.0438	-0.1547	-0.2333	-0.0129	0.0397	0.3805	**-0.6842**	0.0099	0.2585	0.004	-0.0054	-0.4666	0.264	**-0.5346****
CT	0.0254	-0.0877	0.0024	0.0239	-0.0448	-0.0975	0.0359	-0.026	0.0922	0.0395	-0.0326	-0.0465	**0.5696**	-0.0575	0.0013	0.0365	-0.3526	-0.1503	**-0.069**
MII	0.2258	-0.0566	0.0028	0.08	-0.2679	0.3303	-0.5095	-0.0854	-0.1396	-0.0402	0.8337	-1.151	-0.0543	**0.6029**	-0.0077	-0.0113	-0.0549	-0.2307	**-0.5334****
Prot.	-0.0023	0.0198	-0.0357	0.0272	-0.097	-0.1497	0.1071	-0.0545	0.0198	-0.0212	0.4068	-0.2435	0.0169	-0.1044	**0.0443**	0.1384	0.3485	-0.4953	**-0.0747****
SV	0.0036	-0.0692	-0.0021	-0.0469	0.0173	0.0647	-0.0122	0.0186	-0.0415	0.0026	0.0923	-0.0511	-0.0738	0.0241	-0.0218	**-0.282**	0.1014	0.4962	**0.2203**
HW	-0.0115	-0.0076	0.0299	-0.079	0.0694	-0.0293	0.0321	0.1464	-0.0406	-0.0655	-0.9495	1.2385	-0.1986	-0.0327	0.0153	-0.0283	**1.0113**	-0.6842	**0.4162***
WGC	0.0995	0.0035	0.0426	-0.0048	-0.0681	0.1257	-0.1226	0.0404	-0.0386	-0.025	-0.3595	0.5731	0.0692	0.1124	0.0178	0.1132	0.5595	**-1.2367**	**-0.0985****

Residual effect=0.3020

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.5.2 : Phenotypic path coefficient among nineteen characters under timely sown irrigated (TSI) conditions at Savalvihir.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.1314**	-0.0642	0.0141	0.1167	0.0722	0.2164	0.1048	0.0033	0.0036	-0.0149	-0.0466	0.0357	-0.0008	0.0726	-0.0004	0.0015	0.0019	0.0153	**0.3996****
Matu.	-0.0622	**-0.1358**	0.0047	0.0011	0.0413	0.1202	0.039	-0.0062	-0.0002	-0.0007	0.094	-0.0423	-0.0053	0.0295	0.0021	-0.0228	0.00012	0.001	**0.0563**
PH	-0.0069	-0.0024	**0.2695**	0.0551	0.0699	0.0354	-0.012	-0.0006	0.0031	-0.0137	-0.0493	0.0373	0.0002	-0.0017	-0.0049	-0.0009	0.0047	-0.0121	**0.3707***
Till/m	-0.0374	-0.0004	0.0362	**0.4103**	0.0532	0.0557	0.0305	0.0328	0.0011	-0.032	-0.1633	0.105	-0.0022	0.0595	-0.0038	0.0191	0.018	0.0004	**0.5825****
SL	-0.0658	-0.0389	0.1309	0.1515	**0.144**	0.1325	0.0515	0.0055	0.0008	-0.0182	-0.0823	0.059	-0.0014	0.0679	-0.0044	0.0011	0.0054	0.0067	**0.5458****
Gr/Sp	-0.1066	-0.0612	0.0358	0.0856	0.0715	**0.2667**	0.0963	-0.0022	0.004	-0.027	-0.0071	0.0118	0.0028	0.0699	0.0063	-0.0109	0.0002	0.0085	**0.4442****
TGW	0.1104	0.0425	0.0261	-0.1005	-0.0595	-0.2061	**-0.1246**	-0.0024	-0.0024	0.0195	0.0328	-0.0272	-0.0005	-0.0735	-0.003	0.0001	-0.0014	-0.0072	**-0.3771****
PR	-0.0071	0.0139	-0.0027	0.2219	0.0131	-0.0099	0.005	**0.0606**	0.0022	0.0299	-0.1969	0.1183	-0.0005	0.0355	-0.0032	0.0063	0.0192	-0.005	**0.3007***
TR	-0.0315	0.0015	0.0567	0.0296	0.0081	0.0717	0.0203	0.009	**0.0148**	-0.0559	-0.0522	0.0272	0.0049	0.052	0.0023	-0.0108	-0.0033	0.0068	**0.1511**
PAR	-0.0112	-0.0006	0.0211	0.0751	0.015	0.0412	0.0139	-0.0104	0.0047	**-0.1749**	0.0594	-0.0397	0.003	0.0303	-0.0032	0.001	-0.0162	0.0064	**0.0149**
SC	-0.0195	0.0406	0.0423	0.2133	0.0377	0.006	0.013	0.038	0.0025	0.033	**-0.3142**	0.1765	0.0001	0.0435	-0.0047	-0.004	0.0156	-0.0059	**0.3137***
SR	0.0257	-0.0315	-0.0551	-0.2363	-0.0466	-0.0172	-0.0186	-0.0393	-0.0022	-0.0381	0.3041	**-0.1823**	0.0004	-0.0568	0.0029	0.0031	-0.0192	0.0104	**-0.3967****
CT	0.0056	0.0387	0.0029	-0.0488	-0.011	0.0399	0.0033	-0.0015	0.0039	-0.0287	-0.0003	-0.0038	**0.0185**	0.0127	0.0018	-0.0106	-0.0141	-0.0063	**0.0022**
MII	0.0666	0.0279	0.0032	-0.1703	-0.0682	-0.1301	-0.0639	-0.015	-0.0054	0.037	0.0955	-0.0723	-0.0016	**-0.1432**	-0.005	0.0038	-0.0023	-0.0109	**-0.4544****
Prot.	0.0018	-0.0094	-0.0432	-0.0509	-0.0205	0.0541	0.0122	-0.0064	0.0011	0.0182	0.0477	-0.0172	0.0011	0.0232	**0.0308**	-0.0418	0.015	-0.0218	**-0.0061**
SV	-0.0021	0.0323	-0.0024	0.0821	0.0017	-0.0305	-0.0001	0.004	-0.0017	-0.0019	0.013	-0.006	-0.002	-0.0056	-0.0135	**0.0957**	0.0041	0.0225	**0.1897**
HW	-0.0051	0.0001	0.0262	0.1532	0.0161	0.0011	0.0036	0.0242	-0.001	0.0587	-0.1016	0.0728	-0.0054	0.0069	0.0096	0.0081	**0.0481**	-0.0251	**0.2903**
WGC	0.0303	-0.0001	0.0495	-0.0022	-0.0147	-0.0342	-0.0136	0.0046	-0.0015	0.0168	-0.028	0.0287	0.0018	-0.0236	0.0102	-0.0326	0.0183	**-0.0661**	**-0.0563**

Residual effect=0.6203

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.6.1 : Genotypic path coefficient among nineteen characters under late sown irrigated (LSI) conditions at Savalvihir.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.9216**	-0.7012	0.0681	0.2948	0.2389	0.1741	0.9997	-0.9033	0.4028	0.1399	0.4664	0.476	-0.7322	0.91	-0.4003	-0.0265	0.0103	0.1647	**0.6606****
Matu.	-0.7401	**-0.8305**	0.0636	0.0886	0.1147	0.0548	0.5716	-0.9961	0.3544	-0.3713	0.5295	0.4945	-0.125	0.6471	0.0367	0.0939	0.0196	0.2771	**0.2831**
PH	-0.3704	-0.2343	**0.2796**	0.0669	0.1446	-0.0066	-0.2746	0.6028	0.2235	0.0567	-0.0927	-0.3439	0.0595	-0.0942	0.0362	0.0243	-0.0021	0.2417	**0.317***
Till/m	-0.6908	-0.1406	0.0288	**0.6493**	0.0796	0.0515	0.2384	-1.3733	0.2043	0.2801	0.3547	0.1641	-0.1986	0.7744	0.0418	-0.0239	-0.0349	0.409	**0.8139****
SL	-0.9057	-0.2946	0.1007	0.1288	**0.4014**	0.1433	0.6087	-1.0092	0.2624	-0.0982	0.3446	0.96	0.1303	0.5602	0.0205	-0.1581	0.0206	-0.5386	**0.6771****
Gr/Sp	-0.2079	-0.2573	-0.3084	0.1524	0.2622	**0.2194**	0.7971	-0.9232	0.1244	-0.025	0.2017	0.6366	0.0738	0.1702	0.072	-0.0805	-0.0024	-0.2163	**0.6886****
TGW	1.0043	0.3888	0.0507	-0.1022	-0.1613	-0.1154	**-0.5147**	0.8303	-0.2594	0.0503	-0.3956	-0.2516	0.1025	-0.9685	0.0207	-0.0028	-0.0364	-0.0368	**-0.3972****
PR	-0.7985	-0.4528	-0.0353	0.323	0.1691	0.0562	0.8987	**-0.9704**	0.648	-0.1068	0.8676	0.5069	-0.9279	0.1428	0.0442	0.0087	-0.0035	0.2214	**0.5913****
TR	-0.5808	-0.3461	0.0592	0.1257	0.0998	0.0259	0.3723	-0.9293	**0.0553**	-0.3283	0.5582	0.6643	-0.0646	0.2725	0.0614	0.0045	-0.0237	0.2813	**0.3078***
PAR	0.1766	-0.1463	-0.0131	-0.1508	0.0327	0.0046	0.0632	-0.4224	0.2873	**-0.9061**	-0.3341	-0.0045	0.2216	0.85	0.0699	0.086	0.0168	0.0713	**-0.0973**
SC	-0.7045	-0.5417	-0.0257	0.2287	0.1373	0.0439	0.5949	-1.1087	0.5848	0.0408	**0.7332**	0.0073	-0.182	0.5695	0.0229	0.0052	-0.0059	0.0899	**0.4897****
SR	1.3914	0.5427	0.4339	-0.2663	-0.1358	-0.0492	-0.6681	1.2141	-0.6189	-0.0019	-0.9701	**-0.8378**	0.1529	-0.6633	-0.0105	-0.0102	0.0053	0.0003	**-0.4915****
CT	0.3124	0.04	0.0258	-0.2002	0.0812	0.0251	-0.2411	0.9477	-0.1059	-0.4151	-0.2846	-0.6739	**0.644**	0.1739	-0.0042	-0.0244	0.027	-0.4952	**-0.1673**
MII	0.6135	0.2955	0.0117	-0.2228	-0.2775	-0.1137	-0.6501	0.4157	-0.1274	0.4543	-0.2542	-0.8341	-0.0496	**-0.2567**	-0.0159	0.1152	-0.0162	0.3069	**-0.6055****
Prot.	0.0018	-0.1311	0.0351	0.0941	0.0285	0.0548	-0.1087	-0.7306	0.2248	-0.2924	0.08	0.1033	-0.0093	0.1242	**0.2884**	0.0384	-0.04	0.3791	**0.1404**
SV	-0.1245	0.2981	-0.021	0.0477	0.1957	0.0544	-0.0131	0.1273	-0.0147	0.3197	-0.016	-0.0889	0.0484	0.801	-0.0342	**-0.3244**	-0.0135	-0.9783	**0.2638**
HW	0.1811	0.2339	0.0069	0.2622	-0.0957	0.0061	-0.6377	-0.1906	0.2886	0.2344	0.0685	0.1743	-0.2009	-0.4226	0.1332	-0.0505	**-0.0865**	0.4068	**0.3116***
WGC	-0.1835	-0.209	0.0495	0.1944	-0.1582	-0.0347	0.4408	-0.773	0.2173	-0.063	0.0663	-0.0006	-0.2334	-0.507	0.08	0.2323	-0.0258	**0.9661**	**0.0585**

Residual effect=0.2587

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.6.2: Phenotypic path coefficient among nineteen characters under late sown irrigated (LSI) conditions at Savalvihir.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.1044**	-0.0425	0.0488	0.1011	0.0602	0.0607	0.1031	-0.057	-0.0401	-0.0026	0.2957	-0.1876	-0.0139	0.1126	-0.002	-0.0023	-0.0408	0.002	**0.4997****
Matu.	0.0462	**-0.0961**	0.0477	0.0409	0.0247	0.0224	0.052	-0.0464	-0.0344	0.0031	0.3151	-0.1755	0	0.0749	-0.013	0.0044	-0.0781	0.0037	**0.1916**
PH	0.0177	-0.016	**0.2876**	0.0014	0.0187	0.0044	-0.0227	0.0064	-0.0167	-0.001	-0.0455	0.0358	0.0029	-0.011	-0.0029	0.0063	0.028	0.0015	**0.2951***
Till/m	0.0376	-0.014	0.0014	**0.2803**	0.027	0.0128	0.0199	-0.0443	-0.0172	-0.0046	0.194	-0.1269	-0.015	0.081	-0.0225	-0.0021	0.1234	0.005	**0.5357****
SL	0.0476	-0.018	0.0407	0.0573	**0.1322**	0.0465	0.0483	-0.0353	-0.0185	0.0017	0.1694	-0.0965	0.0124	0.1551	-0.0082	-0.0073	-0.0607	-0.0057	**0.461****
Gr/Sp	0.065	-0.0221	0.0131	0.0368	0.0631	**0.0975**	0.0598	-0.0242	-0.0095	0.0002	0.0938	-0.0646	0.0079	0.1142	-0.0313	-0.0064	-0.0037	-0.0021	**0.3874****
TGW	-0.066	0.0307	0.0401	-0.0342	-0.0392	-0.0357	**-0.163**	0.0623	0.025	-0.001	-0.25	0.1547	0.0097	-0.1163	-0.0096	-0.0009	0.1376	-0.0006	**-0.2563**
PR	0.0523	-0.0392	-0.0162	0.1091	0.041	0.0207	0.0892	**-0.1138**	-0.064	0.002	0.5423	-0.309	-0.0126	0.1375	-0.0189	-0.0006	0.0199	0.0028	**0.4425****
TR	0.0384	-0.0303	0.0439	0.0442	0.0225	0.0085	0.0373	-0.0667	**-0.1092**	0.0062	0.3576	-0.211	-0.0058	0.0331	-0.0347	-0.0012	0.0957	0.0039	**0.2325**
PAR	-0.0115	-0.0123	-0.0116	-0.054	0.0095	0.0007	0.0065	-0.0094	-0.0285	**0.0238**	-0.0194	-0.0011	0.0222	0.1058	-0.0372	0.006	-0.0692	0.0009	**-0.0789**
SC	0.0464	-0.0456	-0.0197	0.0818	0.0337	0.0137	0.0613	-0.0928	-0.0587	-0.0007	**0.665**	-0.3563	-0.0193	0.0702	-0.0133	0.0011	0.024	0.0014	**0.3922****
SR	-0.0528	0.0455	0.0278	-0.0959	-0.0344	-0.017	-0.068	0.0948	0.0621	-0.0001	-0.639	**0.3708**	0.0164	-0.0817	0.0066	-0.0013	-0.0216	-0.0001	**-0.3881****
CT	-0.0202	0.0002	0.0115	-0.0584	0.0229	0.0108	-0.022	0.0199	0.0088	0.0074	-0.178	0.0843	**0.0719**	0.0198	0.0011	-0.0034	-0.1142	-0.0062	**-0.1441**
MII	-0.0417	0.0255	0.0112	-0.0805	-0.0727	-0.0395	-0.0672	0.0555	0.0128	-0.0089	-0.1654	0.1074	-0.0051	**-0.2821**	0.0085	0.0073	0.0672	0.0042	**-0.4633****
Prot.	0.0012	-0.0073	0.0048	0.0367	0.0063	0.0177	-0.0091	-0.0125	-0.022	0.0051	0.0515	-0.0143	-0.0004	0.0139	**-0.1724**	-0.0003	0.1367	0.0045	**0.0402**
SV	0.0078	0.0135	-0.058	0.0192	0.031	0.0200	-0.0047	-0.0023	-0.0043	-0.0045	-0.0235	0.016	0.0078	0.0661	-0.0016	**-0.0313**	0.0097	-0.0091	**0.0516**
HW	-0.011	0.0194	0.0208	0.0893	-0.0207	-0.0009	-0.0579	-0.0058	-0.027	-0.0043	0.0412	-0.0207	-0.0212	-0.0489	-0.0608	-0.0008	**0.3874**	0.0047	**0.2827**
WGC	0.0109	-0.0182	0.0228	0.0721	-0.0386	-0.0108	0.0048	-0.0165	-0.0219	0.0011	0.0473	-0.0023	-0.0231	-0.0614	-0.0401	0.0147	0.0946	**0.0194**	**0.0547**

Residual effect=0.5737

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.7.1: Genotypic path coefficient among nineteen characters pooled over environments.

Char.	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**-0.1242**	0.1308	0.0703	0.0336	-0.0478	0.2572	0.0168	0.1667	0.0544	0.0057	0.0291	-0.3118	0.145	0.1766	-0.0016	0.0067	0.0068	0.1122	**0.7265****
Matu.	-0.1013	**0.1603**	0.1324	0.0566	-0.0465	0.2171	0.0072	0.4144	0.0194	0.0017	0.0618	-0.5718	0.2655	0.1051	0.003	-0.0042	0.0201	0.1123	**0.8532****
PH	-0.0347	0.0845	**0.2511**	0.0739	-0.0257	0.0416	-0.0081	0.3973	-0.0186	-0.0046	0.0492	-0.3979	0.3092	-0.0435	0.028	-0.0801	0.023	0.1636	**0.8083****
Till/m	-0.0312	0.0677	0.1385	**0.134**	-0.0196	0.0574	-0.0028	0.574	-0.0281	-0.0061	0.0661	-0.6	0.3306	-0.0409	0.011	-0.0641	0.0271	0.0138	**0.6275****
SL	-0.084	0.1054	0.0915	0.0372	**-0.0707**	0.2334	0.0051	0.3492	0.0308	0.0078	0.0394	-0.3844	0.0752	0.1463	0.0132	-0.076	0.0056	0.088	**0.6131****
Gr/Sp	-0.1123	0.1224	0.0368	0.0271	-0.058	**0.2844**	0.0167	0.2185	0.0722	0.0058	0.0391	-0.3952	0.0891	0.1971	0.0008	-0.0257	-0.0004	0.1228	**0.6411****
TGW	0.071	-0.0392	0.0691	0.013	0.0123	-0.1616	**-0.0294**	0.0629	-0.0471	0.0032	0.0014	0.0612	0.0544	-0.17	0.008	0.0048	0.036	-0.0674	**-0.1173**
PR	-0.0303	0.0974	0.1463	0.1127	-0.0362	0.0911	-0.0027	**0.6822**	-0.0329	-0.0059	0.0735	-0.6713	0.2433	0.0161	0.0162	-0.0855	0.0145	0.0544	**0.6827****
TR	-0.0494	0.0227	-0.0341	-0.0275	-0.0159	0.15	0.0101	-0.1638	**0.1369**	0.0124	0.0068	-0.1307	0.0128	0.1254	0.0022	-0.0201	-0.0175	0.1463	**0.1664**
PAR	-0.0264	0.0104	-0.0428	-0.0305	-0.0205	0.0618	-0.0035	-0.1509	0.0633	**0.0268**	-0.0108	0.0553	-0.0997	0.0254	0.0017	0.0054	0.003	0.0225	**-0.1093**
SC	-0.0423	0.0161	0.0447	0.1036	-0.0326	0.1303	-0.0005	0.4872	0.0109	-0.0034	**0.5854**	-0.773	0.2558	0.0081	0.015	-0.0902	0.0122	0.0438	**0.771****
SR	0.1496	-0.1173	-0.128	-0.1029	0.1348	-0.1439	-0.0023	-0.5863	-0.0229	0.0019	-0.0845	**0.5811**	-0.3313	-0.0319	-0.0138	0.088	-0.0084	-0.1326	**-0.7509****
CT	0.0378	-0.0893	-0.163	-0.093	0.0112	-0.0532	0.0034	-0.3483	-0.0037	0.0056	-0.0638	0.5431	**-0.4765**	0.0529	-0.0111	0.0453	-0.0245	-0.1261	**-0.7532****
MII	0.0944	-0.0725	0.047	0.0236	0.0445	-0.2415	-0.0215	-0.0473	-0.0739	-0.0029	-0.003	0.1072	0.1087	**-0.2322**	0.0069	0.0175	0.0203	-0.0551	**-0.2797***
Prot.	-0.0052	-0.0123	-0.1805	-0.038	0.0239	-0.006	0.0061	-0.2837	-0.0077	-0.0011	-0.033	0.2775	-0.1354	0.0409	**-0.0389**	0.1231	0.0102	-0.2178	**-0.478****
SV	0.0052	0.0042	0.126	0.0538	-0.0337	0.0459	0.0009	0.3658	0.0173	-0.0009	0.0483	-0.4308	0.1352	0.0255	0.03	**-0.1595**	-0.0232	0.1651	**0.3752***
HW	-0.0138	0.0527	0.0944	0.0595	-0.0065	-0.0019	-0.0174	0.1619	-0.0392	0.0013	0.017	-0.1077	0.1911	-0.0772	-0.0065	0.0606	**0.0611**	-0.0917	**0.3378***
WGC	0.0458	-0.0592	-0.1352	-0.0061	0.0205	-0.1149	-0.0065	-0.122	-0.0659	-0.002	-0.0404	0.3407	-0.1977	-0.0421	-0.0279	0.0867	0.0184	**-0.3039**	**-0.6118****

Residual effect=0.2965

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

Table 4.5.7.2 : Phenotypic path coefficient among nineteen characters pooled over environments.

Char	Flow	Matu	PH	Till/m	SL	Gr/Sp	TGW	PR	TR	PAR	SC	SR	CT	MII	Prot.	SV	HW	WGC	GY
Flow.	**0.1049**	-0.0294	0.0491	0.0438	0.0294	0.0724	0.0417	0.0225	-0.0246	-0.0003	0.0302	-0.0414	0.0393	0.0996	0.0027	-0.002	0.0003	0.0325	**0.4707****
Matu.	0.0556	**-0.0553**	0.0995	0.0232	0.0246	0.0429	0.0116	0.0309	-0.0116	-0.0004	0.0359	-0.0492	0.0654	0.0538	0.0002	0.0026	0.008	0.0116	**0.3492***
PH	0.0181	-0.0193	**0.2851**	0.0372	0.0173	0.0088	-0.0132	0.0288	-0.0032	0.0022	0.0275	-0.0305	0.0595	-0.0098	0.0033	-0.003	0.0251	0.017	**0.4509****
Till/m	0.0266	-0.0074	0.0614	**0.1727**	0.012	0.0179	0.0052	0.058	-0.0029	0.0019	0.0526	-0.0668	0.0512	0.0622	0.0031	-0.0062	0.0347	0.0161	**0.4924****
SL	0.0526	-0.0232	0.0838	0.0353	**0.0587**	0.0587	0.0145	0.0247	-0.0091	-0.0012	0.0249	-0.0336	0.0101	0.0935	0.0031	-0.0081	-0.0037	0.0302	**0.4112****
Gr/Sp	0.0729	-0.0228	0.0241	0.0297	0.0331	**0.1042**	0.0363	0.0196	-0.0239	-0.0016	0.0256	-0.0366	0.0095	0.1028	-0.0005	-0.0003	-0.0045	0.0293	**0.3968****
TGW	-0.0587	0.0087	0.0505	-0.0121	-0.0115	-0.0508	**-0.0744**	-0.0012	0.0188	-0.0003	-0.0036	0.0134	0.0065	-0.0879	0.0006	-0.0035	0.0554	-0.0124	**-0.1624**
PR	0.0216	-0.0156	0.0753	0.0918	0.0133	0.0187	0.0008	**0.1092**	-0.0063	0.002	0.0976	-0.1139	0.0584	0.0594	0.0033	-0.0044	0.035	0.0095	**0.4555****
TR	0.033	-0.0083	0.0117	0.0063	0.0069	0.0319	0.018	0.0088	**-0.078**	-0.0042	0.0301	-0.0456	0.0007	0.0619	0.001	-0.0003	-0.0108	0.0239	**0.0873**
PAR	0.0017	-0.0013	-0.0377	-0.0193	0.0041	0.01	-0.0014	-0.0127	-0.0195	**-0.0168**	-0.0123	0.0116	-0.0277	0.0319	-0.0005	0.0047	0.0009	-0.0028	**-0.0871**
SC	0.0239	-0.015	0.0592	0.0687	0.011	0.0201	0.002	0.0805	-0.0177	0.0016	**0.1324**	-0.1495	0.0706	0.0489	0.0025	-0.0025	0.0271	0.0196	**0.3834****
SR	-0.0277	0.0173	-0.0554	-0.0735	-0.0126	-0.0243	-0.0063	-0.0792	0.0227	-0.0012	-0.1261	**0.157**	-0.067	-0.0594	-0.0022	0.0025	-0.0176	-0.0198	**-0.3729****
CT	-0.0225	0.0198	-0.0927	-0.0483	-0.0032	-0.0054	0.0026	-0.0348	0.0003	-0.0025	-0.0511	0.0574	**-0.183**	0.0324	-0.0019	0.0048	-0.0348	-0.0219	**-0.3849****
MII	-0.0432	0.0123	0.0116	-0.0445	-0.0227	-0.0443	-0.027	-0.0268	0.02	0.0022	-0.0268	0.0385	0.0245	**-0.2418**	0.0006	-0.0001	0.0101	-0.028	**-0.3854****
Prot.	-0.0179	0.0008	-0.0599	-0.0338	-0.0116	0.0031	0.003	-0.0232	0.0051	-0.0005	-0.0213	0.0224	-0.0222	0.0094	**-0.0157**	0.021	0.0242	-0.0576	**-0.1749**
SV	0.0046	0.003	0.0181	0.023	0.0102	0.0006	-0.0056	0.0104	-0.0005	0.0017	0.0071	-0.0084	0.0188	-0.0006	0.0071	**-0.0465**	-0.0086	0.0401	**0.0746**
HW	0.0002	-0.003	0.0487	0.0409	-0.0015	-0.0032	-0.0281	0.026	0.0057	-0.0001	0.0245	-0.0188	0.0434	-0.0166	-0.0026	0.0027	**0.1466**	-0.0271	**0.2378**
WGC	-0.0259	0.0049	-0.037	-0.0212	-0.0135	-0.0232	-0.007	-0.0079	0.0142	-0.0004	-0.0197	0.0237	-0.0306	-0.0515	-0.0069	0.0142	0.0302	**-0.1313**	**-0.2889***

Residual effect=0.6376

Flow.- Days to 50% flowering, Matu.-Days to maturity ,PH-Plant height , Till/m- Tillers per meter, SL-Spike length , Gr./Sp , Grains per spike , TGW-Thousand grain weight ,PR-Photosynthetic rate , TR-Transpiration rate, PAR- Photosynthetically active radiation, SC- Stomatal conductance, SR-Stomatal resistance, CT -Canopy temperature, MII-Membrane Injury Index, Prot-Protein, SV- Sedimentation Value, HW-Hectoliter weight, WGC-Wet gluten content , GY-Grain yield

5. DISCUSSSION

Since the introduction of Norin 10 based semi-dwarf wheat varieties in India, there has been considerable progress in different aspects of wheat breeding through skillful manipulation of different morphological traits. But not much attention has been given towards morpho-physiological and quality attributes, which are responsible for the increase in the physiological efficiency and the quality of end product. Keeping this in view, twenty new wheat genotypes have been developed at ARS, Niphad. In the present study,these twenty genotypes along with three check varieties have been studied in multilocation trials to assess their yield, yield attributes, physiological and quality parameters. A thorough analysis of the present study has been done to understand the impact of the selected genotypes on the improvement of morpho-physiogiolocal and quality traits of wheat. The results obtained of the present study are discussed below under different sections.

5.1 Mean performance of new wheat genotypes for morpho-physiological and quality traits

The mean performance of twenty new wheat genotypes along with three standard checks indicated considerable variability for most of the traits. Considering the yield components, physiological and quality traits under TSI and LSI the genotypes were more input responsive and exhibited better performance under TSI than LSI condition. However, some of the genotypes performed well under LSI condition as well, because of their resilience and plasticity to give better performance in a given environment.

5.1.1 Grain yield (kg/plot)

The genotypes NIAW 1885, NIAW 1994, NIAW 2268, NIAW 2279, NIAW 2348, NIAW 2349, NIAW 2351 and NIAW 917 exhibited high *per se* performance under TSI and LSI conditions at all locations. The genotype NIAW 2255 exhibited superipor performance under TSI condition at all locations. The genotypes NIAW 2065, NIAW 2248 and NIAW 2275 were found promising under LSI conditions. Hence these genotypes can be considered in various plant breeding progammes.

5.1.2 Days to 50 % flowering

The genotypes NIAW 1951, NIAW 1994, NIAW 2065, NIAW 2255, 2275, NIAW 2279, NIAW 2300, NIAW 2303, NIAW 2304 , NIAW 2310, NIAW 2346 and NIAW 34 exhibited early flowering under TSI and LSI condition at all locations.

5.1.3 Days to maturity

The genotypes NIAW 1951, NIAW 2065, NIAW 2248, NIAW 2255, NIAW 2313, NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2304 , NIAW 2346 NIAW 2348 , NIAW 2349 and NIAW 34 recorded earlier maturity under TSI and LSI condition at all locations. While, NIAW 2300 exhibited early maturity performance under TSI condition at all locations.

5.1.4 Plant height (cm)

Genotypes NIAW 1994, NIAW 2065, NIAW 2304, NIAW 2248, NIAW 1415 and NIAW 917 which were short to medium stature under all growing conditions can be utilized in the breeding programmes so as to combine with other desirable traits. Most of the genotypes exhibited semi dwarf stature in the present study and their association with grain yield under certain situations was also found to be positive. The positive association with grain yield implies that tall plants produce higher yield. In contrast, the positive association with grain yield implies that the mean height of the genotypes which were semi-dwarf was found to be favourable for realizing the higher yield.

5.1.5 Number of tillers per meter

With respect to number of tillers per meter differences in crop season, location and environmental condition had significant effect. The genotypes NIAW 2065 and NIAW 2275 exhibited high *per se* performance under TSI and LSI condition at all the locations. The genotypes NIAW 2073, NIAW 2279 and NIAW 917 were found promising only under TSI condition at all locations. The genotypes NIAW 2349 and NIAW 2351 produced higher number of tillers per meter under LSI condition. These genotypes can be considered in various plant breeding progammes.

5.1.6 Spike length (cm)

The genotypes NIAW 2345, NIAW 2348, NIAW 2349 and NIAW 1415 recorded higher spike length than population mean under all TSI and LSI conditions. While, the genotypes NIAW 2303 under LSI condition and NIAW 1885, NIAW 1994 , NIAW 2313 and NIAW 917 under TSI condition were found promising at all locations.

5.1.7 Number of grains per spike

Number of grains per spike is considered as an important yield component. The genotypes NIAW 2348, NIAW 2349 and NIAW 1415 produced higher number of grains per spike under TSI and LSI condition at all the locations. The genotypes NIAW 2351 and NIAW 2345 under TSI condition and NIAW 2313 and NIAW 1994 under LSI condition at all the locations produced high *per se* performance and these genotypes can be considered for breeding for specific environment.

5.1.8 Thousand grain weight (g)

Thousand grain weight was found to be high under TSI condition than LSI condition indicating that high temperature under LSI condition reduces the grain weight due to reduced grain filling duration. The genotypes NIAW 2300, and NIAW 2310 produced higher thousand grain weight over locations and environments. While, the genotypes NIAW 2303 and NIAW 2346 under TSI condition and NIAW 1994, NIAW 2073 and NIAW 2279 under LSI condition all all locations produced high *per se* performance and these genotypes can be considered for breeding for specific environment.

5.1.9. Photosynthetic rate (μ mol m^{-2} s^{-1})

Photosynthetic rate is important physiologicat trait, which regulates the other physiolocal activity of the crop plant. The genotypes NIAW 2313 and NIAW 2351 exhibited high *per se* performance under TSI and LSI condition at all the locations. The genotypes NIAW 2065, NIAW 2248 and NIAW 34 found promising under TSI condition at all the locations. The genotypes

NIAW 1885 and NIAW 1415 showed high *per se* performance under LSI condition. These genotypes can be considered in various plant breeding progammes.

5.1.10. Transpiration rate (m mol m^{-2} s^{-1})

Transpiration rate is considered an important trait to reduce evapotranspiration losses. The genotypes NIAW 1994 and NIAW 2073 recorded low transpiration rate under TSI and LSI condition at all the locations. The genotypes NIAW 1885 and NIAW 2304 under TSI condition while NIAW 2248, NIAW 2279, NIAW 2310 and NIAW 2346 under LSI condition at all the locations recorded better performance and these genotypes can be considered for breeding for specific purpose.

5.1.11 Photosynhetically active radiation (µ mol m^{-2} s^{-1})

The genotypes NIAW 2279, NIAW 1415, NIAW 917 and NIAW 34 recorded better PAR values under all TSI and LSI conditions.

5.1.12 Stomatal counductance (µ mol m^{-2} s^{-1})

Stomatal couductance is an important physiological trait in regulating balance between transpiration and net uptake of CO2 in photosynthesis. The genotypes NIAW 2313 and NIAW 2351 exhibited high *per se* performance under TSI and LSI condition at all locations The genotypes NIAW 2065, NIAW 2248 and NIAW 34 were found promising under TSI condition at all locations. The genotypes NIAW 1885 and NIAW 1415 had high *per se* performance under LSI condition. These genotypes can be considered in various plant breeding progammes to improve abiotic stress tolerance.

5.1.13 Stomatal resistance (µ mol m^{-2} s^{-1})

The genotypes NIAW 2313 and NIAW 2351 exhibited lower resistance, which is better performance under TSI and LSI condition at both locations. The genotypes NIAW 2065, NIAW 2248 and NIAW 34 were found promising only under TSI condition at all locations. The genotypes NIAW 1885 and NIAW 1415 have recorded lower resistance under LSI condition. These genotypes can be considered in various plant breeding progammes to improve abiotic stress tolerance.

5.1.14 Canopy temperature (^{0}C)

Canopy temepearture is an important physiological trait, cooler the canopy temperature during crop growth period is a complementary to improve the other physiological process. The genotypes NIAW 1885, NIAW 1951, NIAW 1994, NIAW 2065 and NIAW 2073 exhibited lower canopy temperature, which was beneficial under TSI and LSI condition at both locations. The genotypes NIAW 2248, NIAW 2255 and NIAW 2300 were found promising only under TSI condition at all locations. The genotypes NIAW 917 and NIAW 34 have recorded lower canopy temperature under LSI condition. These genotypes can be considered in various plant breeding progammes to improve abiotic stress tolerance.

5.1.15 Membrane injury index (%)

The genotypes NIAW 1994, NIAW 2345, NIAW 2348, NIAW 2349, NIAW 2351, NIAW 917 and NIAW 34 exhibited low membrane injury index under TSI and LSI condition at all locations. These genotypes can be considered in plant breeding progammes to improve thermotolrance.

5.1.16 Protein (%)

Higher grain protein (≥11%) is desirable for bread making while, lower protein (≤ 10 %) is preferred for biscuit quality. Higher protein levels were realized under LSI condition than TSI condition. The genotypes NIAW 1415, NIAW 917, NIAW 34 and NIAW 1951 exhibited higher *per se* performance under TSI and LSI conditions at all locations. The genotypes NIAW 1994 and NIAW 1885 under TSI condition and the genotype NIAW 2248 and NIAW 2310 under LSI condition produced high protein % at both locations. The above genotypes can be considered for increasing protein % by conventional breeding.

5.1.17 Sedimentation value (ml)

Sedimentation value is a measure of gluten strength. The stronger the wheat, the better is the bread quality. Similarly, weaker the wheat better is the biscuit quality. The values of sedimentation obtained in the genotypes across locations indicated that most of the genotypes possess weak to medium strong gluten. The genotypes NIAW 2073, NIAW 2275, NIAW 2313, NIAW 2346, and NIAW 2349 under TSI condition at all locations produced higher sedimentation value than the grand mean. While, the genotypes NIAW 2065, NIAW 2279 and NIAW 2348 were found promising for higher sedimentation value (ml) under LSI condition at all locations.

5.1.18 Hectoliter weight (kg/hl)

Hectoliter weight is an important quality trait in terms of trade and it indicates grain density. Higher the hectoliter weight, higher is the flour recovery. Bread wheat with ≥ 76.4 kg/hl is considered to be grade 1 category. In general, most of the genotypes in our present study fall under grade 1 category. When the *per se* performance is considered the genotypes NIAW 1951, NIAW 2255, NIAW 2300 and NIAW 2351 were found promising under TSI condition and the genotypes NIAW 2275, NIAW 2310 and NIAW 2313 possessed higher hectoliter weight under LSI condition than the population mean. The genotypes NIAW 1994, NIAW 2065, NIAW 2268 and NIAW 2275 were found promising under TSI and LSI conditions at all locations.

5.1.19 Wet gluten content (%)

Gluten content is often related to protein per cent and sedimentation value. Under TSI conditions across locations, the genotypes NIAW 1994, NIAW 2073, and NIAW 1415 exhibited higher *per se* performance. While, the genotypes NIAW 2275, NIAW 2310 and NIAW 2313 were found promising under LSI condition at both locations. The NIAW 1885, NIAW 1951, NIAW 2248, NIAW 2255, NIAW 917 and NIAW 34 were found promising under TSI and LSI condition at all locations.

5.2 Stability analysis

5.2.1 Pooled analysis of variance for stability

The analysis for stability for twenty genotypes along with three check varieties was out pooling the data across locations and environments as per Eberhart and Russell (1966) model. The analysis was carried out for ninteen characters. Pooled analysis of variance revealed significant differences in the

G x E interactions for all the characters studied. According to Eberhart and Russel a stable genotype should have high mean (X) with bi = 1 and S^2di =0 or close to these values (non significant deviation). Where bi > 1*, the genotypes is responsive to favourable enviornment and bi < 1* the genotypes performs well despite an unfavourable environment. Thus, this analysis allows the identification of stable genotypes for a trait across the environments and the genotypes that are most responsive to a favourable or unfavourable environment. Also, a favourable or unfavourable environment is indicated in this model; higher of environmental index indicated relatively more favourable environment is required for the higher expression of the trait.

The mean sum of squares due to genotypes were significant for all the nineteen characters studied across the environments, which indicated the presence of substantial variation in the material studied. The analysis also indicated significant variation among the environments for all the characters. The values of G x E interaction were significant for all nineteen characters which indicated that genotypes interacted differently with environmental variations for the said characters and variation due to E + (G x E) were further partioned into three components (i) Environment (linear) (ii) G x E (linear) and (iii) Pooled deviation (G x E; non linear).

Highly significant values of mean squares due to environments (linear) for all the characters indicated that the linear responses of genotypes to environment differed significantly for the said characters; while mean square values due to G x E (pooled error) were also significant for all the characters. However, relative magnitude of linear component of G x E interaction was higher than non linear component for all characters.Mondal *et al*. (1989) also reported significant differences among genotypes, environments and G x E interaction for grain yield and plant height. Menon *et al.*(1997) reported that environmental linear component was significant for grain yield, tiller number and plant height. Madariya *et al.*(2001) reported both linear and non linear component of G x E interaction for grain yield, number of spikelets per spike, number of grains per spike and 1000 grain weight. Gowda *et al.* (2010) reported variance due to variety x environment have shown significant interaction for the characters grain yield, protein per cent, hectoliter weight, and sedimentation value showing differential response of the genotypes with different environments. Similar results were also reported by Kota *et al.* (2013).

5.2.2 Stabilty parameters of morpho-physiological and quality traits

The stable genotypes in terms of morpho-physiological and different quality traits are described as under and listed in Table 5.2.2.1 and Table 5.2.2.2

5.2.2.1 Grain yield (kg/plot)

With respect to grain yield, only NIAW 1885 was found to be below average stable and suitable for favourable environment. Whereas, NIAW 2351 was grouped as above average stable and suitable for poor or stress environment. Based on *per se* performance, regression coefficient and deviations from regression, the genotypes NIAW 1994, NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2313 and NIAW 917 were found to be stable and adaptable to a wide range of environments suggesting that these genotypes be better exploited in terms of grain yield.

Sial *et al.* (2000), Aycicek and Yeldrim (2006), Majid *et al.* (2007), Parveen *et al.* (2010), Bhoite *et al.* (2011), Kota *et al.* (2013) and Meena *et al.* (2014) reported higher linear component for grain yield, while Kant *et al.* (2014) observed non linear component higher for this trait.

5.2.2.2 Days to 50 per cent flowering

Most of the genotypes exhibited significant deviations from the regression coefficient for the days to 50% flowering and hence they were unstable over environments. However, NIAW 1994 and NIAW 2255 were grouped as above average stable and suitable for poor or stress environment. Based on *per se* performance, regression coefficient and deviations from regression, the genotype NIAW 1951 was found to be stable for all environments.

Ranjana and Suresh Kumar (2013a) and Kota *et al.* (2013) reported higher linear component of G x E interaction was important for this trait.While, Aycicek and Yeldrim (2006), Yadav *et al.* (2013) , Meena *et al.* (2014) and Kant *et al.* (2014) reported non linear magnitude were higher in G x E interaction.

5.2.2.3 Days to maturity

In case of days to maturity, based on per se performance, regression coefficient and deviations from regression, the genotypes NIAW 1951, NIAW 2065, NIAW 2255, NIAW 2268 and NIAW 2348 were found to be stable and adaptable to a wide range of environments. NIAW 2349 was found to be below average stable and suitable for favourable environment. Whereas, NIAW 2248, NIAW 2275, NIAW 2279, NIAW 2300 and NIAW 2304 were grouped as above average stable and suitable for poor or stress environments.

Banerjii *et al.* (2006), Ranjana and Suresh Kumar (2013a) and Yadav *et al.* (2013) revelaed linear significant of G x E interaction was important for this trait.

5.2.2.4 Plant height (cm)

For this character, the genotypes NIAW 1951, NIAW 1994, NIAW 1415, and NIAW 917 showed unit regression and minimum deviation from the regression coefficient and hence they were found to be stable and suitable for all environments. NIAW 2300 and NIAW 2304 were grouped as above average stable and suitable for poor environment. (bi < 1*). NIAW 2248 and NIAW 2275 were found to be below average stable across locations and suitable for favourable environment. (bi > 1*).

Similar to these results, Moneim (1987), Mondal *et al.*(1989), Menon *et al.* (1997) and Aycicek and Yeldrim (2006) also reported significant differnces due to environments linear component.

5.2.2.5 Spike length (cm)

With respect to spike length, the genotypes NIAW 1885, NIAW 1994, NIAW 2310, NIAW 2345 and NIAW 2351 showed unit regression and minimum deviation from the regression coefficient and hence they were found to be stable and suitable for wide range of environments. None of the genotypes were found to be responsive to favourable environment due to significant deviations from regression coefficient. NIAW 2349 was grouped as above average stable and suitable for poor environment ($\beta i < 1^*$).

Karmizadeh *et al.* (2012), Yadav *et al.* (2013) and Ranjana and Suresh Kumar (2013) reported the importance of G x E interaction for this character.

5.2.2.6 Number of tillers per meter

Based on *per se* performance, regression coefficient nearer to unity and least deviation from regression NIAW 2300 was found to be stable and suitable for all environments for number of tillers. NIAW 2279 and NIAW 917 was found to be below average stable and suitable for favourable environments (bi > 1*). NIAW 1994, NIAW 2065, NIAW 2275, NIAW 2349 and NIAW 2351 were grouped as above average stable and suitable for poor environment. (bi < 1*).

In previous studies, Sial *et al*. (2000) and Banerjii *et al.* (2006) suggested the importance of linear component for this trait. Yadav *et al.* (2013) and Meena *et al.* (2014) reported significance of non linear portions of G x E interaction for this trait.

5.2.2.7 Number of grains per spike

With respect to number of grains per spike, NIAW 2313 was grouped as above average stable and suitable for stress environment (bi < 1*). NIAW 1994 and NIAW 2348 were found to be below average stable across locations and suitable for favourable environment (bi >1*). None of the genotypes was found to be suitable to wider range environment due to significant deviations from regression coefficient.

Sial *et al.* (2000), Banerjii *et al.* (2006), Aycicek and Yeldrim (2006), Karmizadeh *et al.* (2012), Yadav *et al.* (2013) and Meena *et al.* (2014) reported significant G x E interaction for this trait.

5.2.2.8 Thousand grain weight (g)

For the character thousand grain weight, the genotypes NIAW 2255 and NIAW 2279 exhibited high *per se* performance, non significant, regression coefficient (bi = 1) and minimum deviations from regression coefficient. Hence, they were stable and suitable for wide range of environments. The genotypes NIAW 2346 is recommended for favourable environment because of its specific response (bi > 1*) to favourable environment. None of the genotypes was found to be responsive to poor environment due to significant deviations from regression coefficient.

Aycicek and Yeldrim (2006), Karmizadeh *et al* (2012), Yadav *et al* (2013) and Meena *et al* (2014) reported significant G x E interaction for this trait.

5.2.2.9 Photosynthetic rate (μ mol m^{-2} s^{-1})

With respect to photosynthetic rate, NIAW 1994 was grouped as above average stable and suitable for poor or stress environment. (bi < 1*). Whereas, NIAW 2279 was found to be below average stable across locations and suitable for favourable environment. (bi > 1*). The rest of the genotypes exhibited significant deviations from regression coefficent leading to instability across environment.

Delgado *et al.* (1994) and X. Chen *et al.* (2012) have reported significant G x E interaction for this trait.

5.2.2.10 Transpiration rate (m mol m^{-2} s^{-1})

For the character transpiration rate, the genotypes NIAW 1951 and NIAW 2248 exhibited high *per se* performance, non significant, regression coefficient (bi = 1) and minimum deviations from regression coefficient. Hence, they are stable and suitable for wide range of environments. The rest of the genotypes exhibited significant deviations from regression coefficent leading to instability across environment. X. Chen *et al.* (2012) have reported significant G x E interaction for this trait.

5.2.2.11 Photosynthetically active radiation (µ mol m^{-2} s^{-1})

With respect to photosynthetically active radaition, the genotype NIAW 2255 exhibited high *per se* performance, non significant, regression coefficient (bi = 1) and minimum deviations from regression coefficient. Hence, NIAW 2255 was stable and suitable for wide range of environments. The rest of the genotypes exhibited significant deviations from regression coefficent leading to instability across environment.

5.2.2.12 Stomatal counductane (µ mol m^{-2} s^{-1})

With respect to stomatal counductance, none of the genotypes were found to be stable across genotypes due to significant deviations from regression coefficient.

5.2.2.13 Stamatal resistance (µ mol m^{-2} s^{-1})

Only NIAW 34 exhibited high *per se* performance, non significant, regression coefficient (bi = 1) and minimum deviations from regression coefficient. Hence, NIAW 34 was stable and suitable for wide range of environments. Rest of the genotypes exhibited significant deviations from regression coefficent leading to instability across environment.

5.2.2.14 Canopy temeperature (^{0}C)

With respect to canopy temperaure, none of the genotypes were found to be stable across environments due to significant deviations from regression coefficient.

5.2.2.15 Membrane injury index (%)

For the character membrane injury index, the genotypes NIAW 2313, NIAW 917 and NIAW 34 exhibited high *per se* performance, non significant, regression coefficient (bi = 1) and minimum deviations from regression coefficient. Hence, they were stable and suitable for wide range of environments. The genotypes NIAW 2279 is recommended for favourable environment because of its specific response (bi > 1*). NIAW 1994 is recommended for poor environment because of its specific response (bi < 1*) to unfavourable environment.

Gowda *et al.* (2011) and Tripura *et al.* (2011) have reported significant G x E interaction for this trait.

5.2.2.16 Protein (%)

In case of protein %, NIAW 1994 , NIAW 1415, NIAW 917 and NIAW 34 are recommended for poor environment because of its specific response (bi < 1*) to poor environment. Rest of the genotypes recorded lower protein per cent than population mean as well as the instability across environments resulted due to significant deviations from regression coefficient. Different levels of protein per cent are preferred for different end use quality. There was good amount of variability among the genotypes for protein %, but they were unstable because of greater role of G x E interactions as well as environmental effects.

Zeki *et al.* (2010), Gowda *et al.* (2011) and Yadav *et al.* (2013) have reported significant G x E interaction for this trait.

5.2.2.17 Sedientation value (ml)

With respect to sedimentation value, the genotypes NIAW 1951, NIAW 2248 and NIAW 1415 exhibited high *per se* performance, non significant regression coefficient (βi = 1) and minimum deviations from regression coefficient. Hence, they are stable and suitable for wide range of environments. The genotypes NIAW 1994, NIAW 2255, NIAW 2304, NIAW 2345 and NIAW 34 is recommended for favourable environment because of its specific response (βi > 1*) to favourable environment. None of the genotypes were found to be responsive to poor environment due to significant deviations from regression coefficient.

Zeki *et al.* (2010), Kota (2010) and Yadav *et al.* (2013) have reported significant G x E interaction for this trait.

5.2.2.18 Hectoliter weight (kg/hl)

Hectoliter weight is a desirable trait as it is positively correlated with yield. The genotypes NIAW 1885, NIAW 1994, NIAW 2268, NIAW 2275, NIAW 2279 NIAW 2313 and NIAW 2351 can be recommended for all the six environments since they exhibited high *per se* performance, non-significant regression coefficient and non-significant deviations from the regression coefficient. Only NIAW 1951 is recommended for favourable environment because of its specific response (bi > 1*) to favourable environment. None of the genotypes was found to be responsive to poor environment due to significant deviations from regression coefficient.

Zeki *et al.* (2010) and Yadav *et al.* (2013) have reported significant G x E interaction for this trait.

5.2.2.19 Wet gluten content (%)

For the character wet gluten content, based on *per se* performance, the genotype NIAW 1951was found stable and suitable for all the environments. The genotype NIAW 1885 was responsive to favourable environments (b > 1*). None of the genotypes were found to be responsive to poor environment due to significant deviations from regression coefficient.

Dencic *et al.* (2011) have reported significant G x E interaction for this trait.

5.3 Environmental Index

Environmental index is the effect of environment in the expression of grain yield, physiological and quality chareterstics and measured as the deviation of the mean of all the genotypes at a given location from the overall mean. For earliness characters days to 50 per cent flowering and days to maturity LSI environments were better than TSI environments. However, TSI environments were better for tillers per plant, grain yield, spike length, grains per spike, plant height and thousand grain weight. Similar, results were reported by Gowda (2009) and Kota (2010). In case of physiological traits *viz.* photosynthetic rate, transpiration rate and stomatal counductance were adversely affected in LSI environments than TSI environments. For quality characters like protein per cent and wet gluten content all LSI environments were rich enviromnments with positive environmental indices, TSI environemts were poor as these traits were with negative environmental indices. Similar, results for grain protein per cent and gluten content were reported by Kota (2010).

Table 5.2.2.1: Stability status of bread wheat genotypes for morpho-physiological and quality traits.

Character	Bread wheat genotypes under different stability groups		
	Average stable	Below average stable	Above average stable
	Stable for all environment	Better for favorable environment	Better for un-favorable environment
	High mean bi=1,S^2di=NS	High mean bi>1*,S^2di=NS	High mean bi<1*,S^2di=NS
Grain yield (kg/plot)	NIAW 1994 NIAW 2268 NIAW 2275 NIAW 2279 NIAW 2313 NIAW 2349 NIAW 917 (C)	NIAW 1885	NIAW 2351
Days to 50 % flowering	NIAW 1951	-	NIAW 1994, NIAW 2255
Days to maturity	NIAW 1951 NIAW 2065 NIAW 2255 NIAW 2268 NIAW 2348	NIAW 2349	NIAW 2248, NIAW 2275, NIAW 2279 , NIAW 2300 NIAW 2304
Plant height (cm)	NIAW 1951 NIAW 1994 NIAW 1415 (C) NIAW 917 (C)	NIAW 2248 NIAW 2275	NIAW 2300 NIAW 2304
Number of tillers per meter	NIAW 2300	NIAW 2279 NIAW 917 (C)	NIAW 1994 NIAW 2065 NIAW 2275 NIAW 2349 NIAW 2351
Spike length (cm)	NIAW 1885 NIAW 1994 NIAW 2310 NIAW 2345 NIAW 2351	-	NIAW 2349

Table contd..

Character	Bread wheat genotypes under different stability groups		
	Average stable	Below average stable	Above average stable
	Stable for all environment	Better for favorable environment	Better for un-favorable environment
	High mean bi=1,S^2di=NS	High mean bi>1*,S^2di=NS	High mean bi<1*,S^2di=NS
No. of grains per spike	-	NIAW 1994 NIAW 2348	NIAW 2313
Thousand grain weight (g)	NIAW 2255 NIAW 2279	NIAW 2346	-
Photosynthetic rate (µmol m^{-2} s^{-1})	-	NIAW 2279	NIAW 1994
Transpiration rate (m mol m^{-2} s^{-1})	NIAW 1951 NIAW 2248	-	-
Photosynthetically active radiation (µmol m^{-2} s^{-1})	NIAW 2255	-	-
Stomatal conductance (µ mol m^{-2} s^{-1})	-	-	-
Stomatal resistance (µ mol m^{-2} s^{-1})	NIAW 34 (C)	-	-
Canopy temp.(^{0}C)	-	-	-
Membrane injury index (%)	NIAW 2313 NIAW 917 (C) NIAW 34 (C)	NIAW 2279	NIAW 1994

Table contd..

Character	Bread wheat genotypes under different stability groups		
	Average stable	Below average	Above average

		stable	stable
	Stable for all environment	Better for favorable environment	Better for un-favorable environment
	High mean bi=1,S^2di=NS	High mean bi>1*,S^2di=NS	High mean bi<1*,S^2di=NS
Protein (%)	-	-	NIAW 1994 NIAW 1415 (C) NIAW 917 (C) NIAW 34 (C)
Sedimentation value (ml)	NIAW 1951 NIAW 2248 NIAW 1415 (C)	-	NIAW 1994 NIAW 2255 NIAW 2304 NIAW 2345 NIAW 34 (C)
Hectoliter weight (kg/hl)	NIAW 1885 NIAW 1994 NIAW 2268 NIAW 2275 NIAW 2279 NIAW 2313 NIAW 2351	NIAW 1951	-
Wet gluten content (%)	NIAW 1951	NIAW 1885	-

Table: 5.2.2.2 Stable genotypes for grain yield and its stability for other related characters

Genotype	Stable performance for other characters
NIAW 1994	GY, Flow., Till/m, SL, Gr/Sp, PR, MII, Prot. SV, HW
NIAW 2279	GY, Matu. Till/m, Gr/Sp TGW, PR, MII, HW
NIAW 2275	GY, Matu. Pl. Ht., Till/m, HW
NIAW 917 ©	GY, Matu. Pl. Ht. Till/m, MII, Prot.
NIAW 2349	GY, Till/m , Gr/Sp
NIAW 2351	GY, Till/m , Gr/Sp

5.4 Variability parameters

Variability parameters are most important for assessing the extent of variability present among the genotypes for the characters under consideration. The estimates of phenotypic coefficient of variance (PCV) were higher in respect of all the ninteen characters studied in all environments than the corresponding genotypic coefficient of variance (GCV). The reason for higher phenotypic level variability is due to both genotypic and environmental variability where response of genotype over environment is aparently realized. The characters spike length, number of tillers per meter, the number of grains per spike,membrane injury index, photosynthetic rate, stomatal counductance transpiration rate,stomatal resistance sedimentation value , wet gluten content and grain yield exhibited larger amount of variability both at phenotypic level and genotypic level in most of the environments suggesting that selection can be practiced for the above traits and this variability can be utilized in various plant breeding programmes. Sharma *et al*. (1995) and Uddin *et al*. (1997), Kota (2010) also reported similar observations. Gowada *et al.* (2011) also reported high variability for memebrane injury index. However days to maturity, thousand grain weight, canopy temperature, photosynthetically active radiation, hectolitre weight and protein exhibited low levels of variability. Hence there is need to increase the extent of variability for these traits through various means like distant hybridization, mutation and biotechnological tools.

5.5 Heritability and genetic advance as per cent of mean (GAM)

All the characters in the present study exhibited high heritability in all the individual environments at all the locations. Characters *viz*, spike length, number of grains per spike, days to 50 per cent flowering, membrane injury index, photosynthetic rate, stomatal counductance, transpiration rate, stomatal resistance, sedimentation value and wet gluten content exhibited high heritability coupled with high GAM. It indicates that the heritability is due to additive gene effects and the selection may be effective. However, since heritability in broad sense is based on total genetic variance, the influence of favourable environment cannot be ruled out. Similarly Yadav *et al*. (2006), Bahadur and Lodhi (1995) observed high heritability and high genetic advance for grains per spike. Raut *et al*. (1995) reported that grain yield, thousand grain weight, tillers per meter exhibited high heritability along with high genetic advance. Deswal *et al*. (1996b) concluded that due to additive gene effects, thousand grain weight, grains per spike and grain yield per spike had high heritability and high genetic advance. Moyghaddam *et al*. (1998) reported moderate estimates of heritability and genetic advance for grains per spike, thousand grain weight and grain yield. Prasad and Pandey (2001) reported that plant height, productive tillers per plant, 1000-grain weight and sedimentation value showed high heritability.Similarly, Gowada (2009) reported high heritability with GA for memebrane injury index, sedimentation value. Kota (2010) also reported similar observations for grains per spike, sedimentation value and gluten content.

Grain yield, days to maturity, plant height , photosynthetic active radiation, canopy temperature, hectoliter weight (kg/hl), grain hardness index and protein per cent exhibited high heritability coupled with low to intermediate GAM. Heritability estimates along with the genetic advance are normally more helpful in predicting the gain under selection. However, it is not necessary that the character showing high heritability will also exhibit high genetic advance as suggested by Johnson *et al.* (1955). High heritability coupled with low to moderate GAM indicates that the variability present among the genotypes for some of the characters is both additive and non-additive in nature. Gupta *et al*. (1994a) observed low to medium genetic advance for test weight, spikelets per spike and number of grains per spike. Similar to our results, high heritability estimates for protein per cent was reported by Prasad and Pandey (2001). Gowda (2009) and Kota (2010) reported high heritability with low to intermediate GAM for hectolitre weight. In conclusion based on the estimates of variability parameters, heritability and GAM, it appears that there is scope for improvement of these charactes by selection.

5.6 Correlation coefficient analysis among morpho-physiological and quality traits

Yield is a complex and highly variable character and is a result of cumulative effect of its components characters, so it is not correct to go for direct selection as such for yield. The yield components are not independent in their action and are interlinked and may also bring simultaneous changes for others at phenotypic and genotypic level. Correlation analysis measures the mutual relationship between various characters and determines the component characters on which improvement of yield is based.

Days to 50 per cent flowering had significant positive association with grain yield in all the individual environments as well as pooled over environments.Similar, results were reported by Khan *et al.* (1999), Esmail (2001) and Khan and Dar (2010). In contrast, Aycicek and Yeldrim (2006), Ashraf and Mohsen (2014) reported negative association of days to heading with grain yield.With respect to other traits days to flowering shows positive association with maturity, spike length,grains per spike ,transpiration rate and stomatal counductance. Khan and Dar (2010) also showed positive inter-realtions of days to flowering with maturity. Days to 50 per cent flowering observed significant negative association with thousands grain weight, canopy temeperature, stomatal resistance, membrane injury index and wet gluten content. Gowda (2009) reported significant negative association of days to heading with membrane injury index.

Days to maturity had significant positive association with grain yield in all the individual environments as well as pooled over environments except at Rahuri and Savalvihir (TSI). Anwar (2009) also reported positive association of maturity with grain yield. With respect to other traits days to maturity shows positive association with plant height, tillers per meter, spike length, grains per spike, photosynthetic rate, transpiration rate and stomatal counductance. Days to maturity showed significant negative association with canopy temeperature, stomatal resistance, membrane injury index and wet gluten content.

Plant height possessed significant positive correlation with grain yield in all the individual environments as well as pooled over environments except under LSI condition at location Rahuri where, it has negative and non significant association. Considering the mean height of the genotypes in the present study which come under semi dwarf plant type can be used as one of the selection criterion. Similar results were reported by Qayyum *et al.* (1991), Bahadur *et al.* (1993), Esmail (2001) and Khaliq *et al.* (2004), Kota (2010), Tripathi *et al.* (2011) and Mohmmadi *et al.* (2012). In contrast, Bhagat *et al.* (2004) and Gowda (2009) reported negative association of plant height with grain yield. It was suggested that genotypes with medium height are higher yielding than tall types. With respect to other component traits, plant height showed significant positive association with number of tillers per meter, spike length, photosynthetic rate , stomatal counductance and hectolitre weight. Whereas, negative association with stomatal reistance, canopy temperatre and wet gluten content in pooled environments.

Number of tillers per meter possessed significant positive correlation with grain yield in all the individual environments as well as pooled over environments except under TSI condition at location Niphad where, it has positive but non significant association. Similar results were reported by Mohan *et al.* (1993), Singh and Sharma (1994), Chatruvedi and Gupta (1995), Munjal and Dhanda (2001), Khaliq *et al.* (2004) and Bhagat *et al.* (2004), Kota (2010), Tripathi *et al.* (2011) and Mohmmadi *et al.* (2012). With respect to other component traits number of tillers per meter showed significant positive association with spike length, photosynthetic rate, stomatal counductance, and sedimentation value and hectolitre weight. Whereas, negative association with stomatal reistance, canopy temperatre and proten content in pooled environments.

Number of grains per spike had significant positive association with yield in all the environments and pooled over environments. Most of the studies in wheat support our results and this character can be considered as an important selection parameter in various breeding programmes. Mohan *et al.*

(1993), Singh and Sharma (1994), Kota (2010), Tripathi *et al.* (2011) , Abderrhmane *et al.* (2013) and Ashraf and Mohsen (2014) also reported similar results with respect to number of grains per spike. With respect to other component traits number of grains per spike showed significant positive association photosynthetic rate, stomatal counductance and transpiration rate. While, negative association with thousands grain weight, stomatal reistance, membrane injury index and wet gluten content in pooled analysis.

With respect to thousand grain weight, there was negative and significant association with grain yield under both conditions at Niphad and Savalvihir. However, at Rahuri under both conditions and pooled environment shows a non-significant negative association with grain yield. It shows that practical difficulty of simultaneous improvement due to lack of closely linked genes that cause covariation in the traits. . Similar results were also reported by Faalconer (1989), Sarkar *et al* (2002), Khaliq et al (2004), Gowada (2009) and Degewioine *et al* (2013). In contrast , Singh *et al*. (1997), Rahman *et al*. (1997), Uddin *et al*. (1997), Khan *et al*. (1999), Jedynski (2001), Munjal and Dhanda (2004), Khaliq *et al*. (2004) and Sahu *et al*. (2005) also reported significant positive association of 1000 grain weight with grain yield. Radmehr *et al*. (1996) also reported reduction in thousand grain weight at high temperatures.

Photosyntetic rate possessed significant positive correlation with grain yield in all the individual environments as well as pooled over environments except under TSI condition at location Nipahd where, it has positive and non significant association. Similar results were reported by Reynolds (1994), Delgado *et al.* (1994) Munjal and Dhanda (2004) and X. Chen *et al.* (2012). Photosynthetic rate had significant positive correlation with stomatal counductance at all environments as well as pooled environments. Similar results were reported by Shimshi and Ephrat (1975), Delgado *et al.* (1993) , Bahar *et al.* (2011) and X.Chen *et al.* (2012). With respect to other component traits transpiration rate, hectolitre weight showed significant positive association .Positive association of photosynthetic rate with transpiration was also reprted by X .Chen *et al.* (2012). Whereas, negative association with stomatal reistance, membrane injury index and canopy temperature was observed in most of the testing environments.

Transpiration rate possessed positive but non significant association with grain yield in all the individual environments as well as pooled over environments except under LSI condition at Savalvihir location where, it has significant positive association. Similar results were reported by X .Chen *et al.* (2012). With respect to other component traits transpiration rate showed significant positive association with canopy temepearure and photosynthetically active radiation. However, negative association was observed with membrane injury index, hectolitre weight and wet gluten content in pooled environments. Photosynthetically active radiation showed positive association with canopy temperature and negative with memebrane injury index.

Stomatal counductance showed significant positive association with grain yield at all locations as well as pooled environments. Whereas, under both condition at Nipahd, it showed positive and non significant association with grain yield. Similar results were reported by Shimshi and Ephrat (1975), Delgado *et al.* (1994), Bahar *et al.* (2009).With respect to other components, it had recorded significant positive association with hectolitre weight and sedimentation value. Whereas, negative association with stomatal reistance, membrane injury index, canopy temperature and wet gluten contenet were observed in pooled environments.

Stomatal resistance possessed significant negative assosciation with grain yield at all locations as well as pooled environments. Whereas, under both condition at Nipahd, it has negative and non significant association with grain yield. With respect to other components, it had recorded significant positive association with canopy temperature, protein and wet gluten. Whereas, negative association with sedimentation value in pooled environments.

Canopy temperature possessed significant negative assosciation with grain yield at Niphad under LSI and pooled environments. Whereas, at remaining environments, it had negative and non significant association with grain yield. Similar results were reported by Das *et al.* (1993), Chakrborty (1994), Onyiibe *et al.* (2003), Tyagi *et al.* (2003), Bahar *et al.* (2011) and Basu *et al.* (2014). With respect to other components, it had recorded significant positive association with protein and wet gluten content. Whereas, negative association was observed with hectolitre weight and memebrane injury index in individual environments.

Membrane injury index possessed significant negative assosciation with grain yield at all locations and pooled environments.Similar results were reported by Gowda *et al.* (2011). Whereas, positive association was noticed with wet gluten content in indvidual environments.

In general, most of the quality traits exhibited significant negative association with grain yield and with other yield components suggesting that selection for higher yield results in reduced quality traits. Among the quality traits, sedimentation value showed significant positive association with grain yield in pooled over environments. Similarly protein % showed significant positive association with wet gluten content in most of the environments. Protein per cent had negative correlation with yield and positive correlation with other quality traits. It is therefore suggested that selection programmes should be focussed by considering two characters simultaneously, that do not fit the general negative relationship and thereby make progress in compromise between grain yield and protein %. Similar results are also reported by Oury and Godin (2007), Gowda (2009) and Kota (2010) The plant breeders argue that selection for yield component is more efficient than the selection for yield *per se* so, it can be concluded that characters that are showing significant positive correlation with grain yield can be considered in selection programmes for the improvement of yield *per se*.

5.7 Path coefficient analysis of morpho-physiolgical and quality traits on grain yield

Path coefficient analysis is a standardized partial regression coefficient, which splits the correlation into direct and indirect effects of independent variables on the dependent variable. It reveals whether the association of these characters with grain yield is due to their direct effect on yield or it is a consequence of their indirect effect via some other character. If the correlation between the yield and a character is due to direct effect of a character, it reveals true relationship between them and direct selection for that trait will be rewarding for the yield improvement.

If the correlation is mainly due to indirect effects of the character through component traits, indirect selection through such trait will be effective in yield improvement. However, if the direct effect is positive and high, but the correlation is negative, in such situation direct selection for such trait should be practiced to reduce the undesirable indirect effect.

In the present study, Number of grains per spike had positive direct effects on yield under LSI at Niphad and Rahuri in the tested environments and pooled environments. Plant height showed direct positive effect and significant positive correlation with yield in pooled environments indicating that direct selection for the above said trait would be effective. In all the tested environments, the correlation between number of grains per spike and grain yield was found to be significant and positive. Similar results were reported by Chowdhary and Mandal (1991), Shelembi *et al*. (1992), Mondal *et al*. (1997), Kumar and Hunshal (1998), Moghaddam *et al*. (1998), Narwal *et al*. (1999), Tarnman *et al*. (2000) and Okuyuma *et al*. (2004).

In case of physiological traits, stomatal counductance had positive direct effect on grain yield in tested environments *viz*., Niphad (TSI), Rahuri (TSI), Savalvihir (LSI) and pooled environment. It also recoreded significant positive correlation with grain yield in pooled environments indicating that direct selection for the above said trait would be effective. Already, importance of these trait were reported by Delgado *et al.* (1994), Bahar *et al.* (2009) and Bahar *et al.* (2011) to help the photosynthetic activity of the crop plant. Stomatal resistance had positive direct effect on grain yield in tested environments at Rahuri (TSI) and pooled environment. It also recoreded significant negative correlation with grain yield in pooled environments indicating that indirect selection for the above said trait would be effective.

Canopy temepearure, membrane injury index and wet gluten content had direct negative effect in pooled environments. These charecters were also negatively correlated with grain yield.Similar results were reported by Gowda (2009) and Kota (2010).

In the present study, most of the quality traits contributed negative direct effets on grain yield. Hence, selection programmes should target the positive indirect traits and the breeding programmes should aim at breaking these undesirable negative associations so as to achieve quantity and quality in yield.

6. SUMMARY AND CONCLUSIONS

The present investigation on "G x E Interaction for Morpho-Physiological Aspects In Bread Wheat [*Triticum aestivum,* (L.)]" was undertaken at three locations *viz*., Niphad, Rahuri and Savalvihir under timely sown irrigated (TSI) and late sown irrigated (LSI) conditions during *Rabi*-2013-14. The experimental material consist of twenty new bread wheat genotypes developed at Agricultural Research Station , Niphad and three check varieties. Experimental material was sown in randomized block design with three replications over six environments. The experimental material was evaluated for ninteen morpho-physiological and quality characters. The results obtained are summarized as below.

6.1 Mean performance

The genotypes *viz*., NIAW 1885, NIAW 2268 and NIAW 2349 exhibited high *per se* performance for grain yield at Niphad, Rahuri and Savalvihir under TSI condition. Similarly, the genotypes *viz*., NIAW 2345, NIAW 2348 and NIAW 2349 recorded highest grain yield at Niphad, Rahuri and Savalvihir under LSI condition. On overall basis, NIAW 2349 showed highest *per se* perforamnce for grain yield.

6.2 Stability analysis

The mean sum of squares due to genotypes were significant for all the ninteen characters studied across the environments, which indicated the presence of substantial variation in the material studied. The analysis also indicated significant variation among the environments for all the characters. The values of G x E interaction were significant for all ninteen characters which indicated that genotypes interacted differently with environmental variations for the said characters. Highly significant values of mean squares due to environments (linear) for all the characters indicated that the linear response of genotypes to environment differed significantly for the said characters, while mean square values due to G x E (pooled error) were also significant for all the characters.

For earliness, the characters days to 50 per cent flowering and days to maturity under LSI environments were better than TSI environments. However, TSI environments were better for tillers per plant, grain yield, spike length, grains per spike, plant height and thousand grain weights. In case of physiological traits *viz*., photosynthetic rate, transpiration rate and stomatal counductance were adversely affected in LSI environments than TSI environments. For quality characters like protein per cent and wet gluten content, LSI environments were rich enviromnments with positive environmental indices, while TSI environemts were poor these traits with negative environmental indices.

The genotypes *viz*. NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2313, NIAW 2349, NIAW 1994 and check NIAW 917 had average stability and well adaption to all six types of environments for grain yield. NIAW 2351 had above average stability and is well adapted to poor environment. NIAW 1885 had below average stability and specifically adapted to favourable environments.

Out of the nine stable genotypes for grain yield six genotypes *viz*., NIAW 1994, NIAW 2279, NIAW 2275, NIAW 2349, NIAW 2351 and NIAW 917 exhibited its stable performance for more than one yield contributing characters.

6.3 Variability Parameters

The estimates of phenotypic coefficient of variance (PCV) were higher in respect of all the ninteen characters studied in all environments than the corresponding genotypic coefficient of variance (GCV). The reason for higher phenotypic level variability is due to both genotypic and environmental variability where response of genotype over environment is aparently realized. The characters spike length, number of tillers per meter, number of grains per spike, membrane injury index, photosynthetic rate, stomatal counductance transpiration rate,stomatal resistance sedimentation value, wet gluten content and grain yield exhibited larger amount of variability both at phenotypic level and genotypic level in most of the environments suggesting that selection can be practiced for the above traits and this variability can be utilized in various plant breeding programmes.

6.4 Heritability and genetic advance as per cent of mean

All the characters in the present study exhibited high heritability in all the individual environments at both the situations. Characters *viz.*, spike length, number of grains per spike, days to 50% flowering, membrane injury index, photosynthetic rate, stomatal counductance, transpiration rate, stomatal resistance, sedimentation value and wet gluten content exhibited high heritability coupled with high GAM. It indicates that these charecters are under the control of additive gene effects and the selection may be effective.

6.5 Correlation and path studies

In the present investigation, grain yield showed positive and significant correlation coefficient on overall basis with days to 50% flowering, plant height, days to maturity, tillers per meter, spike length, grains per spike, stomatal conductance, photosynthetic rate, sedimentation value and hectoliter weight. Whereas, significant positive direct effect on grain yield was recorded by grains per spike, tillers per meter, plant height and stomatal counductance.

6.6 Based on the results obtained, the following conclusions can be drawn.

(1) The values of G x E interaction were significant for all nineteen characters which indicated that genotypes interacted differently with environmental variations. As the grain yield is important character for stability point of view, the perusal of results for this character indicated that genotypes NIAW 2268, NIAW 2275, NIAW 2279, NIAW 2313, NIAW 2349, NIAW 1994 and check NIAW 917 had average stability and wider adaptability; whereas, NIAW 2351 had above average stability (bi < 1) and is well adapted to poor environment, similarly NIAW 1885 had below average stability (bi >1) and specifically adapted to favourable environment.

(2) NIAW 1994 and NIAW 2279 showed stable performance for grain yield, yield contributing and physiological traits.

(3) NIAW 1885, NIAW 1994, NIAW 1415 NIAW 917 and NIAW 34 showed better quality parameters among tested genotypes.

(4) Correlation and path analysis revealed that grains per spike , spike length , number of tillers, photosynthetic rate , sedimentation value and hectoliter weight can be considered in selection programme .

(5) Protein % and wet gluten content exhibited negative association with grain yield indicating selection for higher yield results in reduced protein and wet gluten content.

6.7 Future breeding methodology

Based on results obtained from the present study future breeding strategy is suggested for wheat improvement programme.

To plan an efficient breeding strategy, breeder should have genetic information of concerned plant species. The knowledge of genetic structure that determines the expression of character in relation to adaptability and productivity greatly helps in the exploitation of available genetic resource.

The genotypes which showed stable performance for grain yield along with other desirable traits should be included in the crossing programme to generate wider genetic base for developing high yielding varieties. High yielding stable genotypes might be released as variety after additional multilocation testing.

7. LITERATURE CITED

Anonymous, (2013-14a) Progress Report of All India Co-ordinated Wheat & Barley Improvement Project, Project Directors Report, Directorate of Wheat Research, Karnal (ICAR), pp 1-2.

Anonymous, (2013-14b) Report of Department of Agricultural Statistics of Maharashtra state.

Abderrahmane, H. Abidine F., Hamenna B. and Ammar B. (2013) Correlation,path analysis and stepwise regression in durum wheat (*Triticum durum* Desf.) under rainfed conditions. *J. Agric. Sustain*. 3(2):122-131.

Allard, R.W. (1960) Principles of plant breeding. *John Wiley and Sons. Inc*. : 75-98.

Allard, R.W. and Bradshaw, A.D. (1964) Implications of genotype x environment interactions. *Crop Sci.* 4: 503-50.

Ali, N., Javidfar, F. and Mirza. Y. (2003) Selection of stable rapeseed (*Brassica napus* L.) genotypes through regression analysis. *Pak. J. Bot.* 35: 175-183.

Ali, Y., B.M. Atta J., Akhter P. , Monneveux and Lateef Z. (2008) Genetic variability, association and diversity studies in wheat (*Triticum aestivum* L.) germplasm. *Pak. J. Bot*., 40(5): 2087-2097.

Ali, M. A., Nawab N.N., Abbas A., Zulkiffal M. and Sajjad M. (2009) Evaluation of selection criteria in *Cicer arietinum* L. using correlation coefficients and path analysis. *Australian J. Crop Sci.* 3(2): 65-70.

Akanda, S.I. and Mundt C.C. (1996) Path coefficient analysis of the effects of stripe rust and cultivar mixtures on yield and yield components of winter wheat. *Theor. Appl. Genet.* 92(6): 666-672.

Akram, Z., Saif Ullah A. and Muhammad M. (2008) Estimation of correlation coefficient among some yield parameters of wheat under rainfed conditions. *Pak. J. Bot*., 40(4): 1777-1781.

Anjum , F. Wahid A., Javed F. and Arshad M . (2008) Influence of foliar applied thiourea on flag leaf gas exchange and yield parameters of bread wheat (*Triticum aestivum* L) cultivars under salinity and heat stress. *Int. J. Agric.Biol.*10(6):619-626.

Anwar, J., M. Ali A., Hussain M., Sabir W., Khan M. A., Zulkiffal M. and Abdullah M. (2009) Assessment of yield criteria in bread wheat through correlation and path analysis. *The J. of Animal & Plant Sciences* 19(4):185-188.

Anwar, J., M. H., Muhammad A. A., Makhdoom H., Muhammad S., Ghulam M. S., Javed A. and Muhammad M. (2011). Assessment of adaptability and stability of grain yield in bread wheat genotypes under different sowing times in Punjab. *Pak. J. Bot*., 43(4): 1985-1993.

Amin, M., Tila M., Abdul J. Khan, Muhammad I., Akhtar A. and Ghulam R. T. (2005) Yield stability of spring wheat (*Triticum aestivum* L.) in the North West Frontier Province Pakistan. *Songklanakarin J. Sci. Technol*., 27(6) : 1147-1150.

Arain, M.A., Sial A.M., Rajput A.M., and Mirabahar A.A. (2011). Yield stability in bread wheat genotypes. *Pak. J. Bot*., 43(4): 2071-2074.

Ashraf, A. , Abd E-Mohsen, Mohamed A. and Abd E.Shafi. (2014) Regression and path analysis in Egyptian bread wheat. *JAAS Journal*, 2(5): 139-148.

Atli, A. (1999). Wheat and quality of wheat products. *Symposium: Problems and Solutions of Cereal Husbandry in Central Anatolian Region, 8-11 June, Konya, Turkey*. pp. 498-506

Ata A., Balal Y., Khan A S, Ghulam M. S. , Hafiz M. A. and Yousaf A. (2014) Correlation and path coefficient analysis for important plant attributes of spring wheat under normal and drought stress conditions. *J. of Natural Sci. Res*., 4(8) : 66-73

Aycicek M. and Yildirim T. (2006) Adaptability performances of some bread wheat (*Triticum aestivum* L.) genotypes in the eastern region of Turkey . *Int. J. of Sci. & Tech.,* 1(2): 83-89.

Babu, V.R. and Kumar. S.S. (2001) Phenotypic stability in wheat for grain yield and components characters under normal and stress environments. *Annals of Agric. Res.,* 22(2): 318-322.

Balota, M., Payne W.A., Evet S.R. and Peters T.R. (2008) Morphological and physiological traits associated with canopy temperature depression in three closely related lines. *Crop Sci*., 48: 1897-1910.

Banerjee , J., Rawat R. S. and Verma J. S. (2006) Stability analysis in bread wheat *(Triticum aestivum* L. em.Theil) and durum wheat *(T. durum* L.) genotypes *Ind. J. Genet.,* 66(2): 145-146

Bahadur, R., Singh, S.P. and Lodhi, G.P. (1993) Correlation and path coefficient analysis of grain yield and yield contributing characters in wheat. *Crop Res.* 6(3): 411-414.

Bahadur, R.P. and Lodhi. G.P. (1995). Variability and association studies in wheat (*Triticum aestivum* L.). *Crop Res*. Hissar, 9(2): 313-316.

Bahar , B., Yildirim M., Barutcular C. and Genc I. (2008) Effect of canopy temperature depression on grain yield and yield components in bread and durum wheat. *Notulae Botanicae Horti Agrobotanici Cluj-napoca*, 36(1): 34-37.

Bahar, B. ,Yildrim M. and Barutcular C. (2009) Relationship between stomatal conductance and yield components in spring durum wheat under Mediterranean conditions. *Notulae Botanicae Horti Agrobotanvci Cluj-napoca,* 37(2): 45-48

Bahar, B. ,Yildrim M. and Cemal Y. (2011) Heat and drought resistance criteria in spring bread wheat (*T. aestivum*) : Morpho-physiological parameters for heat tolerance. *Sci Res. and Essay* , 6 (10) : 2212-2220.

Basu, S., Parya M., Dutta S.K., Majii S. ,Jena S., Nath R. and Chakrborty P.K. (2014) Effect of canopy temperature and stress degree day index on dry matter accumulation and grain yield of wheat (*Triticum aestivum*) sown at different dates in the Indo Gangetic Plains of Eastern India. *Ind.J. Agric Res*., 48(3) :167-176.

Baric M., M. Pecina, H. Sarcevic, S. Keresa (2004). Stability of four Croatian bread winter wheat (*Triticum aestivum* L.) cultivars for quality traits. *Plant Soil Environ*., *50* (9): 402–408.

Bhagat, I., Randhawa, A.S. and Sharma, S.K. (2004). Path analysis in wheat. *J Res., PAU* 41(2): 183-185.

Bhoite, K.D., Rasal P.N. Gadekar D.A. and Gavhane V.N. (2011) Stabilty of grain yield in rainfed wheat. *New Agriculturist* 22(1, 2): 1-3

Blum, A. (1983) Breeding programme for improving crop resistance to water stress. (*in*) *Crop Reactions to Water and Temperature Stress in Humid Temperature Climates*, pp 263–74. Paper Ir CD and Kramer P J (Ed.).

Borghi, B. and Perenzin, M. (1990) Yield and stability of conventional varieties and F_I bread wheat hybrids. *Genet. Breed.* 44: 307-310.

Burton, G. W. (1952). Quantitative inheritance in grasses. *Proceding of 6th International Grassland Congress.* pp: 227-283.

Castillo, Dalma, Iván Matus, Alejandro del Pozo, Ricardo Madariaga, and Mario Mellado (2012) Adaptability and genotype × environment interaction of Spring wheat cultivars in Chile using regression analysis AMMI, and sreg. *Chilean J. of Agric. Res.,* 72(2):167-174

Chakraborty, P.K. (1994) Effect of sowing dates and irrigation on the diurnal varation in physiological process in the leaf of Indian mustard (*Brassica juncea*).J. Oilseeds Res. , 11(2) : 210-216.

Chaturvedi, B.K. and .Gupta, R.R. (1995) Selection parameters for some grain and quality attributes in spring wheat (*Triticum aestivum* L.). *Agric. Sci. Digest KarnaI* 15(4): 186-190.

Chaubey, J.S. and Sastry E.V.D. (1981) Stability analysis of yield and yield components in some Indian and Mexican varieties of wheat. *Ind. J Agric. Sci.,* 51(1):611-614.

Chowdhury, P.R. and Mandal, A.B. (1991) Association and path analysis for grain yield in wheat at different micro-environments. *Environment and Ecology* 9(4): 906-910.

Das, D.K. , Mishra K.K and Kara N. (1993) Assessing growth and yield of wheat using remotely sensed canopy temperature and spectral indices .*Int. Remote Sense* ,14: (17) 3081-92.

Degewione, Awale , Takele Dejene and Mohammed Sharif (2013) Genetic variability and traits association in bread wheat (*Triticum aestivum* l.) genotypes. *Int'l Res. J. of Agric. Sci.*, 1(2): 19-29.

Delgado, M.I., Reynolds M.P., Larque-Saavedra A. and Nava S.T. (1994) Genetic Diversity for Photosynthesis in Wheat under Heat Stressed Field Environments and Its Relation to Productivity. *Wheat Special Report*, 30: 17.

Dencic, S., N. Mladenov and B. Kobiljski (2011) Effects of genotype and environment on bread making quality in wheat, *Int. J. of Pl. Prod. 5(1): 71-82.*

Deswal, R.K., Singh, D., Berwal, K.K. and Lekhraj. (1996a) Stability analysis for harvest index and some yield components in wheat. *Annals of Agri-Bio. Res.* I(1-2): 83-87.

Deswal, R.K., Grakh S.S. and Berwal K.K. (1996b) Genetic variability and characters association between grain yield and its components in wheat. *Ann. Bioi. Ludhian*, 12(2): 221-224.

Dewey, D.R. and Lu K.H. (1959). Correlation and path coefficient analysis of components of crested wheat grain seed production. *Agron. J.* ,51: 575-578.

Dokuyucu, T. and Akkaya, A. (1999) Path coefficient analysis and correlation of grain yield and yield components of wheat (*Triticum aestivum* L.) genotypes. *Rachis*. 18: 17-20.

Eberhart, S.A . and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.* , 6: 36-40.

Esmail, R.M. (2001). Correlation and path coefficient analysis of some quantitative traits with grain yield in bread wheat (*Triticum aestivum* L.). *Bulletin of the National Research Centre, Cairo.,* 26(3): 395-408.

Falconer, D.S. (1964) An introduction to quantitative genetics. Oliver and Boyd Ltd., *Edinburg* pp 312-318.

Falconer, D.S. (1989) Introduction to Quantitative Genetics. *3rd Edn., Longman Scientific and Technical, New York*,Pp:438.

Fischer, R.A. Rees D. , Sayre K.D., Lu Z.M., Condon A.G. and Larque S.A. (1998) Wheat yield progress is associated with higher stomatal counductance and photosynthetic rate and cooler canopies. *Crop Sci.* , 38(6) : 1467-1475.

Gebeyuhu,G., Ginkel M.V. and Tanner. D.G. (1988) Grain yield stability of bread wheat cultivars in the high lands of Ethiopia. *Fifth regional wheat workshop for astern, Central and Southern Africa and the Indian Ocean, Antsirabe, Madagascar, 5-10 Oct. 1987* pp 61-65.

Geleta, B. Mariam H.G., Tesemma, T. and Gebeyehu G. (1992) Stability of yield and harvest index of improved bread wheat varieties in Ethiopia. *7th regional wheat workshop of Eastern, Central and Southern Africa* pp 56-63 .

Ghobadi, M., Khosravi S., Kahrizi D. and Shirvani D . (2011) Study of water relations, chlorophyll and their correlations with grain yield in wheat (*Triticum aestivum* L.) genotypes. *World Acad. of Sci. Eng. and Tech.* 54:582-585

Gowda S.D.S. (2009) Genetic analysis of high temperature tolerance in wheat (*Triticum aestivum* L.) *M.Sc. (Agri.) thesis submitted at IARI , New Delhi.(Unpublished)* .

Gowda, S. D. S., Singh G.P., Singh A.M. , Deveshwar J.J. Ahalawat A. (2010) Stability analysis for physiological and quality parameters in wheat (*Triticum aestivum*) *Ind. J. of Agri. Sci.,* 80 (12): 1028–32.

Gowda S. D. S., Singh G.P., and Singh A.M. (2011) Relationship between canopy temperature depression, membrane stability, relative water content and grain yield in bread wheat (*Triticum aestivum*) under heat-stress environments. *Ind. J. of Agri. Sci.,* 81 (3): 197–202.

Grausgruber, H.M., Oberforster, M., Werteker, M., Ruckenbauer, P. and Vollmann, J. (2000) Stability of quality traits in Australian-grown winter wheats. *Field Crop Res.,* 66: *703-711.*

Gupta, R.S., Singh, R.P. and Tiwari, O.K. (2004a) Analysis of heritability and genetic advances in bread wheat (*Triticum aestivum em. Thell*). *Adv. PI. Sci.* 17(1): 303-305.

Gupta, R.S., Singh, R.P. and Tiwari. O.K. (2004b). Analysis of path coefficient for yield and its related characters in bread wheat (*Triticum aestivum* L. emThell). *Ad. PI. Sci.* ,17(I): 299-302.

Hanchinal, R.R., Tandon, J.P., Salinath, P.M. and Saunders, D.A. (ed.) Hettel, G.P. (1994) Variation and adaptation of wheat varieties for heat tolerance in Peninsular India. *Proc. Int. Conf. held at Wad Medani, Sudan, 1-4 Feb. 1993 and Dinajpur, Bangladesh, 13-25 Feb., 1993* pp 175-183.

Hailu, J.K., Sarial A.K. and S. Assefa. (2007) AMMI analysis for stability and locations effect on grain protein content of durum wheat genotypes. *Cereal Res. Commun*., 35: 1661-1673.

Hebert, Y., Plomion, C. and Harzic, N. (1995). Genotypic x environment interaction for root traits in maize as analysed with factorial regression models. *Euphytica* ,81: 85-92.

Hokrani, V., H., Rudra Naik, Nadaf H. L., Desai S. A., Deshpande S. K., Kalappanavar I. K. and Patil B. N. (2013) Genetic studies in free threshable advanced segregating population of tetraploid wheat (Triticum dicoccum). *Karnataka J. Agricultural Sciences*. 26(1):10-13.

IPCC (2007) Intergovernmental panel on climate change report: Synthesis: Summary for policy makers. *IPCC, World Meteorological Organization, Switzerland.*

Jackson P, Robertson M, Cooper M and Hammer G (1996). The role of physiological understanding in plant breeding, from a breeding perspective. *Field Crops Res*., 49: 11-37.

Jedynski S. (2001) Heritability and path coefficient analysis of yield components in spring wheat. *Proceedings of a Symposium, Poland* , 30-31 January 2001.No. 218-219 pp.203-209.

Johnson,. H.W, Robinson, H.F. and Comstock, R.E. (1955) Genotypic and phenotypic correlations in soybeans and other implications in selection. *Agronomy J.* 47: 477-483.

Kant S, RAS Lamba, R K Arya and Panwar I S. (2014) Effect of terminal heat stress on stability of yield and quality parameters in bread wheat in southwest Haryana. *J. of Wheat Res.,* 6(1):64-73.

Kattenberg, A., Giorgi F., Grassl H., Meehl, G.A., Mitchell J.F.B., Stouffer R.J., Tokioka T., Weaver A.J. and Wigley T.M. (1995) Climate models-projection of future climate. In the science of climate change. Contribution of working group I to the 2nd assessment report of the intergovernmental panel on climate change. Eds. J. T. Houghton, L.G.M. Filho, B.A. Callander, N. Harris, A. Kattenberg, Maskell, Climate change. Cambridge University Press. pp. 289-357.

Kaushik, S.K., Sharma, S.C. and Sharma, G.R. (1996) Studies on correlation and path coefficients analysis in. sibmated vis-a-vis selfed population in wheat. *HAU J. Res*., 26(4): 235-241.

Karimizadeh, R., M. Mohammadi, M. Armion, M. K. Shefazadeh and H. Chalajour, (2012) Determining heritability, reliability and stability of grain yield and yield-related components in durum wheat (*Triticum durum* L.). *Bulg. J. Agric. Sci.,* 18: 595-607.

Khaliq, I., Parveen, N. and Chowdhury, M.A. (2004). Correlation and path coefficient analysis in bread wheat. *Int. J. Agric. Biol.,* 6(4): 633-635.

Khan, H.A., Shaik M. and Mohammad, S. (1999) Character association and path coefficient analysis of grain yield and yield components in wheat. *Crop Res. Hissar,* 17(2): 229-233.

Khan , Mudasir H. and Dar Abdul N. (2010) Correlation and path coefficient analysis of some quantitative traits in wheat. *African Crop Sci. J.,* 18(1): 9 - 14.

Khan, N. and F.N. Naqvi (2012) Correlation and path coefficient analysis in wheat genotypes under irrigated and non-irrigated conditions. *Asian J. of Agric. Sci,.* 4(5): 346-351.

Khayatnejada, M. , M. Zaefizadehb and Gholamina R. (2010) Study of genetic diversity and path analysis for yield of durum wheat under drought stress condition. *Plant Ecophysiology,* 2:133-136.

Kheiralla, K.A. and Ismail, A.A. (1995) Stability analysis for grain yield and some traits related to drought resistance in spring wheat. *Astr.J Agric. Sci.* 26 (I): 253-266.

Khumkar, M.S., Choudhary, H.B. and Deshmukh, P.S. (2001) Genetic variability and association of morpho-physiological characters with grain yield in late -sown wheat (*Triticum aestivum L. em. Thell.*). *Ann. Agric. Res*., 22(2): 217- 220.

Koc, M., Barutcular C.,and Genc I. (2003) Photosynthesis and productivity of old and modern durum wheat in a Mediterranean Environment. *Crop Sci.*, 43(6): 2089-2097.

Koc, M., Barutcular C., Tiryakioglu M. (2008) Possible heat-tolerant cultivar improvement through the use of flag leaf gas exchange traits in a Mediterranean Environment. *J. Sci. Food Agric. Res.,* 88: 1638- 1647.

Kota S. (2010) Molecular diversity and G x E interaction for yield and quality attributes in new plant types in bread wheat. *Ph.D. thesis submitted at IARI, New Dlhi. (Unpublished)* .

Kota, S., S.S. Singh, T. Mohapatra, A.M., Singh, Brajendra, V.P. Bhadana And S. Ravichandran (2013) Genotype x environment interaction analysis for grain yield in New plant type (npt) wheat derivatives. *SABRAO J. Breed. Genet.* 45 (3) 382-390.

Kotal, B.D., A. Das and B.K. Choudhury (2010) Genetic variability and association of characters in wheat (*Triticum aestivum* L). *Asian J. Crop Sci.*, 2:155-160.

Korkut, K.Z., Bilgin O., Baser I. and Saðlam N.(2007) Stability of grain vitreousness in durum wheat (*Triticum durum* L. Desf) Genotypes in the North western region of Turkey. *Turk. J. Agric. For.*, 31, 313-318.

Kumar, A N. (2002) Studies on variability and inheritance of some morpho-physiological traits in bread wheat (*Triticum aestivum* L.) under moisture stress conditions'. *M Sc thesis Un-published. Indian Agricultural Research Institute, New Delhi*.

Kumar, B.N.A. and Hunshal, C.S. (1998) Correlation and path coefficient analysis in durum wheat (*Triticum durum* Derf.) under different planting dates. *Crop Res. Hissar,* 16(3): 358-361.

Kumar, S. and Singh, I.S. (1993). Correlation and path analysis in triticale. *Ind. J. Genet*., 53(2): 197-202.

Kumar, B., Lal G.M., Ruchi and Upadhyay A. (2009) Genetic variability, diversity and association of quantitative traits with grain yield in bread wheat (*Triticum aestivum* L). *Asian J. of Agril. Sci.,* 1(1):4-6.

Li P., Chen J. and Wu P. (2012) Evaluation of grain yield and three physiological traits in 30 spring wheat genotypes across three irrigation regimes. *Crop Sci*., 52:110–121.

Madariya, R.B., Poshiya, Y.K. and Kavani, R.H. (2001) Phenotypic stability of yield and its contributing characters in bread wheat (*T. aestivum*. L.) *Madras Agric. J*. ,88 (10-12): 648-650.

Majid, S.A., R. Asghar and Murtaza G. (2007) Yield stability analysis conferring adaptation of wheat to pre- and post-anthesis drought conditions. *Pak. J. Bot*., 39(5): 1623-1637.

Maloo, S.R., Sharma, P.C., Saini, D.P., Rohifasliwa and Sharma, S.N. (1993) Stability of grain yield, biological yield and harvest index in wheat. *J. Res.(BAU)* , 5-: 33-36.

Mann, C.E., Saunders D.A. and Hettel G.P. (1994) Wheat in heat stressed environments: irrigated, dry areas and rice-wheat farming systems. *Proceedings of the International Conferences*. 247-250.

Mehta, H., Sawheny R.N., Singh S.S., Chaudhary H.B., Sharma D.N. and Sharma J .B. (2000) Stability analysis of high yielding wheat at varying level of fertility. *Ind. J Genet*., 60(4):471-476.

Menon, U., Sharma, S.N. and Menon. U. (1997) Phenotypic stability in hexaploid wheat. *Crop Improv*., 24(1): 132-134.

Meena, H. S., Dinesh Kumar, Srivastava T. K. and Rajendra P. S. (2014) Stability for grain yield and its contributing traits in bread wheat (*Triticum aestivum). Ind. J. of Agric. Sci.,* 84 (12): 1486–95.

Mishra, B.K., and Gupta, R.K. and Sewa Ram. (1998) Protocols for evaluation of wheat quality, *Technical Bulletin Directorate of wheat research, Karnal* pp.21-22.

Mohan, D.S.R., Singh H., Khol O.P.S. and Singh H. (1993) Correlation and path analysis in late sowed bread wheat (*Triticum aestivum* L.). *Crow Res. Hissar,* 6 (1): 72-77.

Mohammadi, V., Quannadha M.R., Zali A.A., Yazdi-Samadi B. (2004) Effect of post anthesis heat stress on head traits of wheat. *Int. J. Agric. Biol.,* 6 (1): 42-44.

Mohammadi, M., Sharifi P., Karimizadeh R., Kazem M., Shefazadeh M.K. (2012) Relationships between grain yield and yield components in bread wheat under different water availability (dry land and supplemental irrigation conditions). *Not. Bot. Hortic. Agrobo*., 40(1):195-200.

Mollasadeghi, V., Ali A. I., Reza S. and Majid K. (2011) Correlation and Path Analysis of Morphological Traits in Different Wheat Genotypes under End Drought Stress Condition. Middle-East *Journal of Scientific Research* 7 (2): 221-224.

Mondal, A.B. Sadhu D.P. and Sarkar K.K. (1997) Correlation and path analysis in bread wheat. *Environ. and Ecol.*, 15(3): 537-539.

Mondal, A.B. and Das A.D. (1989) Stability analysis in bread wheat (*T. aestivum* , L.). *Ind. J. Genet*., 49(1): 141-143

Mondal, S.K. and Khajuria, M.R. (2002) Stability analysis III bread wheat (*T. aestivum*). *Environ. and Ecol* ., 20(3): 620-624.

Moneim, B.F.A. (1987) Genotypic stability analysis of yield and related agronomic characers in wheat Agropyron derivatives under varying watering regimes. *Theor. Appl. Genet*., 73: 737-743.

Moyghaddam, M., Ehdie B. and Waines J.G. (1998) Genetic variation for and inter-relationships among agronomic traits in landraces of bread wheat from south western *Iran. J. Genet. Breed*., 52(I): 73-81.

More, D.C., Patil, H.S., Jangale, G.D. and Rasal, P.N. (1990). Stability of grain yield in wheat. *J. Maharashtra Agric. Univ.* 15(1): 31-32.

Munjal, R. and Rana R.K. (2003) Evaluation of physiological traits in wheat (*Triticum aestivum*) for terminal high temperature tolerance.*In Procced.of 10th International Wheat Genetics Symposium Classical and Molecular Breeding,Poestum,Italy,2(3): 804-805.*

Munjul, R. and Dhanda S.S. (2004) Associations for heat tolerance in bread Wheat. *National J. Pl. lmpro.* 6 (I): 71-73.

Naserian, B., Asadi A.A., Rahimi M. and Ardakani M.R. (2007) Evaluation of wheat cultivar mutants for morphological and yield traits and comparing of yield components under irrigated and rain fed conditions. *Asian J. Plant Sci*., 6: 214-224.

Narwal, N.K., Verma, P.K. and Narwal. M.S. (1999) Genetic variability, correlation and path coefficient analysis in bread wheat in two climatic zones of Haryana*. Agric. Sci. Digest Karnal,* 19(2): 73-76.

Qayyurm, S.M., Ansari A.H. and Mirza. A.A. (1991). Inter-relationship among grain yield and its economic characters in wheat (*Triticum aestivum* L.) *Wheat Information Service*. ,73: 25-29.

Onwueme I.C. (1979). Rapid, plant-conserving estimation of heat tolerance in plants. *Journal of Agricultural Science* 92: 527–536.

Onyibe , J.E. Ahmed M.K. , Falaki A.M. and Ramalan A.A (2003) Canopy air temperature differential of wheat varieties grown under different soil moisture regime on semi arid Sudan Savana .*Disc and Innov*, 15 (3/4): 177-185.

Oury, F.X., and Godin C. (2007) Yield and grain protein concentration in bread wheat: how to use the negative relationship between the two characters to identify favourable genotypes. *Euphytica,* 157 : 45-57.

Ozkan, H., Yagbasanlar T.and Genc I. (1998) Tolerance and stability studies on durum wheat under drought and heat stress conditions. *Cereal Res. Commun.,* 26: 405-412.

Panse, V.G. and Sukhatme, P.V. (1954) Statistical methods for agricultural works. *Indian Council of Agricultural Research Publications.,* 87-89.

Parkash, C. and Pandey, H.N. (2001) Stability for grain yield and quality traits in durum (*Triticum durum* Desf.) strains derived from *Triticum durum x Triticum timopheevi* crosses. *Ann. Agric. Res.,* 22: 212-216.

Parveen, Latafat, Iftikhar Hussain Khalil, and Shad K. Khalil (2010) Stability parameters for tillers, grain weight and yield of wheat cultivars in north-west of Pakistan. *Pak. J. Bot*., 42(3): 1613-1617.

Prasad, V.S. and Pandey, H.N. (2001) Evaluation of variability parameters, characters associations and genetic distance in *Triticum duru*m genetic stocks. *Madras Agric. J*. 87 (1-3): 26-29.

Okuyama, L.A., Federizzi L.C. and Barbosa Neto J.F. (2004) Correlation and path analysis of yield and its components and plant traits in wheat. *Ciencia Rural,* 34(6): 1701-1708.

Radmehr, M., Lotfal-Aenneh, G. and Kajbaf, A . (1996). Study on the effect of heat stress on agronomic traits, grain yield and yield components in twenty five bread wheat genotypes. *Seed and Plant* 12(I): 13-23.

Rahman, M.M., Hossain A.B.S. and Saha N.K. and Malaker P.K. (1997) Selection of morpho-physiological traits for heat tolerance in wheat. *Bangladesh J. Sci. Indus. Res.* , 32(2): 161-16~.

Raut, S. K., Manjaya L.G: and Khorgade P. W. (1995) Selection criteria in wheat. *PKV Research J.19(1): 17-20.*

Ranjana and Suresh Kumar (2013a) G x E interaction over extended dates of sowing for grain yield and its attributing traits in wheat (*Triticum aestivum* L.) *Annals of Biological Research*, 4 (1):238-241.

Ranjana and Suresh Kumar (2013b) Study of genetic variability and heritability over extended dates of sowing in bread wheat (*Triticum aestivum* L.) *Res. in Pl. Biol.,* 3(1): 33-36.

Reynolds, M.P., Balota M., Delgado M.I.B., Amani I. and Fischer R.A. (1994) Physiological and morphological trais associated with spring wheat yield under hot, irrigated conditions. *Aust. J. Plant Physiol*., 21: 717- 730.

Sahu, S., Ohari R. and Joshi A.K. (2005) Variability studies in wheat (*Triticum aestivum* L.) under late sown condition. *Indian 1. Genet*., 65(4): 309-310.

Sandhu, C.S., Gill K.S. and Ghai B.S. (1980) Correlation and path coefficient analysis in bread wheat. *J. Agric. Sci*., 52(6): 355-359.

Satyavari, Yadava R.K. and Singh G.R. (2002) Variability and heritability estimates in bread wheat. *Env. Ecol*., 20(3): 548-550.

Sarkar, C.G.K, Srivastava P.D.L., and Deshmukh P.S.(2002) Effect of terminal high temperature stress tolerance in bread wheat (*Triticum aestivum* L. Em.Thell): Estimation of character association and contribution of yield attributes to grain yield. *Ann. Agric. Res.,* 23:75-78.

Shahid, M.A. and Kabir G. (1996) Evaluation of twenty one wheat breeding lines in six environments. *Bangladesh Bot*., 25(I): 45-49.

Sharma, O.J., Yadav R.K. and Sharma R.K. (1995). Genetic variability and association of some yield components in winter x spring nursery wheat. *Adv . . Pl. Sci,*. 8(1): 95-99.

Shelembi, M.A., Wright A.T. and Tanner T.G. (ed.) and Mwangi W.J. (1992) Correlation and path coefficient analysis on yield components of twenty spring wheat genotypes evaluated at 2 locations Arusha region of Tanzania. *7th regional wheat workshop for eastern central and southern Africa, Kenya*. 16-19 Sept. 1991.

Shimpiger, S.S., Hanchinal R.R., Salimath P,M. and Hanamaratti N.G. (1996) Genetic variability studies in durum wheat (*Triticum durum*). *Karnataka J. Agric. Sci.,* 9(3): 538-541.

Shimshi, D and J.Eprhat (1975) Stomatal behavior of wheat cutivars in relation to their transpiration ,photosynthesis and yield. *Agron. J*. 67: 326-331.

Shankarrao, S.B., Subhra Mukherjee A.K. Pal and De D.K. (2010) Estimation of variability for yield parameters in Bread Wheat (*Triticum aestivum* L.) grown in Gangetic West Bengal . *Electronic J. of Pl. Br*., 1(4): 764-768.

Snedecor, G.W. and Cochran, W.G. (1967) (eds). Staistical methods. *Oxford and IBH Publ.* pp 557.

Sial, M.A., Arain M.A, and Ahmad M. (2000) Gentoypic x environment interaction on bread wheat grown over multiple sites and years in Pakistan. *Pak. J. Bot*. ,32(I): 85-91.

Sididique, M.R.B. Hamid A., and Islam M.S.(2000). Drought stress effects on water relations on wheat.*Bot.Bull.Acad.Sin.,*41:35-39

Singh, I. and Sharma S.K. (1994) Inter-relationship £f harvest index and other traits in wheat. *Haryana Agril Univ. J Res,* 24: 33-38.

Singh, N.B., Ziauddin Ahmad and Ahmad Z. (1997) Response of wheat (*Triticum aestivum*) varieties to different dates of sowing. *Ind. J. Agric. Sci*. ,67(5):208-211.

Singh, V. , Singh D,. and Singh N. (2003) Studies on correlation and path coefficient analysis in bread wheat (*Triticum aestivum* L.em.Thell). *National J. Pl. Improv*. 5: 106-109.

Stone, P.J. and Nicholas M.E. (1995) Effect of timing of heat stress during grain filling on two wheat varieties differing in heat tolerance. *Aust. J. Pl. Physiol*., 22: 927-934.

Tahir, M.A., Rahmatullah T. Aziz, M. Ashraf S. Kanwal and Maqsood M.A.(2006) Beneficial effects of silicon in wheat (*Triticum aestivum* L.) under salinity stress. *Pak. J. Bot*., 38(5): 1715-1722.

Tarnmarn, A,M., Ali S.A. and EI Sayed E.A.M. (2000) Phenotypic genotypic correlations and path coefficient analysis in some bread wheat crosses. *Aust.J. Agric. Sci.,* 31(3): 73-85.

Tripura K., G.P. Singh, Anju M. Singh, Ajay Arora, Arvind Ahlawat And R.K. Sharma (2011) Stability analysis for physiological parameters and grain yield in bread wheat (*Triticum aestivum l.*) *Ind. J. Pl. Physiol.*, 16(1): 26-34

Tripathi, S.N., Shailesh Marker, Praveen Pandey, K.K.Jaiswal and B.K.Tiwari (2011) Relationship between some morphological and physiological traits with grain yield in bread wheat (*T.aestivum*.) *Trends in Applied Res.*,6(9):1037-1045.

Tyagi, P.K. , Singh D.P. and Pannu R.K. (2003) Effect of air temperature on yield and yield components of fourteen wheat genotypes . *Environmental Ecol.,* 24(3):550-554.

Uddin, M. J., Mitra B., Chowdhury M.A.Z. and Mitra B.(1997) Genetic parameters, correlation, path coefficient analysis and selection indices in wheat. *Bangladesh J. Sci. Indus. Res*. 32(4): 523-528.

Wardlaw, I.F. and Moncer, L. 1995. The responses of wheat to high temperature following anthesis I. The rate and duration of kernel filling.Aust. *J. Pl. Physiol*., 22: 391-397.

Wright, S. (1921) Correlation and causation. *J. Agric. Res*. , 20: 257-287.

Xhuveli, L. and Collaku A. (1989) Analysis of yield stability in cultivars of bread wheat. *Buletinii Shkencave Bujqesore,* 3: 115-122.

X. Chen , Donghong Mina, Tauqeer Ahmad Yasira and Yin-Gang Hua,b (2012) Evaluation of 14 morphological, yield-related and physiological traits as indicators of drought tolerance in Chinese winter bread wheat revealed by analysis of the membership function value of drought tolerance (MFVD). *Field Crops Res*. ,137 :195–201.

Yadav, D.K, I.S. Pawar G.R., Sharma,R.A. and Lamba S. (2006) Evaluation of variability parameters and path analysis in bread wheat. *Nat. J. of Pl. Improv,*.8 (1): 86-89.

Yadav, A., Kumar A and Jaiswal J.P. (2013) Effect of genotypes and environment on grain yield, its attributes and quality traits in wheat. *Pantanagar J. of Res.,* 11(2):191-198.

Yildirim, M., Kilic H., Kendal E., Karahan T. (2011) Applicability of chlorophyll meter readings as yield predictor in durum wheat. *J. Plant Nutr.,* 34(2): 151-164.

Zeki, M., Nevzat A. H., Orhan B. and Hasan O. (2010) Stability of some quality traits in bread wheat (*Triticum aestivum*) genotypes. *J. of Env. Bio*., 31:489-495.

8. VITA

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