

Correlation Analysis of Growth and Yield Parameters of Wheat (*Triticum Aestivum* L.) at Aliero and Jega, Sudan Savannah Zone of Nigeria

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Abstract

*This study investigated the relationships between selected growth and yield parameters of wheat (*Triticum aestivum* L.) at Aliero and Jega, Kebbi State, Nigeria, during the 2016/2017 dry season. The field experiment evaluated four planting dates (1 November, 15 November, 1 December and 15 December 2016) and three planting methods (drilling, dibbling and broadcasting) using a factorial randomized complete block design with three replications at each location. The wheat variety Gan-Atilla was used. Reported correlation coefficients were used to examine the relationships between grain yield and selected agronomic traits. At Aliero, grain yield was positively correlated with number of grains per spike ($r = 0.833$), total biomass ($r = 0.779$), 1,000-grain weight ($r = 0.754$), number of tillers ($r = 0.725$) and plant height ($r = 0.612$). At Jega, grain yield showed positive correlations with total biomass ($r = 0.891$), number of tillers ($r = 0.839$), 1,000-grain weight ($r = 0.819$), number of grains per spike ($r = 0.817$) and plant height ($r = 0.597$). Leaf length and leaf width had comparatively weak positive correlations with grain yield at both locations. Among the reported relationships between yield components, spike length was positively correlated with number of grains per spike at Aliero ($r = 0.730$) and Jega ($r = 0.723$). Overall, the results indicate that grain number per spike, total biomass, tiller number and 1,000-grain weight were more strongly associated with grain yield than the measured leaf dimensions. These findings identify important trait relationships for further investigation of wheat productivity in the study area. However, the absence of complete statistical output limits conclusions about statistical significance and differences between locations.*

Keywords: *Wheat; correlation analysis; grain yield; growth parameters; yield components; planting date; planting method; Kebbi State.*

Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop used in the production of bread, pasta, biscuits and other food products. Its productivity is influenced by genetic characteristics, environmental conditions and agronomic management practices. In Nigeria, improving the productivity of wheat under suitable irrigated conditions is important for increasing domestic production and reducing dependence on imported wheat. Grain yield is a complex quantitative trait associated with several growth characteristics and yield components. These include plant height, tiller number, spike length, number of grains per spike, grain weight and total biomass.

Understanding the relationships among these characteristics can provide information useful for crop evaluation, agronomic management and the identification of traits associated with improved productivity. Previous studies have examined relationships among wheat biometric traits, yield components and grain production. Chowdhury et al. (1986) investigated yield and yield components using path coefficient analysis, while Asif et al. (2004) examined heritability, genetic variability and path coefficients for traits in spring wheat. Khan et al. (2005) also investigated interrelationships and path coefficients among biometric traits in drought-tolerant wheat. Such studies provide a basis for investigating associations between individual agronomic traits and grain yield. Correlation analysis measures the direction and strength of the relationship between two variables. A positive correlation indicates that higher values of one variable tend to occur with higher values of the other, while a negative correlation indicates an inverse relationship. However, correlation does not establish causation, and a strong correlation between a trait and grain yield does not necessarily mean that the trait independently determines yield. Planting date and planting method are important components of crop management that may influence crop establishment, development and yield formation. Research has examined the effects of planting methods on wheat grain and yield-contributing parameters (Abbas et al., 2008; Sinkader et al., 2003). Similarly, sowing-date studies have investigated variation in wheat yield and yield components among varieties and growing conditions (Ali et al., 2010; Aslani and Mehrvar, 2012; Qasim et al., 2008). Environmental conditions, including temperature and water availability, may also affect wheat growth and yield performance (Hakim et al., 2012; Hossain et al., 2011). Aliero and Jega in Kebbi State, Nigeria, provide locations for evaluating wheat performance under dry-season cultivation. Examining relationships between growth characteristics and grain yield at both sites may help identify agronomic traits associated with yield variation under the conditions represented by the study. The present study therefore examined the correlations between selected growth and yield parameters of wheat and grain yield at Aliero and Jega during the 2016/2017 dry season. Specifically, the study aimed to:

1. Determine the relationships between selected growth parameters and grain yield at Aliero and Jega.
2. Examine the associations between yield components and grain yield at both locations.
3. Compare the reported correlation patterns between the two locations.

Materials and Methods

Study locations

The field experiment was conducted during the 2016/2017 dry season at Aliero and Jega in Kebbi State, Nigeria. The reported geographical coordinates and elevations were approximately 12°18.64' N, 4°29.85' E and 262 m above sea level for Aliero, and 12°12.99' N, 4°21.90' E and 197 m above sea level for Jega. The supplied study material reported minimum temperatures of 18–29°C, maximum temperatures of 30–42°C, relative humidity of 26–39% and wind speeds of 1.9–5 m/s. These environmental ranges should be checked against the original meteorological records to establish the observation period and confirm the reported minimum and maximum temperatures.

Experimental design and treatments

The experiment evaluated four planting dates and three planting methods. The planting dates were 1 November, 15 November, 1 December and 15 December 2016. The planting methods were drilling, dibbling and broadcasting. A factorial randomized complete block design with three replications was used at each location. The wheat variety was Gan-Atilla, with a reported seed rate

of 140 kg/ha. Each gross plot measured 4 m × 3 m, and the net harvest area was 4 m². For drilling, seeds were placed approximately 2–3 cm deep in rows spaced 20 cm apart. For dibbling, seeds were placed at a spacing of 20 cm × 20 cm. Broadcasting involved spreading the seeds by hand and lightly incorporating them with a rake.

Crop Establishment and Management

Seeds were treated with Apron Star 42 WS at the reported rate of 10 g per 4 kg of seed. Fertilizer was applied at rates of 120 kg N/ha, 60 kg P₂O₅/ha and 60 kg K₂O/ha. The original field records should be consulted to confirm fertilizer sources, timing and application procedures.

Irrigation was carried out at three-day intervals. Weeds were controlled by hand hoeing at 3, 6 and 9 weeks after sowing. Rodents were managed using baits and traps. The supplied study material reported no notable insect pest or disease infestation during the experiment.

Measurement of growth and yield parameters

The measured parameters included plant height, number of leaves, number of tillers, days to 50% flowering, leaf length, leaf width, spike length, number of grains per spike, 1,000-grain weight, total biomass and grain yield.

Statistical analysis

Correlation coefficients were used to assess the relationships between grain yield and selected growth and yield parameters at Aliero and Jega. The reported coefficients were compared descriptively to identify the traits with stronger or weaker associations with grain yield at each location. The available material did not provide the complete statistical output, sample sizes for the correlations, confidence intervals or probability values. Consequently, the present analysis reports the supplied coefficients without assigning statistical significance. The original statistical output should be recovered to confirm the correlation method used, the observational units included in the analysis and whether correlations were calculated separately by location or pooled across planting treatments.

Soil Physical and Chemical Properties of Experimental Sites

Physical and chemical properties of soils of study locations prior to the experiments are presented in Table 1. These results indicated that particle size distribution of the soil at the two locations was dominated by sand, with values of 84 and 72% for Aliero and Jega, respectively. For silt particles, it was 10 and 15.7%, respectively. Least particle size distribution was observed with clay having recorded 6.0% for Aliero and 11.5% for Jega. The soils of the two locations were found to be sandy loam. This suggests that the soil in both locations has high macro porosity and low ability to retain water. Soil pH of 7.46 at Aliero was slightly alkaline, while in Jega the pH value was 6.25 indicating that it was moderately acidic. Organic carbon, total N, available P and Ca were observed to be low in both locations. Exchangeable Mg was medium, while exchangeable K and Na were higher in both Aliero and Jega locations.

Correlation Analysis

The correlation coefficient between yield and other parameters for Aliero and Jega locations were respectively presented in Tables 2 and 3. The correlation between grain yield and other parameters showed positive and highly significant relationship in both locations. At Aliero location, yield had positive correlation with plant height ($r = 0.612$), tiller count ($r = 0.725$), spike length ($r = 0.552$),

number of grains per spike (0.833), 1000-grain weight ($r=0.754$) and total biomass ($r=0.779$); moderately positive correlation with leave number ($r=0.498$) and days to 50% flowering ($r=0.333$); weak positive correlation with leaf length ($r=0.260$). There was no significant correlation between grains yield and leaf width. Plant height (8WAP) was strongly correlated with leaf number ($r=0.739$) and total biomass ($r=0.662$). Weak correlated with days to 50% flowering (0.233), spike length (0.237) and grains per spike ($r=0.220$) and had insignificant correlation with tiller count, leaf length, leaf width and 1000-grains weight. Leaf number (8WAP) had strong positive correlation with tiller count ($r=0.672$), moderate positive correlation with 1000 grain weight ($r=0.539$) and total biomass ($r=0.433$), weak positive correlation with spike length ($r=0.213$), weak negative correlation with leaf length ($r=-0.278$). There was no significant correlation between leaf number and days to 50% flowering, leaf width and grains per spike. Tiller count (4WAP) was strongly correlated with total biomass ($r=0.697$), moderate positive correlation with spike length ($r=0.433$) and had insignificant correlation with leaf length, leaf width, spike length and 1000-grain weight. Days to 50% flowering was weakly correlated with leaf width ($r=0.245$) and total biomass ($r=0.297$), weak negative correlation with grains per spike ($r=-0.256$). There was no significant correlation between days to 50% flowering, leaf length, spike length and 1000-grain weight. Leaf length (8WAP) had moderate positive correlation with 1000- grain weight($r=0.359$), weak correlation with leaf width ($r=0.218$) and total biomass ($r=0.265$), weak negative correlation with grains per spike ($r=-0.211$) and insignificant correlation with spike length. Leaf width (8WAP) was weakly correlated with 1000-grain weight ($r=0.243$) and total biomass ($r=0.247$). Spike length was strongly correlated with grains per spike ($r=0.730$); moderately correlated with 1000-grain weight (0.429) and total biomass ($r=0.511$). Grains per spike had strong positive correlation with 1000- grain weight ($r=0.678$) and moderately correlated with total biomass ($r=0.397$).1000-grain weight was strongly correlated with total biomass ($r=0.534$).

At Jega location yield had positively correlation with plant height ($r=0.592$), tiller count ($r=0.839$), spike length ($r=0.660$), number of grains per spike (0.817), 1000-grain weight ($r=0.819$) and total biomass ($r=0.891$); moderately positive correlation with leave number ($r=0.403$) and days to 50% flowering ($r=0.424$); weak positive correlation with leaf length ($r=0.263$). There was no significant correlation between grains yield and leaf width. Plant height at (8WAP) was strongly correlated with leaf number ($r=0.639$) and total biomass ($r=0.675$). Weak correlated with days to 50% flowering (0.303), spike length (0.232) and grains per spike ($r=0.256$) and had insignificant correlation with tiller count, leaf length, leaf width and 1000-grains weight. Leaf number (8WAP) had strong positive correlation with tiller count ($r=0.598$), moderate positive correlation with 1000 grain weight ($r=0.543$) and total biomass ($r=0.445$), weak positive correlation with spike length ($r=0.232$), weak negative correlation with leaf length ($r=-0.264$). There was no significant correlation between leaf number and days to 50% flowering, leaf width and grains per spike. Tiller count (4WAP) was strongly correlated with total biomass ($r=0.672$), moderate positive correlation with spike length ($r=0.445$) and had insignificant correlation with leaf length, leaf width, spike length and 1000-grain weight. Days to 50% flowering was weakly correlated with leaf length ($r=0.298$), leaf width($r=0.220$), grains per spike (0.260) and total biomass ($r=0.272$). There was no significant correlation between days to 50% flowering, spike length and 1000-grain weight. Leaf length (8WAP) had moderate positive correlation with 1000- grain weight($r=0.339$), weak correlation with leaf width ($r=0.282$) and total biomass ($r=0.269$), weak negative correlation with grains per spike ($r=-0.265$) and insignificant correlation with spike length. Leaf width (8WAP) was weakly correlated with 1000-grain weight ($r=0.228$) and total biomass ($r=0.249$). There no significant correlation between leaf with spike length and grains per spike. Spike length was

strongly correlated with grains per spike ($r=0.723$), moderately correlated with 1000-grain weight (0.487) and total biomass ($r=0.479$). Grains per spike had strong positive correlation with 1000-grain weight ($r=0.619$) and moderately correlated with total biomass ($r=0.412$). 1000-grain weight was strongly correlated with total biomass ($r=0.534$).

Discussion

Traits associated with grain yield

The reported coefficients indicated positive relationships between grain yield and the ten agronomic traits considered at both Aliero and Jega. The strongest associations generally involved number of grains per spike, total biomass, number of tillers and 1,000-grain weight. These findings suggest that reproductive characteristics, tiller production and overall crop biomass were associated with grain-yield variation in the reported dataset. The pattern is consistent with the broader research focus on interrelationships among wheat yield components and biometric traits examined by Chowdhury et al. (1986), Asif et al. (2004) and Khan et al. (2005). These studies are relevant background for interpreting associations among agronomic characteristics, although their specific findings should be verified against the original publications before being compared directly with the present results. At Aliero, number of grains per spike had the highest reported correlation with grain yield ($r = 0.833$). This indicates that observations with more grains per spike tended to be associated with higher grain yield. Total biomass, 1,000-grain weight and tiller number also showed comparatively strong positive associations. At Jega, total biomass had the highest coefficient with grain yield ($r = 0.891$), followed by tiller number, 1,000-grain weight and number of grains per spike. These findings identify several traits that were closely associated with grain-yield variation in the reported data. However, a strong correlation does not demonstrate that a trait independently determines yield. Correlated traits may share underlying biological or environmental influences, and the relative contribution of each trait cannot be established from the reported bivariate coefficients alone.

Tiller number and spike characteristics

Tiller number was positively correlated with grain yield at Aliero ($r = 0.725$) and Jega ($r = 0.839$). The higher coefficient at Jega suggests a stronger observed association at that site. Tiller production may contribute to yield through the formation of productive spikes, but the supplied results do not distinguish productive from non-productive tillers. This interpretation should therefore be treated cautiously. Spike length was also positively correlated with grain yield at both sites, with coefficients of 0.552 at Aliero and 0.660 at Jega. Its positive correlation with number of grains per spike ($r = 0.730$ at Aliero and $r = 0.723$ at Jega) suggests that longer spikes tended to be associated with more grains per spike in the reported observations.

Research on yield components and path coefficients in wheat provides a useful context for investigating such relationships (Chowdhury et al., 1986; Khan et al., 2005). Nevertheless, the present correlations do not establish whether spike length independently contributed to grain yield after accounting for other yield components.

Grain number, grain weight and biomass

Number of grains per spike had positive correlations with grain yield at both Aliero ($r = 0.833$) and Jega ($r = 0.817$). The similarity of these coefficients suggests that the positive association was present at both sites. The correlation between 1,000-grain weight and grain yield was also positive at Aliero ($r = 0.754$) and Jega ($r = 0.819$). This indicates that observations with higher grain weight

tended to be associated with higher grain yield. Total biomass was positively correlated with grain yield at Aliero ($r = 0.779$) and Jega ($r = 0.891$). The larger coefficient at Jega indicates a stronger observed linear association between biomass and grain yield in the reported results. However, this relationship alone does not establish the efficiency of biomass conversion into grain. Analysis of harvest index, together with the underlying observations, would provide additional information about the relationship between vegetative growth and grain production.

Leaf characteristics, plant height and flowering

Plant height had positive correlations with grain yield at Aliero ($r = 0.612$) and Jega ($r = 0.597$). These coefficients suggest that taller plants tended to be associated with higher grain yield in the reported data. Plant height should not, however, be interpreted as a direct measure of productivity because grain yield depends on several characteristics and growing conditions. The number of leaves showed positive correlations of 0.498 at Aliero and 0.403 at Jega. Days to 50% flowering had coefficients of 0.333 and 0.424, respectively. These values were lower than those reported for total biomass and several yield components. Leaf length and leaf width had the weakest reported associations with grain yield. The coefficients for leaf length were 0.260 at Aliero and 0.263 at Jega, while those for leaf width were 0.143 and 0.155, respectively. Within the reported dataset, variation in these leaf dimensions was therefore less closely associated with grain yield than variation in grain number, tiller number, grain weight and total biomass. These results do not establish that leaf characteristics are unimportant to crop growth. They indicate only that their reported linear associations with grain yield were comparatively weak. Statistical significance cannot be inferred from coefficient magnitude alone without the sample size and appropriate statistical tests.

Differences between Aliero and Jega

The direction of all reported correlations between the selected agronomic traits and grain yield was positive at both locations. However, the magnitude of the coefficients differed. Total biomass and tiller number had higher coefficients at Jega, whereas number of grains per spike had a slightly higher coefficient at Aliero. Planting date and planting method have been investigated in previous wheat studies as factors related to crop growth and yield (Abbas et al., 2008; Ali et al., 2010; Aslani and Mehrvar, 2012; Sinkader et al., 2003). Environmental conditions, including temperature and water availability, have also been examined in relation to wheat yield and agronomic traits (Hakim et al., 2012; Hossain et al., 2011).

Conclusion

The reported correlation analysis identified positive associations between grain yield and ten growth and yield parameters of wheat at Aliero and Jega, Kebbi State, during the 2016/2017 dry season. At Aliero, number of grains per spike had the highest reported correlation with grain yield ($r = 0.833$), whereas at Jega, total biomass had the highest coefficient ($r = 0.891$). Tiller number and 1,000-grain weight also showed comparatively strong positive correlations with grain yield at both locations. Leaf length and leaf width had comparatively weak positive associations. These results suggest that grain number per spike, tiller number, grain weight and total biomass were more closely associated with grain-yield variation than the measured leaf dimensions in the supplied dataset. However, the correlations alone do not demonstrate causation, statistical significance or the independent contribution of individual traits. Verification using the original

dataset and complete statistical output is necessary before making definitive recommendations for wheat production.

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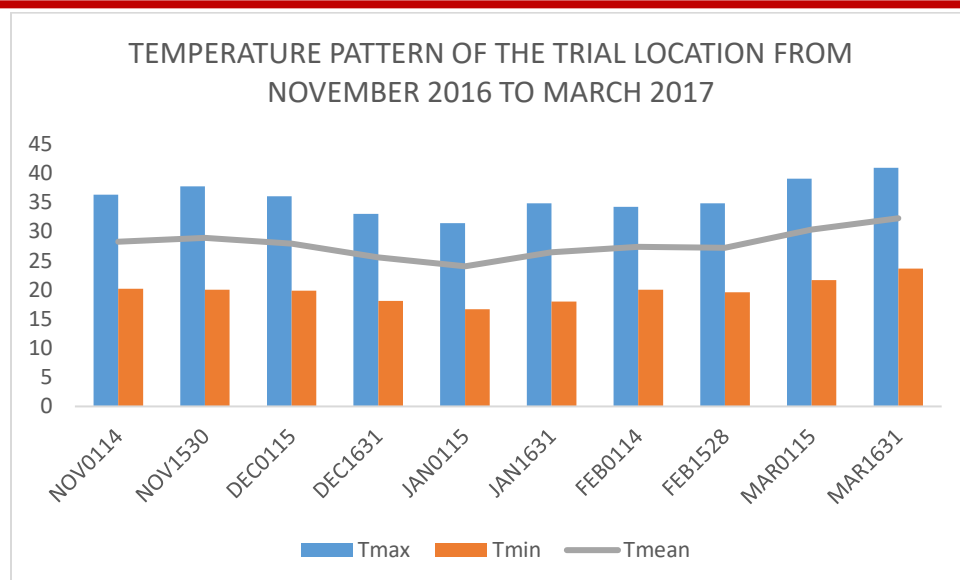
Table 1. Physical and Chemical properties of Soil of the Experimental Sites at Aliero and Jega during 2016/2017 dry season

	Aliero	Jega
	0.30cm	0.30cm
Particles size Analysis		
Sand (%)	84.00	72.50
Silt (%)	10.00	15.70
Clay (%)	6.00	11.80
p ^H (1:2:5)	7.46	6.25
Organic carbon (%)	0.16	0.28
Total Nitrogen	0.03	0.04
Available Phosphorus (Mgkg ⁻¹)	0.08	0.34
Exchangeable bases (Cmolkg ⁻¹)		
Ca	0.35	0.65
Mg	0.45	0.40
K	0.97	1.18
Na	0.45	0.52
Cation exchange capacity CEC (molkg ⁻¹)	2.20	2.75

Appendix I: Air temperature of the study area from November 2016 to March 2017

PLANTING DATES	TEMPERATURE (max)	TEMPERATURE (min)	TEMPERATURE (mean)
NOV 1 – 14	36.31	20.21	28.28
NOV 15 – 30	37.78	20.03	28.91
DEC 01-15	36.07	19.87	27.94
DEC 16 – 31	33.01	18.09	25.55
JAN 01 – 15	31.42	16.69	24.04
JAN 16 – 31	34.87	17.97	26.42
FEB 01 – 14	34.25	20.04	27.36
FEB 15 – 28	34.84	19.61	27.23
MAR 01 – 15	39.05	21.66	30.36
MAR 16 – 31	40.94	23.67	32.28

SOURCE: KSUSTA Meteorological station



Temperature pattern of the trial location from November 2016 to March 2017

Table 2: Correlation matrix among yield, growth and yield characters of wheat at Aliero during 2016/2017 dry

	1	2	3	4	5	6	7	8	9	10	11
Grain yield	1.00										
Plant height (8WAP)	0.61 2**	1.00 0									
Leaf number (8WAP)	0.49 8**	0.73 9**	1.00 0								
Tiller count (4WAP)	0.72 5**	0.10 7 ^{ns}	0.67 2**	1.00 0							
Days to 50% flowering	0.33 3**	0.23 3*	0.12 8 ^{ns}	0.16 8 ^{ns}	1.00 0						
Leaf length(8WAP)	0.26 0*	0.14 4 ^{ns}	- 0.27 8*	0.11 6 ^{ns}	0.10 5 ^{ns}	1.00 0					
Leaf width (8WAP)	0.14 3 ^{ns}	0.13 7 ^{ns}	0.00 7 ^{ns}	- 0.03 4 ^{ns}	0.24 5*	0.21 8*	1.00 0				
Spike length	0.55 2**	0.23 7*	0.21 3*	- 0.17 8 ^{ns}	0.17 9 ^{ns}	- 0.15 1 ^{ns}	0.15 6 ^{ns}	1.00 0			
Grains per spike	0.83 3**	0.22 0*	0.16 8 ^{ns}	0.43 3**	0.25 6*	- 0.21 1*	0.11 5 ^{ns}	0.73 0**	1.00 0		
1000-grain weight	0.75 4**	0.12 2 ^{ns}	0.53 9**	0.16 8 ^{ns}	0.16 7 ^{ns}	0.35 9**	0.24 3*	0.42 9**	0.67 8**	1.00 0	
Total Biomass	0.77 9**	0.66 2**	0.43 3*	0.69 7**	0.29 7*	0.26 5*	0.24 7*	0.51 1 ^{ns}	0.39 7**	0.53 4**	1.000

1. Grain yield/ha, 2. Plant height (8WAP), 3. Number of leaves (8WAP), 4. Tiller count (4WAP), 5.days to 50% flowering, 6.leaves sheath length (8WAP), 7.leaves sheath width (11), 8.spike length (11), 9.grain per spike 10. 1000, grain weight 11. Biomass, 12. ns= not significant at 5%, *=significant at 5%, **= significant at 1%

Table 3: Correlation matrix among yield, growth and yield characters of wheat at Jega during 2016/2017 dry season.

	1	2	3	4	5	6	7	8	9	10	11
Grain yield/ha	1.000										
Plant height (8WAP)	0.597 ^{ns}	1.00									
Leave number (8WAP)	0.403 ^{**}	0.63 ^{9**}	1.00								
Tiller count (4WAP)	0.839 ^{**}	0.14 ^{7ns}	0.56 ^{8**}	1.000							
Days to 50% flowering	0.424 ^{**}	0.30 ^{5**}	0.14 ^{8ns}	0.125 [*]	1.00						
Leaf length(8WAP)	0.263 [*]	0.13 ^{4ns}	-	0.145 ^{ns}	0.29 ^{8*}	1.000					
Leaf width (8WAP)	0.155 ^{ns}	0.14 ^{3ns}	0.01 ^{7ns}	-	0.22 ^{0*}	0.282 [*]	1.00				
Spike length	0.660 ^{**}	0.23 ^{2*}	0.22 ^{3*}	-	0.16 ^{7ns}	0.141 ^{ns}	0.16 ^{5ns}	1.000			
Grains per spike	0.817 ^{**}	0.25 ^{6*}	0.17 ^{5ns}	0.445 ^{**}	0.26 ^{0*}	0.265 ^{**}	0.05 ^{8ns}	0.723 ^{**}	1.000		
1000, grain weight	0.819 ^{ns}	0.15 ^{7ns}	0.54 ^{3**}	0.125 ^{ns}	0.12 ^{7ns}	0.339 ^{**}	0.22 ^{8*}	0.487 ^{**}	0.619 ^{**}	1.000	
Total Biomass	0.891 ^{**}	0.67 ^{5**}	0.44 ^{5**}	0.672 ^{**}	0.27 ^{2*}	0.269 [*]	0.24 ^{9*}	0.479 ^{**}	0.412 ^{**}	0.587 ^{**}	1.000

1. Grain yield/ha, 2. Plant height (8WAP), 3. Number of leaves (8WAP), 4. Tiller count (4WAP), 5.days to 50% flowering, 6.leaf length (8WAP), 7.leave width (8WAP) (11), 8.spike length (11), 9.grain per spike 10. 1000, grain weight 11.Biomass, 12. ns= not significant at 5%, *=significant at 5%, **= significant at 1%