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Full Length Research Article

Correlation Analysis of some Growth, Yield, Yield Components and Grain Quality of Wheat (*Triticum aestivum* L.)

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ABSTRACT: Field experiments were conducted during the 2009/2010 and 2010/2011 dry seasons at the *Fadama* Teaching and Research Farm of the Usmanu Danfodiyo University, Sokoto, in the Sudan Savanna ecological zone of Nigeria. The farm is located on latitude $13^{0}01^{1}$N; longitude $5^{0}15^{1}$E and at an altitude of about 350 m above sea level. The study was aimed at investigating the correlation between some growth, yield, yield components and grain quality of wheat *(Triticum aestivum* L.). The treatments consisted of factorial combination of water stress at three critical growth stages which was imposed by withholding water (at Tillering, Flowering, Grain filling) and Control (No stress), two varieties (Star 11 TR 77173/SLM and Kuaze/Weaver) and four sowing dates (21st November, 5th December, 19th December and 2nd January) laid out in a split plot design with three replications. Simple correlation coefficient ® of different crop parameters and grain yield indicated that most of the agro-physiological crop parameters viz. plant height, number of tiller m^{-2}, Leaf Area Index (LAI), Net Assimilation Rate (NAR), Crop Growth Rate (CGR), number of spike m^{-2}, spike length, spikelets per spike, number of grain per spike, 1000-grain weight, total aerial phytomass and harvest index had significant positive correlation with grain yield in both seasons and combined and this indicate their importance in yield determination. Protein and gluten content had varying levels of correlation in both seasons and combined. An over all, it is logical to conclude that spike m^{-2}, number of spikelets per spike, grain per spike, total aerial phytomass yield, grain yield, harvest index and 1000-grain weight are the major contributors towards grain yield since these characters had high correlation. Thus, direct selection of these characters should be major concern for increased grain yield and grain quality of wheat.
Keywords: Correlation, Wheat; growth, yield, yield components, grain quality

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to the tribe *Triticeae* which is one of the largest and most important tribes in the grass *Poaceae* family (Dewey, 1984). Wheat is one of the important cereal staple food crops of the world (Akbar *et al.,* 2001). It grain is used to produce flour for making bread, spaghetti, semolina, macaroni, biscuits, cookies, cakes, pasta, noodles and couscous; beer, many different alcoholic spirits and biofuel. The husk bran and germ are rich sources of vitamins, minerals and protein (David and Adams, 1985). Since ages, wheat has been playing an important role in the economy several countries (Singh *et al.,* 2010). Increase production of wheat is necessary to provide food security in developing countries. Ways to sustain increasing productivity should be explored. It is now realized that sustaining as well as increasing productivity may be essential. The knowledge of factors responsible for high yields has been rendered difficult as yield is a complex character (Singh *et al.,* 2010).

According to Dixet and Dubey (1984), grain yield is a complex trait and highly influenced by many genetic factors and environmental fluctuations. They further added that in plant breeding programme, direct selection for yield as such could be misleading and successful selection depends upon the information on the genetic variability and association of morpho-agronomic traits with grain and yield. Correlation studies provide a better understanding of the association of different characters with grain yield (Dixet and Dubey, 1984). The study of associations among various traits is useful to breeders in selecting genotypes possessing groups of desired traits.

The objective of the study was to find out correlation between growth, yield, yield components and grain quality of wheat for increased grain yield in wheat.

MATERIALS AND METHODS

The trials were conducted in 2009/2010 and 2010/2011 dry seasons at the Fadama Teaching and Research Farm, Usmanu Danfodiyo University, Sokoto, (Latitude

13^0 01'N. longitude 15^0 13E) at Kwalkwalawa village in Sokoto. The farm is located within the Sudan Savanna Zone of Nigeria (Kowal and Knabe, 1972). The area has a long dry season that is characterized by cool dry air during harmattan from November to February and hot dry air during hot season from March to May. Relative humidity ranged from 26-39 % in the dry season. Minimum temperature ranged between 18 and 29 ^{0}C between November, 2009 to March, 2010 and maximum temperature ranged from 30 to 40 ^{0}C November, 2009 to March, 2010 and, wind speed ranged from 1.9 to 5 M/S November, 2009 to March, 2010 [(Sokoto Energy Research Centre) (SERC, 2011)]. The soil is hydromorphic that is seasonally flooded during rainy season. The area was previously used for the cultivation of vegetables and cereals crops.

Prior to planting, soil samples were collected from nine randomly selected points within the experimental site at 0-30 cm depth using soil auger, which were bulked to form a composite sample and subsampied using coning and quatering, air-dried and sieved. The sub sample was used for physico-chemical analysis. The particle size analysis was according to hydrometer method (Boyoucous, 1951). Textural classes were determined using USDA textural triangle. Total nitrogen was determined by regular Macro-Kjeldhal digestion technique (Jackson, 1964), while available phosphorus was determined using Bray No.1 method (Bray and Kurtz, 1945). Potassium and Sodium were determined using a flame photometer method, while Magnesium and Calcium were determined by EDTA titration method. Cation Exchange Capacity (CEC) was determined using ammonium acetate method.

The treatments consisted of factorial combination of water stress which was imposed by withholding water at (Tillering, Flowering, Grain filling) and Control (No stress), two varieties (Star 11 TR 77173/SLM and Kauz/Weaver) and four sowing dates (21st November, 5th December, 19th December and 2nd January). The experiment was laid out in a split plot design with three replications. Water stress and date of sowing occupied the main plot while variety was assigned to the sub plots.

Cultural Practices

The land was cleared, ploughed, harrowed, leveled, followed by construction of basins and water channels. Gross plot size was 3m x 3m ($9m^{-2}$) while the net plot was ($4.5m^{-2}$). One meter (1m) lee-way was left between blocks and 0.5m between plots.

The seeds were treated with Apron star 42 WS (20% w/w thiamethoxam, 20% w/w metalaxyl-M and 2 % w/w difenoconazole) at the rate of 4 kg of seed to 10 g before sowing. The seeds were sown by hand drilling at 20 cm intra row spacing at 2-3 cm depth and at the rate of 120 kg ha^{-1}. The date of sowing was as prescribed by the treatments.

Four irrigations were applied to the crop before withholding water to allow for proper establishment of the crop and subsequently at 5 days interval (Lado, 2004). The method of irrigation used was check basin irrigation; water was applied to soil saturation at 5 days interval. Weeds were controlled manually with hoe at 3 and 6 WAS which ensured weed free plots.

Fertilizer was broadcast at the recommended rate of 120, 60 and 60 kg N, P_2O_5 and K_2O per ha^{-1} respectively, with half dose of nitrogen and full dose of phosphorous and potassium worked in to the soil during seedbed preparation using NPK 15: 15: 15: while, the second dose of 60 kg N ha^{-1} was applied prior to tillering using urea (46% N).

Birds were controlled by scaring while rodents were controlled by using baits and traps. No diseases outbreak was observed.

The crop was manually harvested from the net plot at physiological maturity using sickles when 50% of the peduncles have turned brown. The plants were cut at ground level and sun dried for a period of 4 days. The spikes were beaten out with sticks to expose the grain, which was winnowed in open air with the help of wind current.

The data were recorded on plant height, leaf area index, net assimilation rate, crop growth rate, spikelets per m^{-2}, length of spike, spikelets per spike, grains per spike, 1000-grain weight, total aerial phytomass, harvest index and grain yield.

Correlation between grain yield, growth and some proximate components were determined according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Simple correlation coefficient ® of both growth and yield parameters and grain yield of wheat in 2009/2010, 2010/2011 dry seasons and combined are shown in Tables 1, 2 and 3. The result in both seasons and combined revealed highly significant ($P < 0.01$) positive correlation between plant height at 12 WAS with LAI, NAR, CGR at 12 WAS, number of spike m^{-2}, spike length, spikelets per spike, total aerial phytomass, grain yield, harvest index and 1000-grain weight, but grain per spike and crude protein had highly significant correlation with plant height in 2009/2010 dry season and combined and in the combined analysis respectively. However, the correlation between crude protein content is significant ($P<0.05$) in 2009/2010 dry season, whereas plant height had no significant correlation with protein in 2010/2011 dry season and gluten in both seasons and combined. The positive and significant correlation coefficient between plant height and other growth and grain yield components explains the true relationship between the parameters and direct selection through this trait will be effective, since these characters had high correlation and also high direct effect thus direct selection for these characters should be a major concern for plant breeder.

The result also reveals that in both seasons and combined, there was highly significant positive correlation between LAI at 12 WAS with NAR, CGR at 12 WAS, spike m^{-2}, spike length, number of spikelets per spike, number of grain per spike, total aerial phytomass, grain yield, 1000-grain weight and harvest index (in 2009/2010 dry season and combined), but the correlation between LAI and harvest index is not significant in 2010/2011 dry season. However, the relationship between LAI and crude protein is not significant in both seasons, but in the combined analysis the relationship is highly significant ($P<0.01$), however, the correlation between LAI and gluten content is not significant in 2010/2011 dry season and combined, but the correlation between the former and the latter is highly significant in 2009/2010 dry season. The positive and significant correlation coefficient between LAI and other growth and grain yield components explains the true relationship between the parameters and direct selection through this trait will be effective, thus direct selection for these characters should be major concern for plant breeder.

Correlation analysis in both seasons and combined indicate highly significant positive correlation between NAR at 12 WAS with CGR at 12 WAS, number of spike m^{-2}, number of spikelets per spike, number of grain per spike, grain yield, and 1000-grain weight, but NAR had no significant correlation with spike length and total aerial phytomass in the combined analysis. However, the relationship between NAR and crude protein is not significant in both season and combined. The result of correlation coefficient values in both seasons and combined reveal highly significant ($P<0.01$) positive correlation between CGR at 12 WAS with NAR, spike m^{-2}, spike length, number of spikelets per spike, number of grain per spike, total aerial phytomass, grain yield index and 1000-grain weight but the correlation between CGR and harvest index is not significant in 2010/2011 dry season. However, the relationship between CGR and crude protein was not significant in both season and gluten in 2009/2010 dry season, but protein had significant correlation with CGR in the combined analysis. Similarly gluten had no significant correlation with CGR in 2010/2011 dry season and combined analysis.

The result in both seasons and combined revealed highly significant ($P<0.01$) positive correlation between number of spike m^{-2} with spike length, number of spikelets per spike, number of grain per spike, total aerial phytomass and grain yield. However, the relationship between number of spike m^{-2} and harvest index and 1000-grain weight is not significant in 2010/2011 dry season. Crude protein and gluten have no significant correlation in with number of spike m^{-2} in both seasons, but in the combined analysis the relationship between number of spike m^{-2} and protein is highly significant. In both seasons and combined the result reveal highly significant positive correlation between number of spikelets per spike with NAR, CGR at 12 WAS, number of spike m^{-2}, spike length, number of spikelets per spike, number of grain per spike, total aerial phytomass, grain yield, harvest index and 1000-grain weight. However, the relationship between number of spike m^{-2} and crude protein and gluten is not significant in 2009/2010 dry season.

The result reveal highly significant positive correlation between spike length with number of spikelets per spike, number of grain per spike, total aerial phytomass and grain yield. However, the relationship between spike length with harvest index is not significant in 2010/2011 dry season and combined. Similarly, the correlation between spike length with crude protein and gluten is not significant in both seasons; however the correlation between the former and latter is highly significant in the combined analysis. In both seasons and combined the result revealed highly significant positive correlation between number of spikelets per spike with number of grain per spike, total aerial phytomass, grain yield and 1000-grain weight, but harvest index had no significant correlation with number of spikelets per spike in 2010 dry season and combined. However the correlation between the former and protein is not significant in both years, similarly gluten had no significant correlation with number of spikelets per spike in both seasons and combined.

In both seasons and combined the result indicate highly (P<0.01) significant positive correlation between number of grain per spike with total aerial phytomass, grain yield, but the correlation between number of grain per spike with harvest index and 1000-grain weight is significant (P<0.05) in 2009/2010 dry season, while the correlation between the former and latter is not significant in 2010/2011 dry season. However, the correlation between the former and protein is significant in 2009/2010 dry season and combined, also gluten has no significant correlation with grain per spike in 2010/2011 dry season and combined. The result reveal highly significant (P<0.01) positive correlation between total aerial phytomass with grain yield in 2009/2010 dry season, combined analysis, similarly the correlation between the former and 1000-grain weight is highly significant in the combined analysis. However biological yield had no significant correlation with harvest index in 2009/2010 dry season, 1000-grain weight in 2010 dry season protein in both seasons and gluten in 2009/2010 dry season; however protein and gluten have significant correlation with total aerial phytomass in the combined analysis.

Correlation analysis reveal highly significant (P<0.01) positive correlation between grain yield with harvest index and 1000-grain weight in both seasons and combined, protein in the combined analysis and gluten in 2010/2011 dry season and combined (P<0.05). However both protein and gluten have no significant correlation with grain yield in 2009/2010 dry season. Similarly the result reveal highly significant positive correlation between harvest index with 1000-grain weight in both seasons and combined, however both protein and gluten had no significant correlation with grain yield in 2010/2011 dry season and combined. The results indicate no significant correlation between harvest index with protein and gluten in both seasons and combined. However gluten had significant (P<0.05) correlation with harvest index in 2009/2010 dry season. The result also indicate highly significant (P<0.01) positive correlation between 1000-grain weight with protein in the combined analysis, the former and latter have no significant correlation in both seasons. However, the relationship between gluten and protein is not significant in both season, but the former and the latter indicate significant (P<0.01) correlation in the combined analysis.

Correlation coefficients among most of the traits were statistically significant. Grain yield was positively correlated with plant height, LAI, NAR, number of spikelets per spike, number of grain per spike, spike length, 1000-grain weight and harvest index. LAI was also positively correlated with NAR and CGR this may be due to high specific leaf weight which is contributing more towards the leaf photosynthesis and yield in addition total dry weight had positive correlation with grain yield. Moreover harvest index also exhibited a significant positive association with grain yield which indicated efficient translocation of photosynthesis from source to sink. These results were in agreement with that of Kumar *et al*. (1998); Narwal *et al.* (1999); Ashok Kumar *et al.* (2000); Subhani (2000); Esmail (2003); Singh *et al.* (2006) and Saktipada *et al.* (2008) and Bilgi (2006); which is also similar to that of Singh and Singh (1999, 2001). Singh and Chaudhary (1979) suggested that if the correlation coefficient between a causal factor and the effect (i.e. grain yield) is almost equal to its direct effect, then correlation explains the true relationship and direct selection through this trait will be effective.

CONCLUSION

Over all, it is logical to conclude that number of spike m^{-2}, number of spikelets per spike, number of grain per spike, total aerial phytomass yield, grain yield, harvest index and 1000-grain weight are the major contributors towards grain yield since these characters had high correlation, thus direct selection for these characters should be major concern for plant breeder, for increased grain yield and grain quality of wheat.

Table1: Correlation matrix between growth, yield, yield components, protein and gluten content of bread wheat in 2009/2010 dry season at Fadama Teaching and Research Farm of U.D.U., Sokoto

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Plant height 12 WAS	1.00													
2	LAI 12 WAS	0.72^{**}	1.00												
3	NAR 12 WAS	0.67^{**}	0.85^{**}	1.00											
4	CGR 12 WAS	0.76^{**}	0.95^{**}	0.85^{**}	1.00										
5	Spike m^{-2}	0.61^{**}	0.38^{**}	0.48^{**}	0.41^{**}	1.00									
6	Spike length	0.61^{**}	0.51^{**}	0.56^{**}	0.59^{**}	0.61^{**}	1.00								
7	Spikelets /spike	0.77^{**}	0.70^{**}	0.68^{**}	0.77^{**}	0.72^{**}	0.69^{**}	1.00							
8	Grain/spike	0.57^{**}	0.31^{**}	0.39^{**}	0.39^{**}	0.64^{**}	0.56^{**}	0.73^{**}	1.00						
9	Total phytomass	0.69^{**}	0.52^{**}	0.54^{**}	0.55^{**}	0.57^{**}	0.43^{**}	0.66^{**}	0.53^{**}	1.00					
10	Grain yield	0.65^{**}	0.62^{**}	0.63^{**}	0.67^{**}	0.50^{**}	0.49^{**}	0.62^{**}	0.49^{**}	0.64^{**}	1.00				
11	Harvest index	0.32^{**}	0.41^{**}	0.39^{**}	0.46^{**}	0.23^{*}	0.35^{**}	0.33^{**}	0.25^{*}	0.08^{ns}	0.78^{**}	1.00			
12	1000-g weight	0.28^{**}	0.42^{**}	0.38^{**}	0.44^{**}	0.15^{ns}	0.27^{**}	0.33^{**}	0.25^{*}	0.22^{*}	0.55^{**}	0.51^{**}	1.00		
13	Protein content	0.21^{*}	0.06^{ns}	0.10^{ns}	0.13^{ns}	-0.02^{ns}	0.10^{ns}	0.10^{ns}	0.20^{*}	0.08^{ns}	0.15^{ns}	0.12^{ns}	0.13^{ns}	1.00	
14	Gluten content	0.10^{ns}	0.34^{**}	0.11^{ns}	0.25^{*}	-0.08^{ns}	0.06^{ns}	0.02^{ns}	-0.25^{*}	-0.03^{ns}	0.14^{ns}	0.24^{*}	0.23^{*}	0.00^{ns}	1.00

Ns = Not significant, * = Significant at 5% , ** = Significant at 1%.

Table 2: Correlation matrix between growth, yield, yield components, protein and gluten content of bread wheat in 2010/2011 dry season at Fadama Teaching and Research Farm of U.D.U., Sokoto

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Plant height 12 WAS	1.00													
2	LAI 12 WAS	0.72**	1.00												
3	NAR 12 WAS	0.67**	0.64**	1.00											
4	CGR 12 WAS	0.77**	0.94**	0.79**	1.00										
5	Spike m^{-2}	0.62**	0.40**	0.44**	0.44**	1.00									
6	Spike length	0.59**	0.50**	0.56**	0.57**	0.59**	1.00								
7	Spikelets /spike	0.77**	0.70**	0.70**	0.77**	0.73**	0.66**	1.00							
8	Grain/spike	0.20*	0.25*	0.16^{ns}	0.29**	0.18^{ns}	0.16^{ns}	0.29**	1.00						
9	Total	0.39**	0.30**	0.27**	0.33**	0.43**	0.30**	0.58**	0.22*	1.00					
10	Grain yield	0.29**	0.32**	0.35**	0.35**	0.29**	0.20*	0.31**	0.28**	0.17^{ns}	1.00				
11	Harvest index	0.03^{ns}	0.15^{ns}	0.15^{ns}	0.14^{ns}	-0.07^{ns}	0.06^{ns}	-0.05^{ns}	0.00^{ns}	-0.50**	0.59**	1.00			
12	1000-g weight	0.37**	0.32**	0.41**	0.37**	0.17^{ns}	0.30**	0.34**	0.12^{ns}	0.07^{ns}	0.47**	0.43**	1.00		
13	Protein content	-0.03^{ns}	0.10^{ns}	-0.08^{ns}	0.07^{ns}	-0.24^{ns}	-0.20^{ns}	-0.02^{ns}	0.02^{ns}	0.03^{ns}	-0.06^{ns}	-0.08^{ns}	0.10^{ns}	1.00	
14	Gluten content	0.07^{ns}	-0.06^{ns}	-0.00^{ns}	-0.04^{ns}	0.00^{ns}	-0.01^{ns}	0.04^{ns}	0.02^{ns}	0.28**	0.21*	-0.01^{ns}	0.04^{ns}	0.04^{ns}	1.00

Ns = Not significant, * = Significant at 5% , ** = Significant at 1%

Table 3: Correlation matrix between growth, yield, yield components, protein and gluten content of bread wheat in the combined analysis at Fadama Teaching and Research Farm of U.D.U., Sokoto.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Plant height 12 WAS	1.00													
2	LAI 12 WAS	0.70^{**}	1.00												
3	NAR 12 WAS	0.54^{**}	0.51^{**}	1.00											
4	CGR 12 WAS	0.77^{**}	0.91^{**}	0.67^{**}	1.00										
5	Spike m^{-2}	0.62^{**}	0.43^{**}	0.36^{**}	0.45^{**}	1.00									
6	Spike length	0.47^{**}	0.65^{**}	0.12^{ns}	0.49^{**}	0.50^{**}	1.00								
7	Spikelets /spike	0.77^{**}	0.65^{**}	0.57^{**}	0.77^{**}	0.72^{**}	0.45^{**}	1.00							
8	Grain/spike	0.44^{**}	0.39^{**}	0.26^{**}	0.38^{**}	0.47^{**}	0.47^{**}	0.54^{**}	1.00						
9	Total phytomass	0.46^{**}	0.55^{**}	0.12^{ns}	0.42^{**}	0.47^{**}	0.66^{**}	0.50^{**}	0.43^{**}	1.00					
10	Grain yield	0.47^{**}	0.58^{**}	0.32^{**}	0.52^{**}	0.43^{**}	0.55^{**}	0.44^{**}	0.47^{**}	0.52^{**}	1.00				
11	Harvest index	0.18^{*}	0.24^{**}	0.29^{**}	0.29^{**}	0.07^{ns}	0.11^{ns}	0.13^{ns}	0.14^{*}	-0.22^{**}	0.59^{**}	1.00			
12	1000-g weight	0.35^{**}	0.43^{**}	0.28^{**}	0.43^{**}	0.20^{**}	0.35^{**}	0.34^{**}	0.25^{**}	0.24^{**}	0.54^{**}	0.46^{**}	1.00		
13	Protein content	0.22^{**}	0.45^{**}	-0.15^{ns}	0.18^{*}	0.25^{**}	0.79^{**}	0.15^{*}	0.32^{**}	0.73^{**}	0.51^{**}	-0.05^{ns}	0.30^{**}	1.00	
14	Gluten content	0.08^{ns}	0.07^{ns}	0.08^{ns}	0.06^{ns}	-0.01^{ns}	0.02^{ns}	0.03^{ns}	-0.08^{ns}	0.18^{*}	0.18^{*}	0.07^{ns}	0.11^{ns}	0.24^{**}	1.00

Ns = Not significant, * = Significant at 5% , ** = Significant at 1%

REFERENCES

Akbar, M., Muhammad,T., Tayyab, J., Muhammad, A. (2001). Evaluation of exotic wheat germplasm for seed yield and its components under rain fed conditions. *Sarhad Journal of Agriculture*, **17(4):** 511-513

Ashok Kumar, R., Verma, S. Samdarshi, B., and Kumar, A. (2000). Correlation studies on yield and yield attributes of wheat (*Triticum aestivum*). *Gujarat Agriculture University Research Journal,* **25(8):** 5-8.

Bilgi, S.A. (2006). Physiological investigations in Dicoccum Wheat genotypes. M. Sc. Thesis submitted to the University of Agricultural Sciences Dharwad. July, 2006. pp. 1-76.

Boyoucus, G.H. (1951). A recalibration of hydrometer method for making mechanical analysis of soils. *Agronomy Journal,* **43:** 434-438.

Bray R. H. and Kurtz, L.T. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science,* **59:** 39-45.

David, G. and Adams, P. (1985). *Crops of the Drier Regions of the Tropics* Longman Group. pp 96-98.

Dewey, D.R. (1984). The genomic systems of classification as a guide to intergeneric hybridization with the perennial Triticeae. In: Gustafson JP ed. *Gene manipulation in plant improvement*. Plenum press, NY. pp. 209-279.

Dixet, P. and Dubey, D.K. (1984). Path analysis in lentil (*Lens culinaris* Med.). *Lens Newsletter,* **11:** 15-17.

Esmail, R.M. (2003). Correlation and path-coefficient analysis of some quantitative traits with grain yield in bread wheat (*Triticum aestivum* L.). *Bulletin of the National Centre. Cairo,* **26(3):** 395-408.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research* (2nd edition) John Wiley and son, New York. pp 680.

Jackson, M.L. (1964). Total nitrogen determination. *Soil chemical analysis,* 4th ed., Prentice-Hall, Englewood Cliffs N J, 183 pp.

Kowal. J.M. and Knabe, D.T. (1972). Agro *climatological Atlas of Northern States of Nigeria*. Ahmadu Bello University Press, Zaria. pp 36.

.

Kumar, A., Singh, D.P. and Yadav, S.K. (1998). Partitioning of dry matter accumulation in *aestivum and durum* wheat under irrigated and non-irrigated field conditions. *Indian Journal of Plant Physiology*, **30:** 126-129.

Lado, A. (2004). Effect of irrigation regimes and period of weed interference on growth and yield of two spring wheat (*Triticum aestivum* L.) A M.Sc. Dissertation, Usmanu Danfodiyo University, Sokoto, Nigeria, pp 180 (Unpublished).

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. *Agricultural Science Digest,* **19(2):** 73-76.

Saktipada, M., Bakshi, A., Barai, B. K. and Murmu, K. (2008). Character association for grain yield components in wheat (*Triticum aestivum* L.). *Environment and Ecology,* **26(1):** 145-147.

SERC. (2011). Sokoto Energy Research Centre. Weather records for 2010 and 2011.

Singh, R.K. and Chaudhary, B.D. (1979). *Biometrical Methods in Quantitative Genetic Analysis,* Kalyani Publisher Ludhiana

Singh, K.H. and Singh, T.B. (1999). Character association regarding generations of bread wheat. *Agricultural Science Digest*, **19:** 207–210.

Singh, S.B. and Singh, T.B. (2001). Correlation and path analysis in common wheat (*Triticum aestivum* L.) under light texture soil. *G. B. P. U. A. and T. Res. Station, Ujhani-243 (U.P.), India, Research on Crops*, **2:** 99–101.

Singh, K.N., Kulshreshtha, N., Kumar, V., Kumar, V. and Tim, S. (2006). Genetic variability of wheat (*Triticum aestivum* L.) lines for grain yield and components characters grown under sodic and water logged condition. *Indian Journal of Agricultural Science,* **76 (7):** 414-19.

Singh, B.N., Vishwakarma, S.R. and Singh, V.K. (2010). Character Association and Path Analysis In Elite Lines of Wheat (*Triticum aestivum* L.). *Plant Archives,* **10(2):** 845-847.

Subhani, G.M. (2000). Correlation and path-coefficient analysis in bread wheat under drought stress and normal conditions. *Pakistan Journal of Biological Science,* **3(1):** 72-77