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Correlation and Regression analysis of bread wheat (*Triticumaestivum* L.)varietiesgrown at different Nitrogen levels on a clay soil in the southern valley of Niger republic.

Soulé A.M.[1], Auwalu B. M.[2], Mainassara Z.A.[3] and Yahaya S.U.[2]
[1] *National Institute for Agronomic Research of Niger*
[2]*Department of agronomy, Bayero University Kano, Nigeria*
[3]*International Maize and Wheat Improvement Center (CIMMYT), Zimbabwe*

Abstract
Background*: Wheat is among the most important crop in the world and its consumption in Niger is increasing rapidly, but the national production in the country is very low due to lack of knowledge on cultivation techniques. Adequate Nitrogen and irrigation management practices as well as choice of good variety can significantly increase yield.*
Materials and Methods:*A field experiment was conducted during two dry seasons (2016/2017 and 2017/2018) at Konni in central southern zone of Niger Republic. Analysis of variance and acorrelation analysis were performed between some yield characters of four wheat varieties (El-Madaoua as local check, Sokoll/3/, Norman and Reyna-28) and a regression analysisto explain the variation of grain yield response under four different doses of nitrogen (0, 100, 150 and 200 kg N ha^{-1}) was done. The experiment was laid out in a split plot design with three replications.*
Results*:Results showed that application of nitrogen at 150 kg N ha^{-1}recorded highest grain yield and others characters. Thecorrelation analysis showed that leaf area, number of tillers plant^{-1}, chlorophyll content, number of spikes m^{-2}, number of grains spike^{-1}, thousand kernel weight, straw yield, harvest index and Nitrogen uptake were significantly and positively correlated to grain yield. In contrary, the number of tillers was negatively correlated to grain yield. It was also observed a significant and positive correlation between leaf area and chlorophyll content, harvest index and thousand kernel weight.The regression analysis indicated that the best model for response of grain yield to nitrogen levels was polynomial. The average optimum level of Nitrogen was 168 kg N ha^{-1}.*
Conclusion: *After this study it can be recommended in this area an application of 150 to 168 kg N ha^{-1} of nitrogen.*
Key Word*: Correlation, regression, wheat, Nitrogen, yield, yield components.*

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I. Introduction

In Niger republic wheat production is failing to keep pace with growing demand. At present wheat consumption has notably increased. The country is therefore becoming increasingly dependent upon imports for wheat, and at a time when grain prices in world markets (and thus import bills) are on the rise. Wheat is cultivated in the regions of Agadez under oasis plains, Tahoua, Diffa and Maradi on irrigated schemes under irrigation with an average grain yield of 1.4 ton ha^{-1} (FAO, 2010). Increase production of wheat is necessary to provide food security in developing countries. Ways to sustain increasing productivity should be explored (Sokoto, 2012). An efficient irrigation as well as fertilizer application and a good choice of wheat variety can be the best option to increase the yield of wheat in these regions of Niger republic. Nitrogen (N) fertilization plays a key role in wheat production because wheat is very responsive to N fertilization and very sensitive to insufficient nitrogen.N generally stimulates tiller production when applied before the time of rapid stem elongation (Langer, 1959) and may also result in increased tiller survival (Barley and Naidu 1964). Geleto*et al.* (1995) reported that spike numbers and grain yield were increased with high level of nitrogen. The knowledge of factors responsible for high yields has been rendered difficult as yield is a complex character (Singh *et al.*, 2010). 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 (Sokoto, 2012). On other hand the nature of response of wheat crop to nitrogen need to be clearly understood. Regression models can provide first approximations of yields and yield response to field management. Accurate fertilizer recommendations to cereal producers require predictive equations. Regression models to predict yield in wheat were developed to investigate the effect of nitrogen management on grain yield (Campbell et al., 1997). Regression is a data mining function that predicts a number. Regression techniques are very useful in predicting the yield of crops. Different regression techniques such as quadratic, interactions and polynomial are used for predicting the yield of wheat, maize and cotton crops. The regression models are proposed based on accuracy in predicting the yield of crops. The best regression model is selected based on Root Mean Square Error (RMSE), R^2 etc. (Shastry*et al*., 2017). In this study, correlation and regression analysis were used with the aim of evaluating the relationship between grain yield and other parameters as well as predicting the response of grain yield to different nitrogen levels in the irrigated scheme of Konni in the southernvalley in southern Niger republic.

II. Materials And Methods

Study location and duration: The study was carried out during 2016/2017 and 2017/2018 dry and cold seasons at Konni (13°47'30"N and 5°15'00"E) located in the southern agro-ecological zoneof Niger republic on a clay soil with rainfall around 400-600 mm. The physical and chemical properties of the soils were determined for the experimental site at the Department Soil Science Laboratory of Bayero University Kano (Table 1).

Treatments and experimental design: The treatments consisted of the factorial combination of four wheat varieties (El Madaoua as local check, Norman, Reyna-28 and Sokoll/3/) and four levels of nitrogen fertilization (0, 100, 150 and 200 kg N ha^{-1}) laid out in Split-plot design with three replications. The main plots were allocated for N fertilizer levels while the wheat varieties were randomly arranged in sub-plots.

Plot seize: The unit plot area was 2.4 m^2 consisting of 4 rows of 2 m in length and 30 cm apart. Two central rows with a net plot size of 1.2 m^2 were used for data collection.

Sowing window: Sowing was done by means of single row hand drill on 28 November 2016 in the first year and 25 November 2017 in the second year.

Cultural practices: The plot were irrigated weekly using flooding method through canal with raised borders (20 cm height) carefully compacted to minimize seepage. The discharge of water in the plot was 3 cm from which the amount of water applied was calculated at 30 mm per irrigation during the whole growing season. The fertilizers were applied in the form of NPK (15-15-15), SSP (0-18-0) and Urea (46-0-0). The Phosphorus and Potassium fertilizers were applied in basal application at the constant rate of 60 kg/ha and 40 kg/ha respectively as recommended, while the N fertilizer was top-dressed and applied at the stage of first node emergenceat various levels (0, 100, 150 and 200 N $kg.ha^{-1}$) according to the treatment.

Data collection

Weather data were collected on the experimental field each year on maximum temperature, minimum temperature and relative humidity (Table no 5 in annex). Prior to planting, soil samples were collected for the physicochemical analysis of the soil.

The agronomic data were collected on leaf area, number of productive tillers $plant^{-1}$, chlorophyll content, number of spikes m^{-2}, number of grains $spike^{-1}$, thousand kernel weight,grain yield, straw yield, harvest index and nitrogen uptake (in grains). The nitrogen uptake was collected in 2016/2017 only because of grain sample damage in the second year.

Statistical data analysis

The data analysis was done using the computer package GENSTAT 18th Edition.

The above collected parameters were subjected to the analysis of variance to sort out the significance of effects as influenced by the treatments. On other hand a correlation analysiswas performed to determine the strength and significance of relation between the observed parameters.

A polynomial regressionanalysis was performed to illustrate and evaluate the association and relationship between grain yield and N treatments. Thus, the polynomial regression analysis was used to determine the strength of relationship between crop responses (represented by grain yield) as the dependent variable and N treatment as the independent variable as described by Gomez and Gomez (1984).

Based on the regression equation, the optimum level for Nitrogen fertilization were determined using the following formula reported by Garg and Bansal (1972):

$$X_{op} = \frac{-b}{2c}$$

Where: X_{op}= optimum level of Nitrogen; *b* and *c* are regression constants.

III. Results

Soil physicochemical properties

The soil samples analysis showed that the soil of experimental site was clay with pH (6.76) suitable for wheat production (Table no 1). But the total nitrogen as well as the organic matter and the cation exchange capacity were low as ratted by Sahlemedhin (1999).

Table no 1:Physical and chemical properties of the soils of the experimental site at 0-25cm depth during 2016-2017 dry season at Konni, Niger republic.

Physical properties	
Particle size distribution (g kg^{-1})	
Sand	284
Silt	274.4
Clay	441.6
Texture	Clay
Water Holding Capacity (%)	72
Chemical properties	
pH (H_2O)	6.76
pH ($CaCl_2$)	6.1
Organic Matter (g kg^{-1})	12.92
Nitrogen $NH4^-$ (g kg^{-1})	0.03
Nitrogen $NO3^-$ (g kg^{-1})	0.03
Total Nitrogen (g kg^{-1})	1.4
Available Phosphorus (mg kg^{-1})	14.25
Exchangeable Cations (Cmol kg^{-1})	
K	0.26
Na	0.3
Ca	2.14
Mg	0.41
CEC	3.56

Source: Soil Lab, Department of Soil Science, Bayero University, Kano

Effects of nitrogen levels and wheat variety on the observed parameters

The data analysis showed that grain yield and its components were significantly influenced by the nitrogen levels (Table no 2). The leaf area was highest at 200 kg N ha^{-1} and lowest at the control (0 kg N ha^{-1}). The number of productive tillers, the chlorophyll content, the number of spikes per m^2, the thousand kernel weight, the grain and straw yields were highest at 150 kg N ha^{-1} beyond which there was no significant increase of these parameters. The harvest index and nitrogen uptake in grain were significantly affected by N fertilizer rates during 2016/2017 where the highest value was observed at 150 kg N ha^{-1}.

On other hand the wheat varieties expressed significant differences in all the observed parameters. The local variety El-Madaoua recorded more productive tillers and more number of grains per spike but lower leaf area, thousand kernel weight and grain yield. Reyna-28 and Sokoll/3/ recorded the highest grain yield during both dry seasons. Norman was best in leaf area and chlorophyll content.

Table no 2: Mean value for the effects of Nitrogen levels and wheat variety on leaf area (LA), number of productive tillers (NPT), chlorophyll content (CC), number of spike m^{-2} (NS), number of grain spike $^{-1}$ (NGS), thousand kernel weight (TKW), grain yield (GY),straw yield (SY), harvest index (HI) and Nitrogen uptake (NU) during 2016/2017 and 2017/2018at Konni, Niger republic.

	2016/2017									
	LA	NPT	CC	NS	NGS	TKW	GY	SY	HI	NU
N level (Kg N /ha)										
0	6.94d	1.813	44.54b	185c	21.60b	28.78c	1049b	1949b	34.56c	20.89c
100	18.51c	2.042	54.63a	335ab	33.52a	31.37b	2610a	5040a	34.76bc	61.70ab
150	20.28b	2.086	55.29a	350a	35.93a	33.05a	2845a	4888a	37.16a	70.88a
200	21.58a	2.228	55.20a	329b	35.09a	32.45ab	2734a	4931a	36.79ab	60.88b
LSD (5%)	0.82	0.39	1.078	21.6	1.55	1.64	238.1	689.2	0.029	9.902
Wheat Variety										
El-Madaoua	11.44d	4.451a	49.94b	262b	34.71a	29.01c	1751c	3098b	36.58ab	38.60d
Sokoll/3/	19.05b	1.145b	55.41a	315a	29.48c	35.71a	2631a	4852a	35.30bc	66.49a
Norman	20.53a	1.294b	55.83a	286b	32.56ab	27.03d	2162b	4444a	33.29c	50.97c
Reyna 28	16.29c	1.28b	48.48c	336a	29.45b	33.89b	2694a	4414a	38.11a	58.30b
LSD (5%)	1.03	0.42	1.39	25.7	1.76	1.66	231.7	752.6	2.1	6.94

	2017/2018								
	LA	NPT	CC	NS	NGS	TKW	GY	SY	HI
N level (Kg N /ha)									
0	6.89d	1.547b	40.81c	198c	22.09b	29.45c	1192c	2294b	34
100	17.99c	2.032a	52.49b	356b	34.97a	31.98b	2736b	5387a	34
150	19.58b	1.975a	53.94a	377a	37.64a	33.75a	3030a	5393a	36
200	21.11a	2.174a	53.87a	358b	37.22a	33.20a	3061a	5617a	36
LSD (5%)	0.56	0.34	0.92	17.6	0.99	0.94	169.8	447.6	0.112
Wheat Variety									
El-Madaoua	11.19d	3.770a	46.33c	315b	34.28a	29.42c	2092c	3703b	36.87a
Sokoll/3/	18.59b	1.329b	53.39b	321b	30.93b	36.53a	2692a	5100a	34.65b
Norman	19.88a	1.254b	55.17a	309b	34.71a	28.02d	2415b	4983a	33.14b
Reyna 28	15.91c	1.374b	46.23c	345a	31.99b	34.40b	2820a	4905a	36.56a
LSD (5%)	0.65	0.33	0.89	17.4	1.08	1.09	169.8	449.6	1.9

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Fisher's Least Significant Difference.

Simple Correlation Analysis

The results of simple correlation analysis between grain yield and growth and yield characters of wheat during 2016/2017 and 2017/2018 are presented in Tables no 3 and no 4.

The correlation analysis showed a statistically significant and positive correlation between leaf area, chlorophyll content, number of spikes m^{-2}, number of grains spike^{-1}, thousand kernel weight, straw yield, harvest index and Nitrogen uptake to grain yield of wheat in 2016/2017 (Table no 3). The highest correlation coefficients were observed between GY with leaf area (0.74), number of spikes m^{-2} (0.91), straw yield (0.80) and thousand kernel weight (0.62). In contrary there was a significant but negative correlation between the number of productive tillers plant^{-1} with grain yield. In 2017/2018 dry season all studied yield components were significantly and positively correlated to grain yield as well as some growth and other characters such as leaf area and chlorophyll content (Table no 4). The highest correlation coefficients were observed between GY with straw yield (0.80), number of spikes m^{-2} (0.83), leaf area (0.70) and number of grains spike^{-1} (0.53). However the number of productive tillers was not significantly ($P>0.05$) correlated to grain yield.

On other hand it was observed significant and positive correlation between straw yield and number of spike per m^2 and also straw yield, number of spike per m^2, chlorophyll content withleaf area.

Table no 3: Matrix of Correlation showing association between some growth, yield and other characters with grain yield of wheat during 2016/2017 dry season at experimental site of Konni, Niger republic.

		1 LA	2 NPT	3 CC	4 NS	5 NGS	6 TKW	7 SY	8 HI	9 NU	10 GY
1	LA	1									
2	NPT	-0.2595**	1								
3	CC	0.6507**	-0.139ns	1							
4	NS	0.6734**	-0.1894*	0.4256**	1						
5	NGS	0.545**	0.2842**	0.6074**	0.4021**	1					
6	TKW	0.3022**	-0.1685**	0.064ns	0.5267**	0.0292ns	1				
7	SY	0.6647**	-0.1803**	0.4147**	0.7435**	0.3512**	0.4506**	1			
8	HI	0.0134ns	0.0961ns	-0.052ns	0.2084*	0.0926ns	0.2543**	-0.3084**	1		
9	NU	0.1843*	-0.0739ns	0.1446ns	0.2512**	0.1157ns	0.1877*	0.1238ns	0.1461ns	1	
10	GY	0.7425**	-0.1896**	0.4466**	0.9107**	0.4271**	0.622**	0.8049**	0.2307**	0.2539**	1

LA = Leaf Area. NPT = Number of Productive Tillers Plant^{-1}. CC = Chlorophyll Content. NS = Number of Spikes m^{-2}. NGS = Number of Grains Spike^{-1}. TKW = Thousand Kernel Weight. SY = Straw Yield. GY = Grain yield. HI = Harvest Index. NU = Nitrogen Uptake.

** = significant at 1%; * = significant at 5%; ns = non-significant.

Table no 4: Matrix of Correlation showing association between some growth, yield and other characters with grain yield of wheat during 2017/2018 dry season at experimental site of Konni, Niger republic.

		1 LA	2 NPT	3 CC	4 NS	5 NGS	6 TKW	7 SY	8 HI	9 GY
1	LA	1								
2	NPT	-0.1905**	1							
3	CC	0.6895**	-0.0521ns	1						
4	NS	0.5495**	0.0189ns	0.3772**	1					
5	NGS	0.6075**	0.2121**	0.6007**	0.5151**	1				
6	TKW	0.3613**	-0.1643**	0.1211*	0.4262**	0.0814ns	1			
7	SY	0.6619**	-0.0454ns	0.4272**	0.6777**	0.4568**	0.4187**	1		
8	HI	-0.033ns	0.0221ns	-0.0318ns	0.1692**	0.0738ns	0.1482*	-0.3157**	1	
9	GY	0.6971**	-0.0539ns	0.4554**	0.8239**	0.533**	0.5401**	0.7984**	0.2352**	1

LA = Leaf Area. NPT = Number of Productive Tillers Plant^{-1}. CC = Chlorophyll Content. NS = Number of Spikes m^{-2}. NGS = Number of Grains Spike^{-1}. TKW = Thousand Kernel Weight. SY = Straw Yield. GY = Grain yield. HI = Harvest Index.
** = significant at 1%; * = significant at 5%; ns = non-significant.

Regression Analysis

First and second order polynomials were evaluated to find out the best fitting model to explain the response of grain yield of wheat to different levels of Nitrogen fertilization during both dry seasons. The higher determination coefficient R^2 the best model. The results of regression analysis indicated that the polynomial models gave the best fit for regression of Nitrogen levels on grain yield during both dry seasons. In 2016/2017 dry season the determination coefficient of Nitrogen levels on grain yield was R^2 = 1 andsuggested a quadratic model to explain the response of grain yield to Nitrogen levels. The coefficients of quadratic model (β_1 and β_2)were significant under equation $y = 1049.5 + 22.737x - 0.0716x^2$ (Figure no 1). In 2017/2018 dry season the determination coefficient was R^2 = 0.99. The coefficients quadratic model (i.e. β_1 and β_2)were significant under equation $y = 1193.5 + 21.353x - 0.0602x^2$ (Figure no 2).

Based on the above equation the optimum levels of Nitrogen fertilization in 2016/2017 and 2017/2018 were 158.77 and 177.35 kg N ha^{-1} respectively.

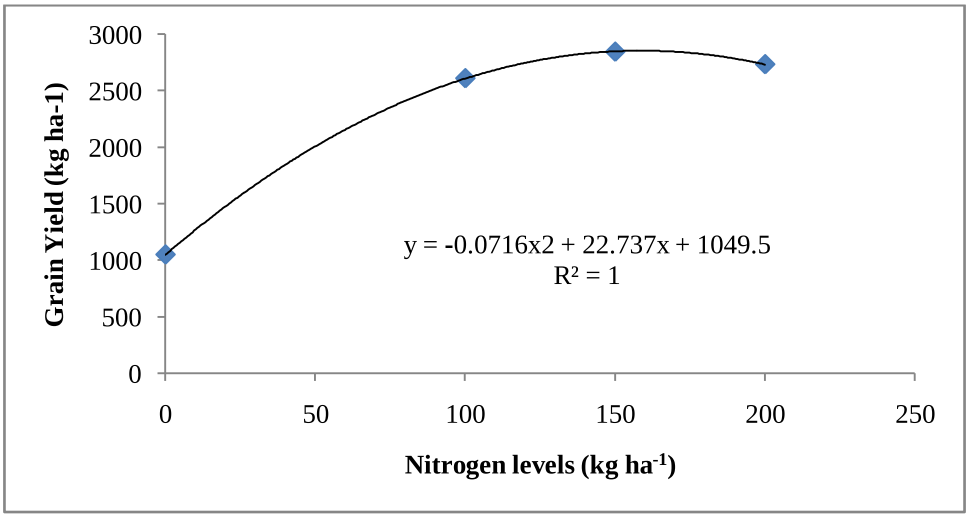

Figure no 1: Polynomial Regression of Wheat Grain Yield in Response to N Fertilizer at Konni during 2016/2017 Dry Seasons.

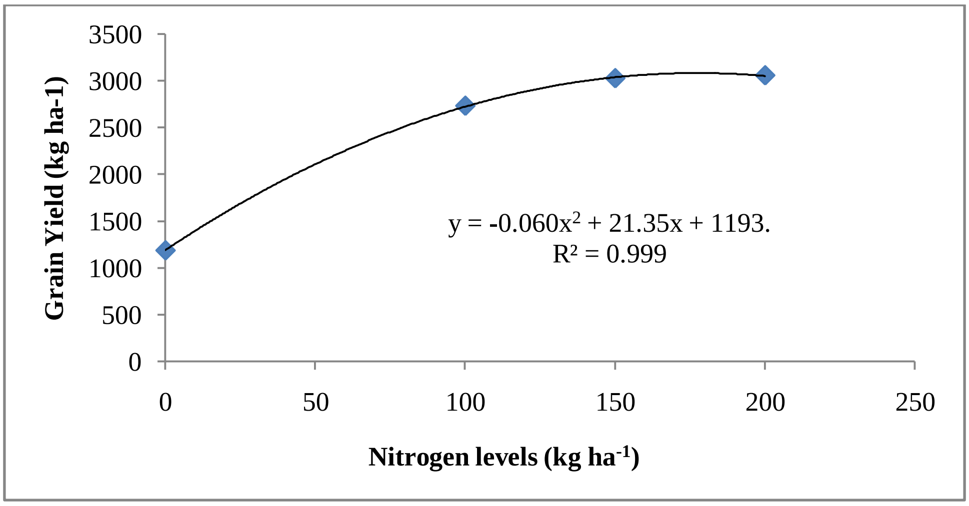

Figure no 2: Polynomial Regression of Wheat Grain Yield in Response to N Fertilizer at Konni during2017/2018 Dry Seasons.

IV. Discussion

The significant effect of nitrogen fertilizer rates on growth and yield characters indicates the key role of nitrogen fertilizer in enhancement of biological and physiological mechanisms that contribute to growth and yield of wheat crop. In this line Scott (1977) reported that the optimum growth of wheat, as of any cereal, depends on adequate mineral nutrition of the plant especially that of nitrogen, often the most limiting nutrient and one which may influence all the yield components. The highest record of the studied parameters at 150 kg N ha^{-1} was earlier reported bymany authors (Heinemann *et al.* (2006).

The significant and positive correlation between leaf area and chlorophyll content with grain yield during both dry seasons might explain an important relationship of these characters with the production of grain yield of wheat. This is consistent to the findings of Sokoto*et al.* (2012) who found a significant and positive correlation of leaf area with grain yield of wheat. Espindula*et al.* (2010) and Shanahan *et al.* (1985) also stated that productive tillers of wheat were reported to be positively correlated with grain yield. Similarly, many authors (Ilze and Ruza (2017); Silva *et al.* (2014)) had established that chlorophyll photosynthetic potential, characterizing the total amount of chlorophyll in the aboveground plant parts during the vegetative period under optimal environmental and climatic conditions was correlated with the grain yield. The negative correlation between number of tillers per plant and grain yield in 2016/2017 dry season was unexpected and might be attributed by the effect ofhigher nitrogen application that might enhanced growth of unproductive tillers at expense of grain yield especially in the case of the local variety ''El-Madaoua'' which showed an important tillering capacity but lower grain yield in this study. As expected, there was a significant and positive correlation of number of spikes m^{-2}, number of grains spike^{-1}, thousand kernel weight, straw yield, harvest index and Nitrogen uptake with grain yield during both dry seasons. This result showed an important association of these yield characters with grain yield of wheat. This might be explained by the fact that high spike density per unit area associated with high number of grains spike^{-1} and individual grain weight will lead to greater grains production which will consequently generate high grain yield as earlier reported by Bulman and Hunt (1988) who found that grain yield of cereals is the product of three yield components: number of spikes per unit area, number of grains spike^{-1} and individual kernel weight. The significant and positive correlation between harvest index and grain yield could be explained by the higher partitioning of assimilates to grains which determine the harvest index and lead to high grain yield. In this lineTohru*et al.* (2018) reported that harvest index is a critical factor for grain yield. The significant and positive correlation between Nitrogen uptake and grain yield might be due to the fact that NU is deducted from the grain yield and represented the proportion of Nitrogen produced per unit of grain yield. This is consistent with Ruisi*et al.* (2015) who found that variations in both grain and biomass yield were significantly correlated with N uptake.

The magnitude of determination coefficients (R^2) of Nitrogen fertilization levels on grain yield suggested the polynomial model as best fit for the regression analysis. In the first and second year the determination coefficients were respectively 1 and 0.99 meaning that 100% and 99% of total variation of grain yield could be attributed to variation of Nitrogen fertilization levels. In this study the optimum level of Nitrogen as fitted by the polynomial model was 159 and 177 kg N ha^{-1} in 2016/2017 and 2017/2018 respectively, averaging 168 kg N ha^{-1}. This result corroborated the findings of Zhu and Wen (1992) who reported the nitrogen level of 150–180 kg N ha^{-1} as optimum for maximum grain yield of wheat.

V. Conclusion

The results of this study had enabled to know the strength of correlation between the studied parameters especially these having an impact on grain yield. The simple correlation analysis revealed that leaf area, number of tillers plant^{-1}, chlorophyll content, number of spikes m^{-2}, number of grains spike^{-1}, thousand kernel weight, straw yield, harvest index and Nitrogen uptake were significantly and positively correlated to grain yield. It was also observed a significant and positive correlation between leaf area and chlorophyll content, harvest index and thousand kernel weight and between Nitrogen uptake and grain yield. Finally, it can be concluded that a positive association between yield and yield components may serve as a basis for trait selection in plant breeding.On other hand the regression analysis indicated that polynomial models gave the best fit for regression of nitrogen fertilization levels on grain yield. Polynomial equations were generated from which the optimum level of nitrogen was determined for maximum grain yield. Across the two years an average optimum level of nitrogen (168 kg N ha^{-1}) was determined, which matched with the range of several studies and can therefore be recommended in this area.

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Table 5: Meteorological data showing Minimum and Maximum Temperature, Relative Humidity (RH) during the 2016/2017 and 2017/2018 dry seasons at Konni.

Month	Decade	Temperature (°C)		RH (%)	
		Min	Max	Min	Max
2016/2017					
	01 - 10	25.38	33.16	19.4	23.56
Nov. 2016	11 - 20	24.14	31.42	18.34	28.16
	21 - 30	22.68	32.36	16.63	28.11
	01 - 10	23.16	30.55	15.44	26.34
Dec 2016	11 - 20	23.67	27.31	18.24	24.7
	21 - 31	22.44	26.52	17.58	22.38
	01 - 10	23.34	25.19	14.5	18.6
Jan. 2017	11 - 20	22.88	28	17.56	26.76
	21 - 31	25.29	27.39	15.99	23.7
	01 - 10	25.4	32.23	11.47	15.42
Feb. 2017	11 - 20	24.91	31.78	10.57	13.9
	21 - 28	27.45	33.42	9.56	13.61
	01 - 10	29.09	33.47	13.82	21.9
Mar. 2017	11 - 20	30.05	35.29	9.09	13.84
	21 - 31	31.87	38.32	13.05	19.87
Mean		25.45	31.1	14.75	21.39
2017/2018					
	01 - 10	24.12	32.41	21.12	25.12
Nov. 2017	11 - 20	24.02	32.25	20.03	28.78
	21 - 30	21.91	30.12	18.39	30.05
	01 - 10	22	30.51	16.89	28.13
Dec. 2017	11 - 20	21.97	26.6	18	27.28
	21 - 31	22.23	25.69	19.08	26.13
	01 - 10	22.57	25	16.16	28.05
Jan. 2018	11 - 20	22.19	27.07	18.26	27.23
	21 - 31	23.61	27.05	17.23	27.16
	01 - 10	24.36	30.61	12.02	20
Feb. 2018	11 - 20	24.51	31.05	11.66	16.41
	21 - 28	26.16	32.22	11.56	14.32
	01 - 10	28.39	34.01	14.11	16.54
Mar. 2018	11 - 20	29.11	34.63	9.56	15.08
	21 - 31	30.77	36.77	11.74	13.74
Mean		24.52	30.39	15.72	22.93

Source: Data logger TINYTAG PLUS-2

Soulé A.M, et. al. "Correlation and Regression analysis of bread wheat (Triticumaestivum L.)varietiesgrown at different Nitrogen levels on a clay soil in the southern valley of Niger republic." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 20(9), 2021, pp. 11-18.