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REGULAR ARTICLE

Correlation and regression analysis in sorghum under different levels of nitrogen

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Abstract

An experiment was conducted with sorghum varieties and different levels of nitrogen to study the correlation between traits and to study the effect of these traits on grain yield to define which traits can be considered as selection criteria for yield improvement in sorghum. A factorial irrigated field experiment was carried out in R.C.B.D. layout with three replications in Iraq, four sorghum varieties (AlKhir, Enkath, Kafir, and Rabeh) were planted under three levels of nitrogen (80,100,120) kg/h manually in 2016 at two sites. After harvest, correlation and regression analysis were studied between grain yield as the dependent variable and each of the following traits as independent variables (dry and green fodder weight, leaf area index, plant height, stem diameter, grain number and grain weight, nitrogen level). Results showed that all studied traits except grain weight were highly significantly correlated with grain yield, and about 35% of variation in grain yield could be explained by the level of nitrogen fertilizer, and also showed that plant height and dry and green fodder weight were the major contributors towards grain yield since these traits explained about (57, 52, 50)% respectively of the variation of grain yield, followed by stem diameter and grain number then leaf area index, which might be a good traits to breeders for developing high yielding cultivars in sorghum.

Key words: Correlation, regression, sorghum, grain yield, nitrogen level

Introduction

Sorghum (*Sorghum bicolor* L.) Moench] is one among the most important food and feed crop in almost all regions specially in semi-arid regions of the world (Ezeaku and Mohammed, 2006) and is grown worldwide (FAO, 2002) for grain or silage (Moges et al., 2007). Forage sorghum plays an important role and introducing a larger number of forage crops into production (Glamočlija et al., 2010).

The selection for secondary characters can be achieved by the study of relationships among traits. If there is a positive genetic correlation between two desirable traits, then it can be easily concluded for improvement. Apart from this, mere simple correlations do not give an insight into the true relationships between traits and yield (Ezeaku and Mohammed, 2006), so regression should be

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analyzed. Regression is a tool to study the inter-dependence among traits, the statistical technique that is used to establish the existence of a linear relationship between the dependent variable and the independent variables is called Regression Analysis. If there is a single independent or predicator variable is referred to as simple linear regression SLRA (Abd El-Mohsen, 2013). In a study by Sarvari and Beheshti, (2012), with 13 grain sorghum genotypes in three different moisture conditions, showed the relationship between grain yield and plant characteristics in grain sorghum genotypes. Ghalejoughi et al. (2013) studied regression and correlation between grain yield and related traits of corn hybrids, and revealed a positive significant correlation between grain yield and the weight of grain, stem diameter and the total number of grains. The equation of regression of grain yield indicates that the effective roles of vegetative organs growth and biological yield in grain yield within this experiment.

The objectives of this study were to study the correlation between traits and to study the effect of these traits on grain yield to define which traits can be considered as selection criteria for yield improvement in sorghum and to study the effect of nitrogen fertilizer level on grain yield via regression analysis.

Materials and methods

A factorial irrigated field experiment was carried out in R.C.B.D. layout with three replications in Iraq, the factors were four sorghum varieties (AlKhir, Enkath, Kafir, and Rabeh) which were planted under three levels of nitrogen (80,100,120) kg/h manually in 2016 on lines (6) m long, space between lines (70) cm and between plants on the same line were (20) cm and one meter space was left between plots for the isolation of varieties. The experiment planted in two sites, the first one was in Al-Eslah district south east of Nassiryah city, while the second was in Qalet Seker district north Nassiryah. All agricultural activities such as Irrigation and pesticide control conducted according to Agriculture Ministry guides, the following traits were studied:

1. Plant height (cm): measured during the flowering stage from the base of the plant to the top of the head (IBPGR/ICRISAT, 1993).
2. Stem diameter (cm): measured during maturity stage at 5 cm height above ground.
3. Leaf area Index: measured from equation LAI= LA/P. in which (LA) is leaf area of the plant and (P) is the area occupied by the plant. Leaf area of the plant was measured from the equation
4. LA= [maximum leaf length × maximum leaf width × 0.75].
5. Green fodder weight (ton/ ha^{-1}): Green fodder weight of shoot system was taken after harvest and converted to (ton/ ha^{-1}).
6. Dry fodder weight (ton/ ha^{-1}): Dry weight of shoot system was taken after drying the green fodder in the oven at (70˚).
7. Grain number in the plant.
8. Grain weight (g).
9. Grain yield (ton/ ha^{-1}): measured by means of grain yield was in plot and converted to (ton/ ha^{-1}).

Correlation between traits was studied using Genstat.12, and regression was studied between grain yield as the dependent variable and each of the following traits as independent variables (dry and green fodder weight, leaf area index, plant height, stem diameter, grain number and grain weight, nitrogen level) using Genstat.12.

Results and discussion

Correlation between studied traits

Results showed that all studied traits except grain weight were highly significantly correlated with grain yield (Table 1), results revealed that the plant height, stem diameter, dry fodder weight, green fodder weight, leaf area index and grain number had significant positive correlation with grain yield (r=0.763**, r=0.532**, r=0.725**, r=0.712**, r=0.504**, r=0.537**) respectively indicating dependency of yield on these characters. Plant height had significant positive correlation with all studied traits (r=0.540** with stem diameter, r=0.752** with dry fodder weight, r=0.657** with green fodder weight, r=0.556** with leaf area index, r=0.687** with grain number, r=0.352* with grain weight). Correlation was also positive and significant between stem diameter and each of dry and green fodder weight (r=0.455**, r=0.486**) respectively and with leaf area index and grain number (r=0.571**, r=0.408**) respectively. Dry fodder weight had significant positive correlation with green fodder weight and leaf area index and grain number (r=0.917**, r=0.628**, r=0.608**) respectively. Green fodder weight also had significant positive correlation with leaf area index and grain number (r=0.610**, r=0.556**) respectively. Leaf area index had significant positive correlation with grain number and grain weight (r=0.570**, r=0.504*) respectively. Finally, the correlation was positive and significant between grain number Grain weight (r=0.398*). These results are in agreement with the findings of many researchers (Khandelwal et al., 2015; Jain and Patel, 2014; Jain et al., 2011; Mahajan et al., 2011; Chavan et al., 2011; Prakash et al., 2010; Nyadanu and Dikera., 2014).

Effect of dry fodder weight on grain yield

Simple linear regression analysis between grain yield and dry Fodder weight was significant as shown in Table 2.

Grain yield had a linear and positive significant relationship with dry fodder weight, correlation value was R= 0.725 and the adjusted coefficient of determination was R^2= 0.519 which revealed that the variation in dry fodder weight explained about 52% of the variation of grain yield and this rate is represented by the nearest dots to the linear line (Fig. 1). The linear regression equation was formed as follows:

$$GY = 1.584 + 0.3391DF$$

where GY grain yield, DF dry fodder weight, 1.584 constant, 0.3391 regression coefficient (b), indicating that the increasing of one unite (ton/hectare) in dry fodder weight will increase grain yield in rate 0.3391.

Table 1. Correlation between studied traits.

	PH	SD	DF	GF	LAI	GN	GW	GY
PH	1							
SD	0.540**	1						
DF	0.752**	0.455**	1					
GF	0.657**	0.486**	0.917**	1				
LAI	0.556**	0.571**	0.628**	0.610**	1			
GN	0.687**	0.408**	0.608**	0.556**	0.570**	1		
GW	0.352*	0.161	0.218	0.185	0.376*	0.398*	1	
GY	0.763**	0.532**	0.725**	0.712**	0.504**	0.537**	0.231	1

Where: PH plant height. SD stem diameter, DF dry fodder weight, GF green fodder weight, LAI leaf area index, GN grain number, GW grain weight, GY grain yield
* significant at 0.05, ** significant at 0.01

Table 2. Regression analysis between grain yield and dry fodder weight.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	23.89	23.8893**	0.725**	0.525	0.519
Residual	70	21.59	0.3084			
Total	71	45.48	0.6405			

** Significant at 0.01, R Correlation value, the R^2 coefficient of determination.

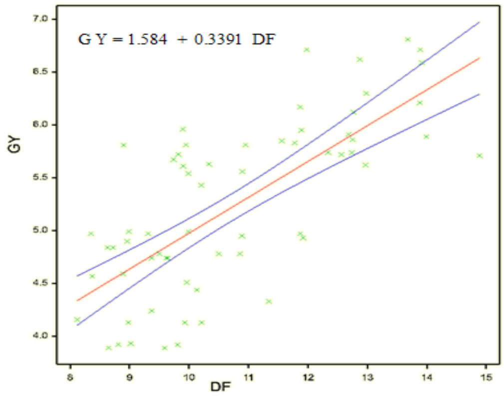

Fig. 1. Effect of dry fodder weight on grain yield.

Effect of green fodder weight on grain yield

Results showed that Simple linear regression between grain yield and green fodder weight was significant (Table 3) with positive significant correlation relationship R=0.712, and the adjusted coefficient of determination was R2 = 0.499 indicated that about 50% of variation in grain yield could be explained by the variation in green fodder weight represented by the nearest dots to the linear regression line as shown in figure 2, linear regression equation was formed as follows:

GY= - 1.769 + 0.2794 GF

where GY grain yield, GF green fodder weight, -1.769 constant, 0.2794 regression coefficient (b) which means that any increasing of one unite (ton/hectare) in green fodder weight will cause an increasing in grain yield in about 0.3391.

Table 3. Regression analysis between grain yield and green fodder weight.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	23.03	23.0340**	0.712**	0.506	0.499
Residual	70	22.44	0.3206			
Total	71	45.48	0.6405			

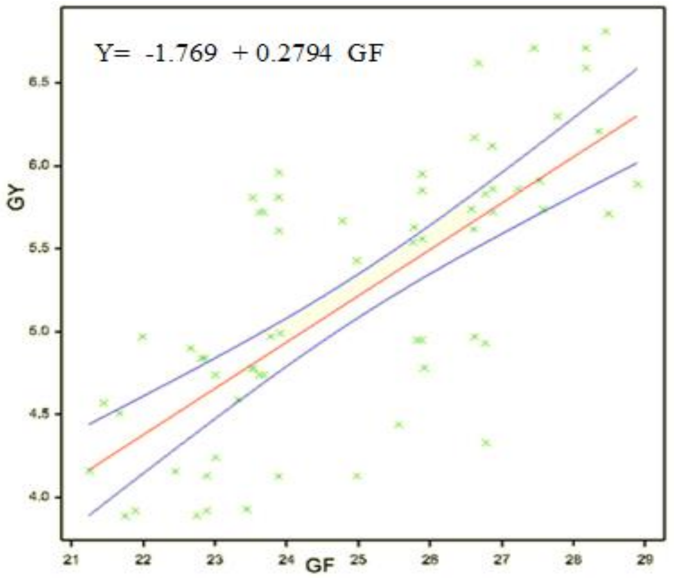

Fig. 2. Effect of green fodder on grain yield.

Effect of leaf area index on grain yield

Analysis of simple linear regression between grain yield and Leaf Area Index was significant as shown in Table 4. Correlation between them was positive and significant R= 0.504, so the adjusted coefficient of determination was R^2 = 0.244 indicated that variation in leaf area index could explain approximately 24% of the variation in grain yield represented by all nearest dots to the linear line (Fig. 3). The linear regression equation was formed as follows: GY= 2.148+ 0.3363 LAI

where GY grain yield, LAI leaf area index, 1.584 constant, 0.3363 regression coefficient (b), that means any increasing of one unite in leaf area index will increase grain yield at the rate of 0.3363.

Effect of plant height fodder on grain yield

Grain yield had a linear and positive relationship with plant height, correlation was R= 0.763, and the simple linear regression between grain yield and plant height was significant as shown in table 5, adjusted coefficient of determination was R^2 = 0.577 revealed that the variation in grain yield could be explained by the variation in plant height in a ratio of about 58% represented by nearest dots to the linear line (Fig. 4). the linear regression equation was formed as follows:

$$GY= - 0.786 + 0.03909\ PH$$

where GY grain yield, PH plant height, -0.786 constant, 0.03909 regression coefficient(b), indicating that increasing of one centimeter in plant height will cause an increasing in grain yield in about 0.03909.

Table 4. Regression analysis between grain yield and leaf area index.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	11.57	11.5667**	0.504**	0.254	0.244
Residual	70	33.91	0.4844			
Total	71	45.48	0.6405			

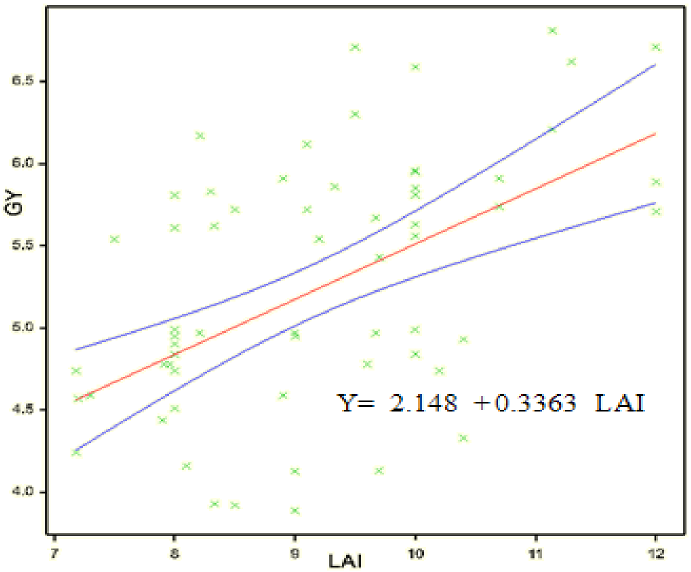

Fig. 3. Effect of leaf area index on grain yield.

Table 5. Regression analysis between grain yield and plant height.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	26.50	26.4979**	0.763**	0.583	0.577
Residual	70	18.98	0.2711			
Total	71	45.48	0.6405			

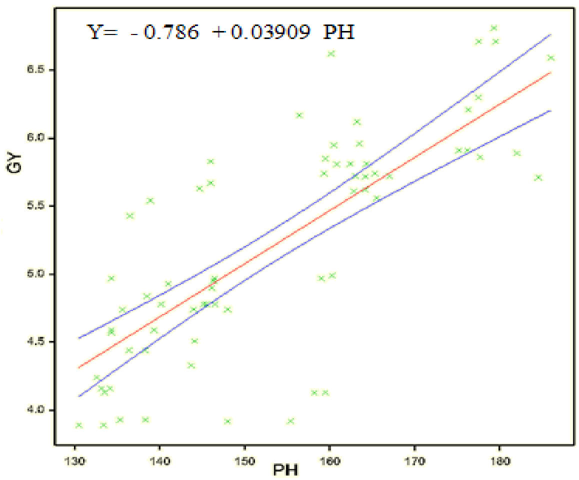

Fig. 4. Effect of plant height on grain yield.

Effect of stem diameter on grain yield

Simple linear regression analysis between grain yield and stem diameter was also significant as shown in table 6. Grain yield had a linear and positive relationship with stem diameter, the correlation was R= 0.532 and adjusted coefficient of determination was R^2 = 0.273 revealed that the variation in grain yield could be explained by the variation in stem diameter for only 27% represented by nearest dots to the linear line (Fig. 5). the linear regression equation was formed as follows:

GY= 2.464 + 0.2330 SD

where GY grain yield, SD stem diameter, 2.464 constant, 0.2330 regression coefficient (b), that means increasing of one centimeter in stem diameter will increase grain yield in about 0.2330.

Effect of grain number on grain yield

Results showed that Simple linear regression between grain yield and grain number was significant (Table 7) with positive relationship correlation R= 0.511, adjusted coefficient of determination was R^2 = 0.251 indicated that about 25% of variation in grain yield could be explained by the variation in grain number represented by the nearest dots to the linear regression line in figure 6, linear regression equation was formed as follows: GY= 3.611 + 0.000894 GN

where GY grain yield, GN grain number, 3.611 constant, 0.000894 regression coefficient(b), which revealed that increasing one grain in grain number will cause an increasing in grain yield in rate of 0.000894.

Table 6. Regression analysis between grain yield and stem diameter.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	12.87	12.8725 **	0.532**	0.283	0.273
Residual	70	32.61	0.4658			
Total	71	45.48	0.6405			

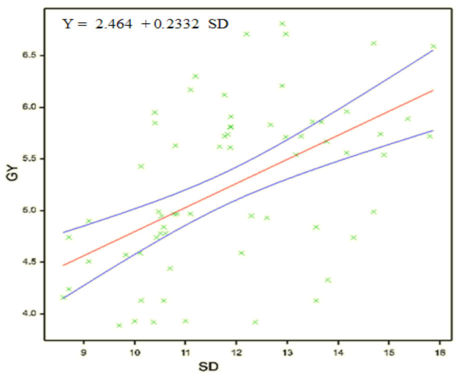

Fig. 5. Effect of stem diameter on grain yield.

Table 7. Regression analysis between grain yield and grain number.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	11.87	11.8739**	0.511**	0.261	0.251
Residual	70	33.60	0.4801			
Total	71	45.48	0.6405			

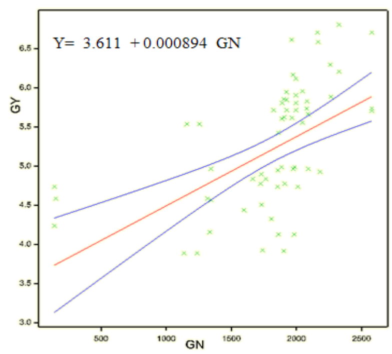

Fig. 6. Effect of grain number on grain yield.

Effect of grain weight on grain yield

In spite of existence of linear positive relationship between grain yield and grain weight correlation (R= 0.231) but it wasn't significant so Simple linear regression analysis wasn't significant too between grain weight and grain yield (Table 8), adjusted coefficient of determination R^2 = 0.040 revealed that the variation in grain weight had no effect on the variation of grain yield as shown in (Fig. 7) majority of dots are far away from the regression linear line. linear regression equation was formed as follows: GY= - 0.02 + 0.213 GW

where GY grain yield, GW grain weight, -0.02 constant, 0.213 regression coefficient(b), which is not significant at all.

Effect of nitrogen fertilizer level on grain yield

Simple linear regression between nitrogen fertilizer level and grain yield was significant (Table 9) with positive relationship correlation R= 0.602, adjusted coefficient of determination R^2 = 0.353 indicated that about 35% of variation in grain yield could be explained by the level of nitrogen fertilizer represented by the nearest dots to the linear regression line in figure 8, linear regression equation was formed as follows: GY= 2.283 + 0.02928 GN

where GY grain yield, N nitrogen level, 2.283 constant, 0.02928 regression coefficient(b), which revealed that increasing one unit in nitrogen level will cause an increasing in grain yield at the rate of 0.02928.

Table 8. Regression analysis between grain yield and grain weight.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	2.44	2.4352 ns	0.231	0.054	0.040
Residual	70	43.04	0.6149	ns		
Total	71	45.48	0.6405			

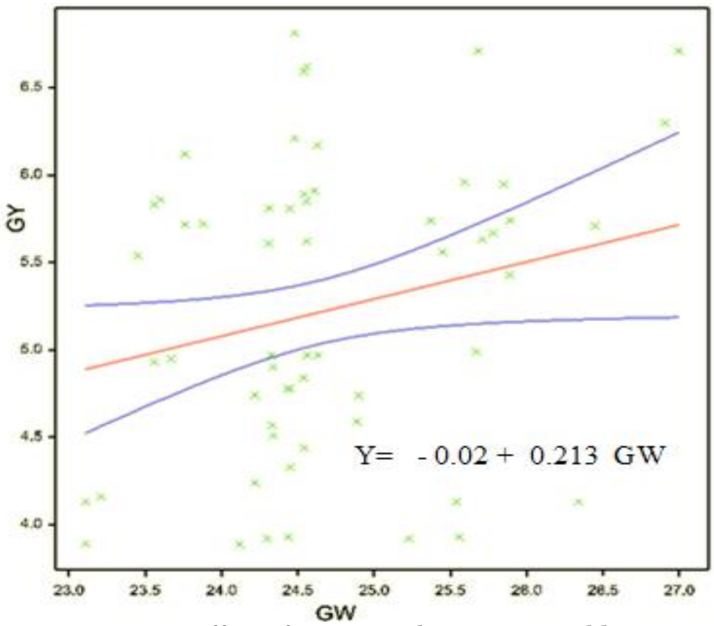

Fig. 7. Effect of grain weight on grain yield.

Table 9. Simple linear regression analysis of grain yield and nitrogen level.

Source	d.f.	Sum of squares	Mean Squares	R	R^2	Adjusted R^2
Regression	1	16.46	16.4619**	0.602*	0.362	0.353
Residual	70	29.02	0.4145			
Total	71	45.48	0.6405			

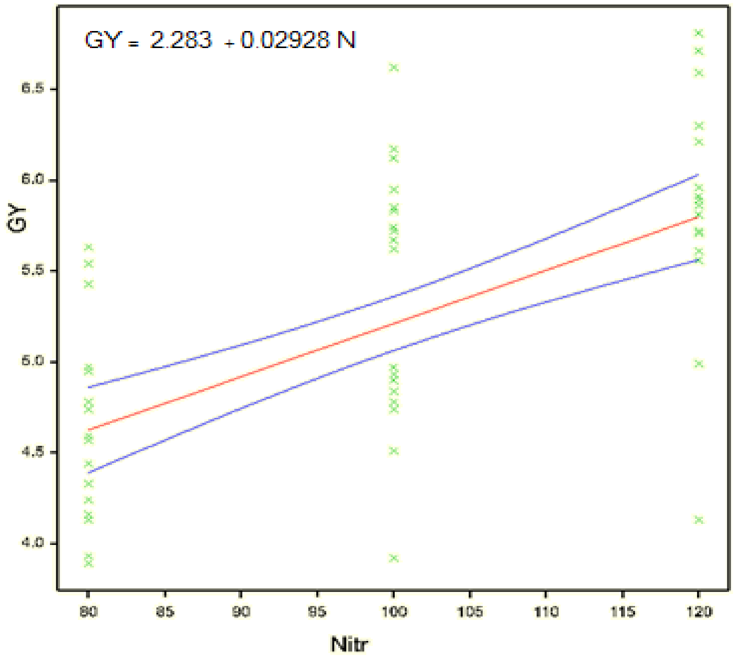

Fig. 8. Effect of nitrogen level on grain yield.

These results are in agreement with Ezeaku and Mohammad (2006) who reported that Grain weight should be considered simultaneously when developing selection criteria for yield improvement in sorghum, and plant height have an effect on grain yield in which taller plants possess heavier head weight and greater grain yield than shorter plants, probably due to greater mobilization of assimilates to the panicle in taller plants. And agree with Yang and Anderson (2000) who mentioned that leaf area index in sorghum is considered as indicator of potential yield, and with Beheshti (2010) mentioned that in sorghum stem and leaf are the organs that reserve photosynthetic assimilates (Slafer and Savin, 1994; Yang et al., 2007) which affect grain yield. and with Saed-Moucheshi et al. (2013) revealed that leaves area is a variable that significantly contributed in grain yield and determined as the most effective variable contributing to the grain yield and it can be useful for the breeding programs. Also with Gupta and Sharma (2013) they mentioned that the grain yield may be described by plant height, LAI, and grains per head and These findings are consistent with the findings of Rao and Saxena (1999), Rajeswari and Nadarajan (1996) and Mahajan et al. (1986) also found the similar kinds of results. Our findings were consistent also with the results of Zaefizadeh et al. (2011) and Mohammadi (2002) who reported that the number of grains and plant height is important traits in showing the yield and in agreement with Johnston (2000) who found that N fertilizer has significantly increased yield in the past few decades as compared to any other agricultural input, and with Smith et al. (1990) who reported that sorghum yield would have dropped by 19% without N fertilizer application.

Conclusion

All studied traits except grain weight were highly significantly correlated with grain yield and about 35% of variation in grain yield could be explained by the level of nitrogen fertilizer, and the traits of Plant height and dry and green fodder weight were the major contributors towards grain yield since these traits explained about(57, 52, 50)% respectively of the variation of grain yield, which might be a good traits for breeders to develop high yielding cultivars in sorghum, followed by stem diameter and grain number then leaf area index.

Recommendation

To use the studied traits as selection criteria to get a high yield in sorghum and to use such studies to make a better selection of suitable traits in plant improvement programs of sorghum.

Author contributions

Salih Hadi Farhood Al-salim - Main author (Research and manuscript writing); Maysoun Mohamed Saleh - Samples collection; Ragheb H. A. ALbourky - Experiment design; Abbas Lateef Abdulrahman - Correction and submission of manuscript

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