Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 7, No. 4, 2021
http://JCNS.ahvaz.iau.ir
OPEN ACCESS

# Assess Correlation between Traits of Sorghum Affected Different Rate of Nitro-gen Fertilizer and Vermicompost under Water Stress Situation

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**RESEARCH ARTICLE**



**ARTICLE INFO.**
***Received Date:*** *26 Sep. 2021*
***Received in revised form:*** *28 Oct. 2021*
***Accepted Date:*** *29 Nov. 2021*
***Available online:*** *30 Dec. 2021*

**To Cite This Article:**
Seyedeh Zohreh Hashemi, Saeed Zakernejad, Khoshnaz Payandeh. Assess Correlation between Traits of Sorghum Affect-ed Different Rate of Nitrogen Fertilizer and Vermicompost under Water Stress Situation. ***J. Crop. Nutr. Sci.,*** 7(4): 13-22, 2021.

**ABSTRACT**

**BACKGROUND:** Yield in Sorghum, similar to the other crops, is a complex trait and constitute by many of morphological and physiological traits. Mentioned trait is affected by genotype and environmental factors because it is a quantitative trait.

**OBJECTIVES:** This study was conducted to predict the most effective traits on sorghum seed yield according correlation between characteristics in response to apply different irrigation regime and nutrition crop.

**METHODS:** Current research was done according split plot experiment based on randomized complete blocks design with four replications along 2017 year. The main factor included water deficit stress at three level ($A_1$: 70, $A_2$: 100 and $A_3$: 130 mm Class A evaporation pan) and combined effect of nitrogen fertilizer and vermicompost at five level ($B_1$: 100% Nitrogen; 100% pure nitrogen equivalent to 200 kg per hectare, $B_2$: 75% Nitrogen+25% Vermicompost, $B_3$: 50% Nitrogen+50% Vermicompost, $B_4$: 25% Nitrogen+75% Vermicompost, $B_5$: 100% Vermicompost) belonged to sub plot.

**RESULT:** According result of analysis of variance effect of different level of irrigation regime and combined effect of nitrogen fertilizer and vermicompost on all measured traits was significant but interaction effect of treatments (instead seed yield and biologic yield) was not significant. Simple correlation coefficients between traits were estimated according to Pearson coefficient. The most positive and significant correlation was observed between seed yield and biologic yield ($0.859^{**}$), harvest index ($-0.703^{**}$) and number of seed per raceme ($0.646^{**}$) at 1% probability level. The traits of number of raceme per race ($0.641^{*}$), race length ($0.541^{*}$), number of seed per race ($0.533^{*}$) and chlorophyll index ($0.521^{*}$) had correlation with the seed yield was significant at 5% probability level.

**CONCLUSION:** According to the results of this research, characteristics such as of biologic yield, harvest index and number of seed per raceme had the most positive-direct effects on Sorghum seed yield can be proposal to plant breeder to more studied process such as stepwise regression and path analysis.

**KEYWORDS:** *Biomass, Harvest index, Leaf area, Relation between traits, Seed weight.*

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## 1. BACKGROUND

Sorghum is indigenous to Africa, and many of today's varieties originated on that continent. Sorghum was also grown in India before recorded history and in Assyria as early as 700 BC. The crop reached China during the thirteenth century and the Western Hemisphere much later (Undersander *et al*., 2013). Sorghums in general can be classified into two types: Forage types (mainly for forage or animal feed) and grain types (mainly for human consumption). The forage sorghums are further grouped into four types: (a) hybrid forage sorghum, (b) Sudan grass, (c) sorghum x Sudan hybrids (also known as Sudan hybrids), and (d) sweet sorghum. The latter is used mainly for molasses but more recently for biofuel production as well (Newmann *et al*., 2010). Multivariate analyses are useful for characterization, evaluation and classification of plant genetic resources when a number of accessions are to be assessed for several characters of agronomic, morphological and physiological importance. Different types of multivariate analysis such as regression analysis, path analysis, principal component analysis (PCA) can be used to identify groups of genotypes that have beneficial traits for breeding and instructing the patterns of variation in genotype accession, to recognize relationships among accessions and possible gaps. Correlation coefficients describe the mutual relationships between different pairs of characters without providing the nature of cause and effect relationship of each character (Sharifi *et al*., 2020). Yield improvement is a major breeding objective of most crop improvement programs (Ghobary and Abd-Allah, 2010). Correlation analysis describes the mutual relationship between different pairs of characters without providing the nature of cause and effect relationship of each character. Significant positive correlations were detected between faba bean seed yield and each of number of pods per plant, number of seeds per plant, seed weight per plant and biological yield (Alghamd, 2007). Seed yield, as the most important quantitative characteristic, will be a result of genotype, environment and genotype-environment interaction effects (Marjanovic-Jeromela *et al*., 2009). Improvement of seed yield in canola has been the main objective of canola breeders for many years (Mahasi and Kamundia, 2007). Seed yield is a quantitative trait, which is principally influenced by the environment and consequently has a low heritability (Ana *et al*., 2009). Abderrahmane *et al*. (2013) reported that total biomass, number of spikes per plant, number of grains per spike are positively correlated with grain yield. Grain yield per plant was positively correlated with grains per spike, harvest index, spikes per plant, spike length and 1000 grain weight (Majumder *et al*., 2008). In a study aimed to know relationships between grain yield and yield components in bread wheat under different water availability, Mohammadi *et al*. (2012) reported that grain yield was positively correlated with plant height, spike length, days to physiological maturity, agronomic score and test weight. Grain yield is considered to be a complicated trait, which can be affected by many factors, and usually as a result of insufficient yield heritability factor, direct selection yield is not much effective for it; as a result, for yield breeding we would better use indirect selection (Artoz, 2012). Yield is a complex character, which depends upon many independent contributing characters. Knowledge on type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield, information on the nature of association between yield and its components help in simultaneous selection for many characters associated with yield improvements (Kumar *et al*., 2012). Knowing about grain yield issue and its components plays an important role for being successful in evaluative programs. Success in breeding and having fruitful varieties of agricultural products with a higher quality depends on knowledge about genetic grain yield controlling and its relation with grain yield components, also to phenologic traits and forage quality (Jafari, 2001). Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield as well as to examine direct and indirect contributions to yield variables (Semahegn Belete, 2011). Correlation analysis helps researchers to discriminate a significant relationship between traits. Non-important traits in the regression model will be omitted via a stepwise regression analysis, therefore the most important traits which have considerable effects on the dependent variable will be verified. Most of the traits which were selected through the stepwise regression model can be used as selection criteria for indirect selection in a breeding program (Sabaghnia *et al*., 2010). 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 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.

## 2. OBJECTIVES

This study was conducted to predict the most effective traits on sorghum seed yield according correlation between characteristics in response to apply different irrigation regime and nutrition crop.

## 3. MATERIALS AND METHODS

### *3.1. Field and Treatments Information*

Current study was conducted according split plot experiment based on randomized complete blocks design with four replications along 2017 year. Place of research was located in Hamideyeh city at longitude 48°10'E and latitude 31°33'N in Khuzestan province (Southwest of Iran). The main factor included water deficit stress at three level ($A_1$: 70, $A_2$: 100 and $A_3$: 130 mm Class A evaporation pan) and combined effect of nitrogen fertilizer and vermicompost at five level ($B_1$: 100% Nitrogen; 100% pure nitrogen equivalent to 200 kg per hectare, $B_2$: 75% Nitrogen+25% Vermicompost, $B_3$: 50% Nitrogen+50% Vermicompost, $B_4$: 25% Nitrogen+75% Vermicompost, $B_5$: 100% Vermicompost) belonged to sub plot. The amount of vermicompost used in the field in 100% vermicompost treatment was equal to 5 tons per hectare. This experiment had 60 plots. Each plot consisted of 6 lines with a distance of 75 cm and 5 meters length. Before performing the experiment, sampling was done from the farm soil and the physical and chemical properties of the soil and vermicompost were determined (Tables 1 and 2).

**Table 1.** Some physical and chemical properties of field's soil

| Depth of soil sampling (cm) | SP | EC ($ds.m^{-1}$) | pH | O.C (%) | N (ppm) | P (ppm) | K (ppm) | Soil texture |
|---|---|---|---|---|---|---|---|---|
| 0-30 | 46 | 3.42 | 7.1 | 0.72 | 0.42 | 9.1 | 150 | Clay loam |
| 30-60 | 44 | 3.21 | 7 | 0.61 | 0.38 | 8.8 | 147 | Clay loam |

**Table 2.** Some physical and chemical properties of vermicompost

| EC ($ds.m^{-1}$) | pH | Mn ($mg.kg^{-1}$) | Zn ($mg.kg^{-1}$) | Fe ($mg.kg^{-1}$) | Nitrogen (%) | Potassium (%) | Phosphorus (%) |
|---|---|---|---|---|---|---|---|
| 2.9 | 6.9 | 21 | 33 | 44 | 4.96 | 3.19 | 0.61 |

### *3.2. Farm Management*

The amount of fertilizer required in the field included 90 $kg.ha^{-1}$ of superphosphate triple and 100 $kg.ha^{-1}$ of potassium sulfate fertilizer. All vermicompost was applied to the soil in the mentioned treatments before planting. After fertilizing, the field soil was mixed with the soil by a light disk. Seed sowing was done manually on August 10, 2017 at a depth of four centimeters. The first irrigation was done immediately after planting. Up to the four-leaf stage of conventional irrigation, and after the four-leaf stage, according to the experimental treatments based on the Class A evaporation pan placed near the field and based on continuous evaporation from it, each of the stress treatments of irrigation water shortage stress (Nadimpour and Mojaddam, 2015). Sorghum seedlings were thinning at four-leaf stage and weed controlled manually without chemical pesticides.

### *3.3. Measured Traits*

In order to determine the yield and yield components, two side rows and a half meters from the beginning and end of the plot were removed as marginal effects. The final harvest was done on the 24$^{th}$ of October of 2017 in an area equivalent to two square meters in each plot. In order to calculate the weight of 1000 seeds, two groups of 500 seeds were separated and if their difference was less than six percent, their total weight was determined as the weight of 1000 seeds. To determine the biological yield, an area of two square meters was taken from each plot and a section of about 500 grams was separated and after transferring the samples to the laboratory, they were placed in a oven dryer at 75 °C for 48 hours. And after drying, their weight was calculated. To determine the percentage of grain protein, the percentage of grain nitrogen was first measured by Kjeldahl method, which includes digestion, distillation and titration. To measure the seed nitrogen content and straw nitrogen content the Kjeldahl method was used. So, to calculate the seed protein content the following formula was used (Bremner *et al*., 1983): **Equ.1.** Seed protein content (%)= Nitrogen percentage × 5.8. Prussic acid was determined according to the AOAC (1990) methods. Harvest index (HI) was calculated according to formula of Gardner *et al*. (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100. Chlorophyll content of five ear leaves in each plot was measured at anthesis stage by SPAD 502 device, accurately three points of leaf measured and the average of three numbers was considered. (SPAD 502, Minolta Company, Japan).

*3.4. Statistical Analysis*

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level. Correlation between traits was determined by Minitab software (Ver. 15).

## 4. RESULT AND DISCUSSION

*4.1. Analysis of variance*

Result of analysis of variance indicated effect of different level of water deficit stress on plant height, race length, number of raceme per race, 1000-seed weight, seed yield, chlorophyll a, chlorophyll b and protein percentage was significant at 5% probability level also on number of seed per race, number of seed per raceme, biologic yield, harvest index, leaf area index, chlorophyll index and protein yield was significant at 1% probability level (Table 3). According result of analysis of variance effect of different level of combined effect of nitrogen fertilizer and vermicompost on plant height, race length, number of raceme per race, 1000-seed weight, seed yield, chlorophyll a, chlorophyll b and protein percentage was significant at 5% probability level also on number of seed per race, number of seed per raceme, biologic yield, harvest index, leaf area index, chlorophyll index and protein yield was significant at 1% probability level (Table 3). Interaction effect of treatments on all measured traits (instead seed yield and biologic yield) was not significant (Table 3).

*4.2. Correlation between traits*

Seed yield is a quantitative trait, which expression is the result of genotype, environmental effect and genotype-environment interaction (Gunasekera *et al*., 2006). Simple correlation coefficients between traits were estimated according to Pearson coefficient. The most positive and significant correlation was observed between seed yield and biologic yield ($0.859^{**}$), harvest index ($-0.703^{**}$) and number of seed per raceme ($0.646^{**}$) at 1% probability level. The traits of number of raceme per race ($0.641^{*}$), race length ($0.541^{*}$), number of seed per race ($0.533^{*}$) and chlorophyll index ($0.521^{*}$) had correlation with the seed yield was significant at

5% probability level (Table 4). Knowledge of the relationship among yield components is essential for the formulation of breeding programs aimed at achieving the desired combinations of various components of yield. The estimates of correlation coefficients among different characters indicate the extent and direction of association. The correlation co-efficient provide a reliable measure of association among the characters and help to differentiate vital associations useful in breeding from those of the non-vital ones (Falconer, 1981).

**Table 3.** Result analysis of variance of studied traits

| S.O.V | df | Plant height | Race length | No. raceme per race | No. seed per race | No. seed per raceme |
|---|---|---|---|---|---|---|
| Replication | 3 | $0.32^{ns}$ | $30.84^{ns}$ | $0.24^{ns}$ | $1816^{ns}$ | $0.48^{ns}$ |
| Water deficit stress (A) | 2 | $453.2^{*}$ | $71.35^{*}$ | $123.37^{*}$ | $476350^{**}$ | $71.03^{**}$ |
| Error I | 6 | 25.9 | 10.13 | 14.48 | 6770 | 4.18 |
| Combination nitrogen with vermicompost (B) | 4 | $380.1^{*}$ | $52.25^{*}$ | $173.92^{*}$ | $243622^{**}$ | $35.14^{**}$ |
| A × B | 8 | $5.34^{ns}$ | $2.67^{ns}$ | $2.03^{ns}$ | $137.74^{ns}$ | $0.25^{ns}$ |
| Error II | 36 | 35.48 | 7.93 | 10.13 | 5025 | 2.24 |
| CV(%) | - | 5.23 | 12.58 | 6.63 | 5.39 | 6.41 |

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

**Continue table 3.**

| S.O.V | df | 1000-seed weight | Seed yield | Biologic yield | Harvest index | Leaf area index |
|---|---|---|---|---|---|---|
| Replication | 3 | $0.2^{ns}$ | $378.24^{ns}$ | $1248.54^{ns}$ | $0.93^{ns}$ | $0.057^{ns}$ |
| Water deficit stress (A) | 2 | $38.3^{*}$ | $651742^{*}$ | $102442^{**}$ | $287.32^{**}$ | $3.49^{**}$ |
| Error I | 6 | 3.172 | 39547 | 457.10 | 6.267 | 0.18 |
| Combination nitrogen and vermicompost (B) | 4 | $20.6^{*}$ | $532638^{*}$ | $98631^{**}$ | $87.12^{**}$ | $2.24^{**}$ |
| A × B | 8 | $0.22^{ns}$ | $209366^{*}$ | $60467^{**}$ | $0.07^{ns}$ | $0.07^{ns}$ |
| Error II | 36 | 2.27 | 3514.30 | 401 | 4.34 | 0.13 |
| CV(%) | - | 6.62 | 5.61 | 5.83 | 6.86 | 9.77 |

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

**Continue table 3.**

| S.O.V | df | Chlorophyll index | Chlorophyll a | Chlorophyll b | Protein percentage | Protein yield |
|---|---|---|---|---|---|---|
| Replication | 3 | $4.08^{ns}$ | $0.041^{ns}$ | $0.178^{ns}$ | $1.764^{ns}$ | $15.34^{ns}$ |
| Water deficit stress (A) | 2 | $97.54^{**}$ | $1.52^{*}$ | $1.35^{*}$ | $8.15^{*}$ | $324.81^{**}$ |
| Error I | 6 | 8.34 | 0.004 | 0.164 | 2.249 | 11.41 |
| Combination nitrogen with vermicompost (B) | 4 | $75.03^{**}$ | $0.954^{*}$ | $0.991^{*}$ | $6.021^{*}$ | $125.64^{**}$ |
| A × B | 8 | $1.57^{ns}$ | $0.001^{ns}$ | $0.003^{ns}$ | $0.05^{ns}$ | $2.45^{ns}$ |
| Error II | 36 | 7.87 | 0.007 | 0.015 | 0.841 | 6.74 |
| CV(%) | - | 5.48 | 5.36 | 12 | 9.08 | 7.72 |

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

**Table 4.** Correlation between studied traits

| **Traits** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | - | | | | | | | | | | | | | |
| **2** | $0.859^{**}$ | - | | | | | | | | | | | | |
| **3** | $-0.703^{**}$ | $0.842^{**}$ | - | | | | | | | | | | | |
| **4** | $0.641^{*}$ | $0.761^{**}$ | $0.776^{**}$ | - | | | | | | | | | | |
| **5** | $0.646^{**}$ | $0.657^{**}$ | $0.745^{**}$ | $0.657^{**}$ | - | | | | | | | | | |
| **6** | $0.533^{*}$ | $0.617^{*}$ | $0.467^{ns}$ | $0.479^{ns}$ | $-0.504^{*}$ | - | | | | | | | | |
| **7** | $0.425^{ns}$ | $0.527^{*}$ | $0.492^{ns}$ | $0.324^{ns}$ | $0.629^{*}$ | $-0.687^{**}$ | - | | | | | | | |
| **8** | $0.247^{ns}$ | $0.563^{*}$ | $0.241^{ns}$ | $0.345^{ns}$ | $0.231^{ns}$ | $0.456^{ns}$ | $0.467^{ns}$ | - | | | | | | |
| **9** | $0.541^{*}$ | $0.557^{*}$ | $0.587^{*}$ | $0.174^{ns}$ | $0.214^{ns}$ | $0.534^{*}$ | $0.317^{ns}$ | $0.157^{ns}$ | - | | | | | |
| **10** | $0.495^{ns}$ | $0.532^{*}$ | $0.611^{ns}$ | $0.531^{*}$ | $0.211^{ns}$ | $0.420^{*}$ | $0.473^{ns}$ | $0.690^{**}$ | $0.188^{ns}$ | - | | | | |
| **11** | $0.521^{*}$ | $0.549^{*}$ | $0.322^{ns}$ | $0.511^{*}$ | $0.122^{ns}$ | $0.155^{ns}$ | $0.277^{ns}$ | $0.693^{**}$ | $0.259^{ns}$ | $0.749^{**}$ | - | | | |
| **12** | $0.496^{ns}$ | $0.516^{*}$ | $0.471^{ns}$ | $0.469^{ns}$ | $0.318^{ns}$ | $0.219^{ns}$ | $0.325^{ns}$ | $0.648^{**}$ | $0.233^{ns}$ | $0.777^{**}$ | $0.559^{*}$ | - | | |
| **13** | $0.498^{ns}$ | $0.518^{*}$ | $0.329^{ns}$ | $0.455^{ns}$ | $0.320^{ns}$ | $0.313^{ns}$ | $0.128^{ns}$ | $0.643^{**}$ | $0.237^{ns}$ | $0.775^{**}$ | $0.561^{*}$ | $0.97^{**}$ | - | |
| **14** | $-0.442^{ns}$ | $0.250^{ns}$ | $0.440^{ns}$ | $0.331^{ns}$ | $0.224^{ns}$ | $0.418^{ns}$ | $0.232^{ns}$ | $0.249^{ns}$ | $0.439^{ns}$ | $0.271^{ns}$ | $0.255^{ns}$ | $-0.66^{*}$ | $0.255^{ns}$ | - |
| **15** | $-0.499^{ns}$ | $0.231^{ns}$ | $0.469^{ns}$ | $0.319^{ns}$ | $0.223^{ns}$ | $0.425^{ns}$ | $0.224^{ns}$ | $0.144^{ns}$ | $0.431^{ns}$ | $0.374^{ns}$ | $0.254^{ns}$ | $-0.76^{**}$ | $0.259^{ns}$ | $0.395^{ns}$ |

$^{ns,\ *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

**1**: Seed yield, **2**: Biologic yield, **3**: Harvest index, **4**: Number of raceme per race, **5**: Number of seed per raceme, **6**: Number of seed per race, **7**: 1000-seed weight, **8**: Plant height, **9**: Race length, **10**: Leaf area index, **11**: Chlorophyll index, **12**: Chlorophyll a, **13**: Chlorophyll b, **14**: Protein percentage, **15**: Protein yield.

Tadesse *et al*. (2011) indicated number of pods per plants, number of seeds per pod, thousand seed weight and plant height had significant association with seed yield per plot. The seed yield per plant exhibited positive and significant correlation with clusters per plant, pod length, plant height, branches per plant, pods per plant and hundred seed weight (Badolay *et al*., 2009). Al-Salim *et al*. (2017) reported 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. Ulukan *et al*. (2003) also found positive and significant relationships between biological yield and plant height and grain number per pod. Keneni and Jarso (2002) indicated positive and significant correlation between Seed yield and number of pods per plant. Sharifi *et al*. (2020) by compare faba bean (*Vicia faba* L.) genotypes by multivariate analyses reported the analysis of variance showed significant differences between genotypes for all of the studied traits. The increase of total dry weight and its direct relation with seed yield show the relations between photosynthesis efficiency of plant and seed yield, therefore varieties which have gained more profit of production factor according to growth conditions and they keep more photosynthesis materials in their sinks, have more efficiency. This status was in conformity with the results of some other researchers (Qulipor *et al*., 2004).

## 5. CONCLUSION

According to the results of this research, characteristics such as of biologic yield, harvest index and number of seed per raceme had the most positive-direct effects on Sorghum seed yield can be proposal to plant breeder to more studied process such as stepwise regression and path analysis.

## ACKNOWLEDGMENT

The authors thank all colleagues and other participants, who took part in the study.

## FOOTNOTES

**AUTHORS' CONTRIBUTION**: All authors are equally involved.

**CONFLICT OF INTEREST**: Authors declared no conflict of interest.

**FUNDING/SUPPORT**: This study was done by support of Department of Agronomy, Islamic Azad University, Ahvaz Branch.

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