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Performance of sesame varieties (*Sesemum indicum* L.) as influenced by period of stress and NPK fertilizer rates in the Sudan Savannah

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ABSTRACT

Field trials were conducted at the Irrigation Research Station, Kadawa to evaluate the response of sesame varieties to stress period and NPK fertilization in Sudan savannah. The treatments were two sesame varieties (NCRIBEN 01 and NCRIBEN 03) three water stress period (at seedling, flowering and podding stages), three NPK application rates (200, 270 and 340 kg NPKha^{-1}). The experimental design used was randomized complete block design (RCBD) laid out in a split plot arrangement where the factorial combination of fertilizer rates and water stress periods were assigned to the main plot and varieties allocated to the sub plot and replicated three times. Results showed that variety NCRIBEN 03 recorded more capsules and higher capsule weight per plant and a grain yield of 1111.4 kg ha^{-1} and 1168.8kgha^{-1}, in 2012/13 and 2013/14 dry seasons respectively. Stressing sesame at podding lead to 17 and 29% decline in number of pods and pod weight per plant, respectively and31% drop in grain yield. Application of 340 kg NPK fertilizer ha1 had highest yield of 1018 and 1078 kg ha^{-1} in 2012/13 and 2013/14 seasons, respectively. The use of variety NCRIBEN 03 + 340 kg NPK fertilizer ha1+ stressing sesame at seedling stage will give best grain yield of sesame.

Keywords: NPK fertilization; sesame; stress; period; variety

INTRODUCTION

Sesame (*Sesamum indicm* L.) is an annual crop belonging to the order Tub florae and family Pedaliaceae cultivated for seed and also one of the most important oil crops of the world. Purseglove (1969) reported that Sesame was one of the first oil seeds from which ancient Hindus extracted oil, which was used for certain ritual purposes. The main reason for their popularity is the fact that they are loaded with health-promoting nutrients and elements. But besides the nutritional value, these seeds are also packed with flavor, crunchiness and a certain smokiness that helps them find use in many cuisines. Sesame seeds are a common ingredient in dishes across the globe. Sesame is an essential ingredient in product such as bread meals, soups, crackers, and meat cuisines (Alegbejo *et al*., 2003). This crop, for a long time, has been cropped in warm and arid areas all around the world (parts of the Mediterranean region, Africa and India as well as in the Far East) and has adapted to these conditions. Sesame seeds are incredibly resilient and able to grow in places where many other

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crops cannot. More specifically sesame is grown widely in countries such as Myanmar, India, Pakistan, Turkey, Iraq, Syria, Sudan, Nigeria and Egypt. India and China are the major world sesame producers; while in Africa, Sudan is the largest producer. Sixty percent of the world's sesame seed production was from Asia, however less than 2% of this total is exported (FAO, 2021). Although Africa has a large internal market but supplies about 80% of the world exports of sesame seed annually. The principal African exporters in order of magnitude are the Sudan, Nigeria, and Ethiopia. Sesame oil contains both insecticidal and anti-fungal properties, that were added to formulations to help coat plant surfaces and used as a surfactant; there is no published science on the use of this ingredient as a stand-alone fungicide. In Nigeria, sesame is grown during rainy season as well as under irrigation during off-season. Perhaps, optimum growth and yield of Sesame varies depending on plant characteristics and availability of growth factors such as moisture and nutrients. Crops recommended for deficit irrigation applications are those that are relatively drought resistant and early maturing, Sesame (*Sesamum indicum* L.) is one of the most ancient, early maturing and resilient crops in the world adapted to both rainy and irrigated crop production activities with good yields.

Fresh water and soil nutrient availability remain the most limiting factors affecting crop growth and yield. Climate variability and drought in recent times increase the threats of freshwater shortage. Urbanisation, population explosion and land tenure issues continuously pose great challenges on availability of cultivable land, hence the need to strategies on its efficient usage. Drought or water stress was identified among the most important environmental variable limiting arable crops yields. The desire to boast sesame production stimulated research into water saving strategies with a view to identifying the most critical period when sesame crops must not be deprived of water. Similarly, the decline in soil fertility experienced in the savannah owing to continuous cultivation and mining of the available soil nutrient leading to low crop yield per unit area. The combination of high crop water productivity and improved crop yield is an important element of sustainable development. This experiment was conducted to determine the grain yield of sesame varieties under different NPK Fertilization rates and period of water stress most detrimental to the productivity of sesame in the Sudan savannah.

MATERIALS AND METHODS

Study Area/Location

Field trials were carried out during 2012/13 and 2013/14 irrigation seasons at the Irrigation Research Station (IRS) farm Kadawa. (11^o 39'N, 08^o 02'E) 500m above sea level. Located in the Sudan savanna belt of Northern Nigeria. The Sudan savanna belt is located in the northern parts of Nigeria and is characterized by high rainfall variability, frequent droughts, and poor soil fertility. The climate of the savannah has a mean annual rainfall of about 1200mm or below, while the monthly mean temperature ranges from 22 °C (72 °F) during nighttime to 33 °C (91 °F) at daytime. The savannas are grasslands that have several months of dryness, followed by a rainy season. Vegetations. of savanna biome is often described as an area of grassland with dispersed trees or clusters of trees. The lack of water makes the savanna a difficult place for tall plants such as trees to grow. Grasses and trees that grow in the savanna have adapted to life with little water and hot temperatures (Sarumi *et al*., 1996). The majority of soils in this area are Alfisols and Ultisols, classified into three primary types based on texture – sand, silt and clay. The percentage of these can vary, resulting in more compound types of soil such as loamy sand, sandy clay, and silty clay. These soils are low in fertility, as reported by Vanlauwe *et al*. (2002).

Table 1: Physical and Chemical properties of the experimental soil during 2012/13and 2013/2014 dry season at Kadawa

Physical Properties	2012/2013 Season	2013/2014 Season
% Clay	28	32
% Silt	22	18
%Sand	50	50
Textural class	Clay Loam	Sandy Loam
Chemical Properties		
pH (H2O 1:2:5	7.20	7.80
pH (0.1M) cacl2	6.30	6.20
%Total nitrogen	0.03	0.05
Available phosphorus (ppm)	7.24	7.62
%Organic carbon	0.18	0.31
Calcium (Cmol/kg)	4.20	5.10
Magnesium (Cmol/kg)	0.63	0.56
Potassium (Cmol/kg)	0.43	0.44
Sodium (Cmol/kg)	1.30	1.52
CEC	6.90	7.60
H *Al	0.10	0.10

Treatments and Experimental Design and Field Layout

The treatments consist of two sesame varieties (NCRIBEN 01 and NCRIBEN 03), three water stress periods, (at seedling stage at flowering and at podding stage). Three NPK fertilizer application rates (200 kg, 270 kg and 340 kg ha^{-1}). The experimental design used was randomized complete block design (RCBD) laid out in a split plot arrangement where the factorial combination of NPK fertilizer rates and water stress period were assigned to the main plot and varieties allocated to the sub plot and replicated three times. The plot size was 3 x 3 m having distance between plots and replications of 1 and 1.5 m, respectively. Soil samples were taken randomly from the experimental field each year from depth of 0-30 cm. The different samples were dried bulked, and a composite sample taken for physical and chemical analysis. Crop was sown in the last week of February 2013 and 2014 on a well-prepared fine seed bed. Half the NPK fertilizer application rate was applied at the time of sowing while the second dose was applied 4 weeks later. Thinning was done in two weeks after sowing to maintain the plant-to-plant distance of 10 cm. Irrigation schedule was at five (5) days interval. Stress period involved withholding irrigation for 15 days. Stressing sesame at seedling starts from 21days after sowing to 36 days, while at flowering irrigation was withheld from 56—70days.Similarly, at podding from 75—90 days after sowing. All other Agronomic practices were kept normal and uniform for all treatments. Crop was harvested on 23rd May 2013 and 20th May 2014. Observations were recorded on different plant parameters, days to 50% flowering was taken when half of the plant population on the net plot area started to flower. Days to 50% podding (capsule formation) was recorded when half of the population have formed capsules. Each phenological stage was determined from visual observation. Number of capsules per plant was counted from ten randomly selected and pre tagged plants per net plot area at physiological maturity of the crop. Capsule weight was estimated from randomly selected 15 capsules (lower, middle and upper positions) from each of the tagged plants and the average was taken. Seed yield of each plot was weighed in grams and converted to area basis to determine the yield per hectare in kg ha^{-1}. On the other hand, since a serious follow up was made during the maturity of the sesame crop, there was no shattered capsule (pod) and hence data on shattering were not analyzed. Moreover, there was no problem of lodging as well as disease or insect infestation and, therefore, data were not analyzed on lodging %, disease and insect infestation.

Statistical Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS software (9.0). All significant treatment means were compared using Duncan Multiple Range Test (DMRT) Duncan 1955 at 5% level of significance.

RESULTS

The effect of treatment on days to 50% flowering and podding of sesame at Kadawa during 2012/2013 and 2013/2014 irrigation season showed significant response (Table 2). NCRIBEN03 recorded longer days to achieve 50% flowering in 2012/2013 season while in 2013/24 both varieties had similar days to 50% flowering. This was repeated for 50% podding.

Table 2: Effect variety stress perion and NPK fertilization on yield performance of sesame at Kadawa during 2012/13 and 2013/14 irrigation season

Variety (V)	2012/13 50% flowering	2013/2014 50% flowering	2012/13 50% podding	2013/2014 50%podding
NCRBEN 01	66.00b	66.93	81.33	86.11
NCRBEN 03	67.04a	67.41	82.00	78.37
SE+_	0.100	0.190	0.262	0..96
Stress period (S)				
At seedling	67.06a	68.17a	82.22	80.17
At flowering	65.39b	64.94b	81.22	78.83
At podding	67.11a	66.94a	82.56	78.72
SE+_	0.149	0.284	0.393	0.523.
NPK fertilizer (kgha-1) F				
200 kgha-1	65.83c	65.39b	80.61b	80.00c
270 kgha-1	66.39b	67.33a	81.78a	87.94b
340 kgha-1	67.33a	67.78a	82.61a	118.78a
SE+_	0.149	0.284	0.393	0.523.
Interaction				
VXS	Ns	ns	ns	ns
VXF	Ns	ns	ns	ns
SXF	Ns	ns	ns	ns
VXSXF	Ns	ns	ns	ns

Means followed by same letter(s) in the same column are not different statistically at P=0.05 using DMRT

NS= Not significant, * = Significant at (P<0.05)   WAS = Weeks After Sowing

Stress period imposed on sesame plant resulted in significant response at flowering, it hastens the attainment of 50%flowering. Stress periods did not differ in days to 50% flowering when sesame was stressed at seedling or podding but shorter number of days were recorded when stressed at flowering in 2012/13. Similar trend was observed in 2013/14 season. Days to 50% podding was not significantly influenced by stress period in both seasons. NPK fertilization had a significant effect on days to 50% flowering and podding in both years (seasons). The highest rate of NPK recorded longer days to 50% flowering, except in 2013/14 were 270kg NPK fertilizer kg ha^{-1} had similar number of days to attain 50% flowering, with plants treated with 340kg NPK ha^{-1}. Similarly, the highest application rate of NPK recorded more days to attain 50% podding. but not statistically different with 270kg in 2012/13. However, in 2013/14 season further increase in the rate of NPK applied lead to an increase in the number of days to attain 50% podding of sesame.

The effect of treatment on pod component of sesame at Kadawa during 2012/2013 and 2013/2014 irrigation season is presented in Table 3. The result obtained showed significant increase in both parameters Number of pod per plant and pod weight were significantly influenced by variety only in 2013/14 season with NCRIBEN 03 recording higher values.

Table 3: Effect variety stress period and NPK fertilization on pod number and pod weight of sesame at Kadawa during 2012/13 and 2013/14 irrigation season

Variety (V)	2012/13 Pod number	2013/2014 Pod number	2012/13 Pod weight/plt	2013/2014 Pod Weight Plt
NCRBEN 01	58.70	65.33b	24.31	31.11b
NCRBEN 03	59.48	86.52a	29.87	41.95a
SE+_	0.300	5.350	0.220	0.423
Stress Period (S)				
At seedling	60.17	84.33a	29.69	43.93a
At flowering	54.00	74.17b	22.43	36.37b
At podding	63.11	70.28c	29.13	31.28c
SE+_	0.449	.024	0..331	0.535
NPK fertilizer (kgha-1) F				
200 kgha-1	57.72b	70.06b	24.32b	32.79b
270 kgha-1	60.33a	79.69a	28.19a	38.34a
340 kgha-1	59.42a	79.72a	28.75a	38.45a
SE+_	0.449	.024	0.331	0.535
Interaction				
VXS	NS	NS	NS	NS
VXF	NS	NS	NS	NS
SXF	NS	NS	NS	NS
VXSXF	NS	NS	NS	NS

Means followed by same letter(s) in the same column are not different statistically at P=0.05 using DMRT; NS= Not significant, * = Significant at (P<0.05), WAS = Weeks After Sowing

Similarly, stress period significantly affected number of pods per plant and pod weight only in 2013/14 Sesame stressed at seedling stage recorded the greatest number of pods per plat and heavier pods, it was followed by sesame stressed at flowering, and that stressed at podding recording the lowest value for both parameters. NPK applied at the rate of 340kg ha1 and 270kg ha1 recorded similar number of pods per plant and pod weight in both seasons but higher than that produced by 200kg. ha^{-1} (Table 3).

The grain yield of sesame was significantly influenced by variety and NPK fertilizer is presented on Table 4. The result showed that sesame grain yield was significantly influenced by variety, with NCRIBEN 03 recording the highest grain yield in both seasons of experimentation. Stressing sesame at certain periods in its life cycle resulted in significant response in the crop's final yield. Higher grain yield was obtained in plots stressed at seedling stage but at par to when sesame was stressed at flowering stage. Lower sesame grain yield was obtained with the crop stressed at podding stage. Application of NPK fertilizer resulted in significant increase in sesame grain yields. Highest grain yield was recorded by application of 340kg ha1, this was followed by 270kg ha1, which had produced grain yield that was higher than when 200kg ha1, was applied which produced the least grain yields.

Table 4: Effect variety stress period and NPK fertilization on seed yield of sesame at Kadawa during 2012/13 and 2013/14 irrigation season

Variety (V)	Grain yield Sesame 201/2013 Season	Kg/ha 2013/2014 Season
NCRBEN 01	719.9b	722.35b
NCRBEN 03	1111.4a	1168.81a
SE+_	54.704	60.107
Stress period (S)		
At seedling	1126.10a	1204.82a
At flowering	1000.60a	998.11a
At podding	620.30b	833.81b
SE+_	72.106	290.161
NPK fertilizer (kgha-1) F		
200 $kgha^{-1}$	805.00b	875.64b
270 $kgha^{-1}$	923.50b	887.63b
340 $kgha^{-1}$	1018.5a	1073.47a
SE+_	72.106	290.161
Interaction		
VXS	ns	ns
VXF	ns	ns
SXF	ns	ns
VXSXF	ns	ns

Means followed by same letter(s) in the same column are not different statistically at P=0.05 using DMRT; NS= Not significant, * = Significant at (P<0.05), WAS = Weeks After Sowing

DICUSSION

The results of this study showed that there were significant differences among the varieties for most of the characters measured. Parameters like, number of capsules per plant, capsule weight, seed yield and grain yield were significantly different among the varieties. This response could be attributed to the genetic makeup of the individual variety expressed in their response to the treatments imposed. This was in agreement with the report of Shuaibu *et al*. (2021) and Abdallah (2004). The number of days to archive 50% flowering and podding exhibited by both varieties could be ascribed to the fact flowering and capsules formation are genetically controlled variables inherent in the crop. Number of capsules per plant were found to differ only in 2013/14 season with NCRIBEN 03 recording higher values for the parameter. This might be due to the more favourable weather conditions during the experimental seasons. Higher grain yield was observed with NCRIBEN 03 in this study, it was expected as the variety recorded a greater number of capsules, and capsule weight, indicating higher dry matter synthesis partitioning and better translocation to the sinks, which translate to higher grain yields. Similar variation in the performance of sesame varieties were observed by Abdallah (2004) Ioramen and Odiaka (2012) who indicated the presence of considerable amount of variation among sesame genotypes in, number of capsules per plant, capsules weight and grain yield. This might explain the consistent differences amongst the tested varieties in all parameters that were measured in this study. Also, this agrees with the findings of Umar *et al*. (2012).

This non-sensitive response of number of days to 50% flowering and 50% capsule formation to stress periods is an indication these parameter are genetically controlled. This implied that even though sesame is sensitive to water stress or drought inherent properties of the crop are not easily altered by environmental influences.

At flowering, reduction in soil moisture led to dehydration (wilting) that result in senescence and fall of the basal leaves, extending to upper young leaves as a consequence of reduced nutrient and water uptake leading to reduced photosynthetic activity and assimilate translocation. Reduction in dry matter production affects the sink source relationship leading to sterilization of flowers and poor seed set. This explains the drop in yield in this study when sesame was stressed at podding stage. Alizaden (2001) maintained that water stress in crop plants is most deleterious at reproductive stage of the crop life cycle.

Result of this study showed grain yield was seriously affected by moisture stress imposed at Podding/pod filling stage as evidenced in a drop in pod weight and final yields of sesame. This is an indication of the sensitivity of sesame to water stress. This observation is in agreement with the findings of (Bismillah-khan *et al*., 2001) who postulated that under the condition of drought, the number of seed per unit area, and seed weight of corn were reduced. Withholding moisture supply after flowering causes pronounced yield loss. This could be attributed to reduction in moisture available to the crop for translocation of assimilate to increase dry matter partitioning. Fredeich *et al.* (2001) and Brevedan *et al.* (2003) reported adverse effects of water stress on yield of soya been, resulting from a drop in grain weight due to inadequate grain filling.

NKP fertilization was found to increase the performance of sesame in this study, through improvement in pod number per plant and pod weight as well as final grain yield of sesame. The positive response to NPK fertilizer might be attributed to the role of NPK in promoting healthy crop growth and development. NPK often referred to as growth booster helps in growth of roots, stems, leaves and useful for getting the best growth in sesame. Increases photosynthesis process for better growth and yield performance had linked to balance nutrients supplied.

Nitrogen is a chlorophyll component, known for its effectiveness in helping plants grow quickly. whilst bettering the crops forage and leaf. Phosphorous is necessary for plant establishment. It is used by plants in forming new roots, making seeds, fruit and flowers and fight disease as reported by (Babaji *et al*., 2006). Potassium helps plants make strong stems and keep growing fast. Concentration of NPK in the nutrient solution gave higher total yield, due to improved nutrition. NPK fertilization was found to increase sesame yield as reported by Auwal *et al*. (1995).

CONCLUSION

This study has demonstrated the superiority of variety NCRIBEN 03 over NCRIBEN 01 in terms of its final yield and other parameters measured. Similarly, sesame is sensitive to moisture stress, therefore, it is very necessary and mandatory for dry season producers to ensure that sesame is not stressed at podding stage, due to its deleterious effect on the final yield. The use of NPK fertilizer in sesame production is highly beneficial. In conclusion a farmer can use NCRIBEN03 + avoiding moisture stress at podding +340kg NPK for good sesame yield in the Sudan savannah.

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