Productivity of Sesame (*Sesamun indicum* L.) Varieties as Influenced by Irrigation Scheduling.

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ABSTRACT

Multi-location trials to determine the productivity of sesame varieties as influenced by irrigation scheduling were conducted simultaneously at Samaru and Kadawa, Nigiera during the dry seasons of 2013 and 2014, at the Institute for Agricultural Research (IAR) farms at Samaru and Kadawa. The IAR farm in Samaru is situated at latitude 11^0 $11^'$N, longitude 7^0 $38^'$E and is 686m above sea levels in the northern Guinea savanna. The Kadawa farm is situated at latitude 11^0 $39^'$N, longitude 8^0 $20^'$E and is 500m above sea levels in the Sudan savanna ecological zone of Nigeria. The treatments consisted of three sesame varieties (E-8, Pbtil, and Ex-Sudan) and three irrigation scheduling, using tensionmeter at soil moisture tension of (0.4, 0.6 and 0.8bar). The treatments were laid out in a split plot design with three replications. Irrigation scheduling was allocated to the main plots while varieties were placed at the sub plot.

The results showed that, increasing soil moisture tension from 0.4 to 0.8bar decreased all the growth and yield characters of sesame crop except the seed oil content which increased with an increase in soil moisture tension. Variety Ex-Sudan produced higher number of capsules and grain yield compared to the other varieties. While Ex-Sudan and E8 produced the same oil content which were significantly higher than Pbtil. Scheduling irrigation at 0.4bar gave the highest grain yield of 937.6 and 1000.1kg/ha at Samaru and Kadawa, respectively. While variety Ex-Sudan produced the highest grain yield of (737.6 and 807.9kg/ha) compared to (712.9 and 780.6kg/ha) for E8 and (664.5 and 736.3kg/ha) for Pbtil at Samaru and Kadawa, respectively. Therefore, scheduling irrigation at 0.4bar produced the highest grain yield of sesame crop at both locations. While Ex-Sudan having produced the highest grain yield compared to the other varieties at both locations in both years is therefore more suited to Samaru and Kadawa ecologies.

(Keywords: irrigation scheduling, sesame, variety, agriculture, savanna)

INTRODUCTION

Sesame belongs to the family *Pedaliaceae* and is one of the most ancient crops and oilseed known and used by mankind. It is also known as beniseed and it was the major oilseed crop in the ancient world due to its easy oil extraction, great stability, and resistance to drought (Onwueme and Sinha, 1991).

There are controversies among researchers on the origin of sesame crop, but it is often asserted that Africa is its origin and the crop spread early through West Asia to China and Japan which themselves became the secondary centers of diversity (Weis, 1984). All of the wild sesame plants with the exception of *Sesamum prostratum* Retz are found in Africa (Purseglove, 1977). The variability and the importance of sesame in the economies of several African countries could further justify the African continent to be the ultimate center of origin.

An estimate of about 15-20 percent of the worldwide total cultivated area is irrigated, however, this small percentage is contributing as much as 30-40 percent of gross agricultural output (FAO., 2005). Presently irrigated lands all over the world may exceed 300 million hectares certainly because of increased demand for food production caused by population growth and by the recent diet changes of emerging countries (Von Braun, 2007). It is also worth mentioning that many civilizations both past and present have been dependent on irrigated agriculture to enhance the food security and provide the basic needs of their society (FAO, 2010).

However, irrigation agriculture faces a number of difficult challenges in both the present and in the future. One of the major concerns is the poor efficiency with which water resources have been used for irrigation. It is estimated that more than 40 percent of the water diverted for irrigation is wasted at the farm level through either deep percolation or surface runoff (FAO, 2003). This coupled with the difficulty in developing additional irrigation water supplies to meet the anticipated demand will lead to increased water scarcity in the foreseeable future (Thankabail, *et al*., 2006). It is also anticipated that irrigation water demand will continue to increase in the foreseeable future principally due to diversion of irrigation water into household and industrial uses in the urban areas (Jury and Vaux, 2007). Therefore more efforts should concentrate on how to increase the efficiency of water use in irrigation. The challenge ahead is how to improve crop productivity while minimizing waste and at the same time achieve a high level productivity on a sustainable basis (Kijne and Molden 2003).

One of the ways to address the above challenges is to employ appropriate and proper irrigation scheduling methods that can minimize water waste and increase crops productivity. The three basic criteria for scheduling irrigation, which include plant criteria, soil moisture status, and climatological approaches, each has its advantages and limitations. The use of tensionmeters to schedule irrigation also has its advantages and limitations. It accurately measures tensions in and around the crop root zone, but cannot be used to measure soil moisture.

Many studies were earlier conducted using these approaches on many crops such as wheat, maize, vegetables, and tree crops but the literature has not yet produced a single study on sesame crops. The yields of many crops may be as much affected by how water is applied as the quantity delivered. Proper irrigation management demands application of water at the time of actual need of the crop with just enough water to wet the effective root zone of the soil, and the intervals between irrigations should be as wide as possible to save irrigation water without affecting adversely the growth and yield (Majumdar, 2004). However, such information is scarce, particularly for sesame crops in this ecology. In line with the above justifications, this study was carried out with the following objectives:

1) To determine the appropriate irrigation scheduling regime for optimum growth and yield of sesame crop.

2) To determine the best variety suitable for cultivation under irrigation in Samaru and Kadawa ecologies.

MATERIALS AND METHOD

Field trials were conducted simultaneously at the Institute for Agricultural Research (IAR) farms Samaru and Kadawa during the dry seasons of 2013 and 2014. The IAR farm Samaru is situated at latitude 11^0 $11^{'}$N, longitude 7^0 $38^{'}$E and 686m above sea level in the northern Guinea savanna. While the Kadawa farm is situated at latitude 11^0 $39^{'}$N, longitude 8^0 $20^{'}$E and 500m above sea levels in the Sudan savanna ecological zone of Nigeria. Soil samples were randomly collected from the experimental site at a depth of 0 – 30cm to cover the effective root zone of the crop.

The treatments consisted of three sesame varieties (E-8, Pbtil and Ex-Sudan) and three irrigation scheduling, using tensionmeter at soil moisture tension of (0.4, 0.6 and 0.8bar). The treatments were arranged in a split plot design. Irrigation scheduling was assigned to the main plots while varieties were placed at the sub plots. The treatments were replicated three times. The gross plot size was 4.5m x 3.0m ($13.5m^2$), consisting of six rows, each measuring 3.0m in length and spaced 0.75m apart. The net plot size was 1.5 x 3.0 (4.5 m^2) consisting of the 2 inner rows.

The experimental field was harrowed twice and ridged 75cm apart. The prepared land was then marked and sub divided into the required plots and replications in accordance with the layout of the experiment. A mixture of one part of sesame seed and two parts of course river sand as carrier was sown manually at a shallow depth of about 1cm, by drilling on ridges. Sowing was done on the 7^{th} February 2013 and 10^{th} February 2014 at Samaru. At Kadawa, the sowing was done on 8^{th} February 2013 and 4^{th} February 2014. The experimental plots were irrigated a day before sowing at Samaru and two days before sowing at Kadawa. This was followed by irrigation at seven and ten day interval at Samaru and Kadawa, respectively, up to 4WAS, to allow the crop to fully establish. Subsequent irrigations were applied as per treatment.

The method used for irrigation was furrow system. Fertilizer was applied at the rate of 50kgN/ha, 19.7kgP/ha and 24kgK/ha using NPK (15:15:15), Urea (46%N), Single Super Phosphate (16%P_20_5). P and K were applied at planting while N was applied in two equal split doses at planting and at 6WAS. Weeds were controlled by hoe weeding at 3 and 6WAS. Cypermethrin at the rate of 150ml in 20litres of water was used to control insect pests. No serious disease incidence was encountered during the periods of the trials.

The crop was harvested when capsules were fully matured and at least half of the capsules at the lower part of the plant dried and the remaining half at the top of the plant turned yellow. The stems were carefully cut from the base using sharp sickle, tied in bundles and staked in an upright state to further dry before threshing. The crops were harvested 95 and 92 days after sowing at Samaru in 2013 and 2014, respectively. While at Kadawa the harvesting took place 95 and 93 days after sowing in 2013 and 2014, respectively. Threshing was done manually by gently beating the dried plants materials with stick to separate the seeds from the capsules. This was followed by winnowing to separate the seeds from the chaffs. Data were collection from five randomly sampled plants for plant height at 12WAS, numbers of branches at harvest, leaf area index at 10WAS as was described by (Watson 1952).

$$LAI = \frac{\text{Total Leaf Area}}{\text{Ground Area}}$$

Ground area = inter x intra row spacing.
LA = Leaf Area determined using leaf disc dry weight method.

The number of capsules was determined by counting the number of capsules on the 5 randomly sampled plants in each plot at harvest. The grain yield was determined from the harvest of each net plot. The seed oil content was determined as described by Association of Official and Analytical Chemist (AOAC, 1980). All agronomic data collected was subjected to analysis of variance (ANOVA) using Statistical Analysis Sciences (SAS 9.4 version), and the means were compared using Duncan Multiple Range Test (DNMRT).

RESULTS

The results for the soil analyses in 2013 and 2014 are presented in Table 1. At Samaru, the soil textures were sandy loam, slightly acidic (P^H 6.5 and 6.8), low organic carbon (0.84 and 0.66), low total nitrogen (0.17 and 0.11), low cation exchange capacity (4.55 and 4.34) and available phosphorus of (3.45 and 2.95) for 2013 and 2014 years respectively. At Kadawa, the soil textures were also sandy loam, slightly alkaline (P^H 7.25 and 7.85), low organic carbon (1.84 and 0.96), low total nitrogen (0.20 and 0.15), low cation exchange capacity (2.58 and 2.39) and available phosphorus of (3.25 and 2.55) for 2013 and 2014 years, respectively.

The plant height response of sesame varieties to irrigation scheduling in 2013 and 2014 and the combined years at Samaru and Kadawa is presented in Table 2. Increasing soil moisture tension from 0.4 to 0.8bar significantly decreased plant height at both locations in both years and the combined. Pbtil variety significantly produced taller plants compared to E8 and Ex-Sudan which are at par with one another statistically at both locations in both years and the combined years at Kadawa only. The plant height of the varieties for the combined years at Samaru showed that, Pbtil and Ex-Sudan produced the same height which is significantly higher than E8.

The number of primary branches response of sesame varieties to irrigation scheduling in 2013, 2014 and the combined years at Samaru and Kadawa is presented in Table 3. Increasing soil moisture tension from 0.4 to 0.8bar significantly decreased the number of primary branches at both locations in both years and the combined. The number of primary branches response of the varieties showed that, Ex-Sudan produced significantly more branches than E8, which in turn produced more branches than Pbtil at both locations in both years and the combined.

The leaf area index response of sesame varieties to irrigation scheduling in 2013 and 2014 and the combined years at Samaru and Kadawa is presented in Table 4. Increasing soil moisture tension from 0.4 to 0.8bar significantly decreased LAI of sesame crop at both locations in both years and the combined. The LAI response of the varieties showed that, Ex-Sudan produced significantly higher LAI compared to E8, which in turn had higher LAI than Pbtil at both locations in both years and the combined.

Table 1: Physico – Chemical Characteristics of soils of the Experimental Sites in 2013 and 2014 Dry Seasons at Samaru and Kadawa.

Properties	Soil Sampling Depth 0-30 cm			
	Samaru		Kadawa	
	2013	2014	2013	2014
Chemical Properties				
N (mg/kg)	0.17	0.11	0.20	0.15
P (mg/kg)	3.45	2.95	3.25	2.55
K (Meq/100g)	0.38	0.34	0.48	0.44
Na (Meq/100g)	0.73	0.73	1.83	2.71
pH 1:2.51:1 H_2O	6.55	6.85	7.25	7.85
pH 0.01 $CaCl_2$	6.21	6.37	6.61	6.98
Ca (Meq/100g)	2.55	2.43	1.59	1.43
Mg (Meq/100g)	1.54	1.20	1.54	1.20
CEC (Meq/100g)	4.55	4.34	2.58	2.39
Organic carbon (%)	0.84	0.66	1.84	0.96
Particles size				
Sand g/kg	570	550	560	570
Silt g/kg	300	330	230	270
Clay g/kg	130	120	180	160
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Table 2: Effects of Irrigation Scheduling on Plant Height (cm) of Three Sesame Varieties at 12WAS During the Dry Seasons of 2013, 2014 and the Combined years at Samaru and Kadawa.

Treatments	Plant height (cm)					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation Scheduling (Bar)						
0.4	112.17a	111.05a	111.61a	116.66a	111.99a	114.32a
0.6	105.01b	103.96b	104.48b	109.91b	104.81b	107.01b
0.8	81.4c	80.64c	81.05c	84.72c	81.33c	83.02c
SE±	0.137	0.134	0.253	0.148	0.14	0.261
Variety						
E8	96.88b	95.91b	96.39b	100.76b	96.73b	98.74b
Pbtill	104.44a	103.39a	103.92a	108.62a	104.27a	106.44a
Ex-Sudan	97.88b	96.34b	96.83a	101.21b	97.13b	99.17b
SE+	0.123	0.121	0.519	0.131	0.122	0.534

Means followed with the same letters within treatments are not statistically different at 5% level of significance.

Table 3: Effects of Irrigation Scheduling on Number of Primary Branches of Three Sesame Varieties During the Dry Seasons of 2013, 2014 and the Combined Years at Samaru and Kadawa.

Treatments	Number of Primary Branches					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation Scheduling (Bar)						
0.4	3.45a	3.07a	3.24a	3.59a	3.05a	3.32a
0.6	2.74b	2.49b	2.63b	2.85b	2.42b	2.64b
0.8	1.44c	1.29c	1.37c	1.48c	1.26c	1.37c
SE±	0.018	0.016	0.0161	0.044	0.037	0.04
Variety						
E8	2.74b	2.47b	2.60b	2.90b	2.46b	2.68b
Pbtill	1.77c	1.59c	1.68c	1.82c	1.55c	1.69c
Ex-Sudan	3.11a	2.80a	2.95a	3.20a	2.72a	2.96a
SE+	0.012	0.011	0.0124	0.035	0.028	0.04

Means followed with the same letters within treatments are not statistically different at 5% level of significance.

Table 4: Effects of Irrigation Scheduling on Leaf Area Index of Three Sesame Varieties During the Dry Seasons of 2013, 2014 and the Combined Years at Samaru and Kadawa.

Treatments	Leaf Area Index					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation Scheduling (Bar)						
0.4	2.77a	2.52a	2.64a	3.18a	2.63a	2.91a
0.6	2.24b	2.01b	2.12b	2.58b	1.91b	2.24b
0.8	1.67c	1.52c	1.59c	1.93c	1.28c	1.60c
SE±	0.049	0.04	0.032	0.057	0.049	0.036
Variety						
E8	2.29b	2.05b	2.17b	2.64b	1.96b	2.31b
Pbtill	1.86c	1.69c	1.78c	2.15c	1.64c	1.91c
Ex-Sudan	2.52a	2.29a	2.41a	2.90a	2.23a	2.57a
SE+	0.036	0.030	0.023	0.038	0.033	0.027

Means followed with the same letters within treatments are not statistically different at 5% level of significance.

Table 5: Effects of Irrigation Scheduling on Number of Capsules of Three Sesame Varieties at Harvest During the Dry Seasons of 2013, 2014 and the Combined Years at Samaru and Kadawa.

Treatments	Number of Capsules					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation scheduling (Bar)						
0.4	51.2a	41.9a	46.6a	82.6a	74.4a	78.5a
0.6	41.3b	34.1b	37.9b	70.4b	63.4b	66.7b
0.8	21.6c	17.8c	19.7c	55.5c	50.0c	52.8c
SE±	0.27	0.22	0.17	0.85	0.77	0.56
Variety						
E8	41.1b	33.8b	37.5b	75.9a	68.4a	74.5a
Pbtill	26.6c	21.9c	24.3c	54.1b	48.8b	72.2b
Ex-sudan	46.6a	38.3a	42.4a	78.4a	70.7a	51.5c
SE+	0.18	0.15	0.20	0.64	0.58	0.49

Means followed with the same letters within treatments are not statistically different at 5% level of significance.

The number of capsules response of sesame varieties to irrigation scheduling in 2013, 2014 and the combined years at Samaru and Kadawa is presented in Table 5. Increasing soil moisture tension from 0.4 to 0.8bar significantly decreased the number of capsules at both locations in both years and the combined. The number of capsules response of the varieties showed that, Ex-Sudan produced significantly higher number of capsules than E8, which in turn produced more capsules than Pbtil at Samaru in both years and for the combined years at both locations. While in 2013 and 2014 at Kadawa, E8 and Ex-Sudan produced the same number of capsules which were significantly higher than Pbtil.

The grain yield response of sesame varieties to irrigation scheduling in 2013, 2014 and the combined years at Samaru and Kadawa is presented in Table 6. Increasing soil moisture tension from 0.4 to 0.8bar significantly decreased the grain yield at both locations in both years and the combined. The grain yield response of the varieties showed that, Ex-Sudan produced significantly higher grain yield than E8, which in turn produced more grain yield than Pbtil at both locations in both years and the combined, except in 2014 at Samaru where Pbtil produced significantly higher grain yield than E8.

The seed oil content response of sesame varieties to irrigation scheduling in 2013, 2014 and the combined years at Samaru and Kadawa is presented in Table 7. Increasing soil moisture tension from 0.4 to 0.8bar significantly increased the oil content of sesame seed at both locations in both years and the combined. The seed oil content response of the varieties showed that, Ex-sudan and E8 had the same oil content which was significantly higher than Pbtil at both locations in both years and the combined.

Table 6: Effects of Irrigation Scheduling on Grain Yield (kg/ha) of Three Sesame Varieties During the Dry Seasons of 2013, 2014 and the Combined years at Samaru and Kadawa.

Treatments	Number of Capsules					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation scheduling (Bar)						
0.4	984.7a	890.5a	937.6a	1037.9a	962.3a	1000.1a
0.6	869.9b	783.7b	826.3b	913.4b	846.6b	880.0b
0.8	351.9c	349.4c	350.7c	449.8c	439.6c	444.7c
SE±	7.92	6.24	4.9	7.35	7.96	5.52
Variety						
E8	743.7b	636.8c	712.9b	804.5b	756.7b	780.6b
Pbtill	692.2c	682.2b	664.5c	763.7c	708.9c	736.3c
Ex-sudan	770.7a	704.6a	737.6a	832.8a	783.0a	807.9a
SE+	6.62	5.36	5.84	6.46	6.88	6.39

Means followed with the same letters within treatments are not statistically different at 5% level of significance.

Table 7: Effects of Irrigation Scheduling on Seed Oil Content (%) of Three Sesame Varieties During the Dry Seasons of 2013, 2014 and the Combined Years at Samaru and Kadawa.

Treatments	Seed Oil Content (%)					
	Samaru			Kadawa		
	2013	2014	Combined	2013	2014	Combined
Irrigation scheduling (Bar)						
0.4	48.38c	48.56c	48.47c	48.55c	48.78c	48.67c
0.6	48.49b	48.67b	48.58b	48.66b	48.89b	48.78b
0.8	49.57a	49.76a	49.66a	49.74a	49.99a	49.86a
SE±	0.015	0.014	0.0104	0.016	0.0159	0.0108
Variety						
E8	48.88a	49.07a	48.98a	49.06a	49.29a	49.18a
Pbtill	48.66b	48.84b	48.75b	48.83b	49.06b	48.95b
Ex-sudan	48.89a	49.07a	48.98a	49.06a	49.30a	49.18a
SE+	0.012	0.011	0.007	0.011	0.0122	0.008

DISCUSSION

Irrigation scheduling significantly influenced all growth characters of sesame crop. Scheduling irrigation at 0.4bar or the lowest soil moisture tension produced taller plants, increased number of primary branches and leaf area index. This may be due to the role moisture played in nutrient uptake and in photosynthesis. High leaf area obtained for treatments irrigated at the lowest soil moisture tension ensured early canopy ground cover, thus capturing sunlight more efficiently and utilizing available soil moisture and nutrient more effectively, which could have been responsible for the increased growth and development of the crop. The increased LAI due to sufficient soil moisture for irrigation scheduled at 0.4bar could have been responsible for the increased number of capsules and grain yield per hectare. The seed oil content was found to have increase in treatments irrigated at the highest soil moisture tension. This could be attributed to the fact that, water stress conditions was known to favorably influenced oil content of crops. This is in line with the finding of Zeinolabedin and Seyyid (2011) and El Naim and Ahmed 2010) who reported an increased oil content of sesame seed with increased irrigation interval.

The high leaf area values recorded by Ex-Sudan compared to E8 and Pbtil might have help it to intercept and convert more solar radiation through photosynthesis that resulted in the increased total leaf area index of this variety. This could have been responsible for the increased number of capsules and grain yield per hectare of Ex-Sudan compared to E8 and Pbtil. The good performance of Ex-Sudan compared to E8 and Pbtil may be attributed to its superiority in producing large leaf area that could have help it to increased assimilate production and consequently increased its yield and yield characters. The greater number of capsules and capsules yields produced by Ex-Sudan were responsible for its high grain yield compared to E8 and Pbtil. Similar varied response of sesame varieties were earlier reported by (Umar, *et al*., 2012; Olowe, *et al.,* 2009) who reported a significant difference between yields of sesame varieties. The higher seed oil content of Ex-Sudan and E8 compared to Pbtil could be attributed to the variation in genetic components of the varieties as was reported in similar studies by Mya, *et al*., (2010).

CONCLUSION

Scheduling irrigation at 0.4bar gave the highest grain yield of 937.6 and 1000.1kg/ha at Samaru and Kadawa, respectively. High seed rate of 5kg/ha gave the highest grain yield of 805.4 kg/ha and 886.4kg/ha at Samaru and Kadawa, respectively. While variety Ex-Sudan produced the highest grain yield of (737.6 and 807.9kg/ha) compared to (712.9 and 780.6k/ha) for E8 and (664.5 and 736.3kg/ha) for Pbtil at Samaru and Kadawa, respectively. Therefore, scheduling irrigation at 0.4bar and seed rate of 5.0kg/ha produced the highest grain yield of sesame crop at both locations. While Ex-Sudan having produced the highest grain yield compared to the other varieties at both locations in both years is therefore more suited to Samaru and Kadawa ecology.

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