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Determination of Suitable Variety and Seed Rate of Sesame (*Sesamum indicum* L) in Sandy Dunes of Kordofan, Sudan

Ahmed M. El Naim*, Entisar M. El dey, Abdelrhim A. Jabereldar, Salaheldeen E. Ahmed, Awad A. Ahmed

Department of Crop Science, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Elobied, Sudan

Abstract Sesame is almost entirely cultivated under rain-fed in the Sudan. There is increasing evidence that the uses of poor management practices (especially the practice of low seed rate) as well as traditional cultivars are the main yield limiting factors in sesame farms of sandy dunes in north kordofan of Sudan. Field experiment was conducted to determine the effects of four different seed rates on the growth, yield and yield components of three sesame varieties. Three varieties of sesame (Sesamum indicum L), Elobeid1, Promo (recently improved cultivars) and Hirhri (an old traditional cultivar) were used. The plants were sown at four seed rate: 0.5, 1.0, 1.5 and 2.0 kg ha^{-1}. The results indicated that increasing seed rate significantly decreased the number of capsules per plant and seed yield per plant. Seed rates of 1.5 and 2.0 kg ha^{-1} were optimum to maximizing seed yield per unit area. The three cultivars had relative similarities in final seed yield (ton ha^{-1}).

Keywords Management practices, Rain-fed, Sandy soil, Seed rate, Sesame

1. Introduction

Sesame (Sesamum indicum L.) is one of the oldest cultivated plants in the world. It was a highly prized oil crop of Babylon and Assyria at least 4,000 years ago. It is known under different names in different countries viz: simsim, benniseed, til, gingelly and a jonjoli[1]. Sesame is one of the main cash crops of the Sudan; beside its value as a source of high nutritive seed value[2]. The Sudan occupies the third rank as world producer; nevertheless it is considered as the first world exporter of sesame seeds. In the Sudan, sesame is a very important oil crop, both for local consumption and export. The crop also is one of the major foreign currency earners[3,4]Sesame seed is a rich source of oil, protein, phosphorus and calcium[5]. As shown in reference[6] the sesame oil percentages range from 43.7-56.2 and protein percentage from 22.3-32.9 with approximate averages 50 and 27. Sesame seeds are used in baking, candy making, and other food industries. Oil from the seed is used in cooking and salad oils and margarine, and contains about 47% oleic and 39% linoleic acid. Sesame oil and foods fried in sesame oil have a long shelf life because the oil contains an antioxidant called sesamol. The oil can be used in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides. Sesame meal, left after the oil is pressed from the seed, is an excellent high-protein (34 to 50%) feed for poultry and livestock. Sesame seed is used in a wide variety of foods, such as confectioneries, cakes and pastries. The high grades of oil are used for cooking margarine manufacturing and in pharmaceutical industries while ,the lower grades are used in soap manufacturing. The annual production of the Sudan amounts to 13.5% of the total world production and about 50% of the African production[6]. Sesame is almost entirely cultivated under rain-fed in the Sudan. It is grown in the 350 - 600 mm rainfall areas and with 500 mm excellent crops are produced. However, a rainfall up to 800 mm can be tolerated if soils are well drained. The total area of production varies from one year to another, mainly due to fluctuations of rainfall, cultural practices, cultivars and prices[1,6,7]. Previous studies indicated that sesame cultivars are variable in their response to plant density[2]. Crop productivity is still very low. On the other hand, there is increasing evidence that the uses of poor cultural practices (especially the practice of low seed rate) as well as traditional cultivars are the main yield limiting factors. Presumably, the adoption of high population densities by farmers meant the avoidance of a climate risk. Yet, the improvement of yield through manipulation of seed rate and introduced new cultivars is possible. Accordingly, the research focused on detecting the suitable variety and seed rate on sesame under rain-fed in the sandy soils.

* Corresponding author:
naim17amn@yahoo.com (Ahmed M. El Naim)
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2. Materials and Methods

A field experiment was conducted during 2005/2006 season under rain-fed at two locations in North Kordofan state, located between latitude 11° 15 and 16° 30 N and longitudes 27° and 32° E. The climate of the area is arid and semiarid zone. The soil is sandy with low fertility. Annual rainfall ranges between (350-500 mm). Average maximum daily temperatures varied between 30℃ to 35℃ most of the year[8].

Three cultivars of sesame; namely, Elobeid1, Promo and Hirhri (designated as V_1, V_2 and V_3 respectively) were used in the experiment. The plants were sown at four seed rates: 0.5, 1.0, 1.5 and 2.0 kg ha^{-1}, designated as S_1, S_2, S_3 and S_4 respectively. The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with four replications. The plot size was 5 × 7 meters.

Sowing dates were on July, 14th. The fields were weeded twice, the first one after two weeks from seeding and the second at four weeks later.

2.1. Growth and Yield Attributes

A sample of five plants was taken at random from each experimental unit at physiological maturity to measure the following parameters.

Plant height (cm): The height of the main stem from ground level to the tip of the plant.

Number of branches/plant: was determined by counting the number of primary reproductive branches.

Height to first capsule (cm)

Number of capsules per plant.

Meanwhile, ten capsules were picked at random from these five plants, put in a small envelope bag, and then the following characters were determined:

Capsule length (cm).

Number of seeds per capsule.

The five selected plants, mentioned above, were cut, put in an envelope and dried naturally in the lap. Their seeds were added to their respective seeds of the ten capsules in the small bags and weighed. Then average seed yield per plant (g) was determined. 1000-seed weight (g) was estimated by counting 1000-seeds at random from each plot four times and weighed using a sensitive balance. The final seed yield (t/ha) was determined as follows:-

$$\text{Seed Yield}\left(\text{t ha}^{-1}\right)=\frac{\text{seed weight}\left(\text{ton}\right)\text{ of plot}}{\text{Harvested plot area}\left(\text{m}^2\right)}\times 10000$$

Harvest index 1s a ratio of economical yield (seed yield per plant to biological yield (shoot dry weight), was determined by using the fallowing formula:-

$$\text{Harvest index}=\frac{\text{Economical Yield}}{\text{Biological yield}}\times 100$$

2.2. Statistical Analysis

Data were analyzed statistically using analysis of variance according to procedure for a randomized complete block design[9]. The differences of means were identified by Duncan's Multiple Range Test (DMRT) at 0.05 level of significance.

3. Results and Discussion

Table 1 shows the effect of seed rate and varieties on plant height and number of branches per plant. Seed rate had no significant difference on plant height at the two locations. Supporting evidences were reported by[1,2] who showed that plant density had no significant effect on plant height. Contrasting results were obtained by[13,26] who stated that an increase in planting population markedly would increase plant height.

Generally, the cultivar Promo (V_2) had a significantly greater height than others. Differences between cultivars in plant height were reported by[1,10,11].

In the present experiment, Seed rate exerts significant effect on number of branches per plant (Table 1). The number of branches was negatively correlated with plant population. Similar results were reported by[12-14]. However,[2] reported that plant population had no significant effect on branching.

Table 1. Effect of Seed Rate and Varieties on Plant Height and Number of Branches per Plant of Sesame

Treatments	Location 1		Location11	
	Plant height (cm)	No. of branches per plant	Plant height (cm)	No. of branches per plant
S_1	84.5	3.4	86.9	4.3^a
S_2	90.9	3.5	85.9	3.4^{ab}
S_3	75.4	2.2	89.5	2.9^{ab}
S_4	77.8	2.4	83.6	2.3^b
SE±	5.1	0.5	4.4	0.3
V_1	81.3	1.4^b	83.6^b	1.1^c
V_2	83.8	3.4^a	93.3^a	3.2^b
V_3	79.2	3.7^a	82.2^b	4.2^a
SE±(v)	3.6	0.3	3.1	0.2
CV%	21.7	57.5	17.5	39.7

Key: S_1= 0.5, S_2 =1.0, S_3 =1.5, S_4 = 2.0 kg ha^- ; V_1 = Elobeid1, V_2 = Promo, V_3 = Hirhri

Table 2. Effect of Seed Rate and Varieties on Height to First Capsule and Capsule Length of Sesame

Treatments	Location 1		Location11	
	First capsule height (cm)	Capsule length (cm)	First capsule height (cm)	First capsule height (cm)
S_1	34.0[ab]	2.9	31.1	31.1
S_2	39.3[a]	2.8	35.1	35.1
S_3	30.6[b]	2.8	33.0	33.0
S_4	30.3[b]	2.8	34.2	34.2
SE±	2.8	0.1	1.7	1.7
V_1	31.5[b]	2.7[b]	25.8[c]	25.8[c]
V_2	39.3[a]	2.9[a]	39.1[a]	39.1[a]
V_3	31.3[b]	2.8[ab]	34.2[b]	34.2[b]
SE±(v)	1.9	0.04	1.2	1.2
CV%	28.4	7.2	17.4	17.4

Key: S_1= 0.5, S_2 =1.0, S_3 =1.5, S_4 = 2.0 kg ha$^-$; V_1 = Elobeid1, V_2 = Promo, V_3 = Hirhri

Hirhri (local cultivar) had a greater number of branches per plant than others. The variations in number of branches per plant were detected in sesame cultivars in previous studies[1,2,11]. Variation among sesame genotypes in morphological characters have been observed by[2] who indicated the presence of considerable amount of variation among sesame genotypes in plant height, leaf number, number of branches, number of nodes per plant and dry matter production. This might explain the consistent differences among the tested cultivars in all growth parameters that were measured in this research study.

Table 2 represent the effect of seed rate and varieties on height to first capsule and capsule's length. Increased seed rate decreased the height of first capsule on the plant. The lowest first capsule height was observed by S_4 at first location. Similar results were obtained by[14] who showed that increasing spacing reduced the height of first capsule. Contrasting results were obtained by[12], who stated that plant population had no effect on height of the first capsule. The seed rate has no effect on the length of capsule (Table 2). This is in line with[5]. In contrast,[14] reported that high seed rate gave the highest capsule length. Promo (V_2) cultivar had a longer capsule length compared to others. This is in line with[11].

The effects of seed rate and varieties on number capsules per plant and number of seeds per capsule of sesame are shown in Table 3. The reduction in number of capsules per plant and number of seeds per capsule with increasing seed rate observed in this investigation concurs with many researchers in different crops ([1,4,13-20]).

They reported that high crop density reduced both the number of capsules and the number of seeds per capsule. These results may be attributed to the competition between plants and between the different parts of the individual plant under high seed rates. In contrast,[2] found that plant population had no significant effect on number of capsules per plant. Also[21] showed that plant population had no influence on number of seeds per capsule. Promo cultivar (V_2) had a higher number of capsules per plant, capsules length and number of seeds per capsule than Elobeid1 (V_1) and Hirhri (V_3). However, the three cultivars had no significant effect on seed yield per plant and final seed yield (t/ha).That is because the other two cultivars (Hirhri and Elobeid1) had the higher 1000-seed weight than Promo.

Table 3. Effect of Seed Rate and Varieties on Number Capsules per Plant and Number of Seeds per Capsule of Sesame

Treatments	Location 1		Location11	
	No. of capsules/ plant	No. of seeds/ capsule	No. of capsules/ plant	No. of seeds/ capsule
S_1	59.1	62.6	89.4[a]	67.4
S_2	59.6	58.5	73.4[a]	63.5
S_3	42.9	57.7	64.3[ab]	63.4
S_4	47.3	56.9	51.9[b]	67.9
SE±	7.5	2.1	5.80	1.8
V_1	49.5	58.9[ab]	65.9	67.0[b]
V_2	51.3	61.5[a]	77.3	71.2[a]
V_3	49.7	55.9[b]	64.8	59.7[c]
SE±(v)	5.3	1.5	4.1	1.3
CV%	52.0	12.2	37.6	9.6

Key: S_1= 0.5, S_2 =1.0, S_3 =1.5, S_4 = 2.0 kg ha$^-$; V_1 = Elobeid1, V_2 = Promo, V_3 = Hirhri

Table 4. Effect of Seed Rate and Varieties on 1000-Seed Weight and Seed Yield (g/plant) of Sesame

Treatments	Location 1		Location11	
	1000-seed weight(g)	Seed yield (g/plant)	1000-seed weight(g)	Seed yield (g/plant)
S_1	3.4	8.8	3.5	8.5
S_2	3.4	8.4	3.4	6.9
S_3	3.2	5.4	3.7	8.2
S_4	3.5	5.3	3.9	5.1
SE±	*0.2*	1.1	0.2	1.0
V_1	3.2	6.8	3.2^b	7.5
V_2	3.4	7.2	3.1^b	7.9
V_3	3.7	7.1	3.9^a	7.5
SE±(v)	0.1	0.8	0.1	0.7
CV%	17.0	52.4	15.8	47.2

Key: S1= 0.5, S2 =1.0, S3 =1.5, S4 = 2.0 kg ha- ; V1 = Elobeid1, V2 = Promo, V3 = Hirhri

Table 5. Effect of Seed Rate and Varieties on Seed Yield (t/ha) and Harvest Index of Sesame

Treatments	Location 1		Location11	
	Final seed yield (t/ha)	Harvest index (%)	Final seed yield (t/ha)	Harvest index (%)
S_1	0.7^{bc}	24.4	0.7^b	24.4
S_2	1.0^{ab}	23.8	08^b	23.8
S_3	1.1^{bc}	21.9	1.2^a	21.9
S_4	1.3^a	23.6	1.3^a	23.6
SE±	0.2	1.9	0.1	1.9
V_1	0.8	26.3	0.9	26.3
V_2	0.9	22.7	0.9	22.7
V_3	0.8	23.3	0.9	23.3
SE±(v)	0.11	1.4	0.1	1.4
CV%	67.9	27.6	44.1	27.6

Key: S1= 0.5, S2 =1.0, S3 =1.5, S4 = 2.0 kg ha- ; V1 = Elobeid1, V2 = Promo, V3 = Hirhri

Seed rate had no effect on mean 1000-seed weight (Table 4). Similar results were observed by[5].

Increasing seed rate decreased seed yield per plant at the two locations. This was primarily because of a reduced number of capsules per plant at higher seed rate. Similarly:[12,14,22] pointed that seed yield per plant substantially decreased with increasing plant population. They attributed this reduction to inter plant competition for assimilates and low pod yield. In contrast, increasing seed rate increased seed yield (t/ha). Supporting evidences were reported by[1,14,23,27].

Table 5 shows the effect of seed rate and varieties on seed yield and harvest index. The low seed rate had a higher harvest index than the high seed rate. This is because the low seed rate had a highest seed yield (g/plant) compared to others. This is in line with[1,24,25].

There was no significant difference in harvest index among cultivars. Similar results were obtained by[11] However,[1] reported that the cultivars had a significant effect in harvest index.

Harvest index among the three cultivars were not significantly different. This confirms the constant relationship between biological yield and seed yield[28].

In the present study, the performance of Promo cultivar is slightly better than Elobeid1 and Hirhri. However, Promo (V_2) cultivar had taller stems, greater number of capsules per plant, seeds per capsule, seed yield per plant and final seed yield (t/ha), compared with V_1 and V_3 cultivars under most treatments. Similar results were obtained by[1,11] who reported that Promo cultivar had higher yield compared with Elobeid1 cultivar. The high yield of Promo (V_2) cultivar might be a result of more number of capsules per plant and number of seeds per capsule.

4. Conclusions

Several conclusions can be drawn from these trials. Among the management factors studied for sesame, seed rate was found to have the largest effect on yield. Increased Seed rate had the general tendency to increase seed yield (t/ha). The results revealed that Seed rate of 1.5 and 2.0 Kg ha^{-1} were optimum for sesame cultivation under rain fed conditions in sandy dunes of North Kordofan state, Sudan

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