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Effect of Intra-row Spacing on Growth and Yield of Three Cowpea *(Vigna unguiculata* L. Walp.) Varieties under Rainfed

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Abstract: A field experiment was carried out under rainy season 2006-07, at two locations (Kordofan university farm and Jabal Kordofan) in Sheikan District, North Kordofan State, Sudan, to investigate the effects of four intra-row spacing (50, 75, 100 and 125cm) and three varieties (Dahab Elgoaze, Eien Elghzal and Buff) A randomized Complete Block Design (RCBD) with four replications was used on growth and yield of cowpea.. The results showed that intra-row spacing had no significant effect on vegetative growth attributes and phenolgical characters. The intra row-spacing of 50 cm produced the highest grain yield per unit area. Buff was characterized by late maturing, high seed weight and high productivity (t/ha). Dahb Elgoaze was early in flowering and maturity. Eien Elgazal gave a highest harvest index.

Key words: Cowpea, intra-row spacing, growth, yield.

INTRODUCTION

Cowpea *(Vigna unguiculata* L. Walp.) also Known as black-eye pea, sothern pea and crowder pea is a legume of Africa origin. It moved to Asia and America[19], then distributed to other parts of Africa and other continents by the migration of people and trades from the West Africa. Immigrants (Barno and Fellata) have introduced it to Western Sudan. The largest production countries in the world are Brazil, Haiti, Myanmar, Srilanka, Australia, Senegal, Niger, Nigeria, Sudan, Somalia, Zimbabwe, Botswana, and Mozambique[3] . The total world cultivated area is about 10.1 million hectares. Annual global grain cowpea production is approximately about 4.9 million tons. Total area cultivated in Sudan is about 173,000 hectares, with productivity of 400-500 kg/ha[2, 7]. Cowpea was adapted to the hot semi-arid zones with poor sandy soil. It is therefore, considered as the best alternative which provided a cheap vegetable protein to supplement the diet of people in the millet and sorghum, and based cropping systems in Western Sudan [10]

Cowpea is an important grain legumes in drier regions and marginal areas of the tropics and subtropics [21]The grain is a good source of human protein, while the haulms are valuable source of lives stock protein[20].

The use of cowpea in Kordofan of Sudan is diversified. The seed can be boiled with water and eaten as "a Ballila." They can also be cooked with meat, tomatoes and onions into 'a thick soup' eaten with pancake and fried or bread. The paste from soaked seeds can be eaten with oil as small dough nuts "Taammia," which can be eaten alone or with bread[7]. Cowpea can be used at all stages of growth as a vegetable crop. The tender 'green leaves' are an important food source in Africa. Green cowpea seeds are boiled as a fresh vegetable and may be canned or frozen. Cowpea now is a broadly adapted and highly variable crop that is useful as a rotational cover crop to control erosion and to improve soil fertility [1]. It also used to intercrop with other field crops such as cereals[24]. Highly efficient of nitrogen fixation it increased the soil fertility by 20 kg / ha[6].

In the last fifteen years the production and yield has been deteriorated due to the main Problems limiting production and expansion of cowpea these problems are: Low yield potential of existing varieties (poor genetic stock), scarcity and reliability of rainfall, limited use of certified seed by the cowpea growers due to deficient marketing and failure to convince the farmers about the advantages of adopting certified seed versus their own seeds, poor cultural practices. The most of traditional farmers sowing cowpea in a very wide space which affect the total production of cowpea, Cowpea is considered as a possible future crop in Sudan, because of its natural production without using chemical fertilizers and insecticides. The objectives of this study were to investigate the effect of

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different intra-row spacing and cultivars on growth and yield of cowpea.

MATERIALS AND METHODS

A field experiment was conducted during season (2006/07) under rain fed, at two locations (Kordofan University Farm and Jabal Kordofan farm) in North Kordofan State, Sudan, latitude (11˚ 15 and 16˚ 30 N) and longitude (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˚ and 35˚C throughout the year[27].

The experiment was laid out in a randomized complete block design (RCBD) with four replications. The plot size was 4m × 2.4m. The treatments consisted of four intra-row spacing of 50, 75, 100 and 125 cm designated as S_1, S_2, S_3 and S_4 respectively and three cultivars of cowpea namely:, Eienelghazal, Buff and Dahabelgoaze, designated as V_1, V_2 and V_3 respectively.

Sowing dates were on the July 19th, 2006 for first location, and 20th of July for second location. Seeds were sown on rows 60 cm apart; in intra-row spacing of 50, 75, 100 and 125 cm. Three seeds were placed in each hole. After two weeks from sowing, seedlings were thinned to two plants per hole. Manual weeding was practiced twice in the two locations.

Growth Attributes: A sample of three plants was taken at random from each plot at 30 days after sowing, then continued at an interval of 15 days to measure the following growth parameters:

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

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

Number of leaves per plant: by counting the number of leaves per plant.

Phenological Attributes: Days to 50 % flowering**:** number of days from sowing to the time when 50 percent of the plants within the plots bear at least one open flower.

Days to 50 % physiological maturity: time to 50 % physiological maturity was taken as the number of days from planting till 50 % of the plants in the plot became yellow, shed their leaves and the lowest pod on the stem were about to spilt open.

Yield Attributes: Three plants were randomly selected from the inner rows of each experimental unit to determine the number of pods per plant.

Ten pods were picked from plant sample to measure the number of seeds per pod. The three selected plants, mentioned above were cut and put in an envelope and dried naturally then average seed yield per plant (g) was determined.

100- Seed weight (g) was estimated by counting 100- seeds at random from each plot four times and weighed by using a sensitive balance.

Final seed yield (t /ha**):** It was determined as follow:

$$\text{Seed yield (t /ha)} = \frac{\text{Seed weight (ton) of plot}}{\text{Harvested area (m}^2\text{)}} \times 10000$$

Harvest index: It was determined by using the following formula:

$$\text{Harvest index} = \frac{\text{Economical yield (Seed yield/plant)}}{\text{Biological yield (Shoot dry weight)}} \times 100$$

Shelling percentage**:** It was determined by using the following formula

$$\text{Shelling percentage} = \frac{\text{Seed weight/pod}}{\text{Pod dry weight}} \times 100$$

Statistical Analysis: Data were analyzed statistically using analysis of variance according to Gomez and Gomez [8] procedure for a randomized complete block design. The differences of means were identified by Duncan's Multiple Range Test (DMRT) at $P \geq 0.05$.

RESULTS AND DISCUSSION

Intra-row spacing had no significant effect on plant height at all sampling occasions (Table 1). This result is in general agreement with that reported by Mohamed [16], who found that intra-row spacing had no significant effect on most of the growth attributes. Mohamed [17] stated that the distances between plants within ridge did not influence the different attributes of vegetative growth in cowpea. Weber *et al*, [28] found that on soybean, plants produced at highest densities were taller and more sparsely branched. The cultivar EienElgazal (V_1) had significantly a tallest plant height. Differences among cultivars in plant height were reported by Miller [15] and Mohammed[17]. The increment in plant height may be attributed to either an increase in node number or internodes length or both. Intra-row spacing had no significant differences in number of branches per plant (Table 2). Supporting evidence was reported by Lazim and Nadi [14] who found that spacing had no effect on mean number of branches per plant, this may be attributed to the growth habit of the cultivars used.

Table 1: Effect of intra-row spacing and cultivars on plant height (cm) of cowpea

Treatments	University Farm			Jabal Kordofan		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
S_1	14.7	25.2	25.4	10	22.1	22.8
S_2	14.7	30.2	30.9	9.7	23.1	24.9
S_3	16.3	32.3	32.6	9.8	21.9	22.8
S_4	14.4	25.8	26.6	9.4	23.9	25.8
SE±	0.98	1.76	1.67	0.61	1.83	1.37
V_1	15.3	30.5[a]	31.0[a]	9	22.9	22.9
V_2	15.2	26.6[b]	26.8[b]	9.9	22.0	23.4
V_3	14.3	28.4[b]	28.4[b]	10.3	25.9	27.3
SE±	0.85	1.53	1.45	0.53	1.59	1.18
C.V%	22.60	21.33	20.2	21.70	26.36	20.85

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test.

Table 2: Effect of intra-row spacing and cultivar on number of branches per plant of cowpea

Treatments	University Farm			Jabal Kordofan		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
S_1	3.7	5.0	6.0	3.2	4.3	5.4
S_2	3.3	4.6	5.6	2.5	4.3	5.5
S_3	3.0	4.5	5.5	3.1	4.3	5.8
S_4	2.8	4.3	5.4	2.6	4.3	5.8
SE±	0.31	0.33	0.31	0.34	0.30	0.35
V_1	3[b]	4.2[b]	5.3[b]	2.8	4.1	5.3[b]
V_2	3.8[a]	5.4[a]	6.7[a]	2.9	4.5	6.3[a]
V_3	2.8[b]	4.1[b]	4.9[b]	2.9	4.4	5.3[b]
SE±	0.27	0.28	0.27	0.29	0.26	0.30
C.V%	33.78	25.29	18.85	41.44	24.27	21.38

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test.

Intra-row spacing had no significant effect on number of leaves per plant (Table 3). This may be attributed to the growth habit of the cultivars used. In contrast, studies showed that, increasing plant population decreased the number of leaves per plant [13].

Differences in growth attributes observed among cultivars may due to the genetically potential of each genotype, Buff cultivar is a prostrate land races that have along vegetative periods, while the improved cultivars are semi-erect and had relatively short vegetative period. Buff permitted the formation of more branches and leaves compared to the improved cultivars (Eien Elgazal and Dahab Elgoaze). Similar results were reported by Suliman [25]. Improved cultivars are semi-erect and had relatively short vegetative period. Generally intra-row spacing s had no significant effect on vegetative growth attributes measured in this investigation. The non significant effect of plant spacing may be explained by the fact that growth habit of cowpea was semi-erect or prostrate, and the plants spread in different directions thus compensating for narrow intra-row spacing by spreading between rows. Mohamed [17] stated that the distances between plants within ridge did not influence the different attributes of vegetative growth in cowpea

Intra-row spacing had no significant effect on days to 50% flowering and 50% physiological maturity (Table 4). Days to flowering or maturity were similar when the crop was sown on low or high population.

Table 3: Effect of intra-row spacing and cultivar on number of leaves per plant of cowpea.

Treatments	University Farm			Jabal Kordofan		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
S_1	13.8	34.6	48.1	10.0	19.8	28.1
S_2	15.5	29.1	40.0	13.2	31.9	46.6
S_3	15.4	35.8	49.7	9.3	36.4	50.
S_4	14.0	25.5	34.8	9.0	31.9	41.1
SE±	1.3	4.1	5.8	2.36	4.96	6.28
V_1	14.1^b	23.3^b	31.4^b	7.8	16.6^b	23.8^b
V_2	17.8^a	49.0^a	69.2^a	14.0	49.9^a	69.7^a
V_3	12.3^b	21.4^b	28.8^b	9.3	23.5^b	31.3^b
SE±	1.1	3.5	5.0	2.04	4.29	5.45
C.V%	29.8	45.32	46.7	8.64	57.24	52.37

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test.

Table 4: Effect of intra-row spacing and cultivar on days to 50% flowering and 50% maturity of cowpea.

Treatments	University Farm		Jabal Kordofan	
	50% flowering	50% maturity	50% flowering	50% maturity
S1	46.16	59.0	46.33	57.75
S2	47.25	59.0	47.16	58.0
S3	47.25	59.0	47.33	57.08
S4	46.83	68.66	47.08	58.16
SE±(W)	0.43	0.46	0.51	0.36
V1	41^b	57.65^b	40.5^b	52.37^b
V2	62.37^a	67.62^a	62.31^a	69.18^a
V3	37.25^c	51.56^c	38.18^c	51.68^c
SE±(V)	0.37	0.40	0.44	0.31
C.V.%	3.22	2.73	3.76	2.18

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test

This is in line with results of Elawad [7] and Salih [22]. Cultivar had significant effect on phenological characters. This may be attributed to the fact that days to flowering in cowpea are considering variety characteristics, which is genetically controlled. The improved cultivar V_3 (Dahb Elgoaze) was early in flowering and maturity (Table 4). Previous studies showed that, the differential response to flowering among varieties was distinct. Elawad [7] reported that all cultivars introduced to Sudan were significantly earlier than the local cultivars. Natre [18] found that, there was considerable variation among cowpea cultivars in the duration of the reproductive period.

Increased intra-row spacing had no significant effect on number of pods per plant, number of seeds per pods 100-seed weight and seed yield per plant (Table 5). This may be attributed to the elasticity of legumes to variation in plant density. However, Hodgson and Blackman[11], Saxena and yadav [23], Kambal[12] and Coelho and Aguar[5] reported that number of pods per plant decreased as plant spacing decreased, but yield per unit area was found to be increased. There were no significant differences in 100-seed weight among different spacing in the both locations. Taha [26] found that 100-seed weight was not affected by plant spacing. In contrast Ziska and Hall [29] noted that seed weight is negatively correlated with the number of seed per plant.

The local cultivar (Buff) had heavier seed weight than the introduced cultivars. This may be due to better

Table 5: Effect of intra-row spacing and cultivar on number of pods/plant, number of seeds/pods, 100-seed weight and seed yield (g/plant) of cowpea.

Treatments	University Farm				Jabal Kordofan			
	Number of Pods/ plant	Number of Seeds/ pod	100- seed weight	Seed yield (g/plant)	Number of Pods/ plant	Number of Seeds/ pod	100- seed weight	Seed yield (g/plant)
S_1	44.5	11.3	22.3	30.1	27.3[c]	11.3	21.2	34.9
S_2	45.2	11..2	21.9	31.7	29.3[b]	11.8	21.9	38.9
S_3	47.9	12.4	20.3	34.1	33.9[a]	12.5	20.9	36.4
S_4	47.8	11.4	20.3	32.9	28.2[b]	11.6	21.1	33.3
SE±	3.9	0.5	1.49	3.38	2.97	0.39	1.01	2.84
V_1	38.3	10.8[b]	21.8[b]	30.8[b]	26.9	11.9[b]	22.3b	34.9[b]
V_2	45.9	8.6[c]	28.0[a]	34.5a	33.8	8.6[c]	28.4a	38.2[a]
V_3	47.4	15.4[a]	14.3[b]	31.3[b]	28.3	15.0[a]	13.13c	34.6[b]
SE±	3.37	0.43	1.29	2.93	2.57	0.3	0.88	2.46
C.V%	30.73	14.77	24.22	36.46	34.72	11.4	16.5	27.38

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test.

Table 6: Effect of intra-row spacing and cultivar on seed yield, harvest index and shelling % of cowpea.

Treatments	University Farm			Jabal Kordofan		
	Seed yield (t/ha)	Harvest index	Shelling (%)	Seed yield (t/ha)	Harvest index	Shelling (%)
S_1	1.59[a]	38.6	78.8	2.00[a]	39.0	83.4
S_2	1.00[b]	35.5	74.7	1.34[b]	36.5	84.7
S_3	0.71[c]	31.7	68.5	1.05[c]	33.7	82.5
S_4	0.6[c]	36.7	74.6	0.79[d]	38.7	86.6
SE±	3.38	2.17	3.74	2.84	2.17	1.7
V_1	0.97[b]	46.9[a]	76.5[b]	1.24	47.9[a]	85.0
V_2	1.14[a]	23.0[c]	81.3[a]	1.38	25.0[c]	85.9
V_3	0.84[b]	37.0[b]	64.6[c]	1.26	37.5[b]	82.0
SE±	2.93	1.88	3.24	2.46	1.67	1.5
C.V%	30.6	21.1	17.4	23.42	20.2	7.1

Similar letters are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test

translocation and partitioning of carbohydrates from source to sink (seeds). Generally, the erect cowpea cultivars had higher yield potentials than the trailing cultivars [9] Contrary to the above findings, the local cultivars produced greater seed yield than the improved cultivars, and the high yield was associated with greater 100-seed weight. Differences in means number of seeds per pod due to cultivars may be attributed to the fact that for any given cultivars, the number of seeds per pod is relatively a stable character[4].

The intra-row spacing had significant effect on seed yield per unit area (Table 6). Intra-row spacing of 50cm had the highest seed yield per unit area. This is because the closer spacing had higher plant population than the wider spacing. Plant density had no significant on harvest index .and shelling percentage (Table 6). This is may be due to similarity partitioning of dry matter to the shoot and seeds. In the present study, cultivars have a highly significant effect on harvest index. Eien Elgazal (V_1) had the greatest harvest index. This indicates that the cowpea cultivars differ in the partitioning of assimilates to the grain and this may identify Eien Elgazal was more efficient in assimilate utilization for improved yield. Similar observation was reported by Suliman [25] who stated that varieties gave the highest value of vegetative growth during growth stages and the highest seed and biological yield at the end of growth season.

Buff (local cultivar) had highest shelling percentage. This might be attributed to genotypic effect.

Champman [4] stated that, local cultivars had greater shelling percentage compared with the improved cultivars.

Conclusion: Intra-row spacing of 50 cm is recommended in cultivation cowpea in north Kordofan of Sudan for maximum grain yield production.

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