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Effect of Intra-Row Spacing on Performance of Cowpea (*Vigna unguciulata L. Walp*) under Rain-Fed Conditions in Darfur, Sudan

Khamis I[1], Fadlalla B[2]*, Tahir AM[3] and Adar HM[2]

[1]*Dryland Research Centre, Agricultural Research Corporation, Sudan*
[2]*Department of Range Science, College of Forestry and Rang Science, Sudan University of Science and Technology, Khartoum, Sudan*
[3]*Nyala Research Station, Agricultural, Research Corporation, Sudan*

Abstract

A three year field study was conducted in Origamali area at Abga ragial Administrative unit, Belil Locality, South Darfur State Nyala City, during the rainy season in 2013, 2014 and 2015. The aim of this study was to test the effect of four intra-row spacing treatments (50 cm, 75 cm, 100cm and 125 cm) on cowpea performance. A completely randomized design (CRD) with four replications was used to identify differences between treatments. It was found that closer intra-row spacing had significant effect on plant density and plant height while it had no significant effect on survival rate, pod yield or seed yield. It is therefore suggested that, for seed and pod production under rainfall conditions in South Darfur, wider spacing may be a rational strategy for farmers as it does not lower pod and seed yield which is advantageous when intercropping is practiced. Further studies are needed to clarify the effect of wider spacing on pod and grain yield in farming systems that adopt intercropping.

Keywords: South Darfur; Growth attributes; Yield attributes

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a traditional leguminous crop grown mainly in the tropics and subtropics. The seeds are a major source of plant protein and vitamins for humans. The forage is also an important feed for livestock. Moreover cowpea is a valuable cash crop providing a stable income for local people. It is a mandated crop identified by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Ibadan, Nigeria. The area planted by cowpea worldwide is 12.61 million ha. Global production of dried cowpeas in 2010 exceeded 5.5 million metric tons with Africa responsible for 94% of that total amount [1]. Nigeria is the largest producer and consumer of cowpea, producing 2.2 million metric tons of dried grain in 2010, followed by Niger, Burkina Faso, Myanmar, Cameroon, and Mali. The average global yield is estimated at 450 kg per hectare, the lowest of the major tropical grain legumes.

In Sudan, the annual total area cultivated is approximately 173, 000 ha [2,3], with productivity ranging between 400 and 500 kg/ha. The country's production of green cowpea forage in 2015 was 284,000 tones. Within the South Darfur State, the total cultivated area of cowpea was estimated at 420 ha [4]. In 2016, production of cowpea forage ranged between 2.5 and 4 tones/ha in the Nyala demonstration farm area [5].

Cowpea is well adapted to hot semi-arid zones with sandy soils that have low fertility. In Darfur, pods of cowpea are eaten in various forms including as boiled grain or crushed and cooked as sauce to be eaten with porridge and other local dishes made from millet or sorghum. Cowpea is grown by a large number of farmers in South Darfur.

In Sudan and in fact most of Sahel countries of Africa where it serves a dual function of producing pods and seeds for human consumption and as an important forage for livestock. Despite its importance cultural practices of growing cowpea are not adequately investigated. It is therefore important to develop appropriate recommendations on cultural practices pertaining to cowpea. The objective of the present study was to investigate the effect of intra-row spacing of cowpea grown under rain-fed conditions on plant height, plant density, survival rate and pod and seed yield.

The paper consists of a brief account of the study area, a description of land preparation and experimental design, and a reference to parameters measured, statistical analysis, results and discussion, conclusion and references.

Materials and Methods

Study area

The study was conducted in Sudan (Map) which is located in north east Africa. The country has an area of 1.88 million km^2. It is characterized by a unimodal pattern of rainfall with rains occurring mainly during the hot summer months of June, July, August, and September with a peak in July and August. Rainfall increases from below 75 mm in the north to more than 800 mm in the southern parts of the country. The River Nile and its tributaries form a major characteristic of the landscape. The livelihoods of the Sudan people depend mainly on agriculture, both crops and livestock. Along the Nile and its tributaries agriculture is based on gravity, residual moisture (recession cropping) and pump irrigation. Away from the Nile rainfed agriculture predominates where farmers grow crops and raise livestock on rangelands.

The experimental site lays at Ori Gamali village, Belail Locality, approximately 7 km to the south of Nyala town, the capital of South Darfur State, in Western Sudan. It lies at latitude 11°.99' N and longitude 24°.50' E with an altitude of 661metre above sea level (masl). Data from Sudan Metrological Authority for Nyala town indicated that mean annual rainfall for the years 2003-2015 was 451.1 mm. Months showing highest rainfall were August (143.6 mm), July (129.1 mm), June (77.5 mm), September (60.1 mm), May (25.8 mm), October (11.4

***Corresponding author:** Fadlalla B, Department of Range Science, College of Forestry and Rang Science, Sudan University of Science and Technology, Khartoum, Sudan, Tel: +249912927800; E-mail: babo_f@yahoo.com

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mm) and April (3.6 mm) for the same period (Figure 1). According to Sudan Metrological Authority the mean relative humidity (%) for Nyala town for the years 2013-2015 was as follows: August (74.0%), September (60.7%), July (60.3%), June (45.7%), October (42.3%), May (32.7%), November (25.0%), December (23.0%), January (22.3%), April (20.7%), March (16.3%) and February (15.7%).

Land preparation and experiment design

The land was prepared by traditional tools (donkey plow).The area which was 805 m^2 was divided into four plots with four replicates. The size of the plot was (8 × 5) m. Four spacing treatments of (*Vigna unguiculata*) were applied along the rows which included (50 cm, 75 cm, 100 cm and 125 cm). A fixed inter row spacing of 100 cm was maintained. The treatments were arranged in randomized complete design (RCD) with four replicates. The number of plots was 16 in total. Cowpea was planted with a fixed spacing between rows of 1 m.

Seeds were sown on July 23/2013, August 22/2014, and August 27/2015. Before sowing seeds were treated with fungicide Thiram as seed dressing against fungal diseases. At sowing five cowpea seeds were placed per hole. The plants were thinned to three plants per hole after two weeks from planting to reduce plant competition.

Parameters measured

Growth parameters:

***Plant density*:** the number of plants/m^2, was determined within a 1 × 2 m^2 quadrate counting all plants that were rooted within the quadrate.

***Plant height*:** The height of a plant is the perpendicular distance from the soil at its base to the highest point reached with all parts in their natural position. Within the same fixed quadrate of 1 × 2 m^2 that was located in each plot three plants were randomly selected and marked, and the cowpea plant height (cm) was measured at the three stages of growth namely seedling, flowering and maturity and the average plant height was recorded.

***Survival rate*:** Survival rate was calculated by counting the number of plants that have survived divided by the number of plants originally planted and multiply by 100 to express as a percentage of survival.

Yield parameters:

***Pods yield*:** At maturity stage 1 × 2 m^2 quadrats were randomly located within each plot and pods were collected and the number per square meter determined. Pods were put inside paper bags, air dried and weighed.

***Seed yield*:** At maturity stage quadrats were randomly located within each plot and pods were collected, air dried, thrashed and the seeds yield was determined in kg/ha.

Statistical analysis

Collected data were analyzed using a generalized linear model (GLM) procedure for analysis of variance using **SPSS** based on methods described by Gomez and Gomez [6]. This process used a completely randomized design. Mean separation was carried out using the Least Significant Difference (LSD) test.

Results and Discussion

Effect of intra-row spacing of cowpea on growth parameters

Plant density: Plant density (Table 1) was found to increase significantly ($P<0.05$) with decreased intra-row spacing of cowpea at all three stages of plant growth. This might be due to the competition of plants for soil moisture within the plant rooting zone when the number per square meter is high. This finding is in line with results [7] who found highly significant differences between treatments, due to spacing, on plant density of Guar plant. Also El Naim AM [3,8] reported that seed rate had a significant effect on plant density. However, the results of El Naim AM [2] showed that intra-row spacing had no significant effect on plant density. Moreover, Malami and Sama'ila [9] stated that,

Figure 1: Map of Sudan.

Spacing	Plant density (Plant/m²) (Mean of three seasons)		
	Seedling	Flowering	Maturity
50 cm	13.0	11.0	10.0
75 cm	12.0	7.7	7.7
100 cm	7.7	6.3	5.7
125 cm	6.0	4.3	4.0
Mean	9.8	7.3	7.0
SE±	1. 68*	1. 46*	1. 09*
LSD		**2.3**	
CV%	34.5	36.98	36.530

Table 1: Effect of intra-row spacing of cowpea on plant density.

Spacing	Plant height (cm) (Mean of three seasons)		
	Seedling	Flowering	Maturity
50 cm	43.2	122.8	144.5
75 cm	51.9	114.0	133.2
100 cm	57.4	132.9	154.5
125 cm	61.1	149.2	163.9
Mean	**53.4***	**129.7***	**149.0***
SE±	3.89	7. 56	6. 60
LSD		**17.14**	
CV%	14.6	11.6	8.9

Table 2: Effect of intra-row spacing of cowpea planting on plant height.

closer inter-row and intra-row spacing recorded highest plant counts of *Lablab purpureus*, while wider inter-row and intra-row spacing scored lowest counts. In contrast other workers El awad [2,3,8] noted that plant spacing had no significant effect on all growth attributes at time of flowering and maturity. These refer to different type of plant and location.

Plant height: Results of the effect of intra-row spacing on plant height are presented in Table 2. There were significant differences ($P<0.01$) among treatments, the wider spacing resulting in taller plants. This might be due to the fact that wider spacing results in reduced competition over soil nutrients and light. These results are comparable with El Naim AM [8] who noted that increasing plant population resulted in significantly increased plant height; other reports Malami and Sama'ila [9], Abdullah [7], El Naim AM [2] found that narrow spacing had insignificant effect on plant height. In addition El Naim AM [3] found that the local cultivar (Buff) had significantly taller shoots with wider spacing which is in concurrence with this study which found taller plants with wider spacing.

Survival rate %: The different intra-row spacing treatments showed that there was no significant effect of spacing on plant survival rate at ($P>0.05$) (Tables 3-5). These results are in line with those of Zaki [7] and Abu [10], who worked on *Clitoria ternata*. These authors also did not find significant differences in survival rates as a result of seed rate. Moreover the authors found that plant mortality was nil for other varieties. Ground cover was higher for variety V. TVU 12349 and Kananado with about 100% and 90% ground covered respectively compared with other varieties at early flowering stage.

Effect of intra-row spacing of cowpea on yield parameters

The effects of intra-row spacing on pod and seed yields are shown in (Tables 4 and 5). No significant differences were found between treatments. These results resemble those of El Naim AM [8] who reported that increasing plant density decreased grain yield per plant, grain yield per unit area and reduced number of pods per plant. Jakusko et al. [11] and Enyi [12] found that spacing of 90 cm between rows gave a good grain yield and number of pods compared with narrow spacing.

Spacing	Plant survival rate% Mean of three season	
	Flowering	Maturity
50 cm	77.5	69.8
75 cm	69.7	51.7
100 cm	85.4	67.9
125 cm	65.8	57.8
Mean	**74.6**	**61.8**
SE±	3. 77^{ns}	4. 28^{ns}
LSD	**45.3**	
CV%	10.1	13.8

NS: No Significant.

Table 3: Effect of intra-row spacing of cowpea planting on plant survival rate (%).

Spacing	Pod yield (g) (Mean of three seasons)	
	Pods weight/plant	Pod weight /m²
50 cm	14.7	50.0
75 cm	17.3	48.3
100 cm	19.3	52.3
125 cm	16.7	51.7
Mean	**17.0**	**50.6**
SE±	0.95^{ns}	0.83^{ns}
LSD	**8.3**	**18.6**
CV%	11.1	3.3

Table 4: Effect of intra-row spacing of cowpea on pod yield.

Spacing	Seed yield (g) (Mean of three season)	
	Seeds weight/plant	Seeds weight/m²
50 cm	66.2	117.4
75 cm	66.3	107.2
100 cm	74.5	116.8
125 cm	72.9	110.4
Mean	**69.7**	**112.9**
SE±	2.18^{ns}	2. 49^{ns}
LSD	21.7	44.3
CV%	6.3	4.3

Table 5: Effect of intra-row spacing of cowpea on seed yield.

On the other hand El Naim AM [8] noted that increased plants/stand increased grain yield (t/ha). The local cultivar (Beldi) gave the utmost grain yield per unit area; however, it seems to be a grain than fodder type variety as it is late maturing with lowest fodder yield. However, Rima et al. [13] and other authors [14-16] reported that, closer spacing resulted in significantly higher seed yield under rain-fed conditions compared with wide spacing. These results are in line with what was found in this study.

Conclusion

Cowpea planting at closer intra-row spacing resulted in increased plant density and decreased plant height. Intra–row spacing in this study was found to have no significant effect on pods and seed yield though intra-row spacing of 100 cm and 50 cm of cowpea planting are better than 75 cm and 125 cm. It appears that the prevailing farmer practice of adopting wider intra-row spacing is rational as it allows intercropping with other crops such as millet without reducing cowpea yield.

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