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Yield and Yield's Components of Cowpea, Sorghum and Roselle Intercropped at Different Spatial Arrangements

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Abstract

Intercropping, the cultivation of two or more crops at the same time in the same field, is a common practice in North Korodfan of Sudan in traditional farms of smallholders. This experiment conducted in rainy season (2019/2020) to investigate the effect of intercropping on yield and yield components of cowpea (*Vigan unguiculta* L), sorghum (*Sorghum bicolor* L. Moench) and roselle (*Hibiscus sabdariffa* var. *sabdariffa* L) intercropped at different spatial arrangements. The experiment consisted of nine treatments: three sole crop of Sorghum Cowpea, and Roselle and eight spatial arrangements of 1:1, 1:2, 2:1, and 2:2 rows of Cowpea with each of Sorghum or Roselle. A randomized complete block design (RCBD) with four replications was used. The results showed that intercropping treatments had significant ($P \leq 0.05$) effect on most of the parameters measured on Sorghum, Cowpea and Roselle intercropping. For sorghum: the spatial arrangements 2:2 and 1:1 had the significant highest 100-seed weight (2.9 g) and final seed yield (0.34 ton/ha). For cowpea: the treatment 2:2 had the highest number of pods per plant, 100 seed weight, and shoot dry weight for cowpea. The intercropping 2C:1S had a highest cowpea seed yield (4.2 ton/ha) compared to others spatial arrangements. For roselle the intercropping 2C:2R (two rows of cowpea alternated with two rows of roselle) had the higher number of calyx per plant (19.7) and calyx yield (9.7 g/plant) than the other spatial arrangements. From this study, the practice of planting two rows of cowpea alternating with two rows of sorghum is recommended for farmers under rain-fed sector.

Keywords: hibiscus, multiple cropping, sole crop, small holders

1. Introduction

Intercropping is a multiple cropping system which indicates the crop intensification in both time and space dimensions (Saad *et al*, 2022; Suleman, 2022). The multiple cropping was defined by Suleman *et al* (2018), Sanchez (1976), Andrews and Kassam (1976), as a state of growing two or more crops in the same field and season. Multiple cropping is practiced extensively in many areas of the world as the method of maximizing land productivity per unit area per season, while intercropping was known as growing two or more crops simultaneously on the same field. Most researchers believe that the intercropping system is especially beneficial to of the tropics (Rana *et al*, 2001; Fujita & Ofosu-Budu, 1996; Willey *et al*., 1979; Gunasena *et al*, 1978). The intercropping of cereal and legumes is widespread among smallholder farmers due to the ability of the legumes cope with soil erosion and with declining levels of soil fertility. The principle reasons for smallholder farmers to intercrop are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed control and balanced nutrition (El Naim *et a*l, 2013). Profitability other advantages of intercropping include potential for increased and low fixed costs for land as a result of a second crop in the same field (Thobatsi, 2009). Furthermore, intercropping can give higher yield than sole crop yields,

greater yield stability, more efficient use of nutrients, better weed control, provision of insurance against total crop failure, improved quality by variety, also cereal as a sole crop requires a larger area to produce the same yield as cereal in an intercropping system (Viljoen & Allemann, 1996). However, the efficient use of basic resources in the cropping system depends partly on the inherent efficiency of the individual crops that make up the system and partly on complementary effect between the crops (Willey & Rao, 1981). In Sudan, intercropping is practiced by the traditional smallholder in the western part of the country. The crops of sorghum, sesame, cowpea, roselle, groundnut and watermelon are grown in different combinations and random mixtures where no considerations are given to plant densities, crop varieties or spatial arrangement. In view of this fact, the improvement and promotion of this system should be considered to help these resource-poor farmers to use their limited resources more efficiently. Sorghum (Sorghum bicolor L. Monech) is a main staple crop in the Sudan (El Naim *et al*., 2018), beside its use as energy source to human consumption, it draws its great value as source of grain and straw that is used for animal feed (El Naim *et al*, 2018). Unfortunately, no proper recommended technologies were under taken by farmers to get rid of problems facing sorghum production in North Kordofan state due to frequent cultivation in mono-cropping system, as well as the absence of awareness of farmers to the advantages of crop rotation and mix cropping. Hassan and Elasha (2008) stated that growing sorghum as sole crop year after year had caused a serious infestation by noxious weeds like striga and Sudan grass, beside the depletion of soil fertility. Accordingly, the grain yield of sorghum in these areas especially during the last two decades was only about 100 kg/ha. Cowpea (*Vigan unguiculta* L.) is one of the important food and cash crops in North Kordofan (Abdelrahman *et al*, 2016; El Naim & Jabereldar, 2010). Usually it is grown as sole crop in limited areas. However, some farmers grow it as mixture with sorghum or pearl millet without particular arrangement the cowpea crop shows a great advantages through its use for human consumption, besides its mothering the germination of *striga hermothica* plants and other weeds (El Naim *et al*, 2013). Roselle (*Hibiscus sabdariffa L*.) is known in Sudan as Karkade, is an important cash crop and source of income for small farmers throught western Sudan, especially, North Kordofan state. The crop is grown mainly in traditional farming systems exclusively under rain fed conditions (Ibrahim *et al*, 2013; El Naim & Ahmed, 2010). The current study was executed to evaluate yield and yield components of, Sorghum, Cowpea and Roselle mono-cropped or intercropped in alternate-rows under North kordofan state.

2. Materials and Methods

2.1 The Experiment

An experiment was conducted under rain fed condition during rainy season (2019/2020) in two locations (University of Kordofan Farm and Khorabied Farm) in Sheikan Locality, North Kordofan state. The area lies between latitude 11˚ 15” and 16˚ 30” N and longitude 27˚ and 32˚ E. The climate of the area is arid and semi-arid. The soil is sandy with low fertility. Annual rainfall ranges between 350 – 450 mm. Average maximum daily temperatures varied between 30 – 50ºC throughout the year (El Naim & Ahmed, 2010).

The trial was laid out in a randomized complete block design with four replicates, the plot size was 4 m^2. The seeds of Sorghum, Cowpea and Roselle were obtained from Elobied (ARC). Sowing was on the July 15st and 21th of July for the University of Kordofan Farm and Khor Banow sites, respectively. Seeds were sown on rows 60 cm apart; in spacing of 50 for Sorghum, 60 for cowpea and 70 cm for Roselle, hand weeding was done two twice at 15 and 30 days after planting in the two locations. The experiment consisted of eleven treatments comprising Cowpea, Sorghum and Roselle grown in pure stands and in different spatial arrangements, these were:

1) One row of cowpea alternated with one row of Sorghum (1:1).
2) One row of cowpea alternated with two rows of Sorghum (1:2).
3) Two rows of cowpea alternated with one row of Sorghum (2:1).
4) Two rows of cowpea alternated with two rows of Sorghum (2:2).
5) One row cowpea alternated with one row of Roselle (1:1).
6) One row of cowpea alternated with two rows of Roselle (1:2).
7) Two rows cowpea alternated with one row of Roselle (2:1).
8) Two rows of cowpea alternated with two rows of Roselle (2:2).

2.2 Characters Studied

A sample of five plants was taken at randomly from the inner rows of each plot to determine the following characters: cowpea were: number of pods per plant, number of seeds per pods, 100-seeds weight (g) and final seed yield (ton/ha). Sorghum parameters studied were: panicle weight, number of seeds per panicle, 100 seed weight (g) and grain yield (g/plant), while for roselle parameters were: number of calyxes/plant. Number of

seeds per calyx, calyxes yield (ton/ha) and seed yield (ton/ha).

2.3 Statistical Analyses

The collected data in each location were statistically analyzed using MSTAT-C package. The model followed in the analyses was described by Gomez and Gomez (1984), for comparison between means, Duncan Multiple Range Test (DMRT) was used at (P = 0.05).

3. Results and Discussion

3.1 Sorghum

3.1.1 Panicle Weight (g)

The effect of intercropping on panicle weight were presented in Table 1. Intercropping treatments had a significant effect on panicle weight in two locations. Highest spatial arrangements was recorded by 1:2 (one row of cowpea alternating with two rows of sorghum) in two location, (15.81 g and 39.28 g) respectively. This could be attributed to the advantage of legume/cereal intercropping and to better utilization of natural resources such as water, light and nutrients.

3.1.2 Number of Seeds Per Panicle

Table 1 shows the effect of sorghum cowpea of intercropping on number of seeds per panicle. Results indicated that, the intercropping had a significant effect on number of seed per panicle in two locations. The highest spatial arrangement (416) recorded by 2:2 (two rows of cowpea alternated with two rows of sorghum in first location, but on second location ranged from 289 to 228 seeds. This may be due to absence of competition between sorghum plants.

3.1.3 100-Seed Weight (g)

Results presented on Table 1 show that, there were a significant differences among different spatial arrangements for cowpea/sorghum intercropping in first location only. The heavy weight was reported by 2:2 arrangements in the first location. But on second location ranged from (3.97 to 3.40 g). El Naim *et al* (2013) found that the highest combined value of 100-seed weight was obtained at 2:2 arrangements.

3.1.4 Grain Yield (g/plant)

Table 1 shows the effect of intercropping on grain yield (g/plant). Results indicated that, the intercropping had a significant effect on grain yield per plant in two locations. The highest grain yield resulted from its highest 100 seed weight and seed number per panicle. The highest spatial arrangements was (12.07 g) recorded by 2:2 arrangement (two rows of cowpea alternated with two rows of sorghum) in first location, but on second location (15.56 g) was observed by sole sorghum. This results in line with El Naim *et al* (2013) a result of intercropping sorghum with cowpea arrangements. Suleman *et al*. (2018) also found that the highest yields of sorghum were obtained in double sorghum rows alternating with double groundnut rows, while Saad *et al*. (2004) revealed that grain yield of sorghum was reduced considerably in intercropping system as compared to sole crop. Similarly El Naim *et al* (2013) reported that a yield increase as a result of intercropping sorghum with cowpea at 1:1 row arrangement

Table 1. Effect of intercropping of cowpea with sorghum on panicle weight, number of seeds per panicle, 100 seed weight (g) and grain yield (g/plant) of sorghum grown during (2019-2020) season

Treatments	Experimental Farm				Khorelbeid Farm			
	panicle weight (g)	No. seeds per panicle	100 seed weight (g)	Yield (g /plant)	panicle weight (g)	No. seeds per panicle	100 seed weight (g)	Yield (g /plant}
Sole Sorghum	15.110^{a}	513^{a}	2.303^{ab}	11.787^{b}	28.23	444^{a}	3.560	15.561^{a}
C/S (1:1)	12.660^{b}	253^{c}	2.387^{b}	5.830^{d}	25.64	289^{b}	3.515	10.124^{b}
(1:2)	15.805^{a}	269^{d}	2.557^{a}	6.896^{c}	39.28	280^{c}	3.563	9.815^{c}
(2:1)	10.160^{c}	204^{e}	1.613^{c}	3.267^{e}	36.62	235^{d}	3.403	8.015^{d}
(2:2)	10.982^{ac}	416^{b}	2.913^{a}	12.074^{a}	37.01	228^{e}	3.968	9.073^{ac}
C.V%	13.6	33.03	14.00	21.29	17.39	31.22	16.92	11.83
SE±	0.756	41.871	0.147	0.7558	2.5941	42.698	0.273	0.5566

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

3.2 Roselle

3.2.1 Number of Calyxes Per Plant

Table 2 shows the effect of intercropping on number of calyxes per plant. Results indicated that, the intercropping had a significant effect on number of calyxes per plant. The sole crop gave the great calyxes per plant (27). Spatial arrangements 2:2 (two rows of cowpea alternated with two rows of Roselle) in first location had the highest number of calyxes per plant (20 calyxes), but in the second location had no significant different were observed among arrangement. This might be due to the different environment of locations.

3.2.2 Number of Seeds Per Calyx

The effect of intercropping on number of seeds per calyx were presented in Table 2. Intercropping treatments had a significant effect on number of seed per calyx in first location. The greater number of seeds was obtained by sole crop (29 and 30 seeds) in first and second location respectively. The spatial arrangement 2:2 (two row of cowpea alternated with two rows of Roselle) recorded 25 seed in first location, but in the second location had no significant different. Due to the complexity of handling more than one crop simultaneously.

3.2.3 Calyx Yield (ton/ha)

The effect of intercropping on calyx yield ton/ha presented in Table 2. Analysis of variance in both location shows that, the intercropping had significant different on calyx yield (ton/ha). This might be due to strong competition between common bean and roselle plants for mineral nutrients that could be import for roselle calyx development. Besides, the findings of El Naim and Ahmed (2010) indicated that Roselle calyx yield was more declined when grown in association with crops and weeds.

3.2.4 Seed Yield (ton/ha)

Table 2 shows the effect of Roselle/cowpea intercropping on seed yield ton/ha in tow location, the highest spatial arrangement was recorded by 2:1 (two rows of cowpea alternated with one row of Roselle) in both location (49.597 ton/ ha) and (52.054 ton/ ha) in first and second location respectively. Thus due to the fact that, yield component in pure stand reflex its supremacy treatments.

Table 2. Effect of intercropping of cowpea with roselle on number of calyxes per plant, number of seeds per calyx, calyxes yield (ton/ha) and seed yield (ton/ha) of rosella grown during (2019-2020) season

Treatments	Experimental Farm				Khorelbeid Farm			
Sole Roselle	No. of calyxes per plant	No. of seeds per calyx	calyxes yield (ton/ha)	Seed yield (ton/ha)	No. of calyxes per plant	No. of seeds per calyx	calyx yield (ton/ha	seed yield (ton/ha)
C/R (1:1)	27.000[a]	28.750[a]	0.57	50.061[a]	18.250	30	0.5	65.978[a]
(1:2)	18[c]	29[c]	0.18	41.110[c]	22	27	0.24	41.823[e]
(2:1)	15[e]	23.750[d]	0.12	39.893[d]	19	27	0.16	49.811[c]
(2:2)	17[d]	24.500[c]	0.24	49.597[b]	19.250	25.500	0.30	52.054[b]
C.V%	20[b]	25.000[b]	0.23	39.856[d]	21.250	26.750	0.26	44.964[d]
SE±	10.66	8.39	33.44	14.65	14.51	10.25	4.56	6.28

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

3.3 Cowpea

3.3.1 Number of Pods Per Plant

Table 3 shows the effect of intercropping on number of pods per plant. Results indicated that, intercropping had a significant effect on mean number of pods per plant. The highest number of pods per plant was obtained from the C/S (2:2) in Experimental Farm and from C/R (2:1) in Khorelbeid Farm. The intercropping C/R (1:2) gave a lesser number of pods (7 pods) per plant in the Experimental Farm while C/R (2:1) gave lesser number of pods per plant and Khorelbeid Farm.

3.3.2 Number of Seeds Per Pod

The effects of intercropping on mean number of seeds per pod were presented in Table 3. Results indicated that, intercropping had no significant effect on number of seed per pod. The highest number of seeds per plant was (9 seeds) recorded by (1:2) in the first location, but on second location was (10 seeds) recorded by 2:1 arrangement.

3.3.3 100-Seed Weight (g)

Results indicated that, no significant differences among spatial arrangement of intercropping on 100-seed weight (Table 3). The weight as recorded was between (18.1 to 16.8g) in experimental farm location and (19.3 to 16.4g) in khorelbeid location.

3.3.4 Final Seed Yield (ton/ha)

The effect of intercropping on seed yield was shown in Table 3. Results indicated that, intercropping had a significant effect on seed yield (ton/ha) in the two locations. The highest spatial arrangement (11.8 ton/ha) recorded by 1:2 (one row of cowpea alternated with two row of sorghum) in the first location. But on the second location was (13.25 ton/ha) obtained by 1:2 arrangements (one row of cowpea alternated with two rows of sorghum). Suleman (2018) reported that below ground interaction often give rise to yield advantage in intercropping, and it was largest in case of legume and non-legume intercrops and he attributed it to the atmospheric nitrogen fixed by legume. Intercropping with legumes has been shown to give higher returns than single cropping, and increases the yield of the associated non-legumes under certain condition.

Table 3. Effect of intercropping of cowpea with sorghum and roselle on number of pods per plant, number of seeds/ pods, 100-seed weight (g) and seed yield (ton/ha) of cowpea grown during (2019-2020) season

Treatments	Experimental Farm				Khorelbeid Farm			
	No. of pods per plant	No. of seeds/ pods	100-seed weight	yield (ton/ha)	No. of pods per plant	No. of seeds/ pods	100-seed weight	yield (ton/ha)
Sole cowpea	8.500^{d}	9.000^{a}	18.753	0.54	7.000^{c}	9.750	18.290^{b}	0.44
C/S (1:1)	8.750^{c}	9.000^{ab}	17.443^{d}	0.23	6.500^{e}	9.500	17.087^{c}	0.30
(1:2)	9.750^{b}	9.750^{a}	16.170^{g}	0.24	6.750^{d}	8.750	16.423^{d}	0.26
(2:1)	8.500^{d}	8.750^{c}	17.053^{f}	0.42	8.250^{a}	10.500	18.050^{b}	0.38
(2:2)	11.500^{a}	9.000^{ab}	17.415^{a}	0.26	6.750^{d}	9.500	17.313^{c}	0.34
C/R (1:1)	8.750^{c}	9.000^{ab}	17.938^{b}	0.26	7.000^{c}	9.250	19.275^{a}	0.23
(1:2)	7.250^{e}	9.250^{ab}	17.340^{e}	0.13	7.500^{b}	10.000	17.472^{c}	0.19
(2:1)	8.750^{c}	8.750^{c}	17.862^{c}	0.37	4.750^{g}	10.750	18.168^{b}	0.43
(2:2)	9.500^{ab}	9.000^{ab}	18.122^{a}	0.23	5.000^{f}	10.000	18.087^{b}	0.27
C.V%	17.01	6.44	7.01	14.09	19.80	9.18	8.72%	6.78
SE±	0.510	87.00	0.410	0.4247	0.4363	0.299	0.517	0.2250

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

4. Conclusions

The results obtained in this study showed that the intercropping cowpea with sorghum and roselle gave the higher yield than single cropping. Thus the intercropping crops with cowpea (legume) is beneficial method of maximizing land productivity per unit area, and increased the yield of the associated non-legumes. Further studies with different inter and intra-row spacing are proposed to determine whether there are greater benefits or yield at other levels than those observed in this study.

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