

Agronomic Evaluation of Groundnut and Two Varieties of Grain Sorghum Intercropped at Different Spatial Arrangements

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Abstract A field experiment was conducted during two consecutive seasons (2013/14 and 2014/2015) at Sheikan Locality, North Kordofan State, Sudan, to investigate the effects of intercropping groundnut with two varieties of sorghum on yield and yield components. The experiment consisted of eleven treatments: three sole crop of groundnut, a local sorghum variety (Zinari) and an improved sorghum variety (Butana) and eight spatial arrangements of 1:1, 1:2, 2:1 and 2:2 rows of groundnut with each of the local or improved sorghum varieties. Treatments were arranged in a randomized complete block design with four replications. The results revealed that the intercropping affected most of the characteristics studied. The treatment 2:2 had the highest number of pods per plant, highest seed weight, 100 seed weight for groundnut. The highest Panicle weight, seed yield, 100-seed weight and number of grain per panicle obtained at 1:1 arrangements followed by 2:2. The highest sorghum grain yield (768 kg ha⁻¹) was found in GSV2 1:1 (one groundnut row alternated with one sorghum row *var.* Butana). For attaining higher total crop yield per unit area of land, where there is no crop bias, the practice of planting two groundnut rows alternating with two-sorghum rows *var.* Butana is recommended for farmers of North Kordofan under rain-fed sector.

Keywords Peanut, Cereals, Legumes, Cropping system

1. Introduction

Intercropping, the cultivation of two or more crops at the same time in the same field is a common practice, especially in the tropics and in the developing countries [1]. Benefits of intercropping may be briefed as better use of resources, improvement of soil fertility by legume components of the system, soil preservation through covering the bare land between the rows, reduction of biotic and abiotic risks by increasing diversity and suppression of weed infestation [2]. In the tropical and sub-tropical region, cereal - legumes intercropping is the most popular practice because of its many additional advantages [3]. When legumes are used as intercrops, they provide the beneficial effect on soil fertility by fixing atmospheric nitrogen. In Sudan, intercropping of cereals with legumes is practiced in small scales as a means of maximizing the use of limited farm lands as well as attaining food security to the subsistence farmers. Baker [4]

observed that in the tropics, cereals are commonly intercropped with legumes, in the hope that the former will benefit from the N-fixed by the latter. Other benefits include maximum resource utilization and income stability [5] and higher total returns [6]. It increases total productivity per unit area through maximum utilization of land, labor and growth resources.

Sorghum (*Sorghum bicolor* (L.) monech) is the fifth most important crop in many parts of the world grown for food, feed and industrial purposes. It is also a major crop in many parts of Africa, Central America and some Asian countries [7]. Sorghum is a warm season crop growing well in tropical and subtropical climates. In the Sudan, sorghum is the main staple food crop, comprised 80% by weight of the cereal crops, and is grown extensively under irrigated and dry land conditions [23]. Thus, sorghum frequently experiences drought stress during vegetative and reproductive growth [8]. Grain sorghum is the main staple food crop of a large section of population in Africa and India. Sorghum crop adapted to drought areas is a crop of hot, semi-arid tropical environment with 400- 600 mm rain fall areas. Sorghum can be cultivated successfully on nearly all soils, but fertile loamy soils are considered the best [9]. In Sudan, the flour from the grain can be used to make "kisra", porridge, "gruel" local beer and snack meals like "Balleela" [10].

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Groundnut or peanut (*Arachis hypogaea* L.) is grown over 20 million hectares in the tropical and sub-tropical parts of about one hundred countries in the world. The total annual world production amounts to about 25 million tons of unshelled nuts, 70% of which is contributed by India, China and U.S.A. [1, 11]. Groundnut is an excellent source of plant nutrients contains 45-50% oil, 27-33% protein as well as essential minerals and vitamins. They play an important role in the dietary requirements of resource poor women and children and the haulm are used as livestock feed.

Sorghum and groundnut are main crops in North Kordofan State. Beside its use as energy source to human consumption, sorghum draws its great value as source of grain and straw used for animal feed. Unfortunately, no proper recommended technologies were undertaken by farmers to get rid of problems that face sorghum and groundnut 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 mixed cropping. Therefore, this system is considered to help farmers utilize their limited resources (natural and labor resources) for attaining yield stability, obtaining higher yields per unit area, and have better control of weeds, pests, and diseases. In addition, it provides safe guard against familiar practice of the single crop. The intercropping of cereal and legumes is preferred by smallholding farmers due to the ability of the legume to cope with soil erosion and increasing levels of soil fertility. Therefore, the main objectives of this research is to study the effects of different intercropping arrangements on groundnut and sorghum yield compared to mono-cropping.

2. Materials and Methods

2.1. Site of the Experiment

An experiment was conducted under rain fed condition for two consecutive seasons (2013/14 -2014/15), in Sheikan Locality, North Kordofan State, to evaluate the growth, yield and profitability of groundnut and two sorghum varieties intercropped at different spatial arrangements. The locality latitude ($11^{\circ} 15$ and $16^{\circ} 30$ N) and longitude (27° and 32° E). The soil is sandy with low fertility. Annual rainfall average ranges between 350-500mm. Average maximum daily temperatures varied between 30°C to 35°C most of the year [12].

2.2. Experimental Design and Treatments

The experiment was laid out in a randomized complete block design with four replicates. The plot size was 4x4 meters. The experiment consisted of eleven treatments comprising groundnut (variety Gubesh), two varieties of sorghum, Zinari (local) and Butana (improved) grown in pure stands and in different spatial arrangements. The eleven treatments tested were:

- Sole sorghum *var.* Zinari (SV1)
- Sole sorghum *var.* Butana (SV2)

Sole groundnut (G)

- 1:1 one row of groundnut alternating with one row of sorghum *var.* Zinari.
- 1:1 one row of groundnut alternating with one row of sorghum *var.* Butana.
- 1:2 one row of groundnut alternating with two rows of sorghum *var.* Zinari.
- 1:2 one row of groundnut alternating with two rows of sorghum *var.* Butana.
- 2:1 two rows of groundnut alternating with one row of sorghum *var.* Zinari.
- 2:1 two rows of groundnut alternating with one row of sorghum *var.* Butana.
- 2:2 two rows of groundnut alternating with two rows of sorghum *var.* Zinari.
- 2:2 two rows of groundnut alternating with two rows of sorghum *var.* Butana.

The seeds of the crops were obtained from the Arab Sudanese Seeds Company, Elobeid Seeds station.

Seeds were treated with Thiram at 3 g/kg seed before sowing to protect seeds against termites and insects. Sowing dates were 28th of July for the first season and July, 15th for the second season.

Seeds were sown on rows 50 cm apart, with four seeds were placed in each hole for sorghum varieties and three seeds per hole for groundnut crop, which were then thinned to one plants per whole, two weeks later for each crop. The first weeding was after two weeks from sowing and the second weeding was after 30 days.

2.3. Characters Studied

A sample of five plants was taken at random from the inner rows of each experimental unit to measure the following attributes for sorghum and groundnut.

2.3.1. Sorghum

The following data were collected for sorghum

1. Panicle weight (g).
2. Number of grains per panicle.
3. 100- seed weight: by counting 100 seeds at random from each lot of plot four times and weighed by a sensitive balance.
4. Seed yield (g/plant) determined by the average seed yield per plant (g).
5. Seed yield (ton/ha): seed yield (g)/ plant X number of plants /ha.

2.3.2. Groundnut

The following data were collected for groundnut

1. Number of pods per plant: was determined by counting the number of pods/plant.
2. 100 seed weight (g): by counting 100 seeds at random from each lot of plot four times and weighed by a sensitive balance.
3. Seed yield (g/plant).
4. Seed yield (t/ha): seed yield (g)/ plant X number of

plants /ha.

2.4. Statistical Analysis

The data collected in the two seasons were analyzed using statistical analyses for randomized complete block design according to Gomez and Gomez [24]. Means were separated using Duncan's Multiple Range Test (DMRT) at 0.05 level of significance.

3. Results and Discussion

3.1. Sorghum

Table 1. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on panicle weight of sorghum (g) grown during (2013/14-2014/15) seasons

Reatments	2013/14		2014/15	
	var. Butana	var. Zinari	var. Butana	var. Zinari
Sole sorghum var. Butana	43.2 ^a	—	19.5 ^c	—
Sole sorghum var. Zinari	—	65.1 ^{ab}	—	44.4 ^b
G:S 1:1	44.4 ^a	71.7 ^a	32.0 ^a	78.3 ^a
G:S 1:2	42.9 ^a	58.4 ^{bc}	16.2 ^d	29.2 ^c
G:S 2:1	39.9 ^a	53.5 ^c	22.3 ^{bc}	42.9 ^b
G:S 2:2	44.3 ^a	69.6 ^{ab}	24.8 ^b	49.4 ^b
C.V%	13.9	13.1	13.9	12.2
SE±	2.9	4.1	2.9	2.9

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT

Table 2. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on number of grains per panicle of sorghum grown during (2013/14-2014/15) seasons

Treatments	2013/14		2014/15	
	var. Butana	var. Zinari	var. Butana	var. Zinari
Sole sorghum var. Butana	1875.0 ^c	—	1892.8 ^b	—
Sole sorghum var. Zinari	—	653.7 ^b	—	709.7 ^b
G:S 1:1	2247.1 ^a	814.3 ^a	1976.9 ^a	727.0 ^a
G:S 1:2	2092.3 ^a	642.5 ^c	1663.6 ^c	540.6 ^c
G:S 2:1	2166.7 ^b	704.8 ^{bc}	1875 ^b	717.9 ^{ab}
G:S 2:2	2170.6 ^a	767.4 ^a	1657.1 ^{bc}	719.4 ^{ab}
C.V%	5.43	9.75	9.72	14.94
SE±	57.524	45.221	68.150	52.695

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT.

The 1:1 arrangements gave the highest panicle weight (Table 1), highest seed yield (g/plant) (Table 2) and number of grains (Table 3), followed by the arrangements 2:2. This could be due to a wider inter-row spacing of sorghum plants in this treatment. Since sorghum roots extract moisture from a deeper soil horizon than groundnut, sorghum plants had a wider area to derive water and nutrients in this treatment (1:1)

than sorghum in the other intercropping treatments; also this may be due to fixed atmospheric nitrogen by groundnut, which may be utilized by sorghum plants or may be excreted from the nodules into the soil and be used by other plants growing nearby. Similar results were recorded by Musa [13] who found that the arrangement of 1:1 gave the highest forage yield. Gabatshele et al. [14] reported that sole crop produced significantly more dry matter weight than maize intercropped with cowpeas.

Table 3. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on 100 seed weight (g) of sorghum grown during (2013/14-2014/15) seasons

Treatments	2013/14		2014/15	
	var. Butana	var. Zinari	var. Butana	var. Zinari
Sole sorghum var. Butana	1.6 ^a	—	1.4 ^{ab}	—
Sole sorghum var. Zinari	—	4.1 ^a	—	3.1 ^c
G:S 1:1	1.7 ^a	4.6 ^a	1.6 ^a	3.7 ^a
G:S 1:2	1.3 ^c	4.0 ^a	1.1 ^c	3.2 ^b
G:S 2:1	1.5 ^b	4.2 ^a	1.4 ^{ab}	3.2 ^b
G:S 2:2	1.6 ^a	4.5 ^a	1.4 ^{ab}	3.7 ^a
C.V%	7.03	8.49	7.03	7.79
SE±	0.05	0.18	0.05	0.13

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT

The final seed yield (ton/ha) was obtained from sole sorghum (Table 4). Raghuwanshi et al. [15] reported that maximum grain yield of sorghum was obtained from sole crop of sorghum as compared to intercropping with soybean.

Table 4. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on final yield (ton ha⁻¹) of sorghum grown during (2013/14-2014/15) seasons

Treatments	2013/14		2014/15	
	var. Butana	var. Zinari	var. Butana	var. Zinari
Sole sorghum var. Butana	1.20a	—	1.06a	—
Sole sorghum var. Zinari	—	1.07a	—	0.86b
G:S 1:1	0.77ab	0.80a	0.52a	0.54a
G:S 1:2	0.71b	0.67b	0.48b	0.45b
G:S 2:1	0.48c	0.45b	0.39c	0.37b
G:S 2:2	0.74ab	0.71b	0.46a	0.52b
C.V%	29.45	14.09	7.68	5.88
SE±	5.86	2.17	0.67	0.69

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT

The best seed yield of sorghum among different spatial arrangements was obtained at the arrangement of 1G: 1S and 2G: 2S (in the two seasons consecutively). The highest grain yield resulted from its highest 100 seed weight and seed number per panicle. Langat et al. [16] also found that the highest yields of sorghum were obtained in double sorghum rows alternating with double groundnut rows. Angadi et al. [17] revealed that grain yield of sorghum was reduced

considerably in intercropping system as compared to sole crop. Singh and Ahuga [18] reported that a yield increase as a result of intercropping sorghum with cowpea at 1:1 row arrangement. Arrangement of 1G:1S and 2G:2S (consecutively in the two seasons) gave the highest 100- seed weight. This may be due to absence of competition between sorghum plants. Safar and Sajjad [19] reported that in intercropping maize, soybean and sorghum, soybean seed weight was not significant. Musa [13] also found that the highest combined value of 100-seed weight was obtained at 2:2 arrangements.

Table 5. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on number of pods per plant, seed yield (g/plant) and 100-seed weight (g) of groundnut grown during (2013/14-2014/15) seasons

Treatments	2013/14			2014/15		
	Number of pods	Seed yield (g/plant)	100 seed weight(g)	Number of pods	Seed yield (g/plant)	100 seed weight(g)
Sole Groundnut	24.6 ^b	13.6 ^{bcd}	55.3 ^d	27.5 ^a	12.1 ^{de}	44 ^f
GSV1 1:1	24.7 ^b	18.4 ^b	74.5 ^{bc}	24.3 ^b	16.3 ^c	68 ^{cd}
GSV2 1:1	18.2 ^c	12.8 ^{cd}	70.3 ^c	19.8 ^{de}	14.0 ^d	71.2 ^c
GSV1 1:2	24.0 ^c	17.9 ^b	74.5 ^{bc}	23.9 ^{bc}	17.8 ^{ab}	74.3 ^{bc}
GSV2 1:2	23.5 ^c	16.5 ^{bc}	70.2 ^c	23.8 ^{bc}	17.7 ^{ab}	74.8 ^b
GSV1 2:1	22.3 ^d	12.4 ^{cd}	55.6 ^d	23.0 ^c	11.9 ^{de}	51.7 ^c
GSV2 2:1	18.8 ^c	12.2 ^{cd}	64.9 ^{cd}	19.3 ^{de}	11.2 ^e	58.0 ^d
GSV1 2:2	30.0 ^a	22.9 ^a	76.3 ^a	24.0 ^b	18.9 ^a	78.7 ^a
GSV2 2:2	22.2 ^d	16.7 ^{bc}	75.2 ^b	20.9 ^d	16.2 ^c	77.5 ^a
C.V%	7.01	13.23	10.3	8.34	7.94	9.8
SE±	0.8573	1.1452	1.23	0.9965	0.6491	0.8

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT.

Table 6. Effect of intercropping groundnut and two varieties of sorghum at different spatial arrangements on final yield (ton/ha) of groundnut grown during (2013/14-2014/15) seasons

Treatments	2013/14	2014/15
Sole Groundnut	0.90 ^a	0.800 ^a
GSV1 1:1	0.61 ^b	0.537 ^b
GSV2 1:1	0.42 ^c	0.464 ^c
GSV1 1:2	0.40 ^d	0.45 ^c
GSV2 1:2	0.36 ^d	0.39 ^d
GSV1 2:1	0.55 ^{bc}	0.52 ^{bc}
GSV2 2:1	0.54 ^{bc}	0.49 ^c
GSV1 2:2	0.76 ^{ab}	0.62 ^{ab}
GSV2 2:2	0.55 ^{bc}	0.53 ^b
C.V%	13.23	7.94
SE±	1.1452	0.6491

N.B. Similar letters in the same column are not significantly different at the 0.05 level of probability according to DMRT.

This could be due to shading effect of sorghum on groundnut due to variation in plant architecture, which could have affected soil moisture levels. This finding agrees with that of Reddy and Reddy [21] that the number of pods per plant is influenced by moisture. Langat et al. [16] reported that the lowest number of pods was realized in one row of groundnut alternating with one row of sorghum and in pure

3.2. Groundnut

The maximum groundnut 100- seed weight was obtained from the treatment (2:2) with sorghum var. Butana (Table 5). Son and Chung [20] reported increase in 1000-grain weight of sorghum in sorghum and soybean intercropping system.

The highest number of pod obtained at 2:2 arrangements on the improved variety in the two seasons and the lowest number of pods obtained at the same arrangement with the local variety (Table 5).

groundnut. El Naim et al. [1] reported that the arrangement of 1:1 had obtained a higher number of pods per plant at all treatments. The arrangement of 2:2 had the highest seed yield of groundnut in the two season (Table 6).

This is in agreement with the findings of Pal et al. [22] who found out yield advantages of legumes-cereal intercropping over sole cropping. The spatial arrangement had no significant effect on cowpea pod yield. Asim et al. [26] observed that number of pods plant⁻¹ of mungbean was higher in monoculture as compared to their corresponding intercropping.

4. Conclusions

For a farmer interested in getting maximum yield from sorghum, the crop pattern GSV1 1:1 (one groundnut row alternating with one row of sorghum var. Butana) would be the best to use. If groundnut is the chosen crop, GSV1 2:2 arrangement (two groundnut rows and two sorghum rows var. Butana) would be ideal. Only intra row spacing was used for the different patterns of this study. An expanded study with different inter and intra-row spacings need further study to determine whether there are greater benefits or yield increases at other levels than those observed this study.

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