Sabaragamuwa University Journal
Volume 18 Number 1 August 2020 pp 66-78
ISSN 1391-3166 eISSN 2386-2041
http://dx.doi.org/10.4038/suslj.v18i1.7755

Spatial Arrangements on Growth and Yield of Cowpea (*Vigna unguiculata* L. Walp.) in Intercropping

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Abstract

This experiment was conducted at the Crop Farm of Eastern University, Sri Lanka to evaluate the effect of different spatial arrangements on growth and yield of cowpea (*Vigna unguiculata* L. Walp) under okra (*Abelmoschus esculentus* L.) cowpea intercropping in sandy regosol. The experiment was laid out in a Randomized Complete Block Design (RCBD) having monocropping and different intercropping patterns. The results revealed that there was a significant difference ($P<0.05$) among treatments for plant height, root length, leaf area, leaf area index, pod length, number of total and effective nodules per plant, dry weight of effective nodules and total pod yield of cowpea. However, seeds per pod was not significantly different ($P>0.05$) with different plating patterns. The study concluded that 60 cm between two rows with 150 cm between two pairs of rows of okra with three rows of cowpea in between paired rows would be the most suitable planting system to get maximum growth and yield of cowpea.

Keywords: Cowpea, Intercropping, Monocropping, Nodule, Yield

Introduction

Systems of food production should be increased for the continuous increasing population in the world while minimizing harmful effects to the environment. Most framers in both developing and developed countries are using various strategies with the sense of increasing the productivity and thus the income. Among these various strategies, smallholder farmers in the developing countries have tended to practice intercropping which increases the productivity per unit land area. Intercropping can be elaborated as a multiple cropping system where two or more crops species are planted simultaneously in a field during a growing season [Mousavi & Eskandari, 2011].

Cowpea (*Vigna unguiculata* L. Walp.) mature grain contains 20 to 25% of protein, 1.3 to 1.5% lipid and 5.1 to 5.8% crude fiber [Basaran *et al.*, 2011]. Cowpea can give good yield under adverse climatic conditions and under poor soil fertility. Land use and climate related-drivers are most important in determining agricultural productivity. Productivity of any crop can be influenced by various factors. Those factors may be either climatic or non-climatic. Low agricultural productivity can be attributed to non-climatic drivers such as limited use of external inputs like water and light, nutrient mining, soil erosion and deforestation and to climatic drivers such as precipitation, temperature and greenhouse gas emission [Epule *et al.*, 2018]. The ability of the cowpea plant to fix atmospheric nitrogen is an important factor to maintain soil fertility and its deep roots improve soil structure while its tolerance to drought extends adaptation to drier areas considered marginal for most other crops [Singh *et al.*, 1995].

Crop spacing can be defined as systematic distribution and planting of a material in a site with the intention of providing each individual by the same space and resources, like light, moisture and mineral nutrition [Milovanovic *et al.*, 2011]. When practicing intercropping, spatial arrangement between base and intercropped plants are very much important in considering the productivity of the plants. When the inter-row spacing for the base crop is widened, it may provide adequate space and enable adequate sunlight reach to the intercropping plant and helps to produce more branches than under narrower inter-row spacing. Ultimately, it results in higher yield from intercropped plants. And spatial arrangement should be taken into consideration because it affects the shading of intercrop and causes poor sunlight penetration which ultimately causes poor production [Ocaya et al., 2001]. This study was done with the intention of evaluating the impact of different spatial arrangements on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) under okra

(*Abelmoschus esculentus* L.) cowpea intercropping.

Methods

The field experiment was conducted at the crop farm, Eastern University, Sri Lanka, to evaluate the impact of different spatial arrangements on growth and yield of cowpea (*Vigna unguiculata* L. Walp) under okra (*Abelmoschus esculentus* L.) intercropping. Crop farm of Eastern University belongs to the agro ecological region of low country dry zone in Sri Lanka. The soil of the experimental site is sandy regosol. The experiment was carried out using Randomized Complete Block Design (RCBD) with four replicates. Cowpea variety Waruni was used for the experiment and the size of each plot was 4 m × 3 m. Treatments were cowpea as a monocrop with the spacing of 30 cm × 15 cm, alternative planting of okra and cowpea, 60/150 cm and 75/120 cm paired row planting of okra with two rows and three rows of cowpea in between paired rows. All the agronomic practices were done according to the recommendations of the Department of Agriculture, Sri Lanka. Growth parameters of cowpea were taken at two weeks intervals up to 60 days by the destructive sampling method. Plants were watered thoroughly and the root area with soil was uprooted by hand without damaging. Leaf area was measured by using the leaf area meter. Leaf Area Index (LAI) was calculated by the equation 1.

$$LAI = \frac{Leaf\ area}{Canopy\ area} \quad (1)$$

Harvesting was started at 50 days after planting and continued at weekly intervals up to 70 days.

Results and Discussion

Plant height

There was a significant difference ($P<0.05$) in plant height at 6^{th} week after planting (WAP). However, the plant height of cowpea was not significantly different ($P>0.05$) among tested treatments at 2^{nd} and 4^{th} WAP as both okra and cowpea were trying to reach the vegetative growth. At 6^{th} WAP, the increase of plant height may be due to higher solar radiation caption by cowpea as okra plant height has predominantly suppressed. Tallest plants were noted in alternative planting (49.90 cm) and statistically the same height was noted in 75/120 cm paired row planting with three rows of cowpea. Zyada (2016) stated that cowpea plant height was higher in okra cowpea intercropping in 1:1 ratio, than sole cropping. Obedoni *et al.* (2005) stated that cowpea plant height was high in intercropping with low plant density of tomato, than sole cropping of cowpea. At 8^{th} WAP, there was no significant difference, because life cycle of cowpea ended up and most of the energy of the plant has expended for the yield.

Root length

There was no significant difference ($P>0.05$) between treatments at 2^{nd} week and 4^{th} WAP. Significant difference ($P<0.01$) was observed in 6^{th} and 8^{th}WAP. Alternative row planting showed the maximum root length (19.84 cm) while 75/120 cm paired row planting of okra with two rows of cowpea (11.38 cm) showed the minimum mean values of root length. However, minimum value was not significantly different from same paired row planting with three rows of cowpea at 6^{th} WAP.

At 8^{th} WAP, root length in monocropping, 60/150 cm and 75/120 cm paired rows of okra with two and three rows of cowpea was not significantly different. But these significantly differed from alternative planting. This may be due to plant density of both okra and cowpea in alternative planting was less and this was less than monocropping also. So, under the ground level, cowpea roots grew well and freely with less disturbance, dense rooting, in searching water and nutrients. Banik *et al.* (2006) stated that, there is no significant difference in root length of chick-pea when intercropped with wheat.

Number of leaves and branches per plant

There was no significant difference ($P>0.05$) in number of leaves per plant with different planting patterns at 2^{nd}, 4^{th} and 8^{th} WAP. But there was a significant difference ($P<0.05$) in number of leaves with cropping system was observed at 6^{th} WAP. Highest number was observed in alternative rows (11) and lowest was observed in 75/120 cm paired row planting of okra with two rows (8). This may be due to the increased plant density in sole cropping of cowpea than intercropping systems. It may cause higher competition for space, light and nutrients. Zyada (2016) stated that the number of leaves per plant was higher in intercropping than sole cropping of cowpea. Madisa *et al.* (2015) also has stated that, higher plant densities cause more competition for space, light and nutrients.

Table 1: Plant height (cm) of cowpea at two weeks interval

Treatment	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	13.05∓0.46	22.60∓1.78	32.51∓4.39c	34.34∓2.50
Alternative row planting	10.75 ∓1.17	23.60∓0.90	49.90∓1.18a	40.95∓4.06
60/150 cm paired row planting				
Two rows	13.00∓0.07	20.81∓1.11	37.87∓3.84c	34.85∓2.60
Three rows	10.45∓1.17	22.27∓0.49	39.49∓2.70bc	35.89∓4.06
75/120 cm paired row planting				
Two rows	11.55∓3.88	22.35∓0.51	34.90∓2.10c	35.92∓4.20
Three rows	7.35 ∓1.52	17.16∓2.42	48.04∓3.38ba	40.83∓1.67
F test	ns	ns	*	ns

Value represents mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

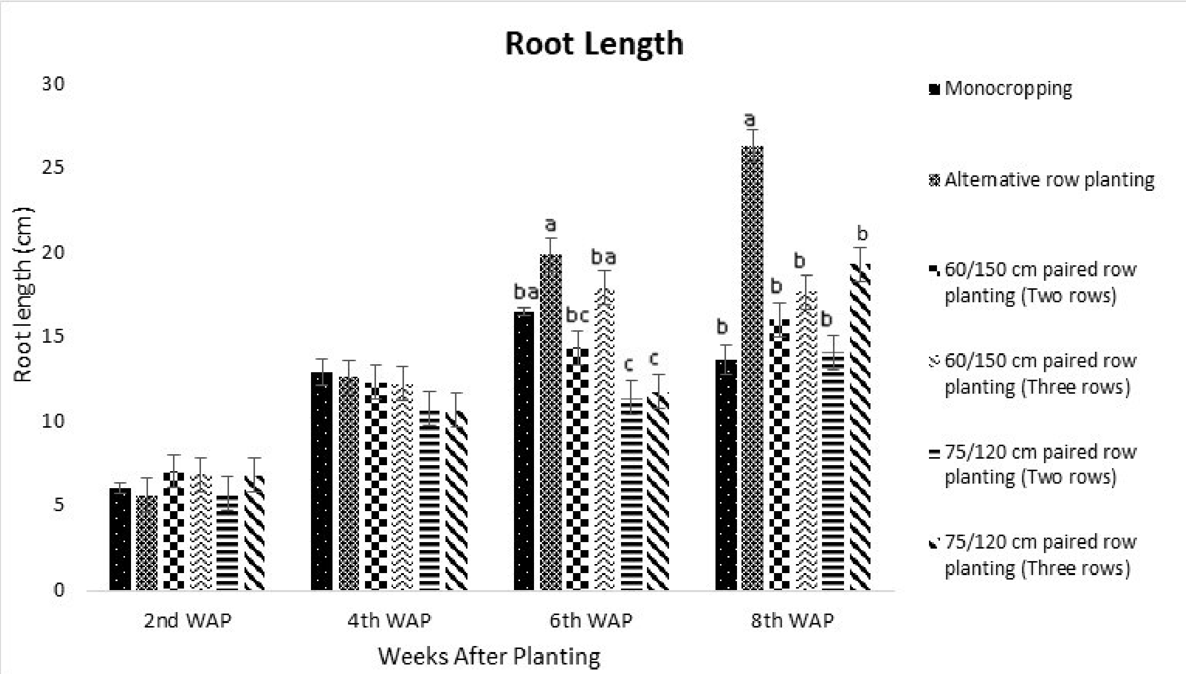

Figure 1: Root length (cm) of cowpea at two weeks interval

Number of branches was not significantly different (P>0.05) with the planting pattern at 4^{th} WAP. There were significant differences (P<0.05) at 6^{th} and 8^{th} WAP. At 4^{th} WAP, there was no shading effect from okra on cowpea. But at 6^{th} and 8^{th} WAP, significant differences (P<0.05) were noted in branching, with different planting pattern may be due to shading effects. Kouyate *et al.* (2012) found that the shading effect of main crop influences the branching habit of cowpea. That may be the reason to have lower number of branches in sole cowpea at 6^{th} WAP, because it limits the light reaching inside the plant because of higher crop cover. Alternative row had maximum value due to the higher spacing than other intercropping treatments as well sole cropping. But at 8^{th} WAP, cowpea plants were at the latter part of the life cycle. So, no vegetative growth was observed. Therefore, in most of the treatments, the numbers of branches were not newly emerged. At 8^{th} WAP, the maximum numbers of branches were observed in alternative row. This may be due to the higher spacing. Zyada (2016) also reported that sole cropping of cowpea had the lowest number of branches per plant and the intercropping system of okra and cowpea in 2:2 ratio had the maximum number of branches per plant.

Leaf area

It was found that the leaf area was significantly different (P<0.01) between treatments at each

Table 2: Number of leaves and branches per plant of cowpea at two weeks interval

	2^{nd} WAP	4^{th} WAP		6^{th} WAP		8^{th} WAP	
Treatment	Leaves	Leaves	Branches	Leaves	Branches	Leaves	Branches
Monocropping	4	7	3	10	4	8	4
Alternative row planting	5	9	5	11	8	11	7
60/150 cm paired row planting							
Two rows	4	8	4	9	5	9	4
Three rows	5	8	6	10	6	10	6
75/120 cm paired row planting							
Two rows	4	8	4	8	3	7	4
Three rows	3	7	5	9	3	7	4
P value	0.132	0.512	0.271	0.009	0.000	0.156	0.017
Chi - square	5.24	4.27	6.38	15.44	29.00	8.00	13.76

Table 3: Leaf area (cm^2) of cowpea at two weeks interval

Treatment	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	169.17∓0.05a	413.70∓0.05c	1084.61∓0.05a	885.48∓0.45b
Alternative row planting	134.56∓0.24b	369.70∓0.24d	945.48∓0.01b	830.37∓2.24b
60/150 cm paired row planting				
Two rows	131.07∓0.25b	490.78∓0.01b	931.08∓0.23b	777.10∓1.24cb
Three rows	171.56∓0.04a	704.68∓0.02a	1209.71∓1.65a	1015.40∓1.01a
75/120 cm paired row planting				
Two rows	125.92∓0.01b	395.35∓0.11dc	630.74∓0.98c	601.35∓0.93c
Three rows	129.74∓0.09b	405.68∓0.08c	828.84∓0.27b	650.35∓1.23c
F test	*	**	*	**

Value represents mean ∓ standard error of four replicates. F test: - *: P<0.05; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

Table 4: LAI of cowpea at two weeks interval

Treatment	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	0.24∓0.01	0.62∓0.01b	1.16∓0.11b	1.04∓0.01b
Alternative row planting	0.31∓0.01	0.50∓0.01d	0.89∓0.11c	0.85∓0.11cb
60/150 cm paired row planting				
Two rows	0.20∓0.02	0.53∓0.11cd	0.68∓0.01dc	0.81∓0.02c
Three rows	0.31∓0.01	0.70∓0.02a	2.47∓0.03a	1.83∓0.01a
75/120 cm paired row planting				
Two rows	0.17∓0.03	0.32∓0.11e	0.58∓0.02dc	0.56∓0.03b
Three rows	0.38∓0.01	0.59∓0.01cb	0.80∓0.01d	0.71∓0.14cd
F test	ns	*	**	**

Value represents mean ∓ standard error of four replicates. F test: - *: P<0.05;**: P<0.01 ns: not significant Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

sampling point (table 3). Observed differences may be due to levels of light interception [Wei, 2016]. Plants with different heights make more use of light when intercropped than monocropped [Herve *et al.*, 2017]. The advantage of increasing leaf area in intercropped plants may be due to the height increase in different levels. At the 8^{th} WAP, mean values in all the treatments decreased because leafs started senescence. But, in 60/150 cm paired rows with three rows of cowpea had the highest value among them, as the senescence rate of that treatment was less because of the shading effect due

Table 5: Leaf dry weight (g) of cowpea at two weeks interval

Treatment	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	0.74∓0.01a	4.58∓0.33a	13.13∓1.59a	4.39∓0.63
Alternative row planting	0.62∓0.03cb	4.05∓0.46a	11.45∓0.54a	5.09∓0.36
60/150 cm paired row planting				
Two rows	0.64∓0.02b	3.27∓0.12bac	4.64∓0.27c	4.05∓0.97
Three rows	0.53∓0.04cd	3.03∓0.02bc	7.76∓0.95b	4.86∓1.17
75/120 cm paired row planting				
Two rows	0.44∓0.00e	3.55∓0.21ba	4.76∓0.44c	3.98∓0.78
Three rows	0.46∓0.00ed	2.61∓0.24c	4.09∓0.29c	3.52∓0.43
F test	*	*	*	ns

Value represents mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

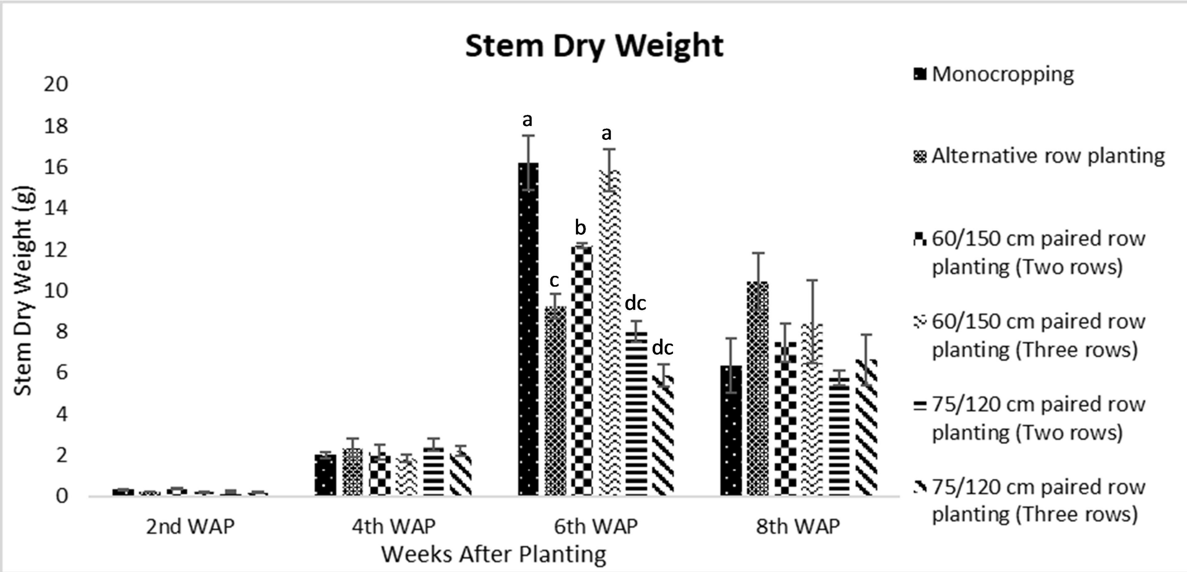

Figure 2: Stem dry weight (g) of cowpea at two weeks interval

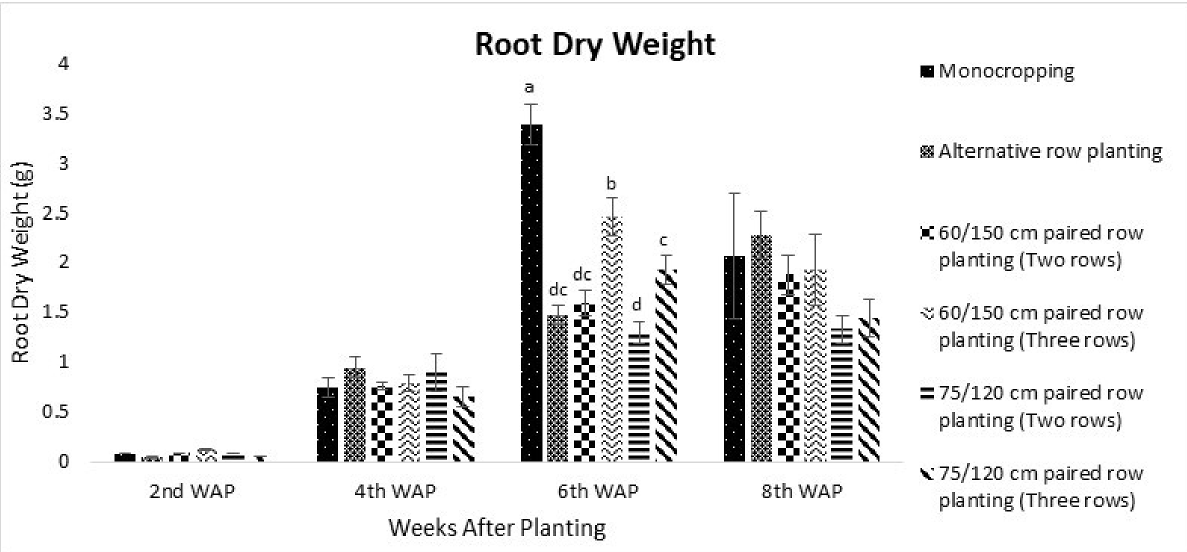

Figure 3: Root dry weight (g) of cowpea at two weeks interval

to crowded nature with higher plant density. Herve *et al.* (2017) reported that leaf area of cowpea was increased when intercropped with maize than sole cropping of cowpea.

Table 6: Number of total nodules per plant at two weeks interval

Treatment	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	40	85	194
Alternative row planting	33	90	200
60/150 cm paired row planting			
Two rows	35	61	116
Three rows	55	89	126
75/120 cm paired row planting			
Two rows	24	53	137
Three rows	25	69	171
P value	0.002	0.000	0.000
Chi - square	19.00	41.00	34.48

Table 7: Number of effective nodules per plant at two weeks interval

Treatment	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	32	93	121
Alternative row planting	22	78	118
60/150 cm paired row planting			
Two rows	28	54	87
Three rows	47	77	109
75/120 cm paired row planting			
Two rows	19	44	78
Three rows	20	54	99
P value	0.007	0.000	0.001
Chi - square	16.00	36.00	22.00

Leaf area index (LAI)

Table 4 shows the LAI of the cowpea in different sampling points. According to that, there is no significant difference (P>0.05) in leaf area index (LAI) of cowpea at 2^{nd} WAP. However, LAI was significantly different (P<0.05) in 4^{th}, 6^{th}, and 8^{th} WAP. The highest value of LAI was attained by a 60/150 cm paired row of okra with three rows of cowpea. At 4^{th}, 6^{th} and 8^{th} WAP, the lowest value was gained by 75/120 cm paired row of okra planting with two rows cowpea.

Higher LAI in 60/150 cm paired row of okra with three rows of cowpea may be due to the higher population of plants that produce a narrow canopy area due to limited spacing. But at 8^{th} WAP, cowpea started senescence. So, LAI may be reduced due to defoliation. Muoneke *et al.* (2012) found that LAI was higher in sole cropping of cowpea than intercropping with maize. Odedina *et al.* (2014) has reported that LAI of cowpea was high in intercropping treatments than sole cropping when cowpea intercropped with okra.

Leaf dry weight

It was found that there was a significant difference (P<0.05) in leaf dry weight at 2^{nd}, 4^{th} and 6^{th} WAP (table 5). Highest mean value of 0.74 g, 4.58 g, and 13.13 g of leaf dry weight was obtained in monocropping at 2^{nd}, 4^{th} and 6^{th} WAP, respectively. Qasim *et al.* (2013) found that dry weight of leaves was high in sole cropping of pea than intercropped with cauliflower. At 6^{th} WAP the difference between monocropping and alternative planting was not significant. Due to the fact that leaf senescence and shedding was lower in sole cropping than intercropping, leaf dry weight was higher in sole cropping than intercropping systems. The reason for this is in intercropping systems, cowpea plants were shaded by okra plants.

Stem dry weight

Stem dry weight was not significantly different (P>0.05) between treatments at 2^{nd}, 4^{th} and 8^{th} WAP. But, a significant difference (P<0.01) was noted in stem dry weight at 6^{th} WAP (figure 2). The maximum mean value was observed in monocropping (16.22 g) which was par with a 60/150 cm paired row of okra with three rows of cowpea (15.85 g). Higher cowpea plant density in monocropping causes higher rate of N_2 fixation and higher light interception causing higher accumulation of dry matter while giving higher stem weight. So, monocropping has a higher shoot dry weight. Mohamed (2007) has reported that intercropping cowpea and sorghum reduces the shoot dry weight of cowpea than sole cropping of cowpea. He also stated that this may be due to the shading effect from the other plant than cowpea.

Dry weight of root

It was found that, there is no significant difference (P>0.05) of root dry weight between

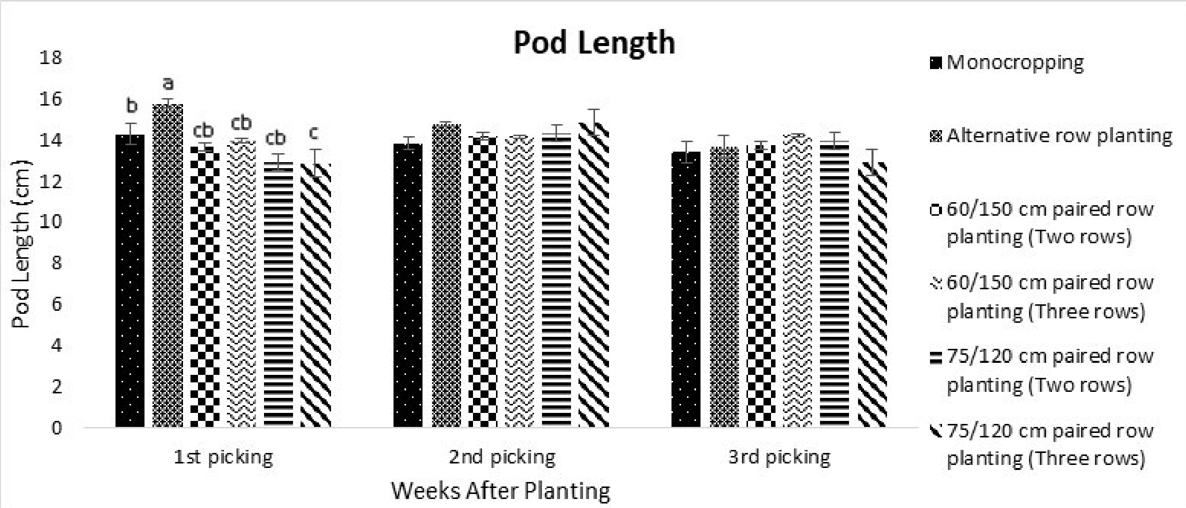

Figure 4: Pod length (cm) of cowpea at each picking

Table 8: Dry weight of effective nodules (g) at two weeks interval

Treatment	4^{th} WAP	6^{th} WAP	8^{th} WAP
Monocropping	0.08∓0.02b	0.12∓0.06c	0.50∓0.02b
Alternative row planting	0.07∓0.005b	0.34∓0.04b	0.62∓0.03a
60/150 cm paired row planting			
Two rows	0.08∓0.003b	0.11∓0.05c	0.44∓0.03b
Three rows	0.18∓0.06a	0.59∓0.04a	0.66∓0.02a
75/120 cm paired row planting			
Two rows	0.02∓0.006b	0.07∓0.005c	0.40∓0.02b
Three rows	0.03∓0.008b	0.32∓0.08b	0.51∓0.06b
F test	*	*	*

Value represent mean ∓ standard error of four replicates. F test: - *: P<0.05; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

treatments at 2^{nd}, 4^{th}, and 8^{th} WAP. Significant differences (P<0.05) was observed only at 6^{th} WAP (figure 3). At 6^{th} WAP, the maximum value was gained by monocropping (3.39 g) while minimum of 1.30 g was recorded in 75/120 cm paired row of okra with two rows of cowpea. This may be due to the higher absorption and accumulation of nutrients due to less competition between species in monocropping. Mohamed (2007) stated that root dry weight was higher in sole cropping than intercropping with sorghum. Oliveira *et al.* (2017) stated that root dry weight of cowpea is not significantly affected, when cowpea intercropped with millet.

Number of total nodules per plant

It was observed that there was a significant difference (P<0.01) in total number of nodules per plant at each WAP (table 6). Njira *et al.* (2017) reported that number of nodules in pigeon pea was reduced when intercropped with cowpea. Further, Njira *et al.* (2017) noted that, this may be due to the competition for resources when intercropping legume - legume or legume - cereals. Number of nodules increased with increasing row spacing [Banik *et al.*, 2006]. That may be the reason for increasing nodule number in the alternative row. Higher number of nodules may also be due to the facilitative interaction of intercropping [Banik *et al.*, 2006].

Number of effective nodules per plant

Effective nodules are the sites of symbiotic nitrogen fixation. It was found that the number of effective nodules was significantly different (P<0.01) at each weekly interval at 5% significance

Table 9: Days for 50% and 100% flowering in cowpea

Treatment	Days for 50% flowering	Days for 100% flowering
Monocropping	32	39
Alternative row planting	36	44
60/150 cm paired row planting		
Two rows	42	43
Three rows	38	44
75/120 cm paired row planting		
Two rows	43	48
Three rows	44	50
P value	0.003	0.075
Chi - square	18.00	10.00

Table 10: Number of pods of cowpea per plant at each picking

Treatment	1^{st} picking	2^{nd} picking	3^{rd} picking
Monocropping	4	6	5
Alternative row planting	5	7	6
60/150 cm paired row planting			
Two rows	3	5	3
Three rows	4	6	4
75/120 cm paired row planting			
Two rows	3	4	3
Three rows	2	5	2
P value	0.000	0.017	0.000
Chi - square	28.53	13.82	29.22

level (table 7). At 4^{th} WAP, highest number of effective nodules was observed in 60/150 cm paired row of okra with three rows of cowpea. But at 6^{th} and 8^{th} WAP, the highest number of effective nodules was observed in monocropping. Higher number of effective nodules under intercropping system over sole cropping of legume shows that more atmospheric nitrogen fixation in the crop mixture [Banik *et al.*, 2006]. With support to the present experiment, Kouyate *et al.*, (2012) found that number of effective nodules of cowpea was high in sole cropping than the intercropping with millet. Number of effective nodules was high in haricot beans, when intercropped with maize in 1:1 ratio, than sole cropping of haricot bean [Abuna, 2015].

Dry weight of effective nodules

There were significant differences ($P<0.05$) in dry weight of nodules per plant recorded at 4^{th}, 6^{th} and 8^{th} WAP (table 8). Highest dry weight was observed in 60/150 cm paired row of okra with three row cowpea at each week interval. Minimum weight was observed in 75/120 cm paired row of okra with two rows cowpea. This may be due to that when plant density increased, amount of atmospheric N_2 may limit and it has a partitioning between all the plants and sole portion per plant will be low. But when plant density decreased, amount of atmospheric N_2 may not limit for a small portion as such. And also, the microbial population will be high in low plant density. Kouyate *et al.* (2012) also cited that, increase in dry weight of nodules could be attributed with the different plant densities. Intercropping treatments with lower plant densities showed the highest dry weight of nodules in mungbean when intercropped with sugarcane [Singh *et al.*, 2014]. Dry weight of nodules was high in sole cropping than intercropping, when cowpea intercropped with maize [Muoneke *et al.*, 2012]. Dry weight of nodules was high when cowpea intercropped with millet in 1:2 ratio of cowpea: millet than sole cropping [Kouyate *et al.*, 2012].

Days to 50% and 100% flowering

There was a significant difference ($P<0.05$) between treatments on days to 50% flowering. However, the effect of treatment on days to 100% flowering was not significant (table 9). Monocropping showed early 50% flowering at 32 days. Varying degrees of shading of cowpea by taller plants in intercropping combination, especially at later stages of growth could be responsible for the differences in days to 50% flowering in cowpea [Obedoni, 2005]. Ronald (2014) investigated that 50% flowering increased with the increase in plant density. This may be the reason for the shortening of time duration for 50% flowering in sole cropping of cowpea as the row spacing was reduced and number of plants was increased. Muoneke *et al.* (2007) reported that 50% flowering of soybean was not different whether it is grown in sole or intercropped with maize.

Table 11: Weight per pod (g) of cowpea at each picking

Treatment	1^{st} picking	2^{nd} picking	3^{rd} picking
Monocropping	1.50∓0.04b	1.44∓0.09b	1.58∓0.08
Alternative row planting	1.53∓0.08b	1.71∓0.07ba	1.50∓0.09
60/150 cm paired row planting			
Two rows	1.51∓0.08b	1.59∓0.06b	1.53∓0.05
Three rows	1.51∓0.02b	1.57∓0.14b	1.53∓0.06
75/120 cm paired row planting			
Two rows	1.42∓0.03b	1.79∓0.25ba	1.49∓0.07
Three rows	1.72∓0.07a	2.03∓0.09a	1.62∓0.06
F test	*	*	ns

Value represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

Table 12: Number of seeds of cowpea per pod at each picking

Treatment	1^{st} picking	2^{nd} picking	3^{rd} picking
Monocropping	10	10	12
Alternative row planting	13	13	14
60/150 cm paired row planting			
Two rows	11	10	10
Three rows	12	11	11
75/120 cm paired row planting			
Two rows	10	10	10
Three rows	10	10	10
P value	0.634	0.849	0.156
Chi - square	3.43	2.00	8.00

Number of pods per plant

There was a significant effect (P<0.05) of cropping system on number of pods per plant of cowpea (table 10). Ronald (2014) found that when plant density is high, those plants produce a fewer number of pods per plant. That may be the reason to produce a higher number of pods by alternative row, which was with wider row arrangement. Obedoni *et al.* (2005) stated that, number of cowpea pods were high in intercropped cowpea with tomato, than sole cowpea cultivation. At the 3^{rd} picking, the number pods per plant has reduced to a greater extent, because cowpea plants started senescence. In contrast, Alhassan *et al.* (2012) stated that the number of pods per plant was higher in sole cropping than intercropping with Bambara groundnut.

Pod length

Figure 4 show the average pod length of cowpea at each picking. According to that, the pod length was significantly different (P<0.05) at 1^{st} picking. But there were no significant differences (P>0.05) were recorded at 2^{nd} and 3^{rd}picking. At 1^{st} picking, the highest pod length of cowpea was observed in an alternative row (15.79cm) and lowest was observed in 75/120 cm paired row of okra with three rows of cowpea (12.89cm). Monocropping was not significantly different with 60/150 cm paired rows of okra with two and three rows of cowpea and 75/120 paired rows of okra with three rows of cowpea. The increase in pod length of cowpea in alternative row may be due to more accumulation of dry matter with the increase spacing and light penetration with reduction of plant density compared to sole cropping. Least populated plots may have produced broader leaves which translated into higher pod length. Reducing plant density can increase the width of leaves [Muoneke *et al.*, 2012]. With synchronization to the results, Muoneke *et al.* (2012) stated that higher lengths of cowpea pods can be obtained in cropping systems with least plant population.

Weight per pod of cowpea

The weight per pod was significantly different (P<0.05) in 1^{st} picking and 2^{nd} picking. There was no significant variation in the weight per pod at 3^{rd} picking (table 11). At 1^{st} and 2^{nd} picking, the maximum value per pod of cowpea was obtained

Table 13: Total pod yield (t/ha) of cowpea at each picking

Treatment	1^{st} picking	2^{nd} picking	3^{rd} picking
Monocropping	1.59∓0.18a	2.99∓0.48a	2.03∓0.20a
Alternative row planting	1.55∓0.66a	2.22∓0.29ba	1.87∓0.19ba
60/150 cm paired row planting			
Two rows	1.01∓0.19b	1.77∓0.12b	1.00∓0.22dc
Three rows	1.26∓0.15ba	2.26∓0.39ba	1.39∓0.06bc
75/120 cm paired row planting			
Two rows	0.88∓0.04b	1.79∓0.28b	1.03∓0.13dc
Three rows	0.86∓0.14b	2.19∓0.24ba	0.83∓0.09d
F test	*	Ns	**

Value represent mean ∓ standard error of four replicates. F test: - *: P<0.05;**: P<0.01 ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

Table 14: Sun dried weight of 100 seeds (g) of cowpea at each picking

Treatment	1^{st} picking	2^{nd} picking	3^{rd} picking
Monocropping	9.54∓0.42b	12.93∓0.78d	11.49∓0.49c
Alternative row planting	10.58∓0.74b	13.97∓0.23dc	12.53∓0.29cb
60/150 cm paired row planting			
Two rows	10.88∓1.02b	14.77∓0.01bc	13.33∓0.57b
Three rows	10.32∓0.53b	13.96∓0.11dc	12.52∓0.2cb
75/120 cm paired row planting			
Two rows	12.54∓0.13a	15.68∓0.28ba	14.49∓0.57a
Three rows	12.86∓0.24a	16.06∓0.66a	14.81∓0.31a
F test	**	**	*

Value represents mean ∓ standard error of four replicates. F test: - *: P<0.05; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncans Multiple Range Test at 5% level.

in 75/120 cm paired row of okra with three row of cowpea. This may be due to more accumulation of dry matter in the available limited number of pods causing higher dry weight of 100 seeds.

Number of seeds per pod

There was no significant influence (P>0.05) of planting system on number of seeds per pod (table 12). Legwaila *et al.* (2012) stated that there is no significant difference (P>0.05) in the number of seeds per pod in cowpea when intercropped with maize. Ronald (2014) reported that there was a significant difference in number of seeds per pod under 1 row Maize: 1 row cowpea intercropping pattern and sole cropping systems. Abuna (2015) found results that were supportive to the results of the present experiment that there was no significant difference in the number of seeds per pod of haricot bean, when intercropped with maize.

Total pod yield/picking

It was resulted that, there was significant variation among treatments in 1^{st} picking (P<0.05) and 3^{rd} picking (P<0.01). But there was no significant difference (P>0.05) in 2^{nd}picking was recorded is shown in table 13. At 1^{st} picking, the highest mean value was observed in monocropping (1.59t/ha) and the least mean value was observed in 75/120 cm paired row of okra with three rows cowpea (0.86t/ha). At the 3^{rd} picking, the highest mean value of 2.03t/ha was observed in the sole cropping of cowpea followed by alternative row (1.87t/ha). Least value was observed in 75/120 cm paired row of okra with three row cowpea (0.83t/ha). Zyada (2016) cited that yield of cowpea decreased with the intercropping treatments with okra and highest was given by sole cropping. This may be due to the reduction of competition by two different species. Zyada (2016) has also confirmed the same idea. Quite similar results were obtained by Choudhuri (2011) confirming the results of the present study. He cited as sole cowpea cultivation gave the maximum yield and minimum reduction of yield of cowpea was observed in okra and cowpea intercropping system in between okra planted in 50 × 50 cm compared to other treatments. This may be due to the symbiotic relationship between okra and cowpea.

Dried weight of 100 seeds

Table 14 shows the weight of 100 seeds after sun dried (10/hours/days). It was significantly different ($P<0.05$) from treatments at each picking. The maximum value was observed in a 75/120 cm paired row of okra with three row cowpea, without any significant difference with the same paired row with two row cowpea. Minimum value was observed in monocropping at each picking. This may be due to the quiet higher pod yield in monocropping. So, the maximum amount of photosynthates accumulate in the available seeds. Highest value for 100 seed weight was obtained by 75/120 cm paired row of okra with three rows of cowpea. This was because, in 75/120 cm paired row of okra with three rows of cowpea there was the minimum number of pods (table 10) and minimum number of seeds per pod (table 12). So, the available photosynthates are distributed among the available a few numbers of seeds. Alternative row and 60/150 cm paired row of okra with two and three rows cowpea were not significantly different. Odedina *et al.* (2014) also reported that 100 seed weight of cowpea is higher in intercropping systems of okra and cowpea than mono-cropping of cowpea. And, their findings were supportive to the above results as the 100 seed weight was high in less pod weight. Similarly, Legwaila *et al.* (2012) stated that 100 seed weight of cowpea was not significantly affected under the intercropping system of maize and cowpea.

Conclusion

The present study revealed that plant height, root length, number of leaves and branches and pod length were superior in alternative row. Leaf area, leaf area index, dry weight of effective nodules was high in 60/150 cm paired row of okra with three rows of cowpea. Number of effective nodules was higher in monocropping at 6^{th} and 8^{th} WAP. 50% flowering showed significant difference ($P<0.05$) while giving superior in monocropping. Seeds per pod were not significantly different ($P>0.05$) between plating patterns. Monocropping showed higher pod yield, followed by alternative row and 60/150 cm paired row of okra with three row cowpea. Weight per pod and sun dried weight of 100 seeds was higher in 75/120 cm paired rows of okra with three row cowpea. According to this study, when considering the growth and yield, it can be suggested that among the all tested treatments, 60/150 cm paired row planting of okra with three rows of cowpea in between paired rows would be the most suitable planting system for sandy regosol when compared with other tested treatments.

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