Growth and Dry Matter Accumulation of Okra (*Abelmoschus esculentus* L.) as Influenced by Different Planting Pattern under Okra - Cowpea (*Vigna unguiculata* L.) Intercropping

A.K.M.R.B. Maduwanthi^a and Brintha Karunarathna^{*,b}

Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka

^aakmnishal@gmail.com, ^bilbrintha@yahoo.co.in

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Abstract. Compared to sole cropping, intercropping efficiently use the existing resources which ultimately lead to improved plant growth and dry matter accumulation. Economically sustainable intercropping system mainly depends on adaptation of planting pattern and selection of compatible crops. The experiment was carried out at the Crop Farm of Eastern University, Sri Lanka in 2018 to investigate the growth and dry matter accumulation in okra (*Abelmoschus esculentus* L.) as influenced by different planting patterns under okra-cowpea (*Vigna unguiculata* L. Walp) intercropping in sandy regosol. The experiment was laid out in a Randomized Complete Block Design (RCBD). Treatments were okra as a sole crop (T1), cowpea as a sole crop (T2), alternative planting of okra and cowpea (T3), 60/150 cm paired row planting of okra with two rows and three rows of cowpea in between paired rows (T4 and T5) and 75/120 cm paired row planting of okra with two rows and three rows of cowpea in between paired rows (T6 and T7). Plant height, root length, fresh and dry weights of plant, leaf area, leaf area index, canopy width and cumulative yield of okra were higher in T5, while chlorophyll content showed no significant difference ($P>0.05$) with different planting patterns. The present study concluded that 60/150 cm paired row planting of okra with three rows of cowpea in between paired rows (T5) would be the most suitable planting system in sandy regosol to achieve better growth and dry matter in okra.

Introduction

Okra (*Abelmoschus esculentus* L.) is one of the most economically important vegetable crops belonging to the family *Malvaceae*. It provides essential nutrients for human. Eastern region in Sri Lanka is a warm region and much suitable for the growth and development of okra. However, low yield resulting from poor nutrient status of the soil has been identified as one of the major factors limiting okra production [1]. Also Nitrogen and Phosphorus are most required important elements in fruit, seed and quality development of okra [2].

With the continual increase of the world population, the increase in food production should be taken into consideration in a comprehensive manner. As well, urbanization may cause to limit the agricultural processes by reducing the land area for cultivation. Therefore, at present most farmers in developing countries used to increase the crop yield and food production by increasing production per unit land area. Intercropping with legumes is the most appropriate for suggesting as a solution for all these problems.

Intercropping is the cultivation of two or more crops simultaneously in the same land that provides the possibility of yield benefit in accordance with sole cropping [3]. Intercropping can be performed with different planting patterns, while facilitating the use of environmental resources such as light, moisture and space efficiently to accumulate more dry matter and enhance the growth. Intercropping systems mostly influence to efficient use of soil nitrogen [4]. In this system, one of the crops would be a legume that has the ability to fix atmospheric nitrogen. Intercropping okra with cowpea (*Vigna unguiculata* L.) can improve N-use efficiency because the two crops use different N-pools and cowpea can release biologically fixed N to okra. Thus, okra need less N to produce its best yield. Absorption of mineral N by the non-legume reduces soil N pool, thus stimulating N₂ fixation

by legume [5]. As well, in intercropping systems, more efficient utilization of growth resources may lead to yield advantages and increased stability compared to sole cropping [6].

Intercropping okra with several crops has been reported by several scientists, but there seem to be no sufficient information on growth and dry matter accumulation of okra as influenced by okra - cowpea intercropping studies in Sri Lanka. Therefore, this study was aimed to investigate the growth and dry matter accumulation of okra as influenced by different planting patterns under okra-cowpea intercropping in sandy regosol.

Methodology

Experimental site and climate

The field experiment was conducted at the crop farm, Eastern University, Sri Lanka, in 2018 to investigate the growth and dry matter accumulation of okra as influenced by different planting patterns under okra-cowpea intercropping in sandy regosol. Experimental location is located in the latitude of $7^{\circ} 43'$ and the longitude of $81^{\circ} 42'E$. It belongs to the agro ecological region of low country dry zone in Sri Lanka. The mean annual rainfall of the crop farm ranges from 1400 mm to 1680 mm and temperature varies from $30^{\circ} C$ to $32^{\circ} C$. The soil type in the experimental site is sandy regosol. The proceeding crop in the experimental site was knol khol.

Experimental design and treatments

This experiment was carried out using Randomized Complete Block Design (RCBD) with seven treatments. T1: Okra as a sole crop with the spacing of $90\text{ cm} \times 90\text{ cm}$ (Fig. 1), T2: Cowpea as a sole crop with the spacing of $30\text{ cm} \times 15\text{ cm}$ (Fig. 2), T3: Alternative planting of okra and cowpea (Fig. 3), T4: 60/150 cm paired row planting of okra with two rows of cowpea in between paired rows (Fig. 4), T5: 60/150 cm paired row planting of okra and three rows of cowpea in between paired rows (Fig. 5), T6: 75/120 cm paired row planting of okra and two rows of cowpea in between paired rows (Fig. 6), T7: 75/120 cm paired row planting of okra and three rows of cowpea in between paired rows (Fig. 7).

Figure 1: Sole okra with spacing 90 cm X 60 cm

Figure 2: Sole cowpea with spacing 30 cm X 15 cm

Figure 3: Alternative planting of okra and cowpea

Figure 4: 60/150 cm paired row planting of okra with two rows of cowpea in between paired rows

Figure 5: 60/150 cm paired row planting of okra and three rows of cowpea in between paired rows

Figure 6: 75/120 cm paired row planting of okra and two rows of cowpea in between paired rows

Figure 7: 75/120 cm paired row planting of okra and three rows of cowpea in between paired rows

Varieties used as planting materials

Okra variety *Haritha* and cowpea variety *Waruni* were used as planting materials and the seeds were collected from the seed processing unit of Eastern University, Sri Lanka. Okra seeds were soaked overnight before planting. Okra variety *Haritha* bear medium sized dark green fruits which is suitable for all agro climatic region of Sri Lanka. Its stem has strong anthocyanin pigmentation and *Haritha* is tolerant to Yellow Vein Mosaic Virus. Cowpea variety *Waruni* exhibits erect and determinate growth while flowering in about 40 days after planting. It bears long dark green pods. Seeds are medium in size and reddish brown. It gives an average yield 1650kg/ha.

Field establishment

Land was harrowed and levelled. Cow dung and basal fertilizers were mixed to the land before planting as per recommendation of Department of Agriculture, Sri Lanka. Size of each plot was 4 m × 3 m. Each treatment replicated four times. The total number of plots was 28. A spacing of 0.5 m separated the plot from each other and a space of 1 m wide separated the blocks from each other. 3-4 seeds were planted per one hill. Number of plants per each plot was 28.

Data collection

Three stands of okra were selected from each plot at each time. Data were collected by destructive sampling method. Data collection was commenced two weeks after planting and continued at two weeks interval. Growth parameters such as plant height, root length, number of leaves and branches, leaf area, leaf area index, fresh and dry weights of total plant, shoot, leaves and root and yield parameters such as cumulative yield and 100 seed weight of sun dried seeds were taken. Area Harvest Equivalent Ratio (AHER) was calculated as a productivity index by using the following Equation derived by [7].

$$AHER = \frac{Oyi}{n.Oys} + \frac{Cyi}{n.Cys}$$

where Oyi and Cyi = Yield of okra and cowpea in intercropping; Oys and Cys = Yield of okra and cowpea in sole cropping; n = number of harvest.

Statistical analysis

Statistical software such as SAS and Minitab were used for data analysis. Parametric and non-parametric analysis were done depend on type of data.

Results and Discussion

Plant height

There was no significant difference ($P>0.05$) in plant height at 2nd and 4th week after planting (WAP). But, a significant difference ($P<0.05$) was noted at 6th and 8th WAP is shown in Fig. 8. Tallest okra plant was recorded in T5 (47.54 cm), while shortest plant were recorded in T1 (29.54 cm) at 6th WAP. Average plant height ranged from 51.69 cm (T5) to 39.16 cm (T1) at 8th WAP. There was no significant difference ($P>0.05$) in plant height among T3, T4, T6 and T7. Okra in intercropping has a chance to get more nitrogen for the growth, as nitrogen is much essential for the vegetative growth may be the reason for taller plant in intercropping compared with monocropping. Plant height of okra was high in intercropping with cowpea than in sole cropping [8]. In contrast, [9] revealed that plant height of sole cropping of okra gave higher values than intercropping. Spacing between rows in paired was narrower than monocropping may be the reason for taller plant in intercropping to utilize the solar radiation effectively. This result is agreeable with [10] that plant height of okra increased with the reduction of row spacing in intercropping with groundnut. Similar finding was cited by [11] that, superior plant heights of okra were produced in intercropping systems with maize over sole cropping of okra.

Figure 8: Plant height (cm) of okra at two week interval

Root length

There were no significant differences ($P>0.05$) in root length at 2nd and 4th WAP. However, significant differences ($P<0.05$) were obtained in 6th week and 8th WAP is shown in Table 1. Longest root of 17.04 cm were obtained in T5, while shortest of 11.21 cm was noted in T7 at 6th WAP. But at 8th WAP longest roots were recorded in T1 (23.71 cm). These results are in line with the work of [9] that root length of okra was high in sole cropping than in intercropped with cowpea. On the other hand, [8] noted that, root length was high in okra cowpea intercropping in 1:1 than sole cropping.

Table 1: Root length (cm) of okra at two week interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	8.40 $\pm$ 1.48	9.04 $\pm$ 1.28	14.46 $\pm$ 1.35b	23.71 $\pm$ 1.19a
T3	4.90 $\pm$ 0.57	10.65 $\pm$ 0.57	11.74 $\pm$ 0.88cd	13.96 $\pm$ 0.45c
T4	6.65 $\pm$ 0.50	9.46 $\pm$ 0.30	13.18 $\pm$ 0.54bc	15.24 $\pm$ 1.14bc
T5	6.75 $\pm$ 0.25	10.76 $\pm$ 0.50	17.04 $\pm$ 1.30a	19.56 $\pm$ 1.21b
T6	6.65 $\pm$ 0.01	8.63 $\pm$ 0.61	12.32 $\pm$ 0.37bc	15.09 $\pm$ 0.58c
T7	7.20 $\pm$ 0.14	11.14 $\pm$ 0.86	11.21 $\pm$ 0.84cd	15.81 $\pm$ 1.26bc
F test	ns	ns	*	*

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Number of leaves per plant

There was no significant difference ($P>0.05$) among tested treatments in number of leaves at 2nd and 4th WAP was confirmed with P values of 0.156, and 0.323 and chi square values of 8.00 and 5.83 is shown in Table 2. Recorded number of leaves per plant at weekly interval suggest that differences of cropping system which have been significantly affected the number of leaves at 6th and 8th weeks after planting is confirmed with P values of 0.004, 0.000 and chi square values of 17.02, 29.21. More number of leaves per plant was noted in T1 at 6th (14) and 8th (16) WAP compared to intercropping. These results are in agreement with [12] who stated that the number of leaves per plant is higher in sole cropping of okra than intercropping with cowpea. Wider spacing helps the okra to utilize its energy properly in the production of leaves because there was less competition for light, nutrients nor was overlapping from adjacent okra plants within the row may be the reason for higher

number of leaf in monocropping. Similar findings were reported by [13] that, number of leaves per plant of okra is high in sole cropping than intercropping treatments with cowpea. But in contrast, [11] cited that, the number of leaves per plant of okra increased with intercropping with maize than sole cropping of okra.

Table 2: Number of leaves per okra plant at two week interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	4	8	14	16
T3	3	7	8	9
T4	3	7	9	10
T5	4	7	12	15
T6	3	6	10	12
T7	3	6	10	10
P value	0.156	0.323	0.004	0.000
Chi – square	8.00	5.83	17.02	29.21

Number of branches per plant

There were significant differences ($P < 0.05$) in number of branches per plant with different planting patterns at 4th, 6th and 8th WAP is confirmed with P values of 0.022, 0.009 and 0.000 with Chi square values of 13.13, 15.38 and 23.31 respectively is shown in Table 3. The higher number of branches was observed in T1 may be due to the free and wider spacing between planting rows compared with other tested treatments. So, okra plants used energy properly and produced higher number of branches per plant. Overlapping effect from adjacent plants was reduced in monocropping [14] and plants produced branches freely and properly without any restriction, by utilizing the plant's energy well. The number of branches were high in intercropping treatments than sole cropping of okra, when maize planted four weeks after planting of okra [15]. The finding is not agreeable with present study.

Table 3: Number of branches per okra plant at two week interval

Treatment	4 th WAP	6 th WAP	8 th WAP
T1	2	5	6
T3	0	2	3
T4	1	2	3
T5	2	4	5
T6	1	3	4
T7	0	2	3
P value	0.022	0.009	0.000
Chi – square	13.13	15.38	23.31

Leaf area

It was investigated that, leaf area was significantly different ($P < 0.05$) among treatments at each weekly interval (Table 4). At each weekly interval, leaf area was highest in T5. Minimum leaf area was noted in T7 at 2nd and 4th WAP while it was in T6 at 8th WAP. Light interception percentage is high in intercropping than sole cropping [16]. It explains that, reduced spacing between plants enhances the light interception. That may be the reason for the increase of leaf area in T5 compared

with T1. The leaf area was high in intercropped okra plants with maize than monocropping of okra [17]. In contrast, leaf area of okra was reduced when intercropping with sweet potato [18]. Higher leaf area values were obtained in sole cropping than intercropping of okra with cowpea [13].

Table 4: Leaf area (cm²) of okra at two weeks interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	119.23 $\pm$ 0.02b	278.11 $\pm$ 0.26b	970.12 $\pm$ 0.89b	1952.90 $\pm$ 0.47b
T3	85.98 $\pm$ 0.25c	200.83 $\pm$ 0.02c	368.19 $\pm$ 0.23d	802.60 $\pm$ 1.25d
T4	85.53 $\pm$ 0.34c	157.05 $\pm$ 0.75d	510.55 $\pm$ 0.65c	1109.67 $\pm$ 0.89c
T5	148.18 $\pm$ 0.01a	326.86 $\pm$ 0.05a	1034.33 $\pm$ 0.04a	2228.10 $\pm$ 0.24a
T6	87.78 $\pm$ 0.07c	134.51 $\pm$ 0.46e	395.63 $\pm$ 0.08d	877.22 $\pm$ 0.14d
T7	73.72 $\pm$ 0.53d	168.06 $\pm$ 0.06d	281.22 $\pm$ 0.59e	595.29 $\pm$ 0.75e
F test	*	*	*	*

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Leaf Area Index (LAI)

There was a significant difference (P<0.05) in LAI at each two weeks interval (Table 5). Leaf area index (LAI) was found to be high in T5 at each weekly interval. At 2nd and 4th WAP, least value was found in T4 and T6 respectively while at 6th and 8th WAP, lowest leaf area index was found in T6. Leaf area index is an important parameter in plant growth as leaves are the most important aspect in photosynthesis. The increase in LAI in intercropping than sole cropping was due to the increase of plant population [19]. Higher plant population may produce a narrow canopy due to reduced space and intercept more light, without letting them to penetrate to the soil may be reason in the present study.

Table 5: Leaf area index (LAI) of okra at two weeks interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	0.79 $\pm$ 0.07b	1.12 $\pm$ 0.08ba	1.92 $\pm$ 0.03b	2.84 $\pm$ 0.21b
T3	0.71 $\pm$ 0.07cb	1.13 $\pm$ 0.05ba	1.74 $\pm$ 0.01b	2.84 $\pm$ 0.06b
T4	0.41 $\pm$ 0.06c	0.89 $\pm$ 0.07c	1.33 $\pm$ 0.08c	2.01 $\pm$ 0.05c
T5	1.44 $\pm$ 0.21a	1.29 $\pm$ 0.06a	2.16 $\pm$ 0.01a	3.29 $\pm$ 0.05a
T6	0.56 $\pm$ 0.05cb	0.82 $\pm$ 0.04c	1.13 $\pm$ 0.04d	1.68 $\pm$ 0.08c
T7	0.47 $\pm$ 0.01cb	0.97 $\pm$ 0.07bc	1.39 $\pm$ 0.05c	1.77 $\pm$ 0.01c
F test	*	*	**	*

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Chlorophyll content

Chlorophyll can be identified as one of the most important biochemical parameters of plants and indicate plants' nutritional stress, photosynthetic capacity and the health status of plants. Therefore, it is an important parameter used for ecosystem productivity estimation [20]. It was found that there was no any significant difference (P>0.05) in chlorophyll content among treatments at each weekly interval (Fig. 9). Chlorophyll content vary with different factors such as sunlight, climatic factors such as salt stress, soil type, elements like nitrogen and phosphorus, temperature, water content of leaves and some enzymatic reactions [21, 22]. In the present study, the reason for not

significant difference may be because of not having any affect from those factors. Chlorophyll content (SPAD value) of sole potato was higher than the potato and mustard intercropping treatment [9].

Figure 9: Chlorophyll content (SPAD) of okra at two weeks interval

Canopy width

It was observed that canopy width was not significantly different ($P>0.05$) except at 6th WAP (Fig. 10). At 6th WAP, canopy width was highest in T5 and lowest in T7. There was no significant difference ($P>0.05$) among the treatment except T5 at 6th WAP. Canopy width increase in a linear manner with the increase of height [23] when height increase and due to the need of higher photosynthetic rate, light interception was high and this may cause the development of a higher canopy width in T5 at 6th WAP.

Figure 10: Canopy width (cm) of okra at two weeks interval

Fresh weight of plant

There were no significant differences ($P>0.05$) at 2nd, 4th WAP is shown in Fig. 11. There was significant difference ($P<0.05$) in 6th and 8th WAP. At 6th weeks after planting maximum plant weight was observed in T5 (109.64g) and minimum was observed in T7 (50.91g). While at 8th WAP, maximum plant fresh weight of okra plant was observed in T5 (122.51g) and minimum was obtained in T7 (70.13g). At 6th WAP, the variation may be due to production of higher yield due to higher light interception by taller plants of okra and due to lower soil and air heat because of reduced spacing. Higher plant density reduces soil and air heat [24]. Because lower soil and air heat reduced the water evaporation from soil and plant.

Figure 11: Fresh weight (g) of total plant of okra at two week interval

Fresh weight of leaves

There was significant different ($P < 0.01$) at 6th and 8th WAP is shown in Table 6. Average leaf fresh weight is varies from 18.74g (T3 and T4) to 42.19g (T1) and 20.06g (T7) to 43.77g (T1) at 6th and 8th WAP respectively. This may be resulted from the higher number of leaves per plant in T1. Fresh weight of leaves of cauliflower was higher in sole cropping of cauliflower than intercropping with pea [25].

Table 6: Fresh weight (g) of okra leaves at two week interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	3.55 $\pm$ 0.66	7.91 $\pm$ 1.25	42.19 $\pm$ 7.07a	43.77 $\pm$ 12.48a
T3	1.96 $\pm$ 0.53	7.42 $\pm$ 1.10	18.74 $\pm$ 2.91b	24.43 $\pm$ 4.80b
T4	2.09 $\pm$ 0.20	8.28 $\pm$ 1.27	18.74 $\pm$ 1.46b	29.85 $\pm$ 4.72b
T5	2.52 $\pm$ 0.30	9.98 $\pm$ 2.09	34.73 $\pm$ 4.10a	41.08 $\pm$ 10.60a
T6	2.23 $\pm$ 0.42	6.71 $\pm$ 1.07	21.18 $\pm$ 7.07b	29.68 $\pm$ 1.65b
T7	3.14 $\pm$ 0.17	5.17 $\pm$ 0.87	18.75 $\pm$ 5.74b	20.06 $\pm$ 2.57b
F test	ns	ns	**	**

Value represent mean $\pm$ standard error of four replicates.

F test: - **: $P < 0.01$; ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Fresh weight of stem

Fig. 12 showed that there was no significant difference ($P > 0.05$) at 2nd and 4th WAP and significant difference ($P < 0.05$) was observed at 6th and 8th WAP. The maximum stem weight at 6th WAP was obtained in T5 (52.45g) and the minimum value was obtained in T7 (21.23g). At 8th WAP, maximum value was found in T5 (63.46g) followed by T6 (42.33g). There were no significant differences ($P > 0.05$) between T1, T5 and T6. Heat penetration to the soil may be also low to the treatment T5, due to the low spacing with higher plant density and it leads to low water evaporation from the soil. It may cause for the higher absorption of water from soil. In contradictory, stem fresh weight was high in intercropped okra with cowpea than sole cropping of okra [9].

Figure 12: Fresh weight (g) of okra stem at two week interval

Fresh weight of root

The results revealed that there were no significant differences ($P > 0.05$) at 2nd and 4th WAP. But there was a significant difference ($P < 0.05$) at 6th and 8th WAP is shown in Fig. 13. At 6th week of planting, the highest fresh weight of root was obtained by T5 (12.72g) was par with T1 (8.45g). Minimum was obtained with T4 (5.16g) and it was not significantly differ from T3, T6 and T7. At 8th WAP, highest value was found in T5 (16.96g) and minimum value in T7 (6.97g). Higher moisture content in soil may cause higher absorption of water to the roots. This higher moisture content may be due to the lower evaporation of water from soil due to the shading of soil due to the high population of cowpea and okra plants and also due to frequent irrigation. Soil and air heat may be low due to higher plant density with lower spacing [24]. And also, okra may accumulate more matter with the provision of N_2 by cowpea. Root fresh weight of okra was high in intercropping with cowpea than sole cropping of okra [9]. Root fresh weight of okra was high in intercropping with cowpea than sole cropping of okra [12]. It is agreeable with this study.

Figure 13: Fresh weight (g) of okra root at two week interval

Total dry weight

It was observed that there was no significant difference ($P > 0.05$) at 2nd and 4th WAP. There was a significant difference ($P < 0.05$) at 6th and 8th WAP (Table 7). At 6th WAP, the highest mean value of total plant dry weight of okra was found in T5 (29.82g) and the lowest value was found in T3 (11.39g). This may be due to the availability of light to okra plant with their increased height which increase the production of photosynthates and their reflection on the plant growth, besides the direct transfer of fixed N_2 from cowpea to okra plant. Dry weight of plant is higher in intercropping than sole cropping [8]. At the 8th WAP, the highest mean value for total dry weight was observed in T5 (37.20g) and T1 showed no any significant difference ($P > 0.05$) with T5. Up to 4th WAP, both crops in intercrops and monocrops were in their vegetative stage. So, both use nutrients available in soil,

without any effect of the spacing and excessive N₂ supplement from cowpea, to grow in to maximum vegetative growth. And there was no much variation in between the heights of both okra and cowpea in each treatment at 2nd and 4th WAP. So, much competition for light also was not expected. Therefore, there was no any variation among treatments with light interception and dry matter accumulation up to 4th WAP. So, that may have caused for no any significant difference ($P>0.05$) in total dry weight at 2nd WAP and 4th WAP. With supporting to the findings, it was found that total dry weight of okra is higher in intercropping systems with cowpea than sole cropping of okra [26].

Table 7: Total dry weight (g) of okra at two week interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	0.69 $\pm$ 0.11	2.37 $\pm$ 0.50	20.01 $\pm$ 2.02b	32.42 $\pm$ 2.46ab
T3	0.32 $\pm$ 0.05	2.29 $\pm$ 0.39	11.39 $\pm$ 0.99c	21.55 $\pm$ 2.38bc
T4	0.42 $\pm$ 0.02	2.30 $\pm$ 0.43	15.31 $\pm$ 0.42c	24.16 $\pm$ 2.20bc
T5	0.43 $\pm$ 0.04	3.06 $\pm$ 0.78	29.82 $\pm$ 2.55a	37.20 $\pm$ 3.21a
T6	0.38 $\pm$ 0.06	1.70 $\pm$ 0.33	11.68 $\pm$ 0.47c	22.16 $\pm$ 2.22bc
T7	0.64 $\pm$ 0.07	1.74 $\pm$ 0.24	11.79 $\pm$ 0.33c	19.68 $\pm$ 2.05c
F test	ns	ns	*	**

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Leaf dry weight

No significant differences ($P>0.05$) were observed in 2nd and 4th WAP and significant differences ($P<0.05$) were observed in 6th and 8th WAP (Table 8). At 6th WAP, the highest value was observed in T5 (10.21g) followed by T1 (8.25) and the minimum value was observed in T3 (4.31g). At 8th WAP, the maximum value was observed in T1 (13.75g) and minimum was observed in T7 (5.96g). These results coincide with the highest number of leaves per plant was in T1 may be the reason for higher dry weight of leaf in T1. Okra intercropped with cucumber as well okra intercropped with melon, gave higher leaf dry weight when compared to the sole cropping of okra [27] is disagreeable with this study.

Table 8: Leaf dry weight (g) of okra at two weeks interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	0.43 $\pm$ 0.06a	1.38 $\pm$ 0.27	10.21 $\pm$ 0.54a	13.75 $\pm$ 0.62a
T3	0.23 $\pm$ 0.03b	1.34 $\pm$ 0.67	4.31 $\pm$ 0.52c	7.06 $\pm$ 1.52c
T4	0.25 $\pm$ 0.28b	1.39 $\pm$ 0.24	4.84 $\pm$ 0.31c	8.11 $\pm$ 0.94c
T5	0.31 $\pm$ 0.25ba	1.79 $\pm$ 0.41	8.25 $\pm$ 1.27b	12.23 $\pm$ 2.40b
T6	0.28 $\pm$ 0.05b	0.98 $\pm$ 0.14	4.60 $\pm$ 0.34c	6.84 $\pm$ 0.86c
T7	0.26 $\pm$ 0.00b	0.98 $\pm$ 0.15	5.14 $\pm$ 0.72c	5.96 $\pm$ 0.63c
F test	ns	ns	**	**

Value represent mean $\pm$ standard error of four replicates.

F test: - **: $P<0.01$ ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Stem dry weight

It was obvious that there were no significant differences ($P>0.05$) in 2nd and 4th WAP. But the difference ($P<0.05$) was observed in 6th and 8th WAP (Table 9). Highest mean value was observed in T5 (14.36g) at 6th WAP. Least value was observed with T7 (4.59g). At 8th WAP, maximum dry weight was found in T5 (15.06g) and least was in T7 (6.03g). Higher stem dry weight may be due to the longer stem length. Higher planting density leads to grow taller. It grew taller to obtain sufficient sunlight and allocate more resources than sole planting with higher planting density [28]. Okra intercropped with cucumber, as well okra intercropped with melon, gave higher stem dry weight when compared to the sole cropping of okra [27]. Stem dry weight of okra was reduced with the increase of plant density in intercropping okra and *celosia* than monocropping of okra [29].

Table 9: Stem dry weight (g) of okra at two weeks interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	0.10 $\pm$ 0.07	0.96 $\pm$ 0.31	6.20 $\pm$ 1.22b	10.39 $\pm$ 4.25ba
T3	0.07 $\pm$ 0.01	0.72 $\pm$ 0.17	5.06 $\pm$ 0.64bc	6.62 $\pm$ 0.54c
T4	0.11 $\pm$ 0.00	0.77 $\pm$ 0.20	6.05 $\pm$ 0.65bc	7.87 $\pm$ 1.75c
T5	0.11 $\pm$ 0.01	0.94 $\pm$ 0.28	14.36 $\pm$ 1.49a	15.06 $\pm$ 1.02a
T6	0.08 $\pm$ 0.02	0.58 $\pm$ 0.16	5.38 $\pm$ 0.12bc	7.97 $\pm$ 1.42bc
T7	0.13 $\pm$ 0.01	0.58 $\pm$ 0.07	4.59 $\pm$ 0.45c	6.03 $\pm$ 0.15c
F test	ns	ns	*	*

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Root dry weight

It was investigated that, there were no significant differences ($P>0.05$) in 2nd and 4th WAP. The significant difference ($P<0.05$) was observed in 6th and 8th WAP (Table 10). The maximum value for root dry weight was obtained by T5 (5.48g) followed by T1 (2.89g). But, T3, T4, T6 and T7 didn't show any significant difference in root dry weight while minimum mean value was obtained by T3 (1.24g). At 8th WAP, the maximum value was gained by T5 (5.98g) and minimum by T3 (1.71g). T5 and T1 as well T3, T4, T6 and T7 were not significantly different from each other. This may be due to higher light interception by the okra plants due to lower spacing than sole cropping and higher transformation of photosynthates. Okra intercropped with cucumber as well okra intercropped with melon, gave higher root dry weight when compared to the sole cropping of okra [27].

Table 10: Root dry weight (g) of okra at two weeks interval

Treatment	2 nd WAP	4 th WAP	6 th WAP	8 th WAP
T1	0.06 $\pm$ 0.01	0.22 $\pm$ 0.06	2.89 $\pm$ 0.37b	5.58 $\pm$ 2.48a
T3	0.03 $\pm$ 0.00	0.22 $\pm$ 0.05	1.24 $\pm$ 0.22c	1.71 $\pm$ 0.37b
T4	0.06 $\pm$ 0.01	0.18 $\pm$ 0.06	1.40 $\pm$ 0.24c	2.43 $\pm$ 0.69b
T5	0.03 $\pm$ 0.00	0.31 $\pm$ 0.09	5.48 $\pm$ 0.82a	5.98 $\pm$ 1.64a
T6	0.02 $\pm$ 0.01	0.13 $\pm$ 0.03	1.31 $\pm$ 0.09c	2.51 $\pm$ 0.52b
T7	0.05 $\pm$ 0.00	0.14 $\pm$ 0.02	1.45 $\pm$ 0.23c	2.14 $\pm$ 0.56b
F test	ns	ns	*	**

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Cumulative yield

It was observed that there was significant difference ($P < 0.05$) among tested treatment in cumulative yield (Table 11). The highest mean value was obtained in T5 (4.51t/ha) and the least value was observed in T3 (1.30t/ha). T1 T4 and T6 were not significantly different (Table 11). Higher light interception by taller plants and accumulate more photosynthates [24]. The results may be due to that reason.

Table 11: Cumulative yield (t/ha) of okra

Treatment	Yield (t/ha)
T1	2.47 $\pm$ 0.4cb
T3	1.30 $\pm$ 0.1c
T4	2.99 $\pm$ 0.3b
T5	4.51 $\pm$ 0.5a
T6	2.43 $\pm$ 0.02cb
T7	1.62 $\pm$ 0.02c
F test	*

Value represent mean $\pm$ 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 Duncan's Multiple Range Test at 5% level.

Sun dried seed weight (for seed purpose)

It was revealed that there was no significant difference ($P > 0.05$) in between treatments (Table 12). 100 seed weight was high in sole okra than intercrop with maize, irrespective of cropping system, with the increase of poultry manure rate [30]. They also stated that this may be due to easy solubalization effect of released plant nutrients that improved the nutrient status and water holding capacity and plant nutrients. So, that meant that there is no significant difference ($P > 0.05$) in 100 seed weight with cropping system.

Table 12: Dried weight of 100 seeds (g) of okra

Treatment	Weight (g)
T	5.22 $\pm$ 0.16a
T3	4.84 $\pm$ 0.35a
T4	5.57 $\pm$ 0.21a
T5	5.50 $\pm$ 0.18a
T6	4.79 $\pm$ 0.23a
T7	4.94 $\pm$ 0.29a
F test	Ns

Value represent mean $\pm$ standard error of four replicates.

F test: - ns: not significant; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Area Harvest Equivalent Ratio (AHER)

The concept of AHER combines the area and time factors in a practical manner in order to quantifying intercrop yield advantages, particularly in multi-season associations. AHER was higher in T5 and the least was in T3 (Table 13). AHER was higher in turmeric and maize intercropping than sole cropping of turmeric and maize [31]. AHER showed a comparative advantage of multiple cropping over sole cropping when rubber is intercropped with melon and soybean. Rubber and melon showed a higher AHER of 2.41 while rubber and soybean showed a least value of 1.20 [32].

Table 13: Area Harvest Equivalent Ratio

Treatment	AHER
T3	0.24c
T4	0.55b
T5	0.84a
T6	0.45cb
T7	0.30cb
F test	**

Value represent mean $\pm$ standard error of four replicates.

F test: - **: $P < 0.01$; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Conclusion

The present study was conducted to investigate the growth and dry matter accumulation of okra as influenced by different planting patterns under okra (*Abelmoschus esculentus* L.) cowpea (*Vigna unguiculata* L. Walp) intercropping in sandy regosol. It revealed that there were significant differences ($P < 0.05$) in plant height, root length, fresh weight of total plant, dry weight of total plant, leaf area, leaf area index, canopy width, cumulative yield of okra and those were higher in the planting pattern of 60/150, with three rows of cowpea in between two pair of okra rows (T5). Chlorophyll content was not significantly different ($P > 0.05$) with different planting patterns. Okra in T5 gave 17.1% higher yield than T1. In okra, there was no significant difference ($P > 0.05$) in chlorophyll content, number of flowers per plant, seeds per fruit and 100 seed weight.

When the land is a scarce resource and if the nitrogenous fertilizer availability is limited or if those are with excess price, intercropping of okra and cowpea can be used as an eco-friendly alternative in producing higher quality okra fruits. And also the productivity of okra per unit land area can be increased with the intercropping systems. According to this study, when growth and yield are considered, it can be suggested that, among the all tested treatments, 60/150 cm treatment with paired row planting of okra with three rows of cowpea in between paired rows (T5) would be the most suitable planting system for sandy regosol.

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