Effect Of Different Planting Geometry And Application Of Liquid Organic Fertilizer On The Growth And Yield Of Abelmoschus Esculentus L. Intercropped With Vigna Unguiculata L.

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Abstract: The Increasing world population demands higher agricultural crop production to fulfill the food requirement. Therefore, intercropping is the best way to increase productivity in limited land area with organic inputs. To enhance the positive attitudes towards intercropping and organic farming, this experiment was carried out at the Crop Farm of Eastern University, Sri Lanka from January to April 2019 to study the effect of planting geometry with the application of liquid organic fertilizer (Jeewamirta) on the growth and yield of okra (*Abelmoschus esculentus* L) intercropped with Cowpea (*Vigna unguiculata* L.). The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Treatments were okra as a sole crop with the spacing of 90cm×60cm (T1), cowpea as a sole crop with the spacing of 30cm×15cm (T2), okra in 60cm×60cm with one row of cowpea (T3), okra in 90cm×60cm with 2 rows of cowpea (T4) and okra in 120cm×60cm with three rows of cowpea. This investigation revealed that there was a significant ($p<0.05$) effects in planting geometry in intercropping. The significant ($p<0.05$) highest values were obtained in okra with two rows of cowpea (T4) in plant height, leaf number, shoot biomass, root biomass, leaf area, average weight of fruit, 100 seed weight and yield than respective monocroppings. Further, Land Equivalent Ratio showed a significant ($p<0.05$) increase in T4. Therefore, it could be concluded that okra in 90 cm × 60cm with two rows of cowpea can be recommended for okra-cowpea intercropping to enhance the growth and yield.

Index Terms: Intercropping, Jeewamirta, Land Equivalent Ratio, Liquid organic fertilizer, Plant height, Root biomass, shoot biomass

1 INTRODUCTION

Intercropping is defined as growing two or more crops together in same field in same season. The main objective of intercropping is to improve the productivity per unit land area per unit time with judicious utilization of land, natural resources and farming inputs including labor without reducing basic crop yield [1]. Essential features of intercropping are intensification in space, time and competition among crops for light, nutrients, water and the proper management of these interactions [2]. In intercropping system, all the natural resources utilized to its maximum to get optimum crop production per unit area per unit time [3]. Spatial arrangement or the planting geometry of crops is another method when planting more than one crop in separate rows or alternating rows on same land area [4]. Economically viable intercropping system mostly depends on adaptation of planting geometry and selection of compatible crops [5]. Organic farming identifies the complex relationships between different system components and the sustainability of the system rest upon the functioning of a whole integrated and inter-related system [6]. Organic manures enrich soil fertility and thus crop production by altering physical and chemical properties of soil including soil structure, water holding capacity, soil pH and microbial activities. Compared to conventional farming, organic farming largely prevents synthetic fertilizers, pesticides, livestock feed additives and growth regulators and use bio fertilizers, green manures, botanical pesticides.

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Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world [7]. In Sri Lanka, okra can be successfully grown in wet, intermediate and dry zones. Okra is well grown in sandy to clay soils but, due to its well-established tap root system, relatively light, well drained soils are also suitable. As such loose, friable, loamy soils with manure applied well are desirable. The pH of 6.0 - 6.8 is appropriate for the growth of okra [8]. Cowpea is well known as a drought tolerant plant which is widely cultivated in Sri Lanka. Cowpea is much vital due to its higher proportion of protein compared to other legumes.
Low yield resulting from poor nutrient status of the soil has been identified as one of the major factors limiting okra production [9]. Intercropping systems mostly influence to efficient use of soil nitrogen [10]. In this system, one of the crops would be a legume that has the ability to fix atmospheric nitrogen. Nitrogen as well as phosphorus plays an important role in fruit, seed and quality development of okra. Okra intercropped with cowpea can improve nitrogen use efficiency due to utilization of different nitrogen pools and cowpea can release biologically fixed nitrogen to okra. Therefore, okra requires less nitrogen to produce better yield. Therefore, this study was carried out to find out the best planting geometry with the application of liquid organic fertilizer (Jeewamirta) for high yield of okra intercropped with cowpea.

2 MATERIALS AND METHODS

2.1 Site description

Experiment was conducted in crop farm, Eastern University, Sri Lanka, Vantharumoolai (7.7944° N, 81.5790° E) from January to April 2019. The mean annual rainfall ranges from 1400mm to 1680mm and temperature varies from 30^0 C to 32^0C. The soil type is sandy regosol.

2.2 Experimental design and treatments

Okra (cv. Haritha) and Cowpea (cv. Waruni) used in this experiment the experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The experiment comprised of following treatments okra as a sole crop with the spacing of 90cm×60cm (T1), cowpea as a sole crop with the spacing of 30cm×15cm (T2), okra in 60cm×60cm with one row of cowpea (T3), okra in 90cm×60cm with 2 rows of cowpea (T4) and okra in 120cm×60cm with three rows of cowpea.

2.3 Experimental arrangement

All the agronomic practices were carried out in accordance with the recommendation made by the Department of Agriculture, Sri Lanka. At the initial stage, compost was applied to each plot at the rate of 10t/ha and incorporated into the soil. Size of each plot was 5 m × 2 m. Each treatment had four replicates. Plots were separated with the spacing of 0.5 m from each other.

2.4 Liquid organic fertilizer (Jeewamirta) preparation

Jeewamirta was prepared in 200 L plastic barrel with ingredients at the rate of 10kg of fresh cow dung and 10 L of old cow urine from indigenous cow, 2kg of jaggery, 2kg of pulse powder and one handful of living soil were taken per acre. All ingredients were mixed in plastic barrel and stirred well then, the plastic barrel was covered with cotton cloth. The barrel was placed in shade and stirred clockwise twice a day in order to accelerate microbial activities. Prepared Jeewamirta was applied after three days of fermentation. Before application 1 L of Jeeamirta was diluted with 10 times water and then applied around the root zone of each plant by using watering can at evening time. Land was wetted before application of Jeewamirta. Application of Jeewamirta was started one week before planting.

2.5 Measurements and data analysis

Following measurements were measured viz. plant height, leaf number per plant, shoot biomass, root biomass, leaf area, Average weight of fruit, 100 seed weight, yield and Land Equivalent Ratio. Data were statistically analysed using SAS software and means were separated using Duncan's Multiple Range Test (DMRT) at 5% significant level.

3 RESULTS AND DISCUSSION

3.1 Plant height of okra

The plant height was significantly ($p<0.05$) lowered in all the treatments than sole crop okra. Maximum plant height was recorded in T1 (39.33cm) followed by T4 (31.13cm), T5 (19.83cm) while minimum plant height was recorded in T3 (17.78cm) at 7th weeks after planting (WAP).This finding was in agreement with the statement of Choudhuri [11] that plant height of sole cropping of okra gave higher values than okra-cowpea intercropping. Choudhuri [11] also stated that the highest values for plant height has been obtained in okra-cowpea intercropping system than other intercropping combinations due to better utilization of resources as there was less competition from the component crops for solar radiation, increasing plant height compared to other intercropping treatments. Nutrients in Jeewamirta influenced crop growth by releasing nutrients in to soil [12].

3.2 Number of leaves per plant in Okra

Maximum number of leaves was recorded at 5th WAP in T1 sole cropping okra. Plant height, high rate of nutrient up take, planting space might be the reasons for the maximum number of leaves. 5th WAP onwards number of leaves was reducing due to reduction of chlorophyll content in plants. Intercropping okra with cowpea has provided additional nitrogen to soil by fixing atmospheric nitrogen. This result was supported by Choudhuri and Jana [13]. They indicated that the number of leaves per plant was high in sole cropping of okra than intercropping with cowpea. Devakumar *et al,* [14] mentioned that jeewamirta with beneficial microbes has increased nutrient availability in soil.

3.3 Leaf area in Okra

Maximum leaf area was recorded in T4 (1034.11 cm^2) followed by T5 (648.53 cm^2), T1 (535.98 cm^2) and the lowest value was recorded in T3 (358.12 cm^2). It could be due to higher number of leaves per plant which leads to increase the leaf area. Light utilization was increased due to different canopy layers in T4 and this result was supported by Kumar *et al.,* [15] where they stated that light interception percentage is high in intercropping than sole cropping. Another finding by Akande *et al.*, [16] indicated that, the leaf area was high in intercropped okra plants with maize than monocropping of okra.

3.4 Dry shoot and root biomass of Okra

Maximum dry shoot and root biomass were recorded in T4 as 30.37g and 17.94g. Reason for higher dry shoot biomass was the planting geometry. Planting geometry, higher number of leaves and leaf area leads to higher growth rate, higher production of vegetative parts has increased dry matter content. It could be stated that enhanced biomass might be due to the presence of growth regulatory substances such as essential plant nutrients, effective microorganisms like nitrogen fixing bacteria, actinomycities, azospirillum and phosphor bacteria in jeewamirta.

3.5 Weight of fruit in Okra

Maximum weight was recorded in T4 (22.56g) followed by T5 (16.89g), T1 (11.44g) and the minimum was recorded in T3 (6.66g). Planting geometry is the most important factor which influences the weight of fruit in intercropping system. Application of Jeewamirta also increase nutrient availability in soil [12] and absorption might be the reasons for increasing weight of okra. At 3rd pick maximum weight was recorded in T4 but the weight is lower than 2nd pick because plant has started to senescence thus reducing nutrient availability in soil.

3.6 Average yield of Okra

There was a significant effect ($p<0.05$) on yield at each pick due to planting geometry. Maximum yield was recorded in T4 as 1.8860t/ha. Minimum yield was recorded in T3 0.2545t/ha. This result was supported by Kandeyang [17] where reported that when plants are grown in association, interaction between the components species occurs, which is essentially a response of one species to the environment as modified by presence of other species. Dahanayake *et al.* [18] pointed out that mixed cropping of okra with ground nut (legumes) is more beneficial than monocropping.

***Table 1**. Effect of planting geometry with the application of jeewamirta on plant height, leaf number, dry shoot and root biomass, leaf area, weight of fruit, 100 seed weight and average yield of okra*

Treatment	Plant height (cm)	Leaf number (Nos.)	Shoot biomass (g)	Root biomass (g)	Leaf area (cm^2)	Average fruit weight (g)	100 seed weight (g)	Yield (t/ha)
T1	39.33 ± 0.94^a	14.25 ± 0.25^a	10.88 ± 0.37^c	0.19 ± 0.04^b	535.98 ± 0.87^c	11.44 ± 0.25^c	3.78 ± 0.25^c	0.4605 ± 0.02^c
T3	17.78 ± 0.56^c	7.00 ± 0.57^c	11.85 ± 0.67^c	0.44 ± 0.06^b	358.12 ± 0.61^d	6.66 ± 0.15^d	3.78 ± 0.25^c	0.2545 ± 0.03^c
T4	31.13 ± 1.01^b	11.25 ± 0.48^b	30.37 ± 0.84^a	0.74 ± 0.14^a	1034.11 ± 0.36^a	22.56 ± 0.83^a	6.20 ± 0.15^a	1.8860 ± 0.1^a
T5	19.83 ± 0.47^c	8.75 ± 1.11^c	13.88 ± 0.41^b	0.36 ± 0.03^b	648.53 ± 1.03^b	16.89 ± 0.12^b	4.93 ± 0.04^b	0.9323 ± 0.05^b
F test	*	*	*	*	*	*	*	*

Value represents mean ± standard error of four replicates. * = significant at 5% probability level ($p < 0.05$). NS= nor significant. Means with the same letter are not significantly different in each column according to the DMRT at 5% level of significance.

3.7 Plant height of Cowpea
Maximum plant height was recorded in T4 (14.60cm) compared to T2 (12.08cm) sole cropping cowpea. This was due to the different utilization of nutrients in cowpea seeds at early stage of growing. Similar result was obtained by Dahanayake *et al.,* [18] and Obedoni *et al.,* [19]. They reported that cowpea plant height was high in intercropping than sole cropping. It could be due to production of more photosynthates which increases the plant growth.

3.8 Number of leaves in Cowpea
Maximum leaf number was recorded in T4 treatment (29). This might be due to planting geometry and application of jeewamirta. Planting geometry might facilitate high nutrient uptake from roots, space to capture high amount of solar radiation and directly increase more number of leaves per plant. The result obtained from this study was supported by Zyada [20] that the number of leaves per plant was higher in intercropping than sole cropping of cowpea. In addition, cowpea plants have ability to fix atmospheric nitrogen using nitrogen fixing bacteria. In addition, application of Jeewamirta also increases soil fertility by increasing microbial population and earth worm population in soil [12].

3.9 Leaf area in Cowpea
There was a significant difference ($p<0.05$) among treatments in leaf area at harvesting time. Maximum leaf area was recorded in T4 treatment (1149.33cm^2) followed by T3 (790.31cm^2), T5 (544.54cm^2) and T2 (487.47cm^2). Increased leaf area might be due to the effect of planting geometries, higher efficiency of nutrient utilization and increase in plant height. Similar finding was reported by Herve *et al.,* [21] that plants with different heights make more use of light when intercropping than monocropping. They also stated that, leaf area of cowpea was increased when intercropped with maize, than sole cropping of cowpea.

3.10 Weight of dry shoot and root biomass of Cowpea
Maximum value of dry shoot biomass was recorded in T4 as 19.78g and minimum was in T2 as 10.98g. Maximum dry root biomass was recorded in T4 (1.51g) compared to T2 (0.44g). Increase in shoot biomass was due to increase in plant height, number of leaves, leaf area, higher solar radiation and photosynthetic rate.Higher leaf area attributed to higher dry matter production in shoot. It is in agreement with Srikrishnah *et al.,* [22]. They stated that the application of Jeewamirta directly contacts with soil and increases the soil fertility and increase the availability of nutrients to uptake by plants thus increasing shoot and root biomass of plants.

3.11 Weight of pod and 100 seed weight
There was a significant difference ($p<0.05$) in weight of pods per plant at each pick. In all three picks maximum weight of pods per plant was recorded in T4 (2.90g). Furthermore100 seed weight also maximum in T4 treatment (14.13g). Most of the parameters including weight of pod per plant were increased due to this planting geometry. Application of Jeewamirta also increased pod weight. Ahmed and Abdelrhim, [23] revealed that plant population had a significant effect on most yield components as growing plant population has decreased the number of pods per plant in intercropping because increasing the plant population increased competition among plants for soil moisture, nutrient, light and carbon dioxide.

3.12 Average yield of cowpea
Maximum yield of each picks were obtained by T4 (2.491t/ha). There was no significant difference ($p>0.05$) in T2 and T3 treatments and minimum mean value was obtained by T5 (0.6513t/ha) in first pick. This was supported by Zyada, [20], suggested that intercropping system of okra-cowpea produced the highest values of growth parameters as well as yield components. In T4 treatment most of the parameters such as plant height, leaf number, leaf area, number of effective nodules, pod number, pod weight have increased. Therefore yield have been increased. T4 was having a good interaction between okra and cowpea. Legume crops increase the yield by increasing NO_3^- and NH_4^- concentration in soil and beneficial microorganisms in rhizosphere. This was in agreement with Olasantan, [24], where he reported that increase of nitrogen has given higher yield in maize – cowpea intercropping.

Table 2. *Effect of planting geometry with the application of jeewamirta on plant height, leaf number, dry shoot and root biomass, leaf area, weight of fruit, 100 seed weight and average yield of cowpea*

Treatment	Plant height (cm)	Leaf number (Nos.)	Shoot biomass (g)	Root biomass (g)	Leaf area (cm^2)	Average fruit weight (g)	100 seed weight (g)	Yield (t/ha)
T2	42.85 ± 1.18^c	17.75 ± 1.11^b	10.98 ± 0.59^c	0.44 ± 0.17^b	487.47 ± 1.88^c	1.14 ± 0.06^{bc}	10.60 ± 0.38^c	1.3063 ± 0.14^b
T3	48.25 ± 1.88^b	17.25 ± 0.48^b	15.65 ± 0.48^b	1.12 ± 0.09^{ab}	790.31 ± 0.74^b	1.39 ± 0.18^b	11.47 ± 0.76^{bc}	1.5333 ± 0.31^b
T4	55.03±0.60a	27.00±1.08a	19.82±0.57a	1.51 ± 0.40^a	1149.33±0.96a	2.90±0.02a	14.13±0.60a	2.6833±0.20a
T5	39.18 ± 0.43^d	27.00±1.08a	13.47 ± 0.88^b	13.47 ± 0.88^b	544.54 ± 0.85^c	0.94 ± 0.04^c	12.39 ± 0.23^b	0.6513 ± 0.17^c
F test	*	*	*	*	*	*	*	*

Value represents mean ± standard error of four replicates. * = significant at 5% probability level (p< 0.05). NS= nor significant. Means with the same letter are not significantly different in each column according to the DMRT at 5% level of significance

3.13 Land Equivalent Ratio

All the intercropping treatments provide good efficiency and maximum value was recorded in T4 (3.12) (Table 1). There was no significant difference among T3 (1.19) and T5 (1.72). LER in T4 was 61.85% higher than T3 and 44.79% higher than T5. It was in agreement with Zyada,[20] who stated that beneficial effects of combined leaf canopy of the intercrops can be achieved through more efficient use of light rather than greater light interception. As similar to this study Choudhuri and Jana [13] indicated that the LER was higher in okra and cowpea intercropping system than sole cropping in both okra and cowpea. In addition, Seran and Jeyakumaran, [25] reported that LER was higher in cowpea and capsicum intercropping than sole cropping in cowpea and capsicum.

Table 3. *Effect of planting geometry with the application of jeewamirta on Land Equivalent Ratio*

Treatment	LER
T3	1.1885 ± 0.08^b
T4	3.1157 ± 0.22^a
T5	1.7202 ± 0.20^b

4 CONCLUSION

Highest growth and yield was recorded in T4. Okra in T4 gave 75.58 % higher yield than T1 monocropping. Cowpea in T4 gave 51.31% higher yield than T2 monocropping. Higher LER was also noted in T4. Based on the result obtained by this study, okra 90×60cm with two rows of cowpea (T4) would be the most suitable planting geometry for okra -cowpea intercropping.

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