INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)

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KERALA, INDIA
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INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)

By

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(2018-11-057)

THESIS

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DEPARTMENT OF AGRONOMY

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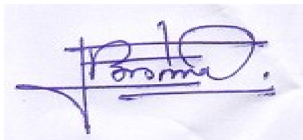
VELLAYANI, THIRUVANANTHAPURAM-695 522

KERALA, INDIA

2020

DECLARATION

I, hereby declare that this thesis entitled **"INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.



Place : Vellayani | Anna Emmanuel

Date: 26-09-2020 | (2018-11-057)

CERTIFICATE

Certified that this thesis entitled **"INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)"** is a record of research work done independently by Ms. ANNA EMMANUEL (2018-11-057) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of Ms. Anna Emmanuel (2018-11-057) a candidate for the degree of **Master of Science in Agriculture** with major in Agronomy, agree that the thesis entitled **"INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)"** may be submitted by Ms. Anna Emmanuel (2018-11-057), in partial fulfillment of the requirement for the degree.

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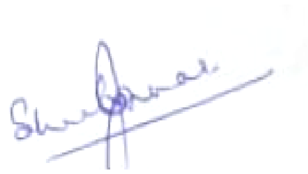

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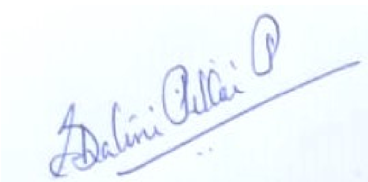

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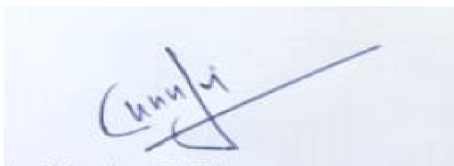

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Anna Emmanuel….

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LIST OF ABBREVIATIONS

Abbreviation	Expansion
%	per cent
@	at the rate of
ºB	Degree brix
ºC	Degree Celsius
₹	Indian rupees
A	Aggressivity
B:C ratio	Benefit cost ratio
BCR	Benefit cost ratio
CD	Critical difference
cm	Centimeter
cm^3	Cubic centimeter
DAE	Days after emergence
DAS	Days after sowing
dSm^{-1}	Deci Siemen per meter
EC	Electrical conductivity
et al.	Co-workers/ co- authors
Fig.	Figure
FYM	Farm yard manure
g	Gram
Ha	Hectare
KAU	Kerala Agricultural University
kg ha^{-1}	Kilogram per hectare

Abbreviation	Expansion
LAI	Leaf area index
LER	Land equivalent ratio
LI	Light interception
m	Meter
Max.	Maximum
mg	milli gram
Min.	Minimum
mm	milli meter
MOP	Muriate of potash
N	Nitrogen
NS	Non-significant
P	Phosphorus
pH	Negative logarithm of hydrogen ion concentration
RBD	Randomised block design
RCC	Relative crowding coefficient
RH	Relative humidity
SEm	Standard error mean
$t\ ha^{-1}$	tons per hectare
viz.	Namely

INTRODUCTION

1. INTRODUCTION

Kerala is blessed with the abundance of natural resources for agricultural production. However, ever increasing population pressure has resulted in major land use changes in the State through shrinkage in area devoted to cultivation of food crops with a concomitant increase in urbanisation. The agricultural census of the State has pointed out that the per capita land availability in Kerala is only 0.18 ha which is the lowest in the country (GOI, 2019). The low availability of land in Kerala has reflected in the land value which is exorbitant even in rural interiors. The limitation of land resources has indeed reflected on the production of food crops especially rice and vegetables for which Kerala depends heavily on neighbouring States.

Diversification of agriculture is necessary for meeting the increased demand of food and the nutritional requirement through enhanced food production. The primary objective of diversified agricultural production systems is to obtain production stability through improved crop protection, increased productivity, and profitability. Intercropping intensifies crop production in two dimensions (time and space) which not only increases farm production but also utilizes natural resources more efficiently and improves the economic conditions of the growers. Intercropping is a way to increase diversity in an agricultural system and enhances the productivity, providing security against the potential risk of monoculture.

Baby corn is a newly emerging vegetable crop which can be grown either as a sole crop or intercrop. . According to FAO statistics, baby corn is cultivated worldwide in 11.71 lakh ha area with a production of 115.17 lakh tons (FAO, 2020). It is very low in calories, rich in soluble fibre, folic acid and anti-oxidants and has excellent nutritional quality which makes it suitable for consumption in the raw or partly cooked form. The possibility of introducing baby corn as a suitable intercrop in coconut gardens and also as a main crop in open conditions such as summer rice fallows have been successfully demonstrated in Kerala. Intercropping baby corn with short duration crops which complete their life cycle within 50-55 days, is a viable option for the effective utilisation of resources such as light, space and nutrients and to obtain more economic returns from the unit area (Thavaprakaash and Velayudham, 2008)..

Baby corn can be intercropped with many compatible crops including vegetables. However, the selection of intercrop in association with a highly competitive crop like maize needs attention. Cowpea is considered as a suitable intercrop in cropping systems due to its N fixing ability and less competitive nature and is nutritionally rich in protein and minerals. The short duration leafy vegetable amaranthus is a rich source of vitamins and minerals, can yield well under a wide range of agroclimatic situations and hence considered as another choice for intercropping. However, exploring the possibilities of growing intercrops in baby corn was not attempted so far in Kerala and for evaluating the feasibility of intercropping, the yield variability of main crop and intercrops and their complementarities and competitiveness within the system should be assessed for identifying the most suitable intercropping system.

In this back drop, the present study was proposed with the following objectives;

- To investigate the feasibility of intercropping cowpea and amaranthus in baby corn
- To find out the effect of crop geometry of component crops on growth, yield, productivity and economics of the intercropping systems.

REVIEW OF LITERATURE

2. REVIW OF LITERATURE

Intercropping is a practice to intensify the crop production in time and space dimensions for diversifying the production and to utilize natural resources more efficiently and also to improve the economic returns. Baby corn is a crop which has gained importance recently and has high demand in the urban areas. Intercropping baby corn with short duration crops is a viable option for the effective utilization of resources and to obtain more economic returns from the unit area. In this chapter a detailed research work done on the effect of intercropping and planting geometries on different aspects of cropping system-based production are presented.

2.1 EFFECT OF INTERCROPPING ON COMPONENT CROPS

2.1.1 Effect of intercropping on growth and growth parameters

Intercropping influences the growth and growth attributes of the main crop as well as intercrops. In a study on maize-cowpea intercropping system, Watiki *et al*. (1993) observed that the leaf area index (LAI) of both maize and cowpea were reduced with reduction in planting density of maize. Thavaprakaash and Velayudham (2008) suggested that the leafy vegetable amaranthus was a better option as intercrop in baby corn as it does not affect the growth parameters of main crop due to its non competitive nature. According to Banik and Sharma (2009), there was an increase in nodule number, dry weight and root length of legumes when intercropped with baby corn compared to monocropping condition. Reddy *et al*. (2009) reported that the plant height of baby corn was significantly influenced due to intercropping of legumes, and intercropping of baby corn with vegetable cowpea significantly increased the height of the base crop (baby corn) compared to that with dolichos bean. On contrary, Rathika (2013) reported that the growth parameters of the main crop baby corn were not influenced by the intercrops fenugreek and fodder cowpea due to the short duration, short plant stature, non-bushiness, noncomplementary and noncompetitive nature of the intercrops.

2.1.2 Effect of intercropping on yield and yield attributes

Inclusion of short duration vegetables as intercrops in baby corn has been tried by some of the researchers. Reddy *et al*. (2009) reported that yield attributes of baby corn were greatly influenced by intercropping systems and intercropping baby corn with vegetable cowpea significantly increased the yield of main crop and intercrop. In a trial on intercropping baby corn with fenugreek and fodder cowpea, Rathika (2013) reported that between intercrops, baby corn + fenugreek registered higher baby corn equivalent yield compared to baby corn + fodder cowpea. The combination also produced 38.1 per cent higher baby corn equivalent yield than the sole crop of baby corn. In another trial, Rani *et al*. (2015) observed that higher baby corn equivalent yields (6655 kg ha^{-1}) was obtained, when vegetable cowpea was intercropped with baby corn over other vegetables like coriander and radish. Tejaswitha (2016) reported that when baby corn was intercropped with leafy vegetables coriander, fenugreek and amaranthus, the baby corn equivalent yield was found to be higher with baby corn + amaranthus combination compared to the combinations involving coriander or fenugreek or sole crop of baby corn.

However contrary results have been reported by Sharma and Banik (2015) who found that when baby corn was intercropped with legumes viz., chickpea, pea, groundnut and lentil, cob yield of baby corn was reduced by 10.5 per cent, 8.5 per cent, 8.5 per cent and 5.5 per cent respectively over the sole baby corn. The yield of legume intercrops were also lower in association with baby corn compared to their sole crop yields in this trial.

2.1.3 Effect of intercropping on light interception

Light transmitted through maize canopy is usually higher to facilitate high light interception by the intercrops. Efficient light interception by maize-cowpea intercropping compared to sole crop of cowpea or maize due to higher light transmission through the canopy of maize was reported by Fawusi and Wanki (1982). In an intercropping study on baby corn with amaranthus and green gram, Thavaprakaash and Velayudham (2008) reported that intercropping increased the light interception by the canopy and was higher in baby corn + amaranthus intercropping system compared to baby corn + green gram. Eskandari *et al.* (2009) reported that the interception of photosynthetically active radiation (PAR) was reduced in cowpea under intercropping with corn due to tall nature of corn, high competition and shading over cowpea. However, the light interception for the intercropping system was higher than either of the sole crop at 70 DAS. According to Ghanbari *et al*. (2010), intercropping can increase light interception and cause increased shading in maize compared to sole cropping.

2.1.4 Effect of intercropping on nutrient content and uptake

The effect of intercropping legumes with maize on nutrient content and uptake of component crops has been studied by many researchers. In an intercropping study on maize and cowpea to examine the effect of N application on productivity, Ofori and Stern (1986) reported that the N uptake by maize and cowpea was affected by intercropping due to difference in dry matter production but not due to the change in N concentration in plant, which remained unchanged. Li *et al.* (2003) reported that in maize + faba bean intercropping system, the concentration of P and K in maize was significantly higher at the time of harvest but the uptake of NPK was not influenced by the intercropping systems. Though the uptake of NPK was higher in faba bean, there was no difference in its NPK concentration. In a study conducted on forage quality of cowpea intercropped with corn, Eskandari *et al.* (2009) reported higher uptake of Ca and Mg in intercrop than sole crop of cowpea and corn. While studying the pulse intercropping with baby corn, Aravinth *et al.* (2011) observed that the nutrient uptake was not affected by the intercropping. Latati *et al.* (2014) reported an increase in shoot and grain P concentration by 73 and 18 per cent, respectively in maize due to intercropping with cowpea, but a reduction in concentration of P in root, shoot and seed by 16, 28 and 34 per cent, respectively was observed in case of cowpea. In a baby corn and vegetable intercropping system, significantly higher uptake of N (195.7 kg ha^{-1}) and P (32.1 kg ha^{-1}) were recorded with baby corn + cluster bean combination while the uptake of K (134.2 kg ha^{-1}) was higher with baby corn + okra combination (Rekha *et al*., 2017)

Contrary to the above findings, Thavaprakaash and Velayudham (2007) reported that the nutrient uptake of baby corn was not affected by the intercropping treatments when it was intercropped with short duration vegetables like amaranthus and green gram. Rathika (2013) also reported that there was no marked influence on nutrient uptake of baby corn due to intercropping of fenugreek or fodder cowpea, as the soil nutrients were not much depleted due to early harvest of the intercrops.

2.1.5 Effect of intercropping on soil properties

Intercropping with legumes was found to influence the soil properties due to the N fixing capacity. In an intercropping study on maize with common bean, Maingi *et al.* (2001) reported that the soil N showed a slight increase or maintained the pre-planting level in intercropped plots. The plots with pure crop of maize showed considerable decline in soil N while the P content in all plots increased 5-66 per cent. In a study conducted to assess the soil properties and yield under maize and cowpea intercropping system, Dahmardeh *et al*. (2010) reported that intercropping with cowpea resulted in increased soil N, P and K content compared to the sole crop of maize. Increase in soil N in intercropped plots and also in sole crop of common bean compared to sole crop of maize was reported by Latati *et al.* (2013). In an intercropping trial with baby corn and leafy vegetables, Tejaswitha (2016) reported higher values of soil available nutrients with sole crop of baby corn and the values were lower with the intercrop combination, baby corn + amaranthus.

2.1.6 Effect of intercropping on pest and disease incidence

In an intercropping study on corn, Sastrawinata (1976) found that corn borer attack was reduced in maize when intercropped with groundnut and soybean. Van

Rheenen *et al.* (1981) reported that bean grown in association with maize showed reduced incidence of diseases such as bean common mosaic, anthracnose, common blight, scab, and to a lesser extent angular leaf spot. Severity of bacterial blight of bean and rust disease of maize was lower due to the intercropping (Chemeda, 1996). In another study, reduced incidence of leaf spot and blight of cowpea was reported when it was intercropped with maize (Sikirou and Wydra, 2008).

2.1.7 Effect of intercropping on crop competition indices

In an intercropping trial with maize and soybean, Hayder *et al.* (2003) reported that the land equivalent ratio (LER) values of maize- soybean intercropping systems were higher than that of respective sole crops which ranged from 1.39-1.52 for different seed rates. As observed by Prasad and Brook (2005), the LER values were higher than unity in all intercropping treatments of maize with soybean under varying planting densities. Banik and Sharma (2009) reported that when baby corn was intercropped with soybean, green gram, black gram, and groundnut at different planting densities, higher LER was observed for all the intercropping treatments and the baby corn + groundnut intercropping system had the highest value. In another intercropping study, Devi and Singh (2018) reported higher LER for intercropping field pea with maize under varying cropping patterns.

As reported by Ghanbari *et al.* (2010), the relative crowding coefficient (RCC) of baby corn was higher than the vegetables and aggressivity values were always positive for baby corn which indicated the competitive nature of baby corn than intercrops in a baby corn + vegetables intercropping trial. In a cowpea and maize intercropping experiment, Alla *et al.* (2014) noted that the LER was 1.65 and the aggressivity had a positive value which indicated that maize (0.45) was the dominant crop, where as cowpea was the dominated (-0.45) crop. In this trial, the competitive ratio of maize and cowpea were 1.75 and 0.57 respectively indicating the more competitive nature of maize over cowpea. The actual yield loss (AYL) of maize was 0.05 and that of cowpea was

-0.40 which suggested that there was a 40 per cent yield reduction in intercropping with cowpea.

2.1.8 Effect of intercropping on economics of cultivation

In an intercropping study on maize and soybean, all seed ratios of maize and soybean intercropping resulted in higher benefit: cost ratio (>2) and net income (> ₹ 20000 ha^{-1}) than the sole crop of maize and soybean (Hayder *et al.,* 2003). In another study, Thavaprakaash *et al.*(2005) reported that intercropping baby corn with radish and coriander resulted in higher baby corn equivalent yield and monetary advantage over sole crop of baby corn. Banik and Sharma (2009) reported higher baby corn equivalent yield and net returns in all intercropping systems with baby corn and legumes compared to respective mono crops, and baby corn + groundnut produced the highest net return compared to black gram, green gram or soybean. Intercropping of cowpea and maize for fodder purpose had higher monetary advantage and land use efficiency than sole crop of maize (Alla *et al.,* 2014). Rani *et al.* (2015) reported higher net returns and benefit: cost ratio with baby corn + cowpea intercropping treatment and all other intercropping systems of baby corn with coriander, okra and radish also produced higher benefit: cost ratio (>2) and net returns than sole crops. In an intercropping study on field pea and baby corn, Devi and Singh (2018) reported higher net returns and benefit: cost ratio in all intercropping systems compared to the sole crop of baby corn.

2.2. EFFECT OF PLANTING GEOMETRY ON COMPONENT CROPS UNDER INTERCROPPING

2.2.1 Effect of planting geometry on growth and growth parameters

Fawusi and Wanki (1982) reported that increasing plant density resulted in increased plant height and dry matter yield when maize was intercropped with cowpea under different planting densities. In an intercropping study on maize with soybean, Prasad and Brook (2005) observed increased dry matter accumulation and leaf area index with increasing plant population. Thavaprakaash *et al.*(2005) reported that in baby corn

+ vegetable intercropping system with radish and coriander, wider space availability between rows and narrow plant to plant spacing facilitated more resource utilization which resulted in increased plant growth and LAI of baby corn.

The paired row planting in maize based cropping systems have been studied by some workers. Significant increase in leaf area index of maize was reported by Shivay and Singh (2000) when maize was intercropped with black gram in paired row planting, and the plant height and dry matter yield did not vary under different cropping systems. Rajshekhar *et al.* (2004) reported a higher dry matter yield and leaf area index in paired row planting of maize over 60 x 30 cm spacing in both intercropped and non-intercropped situation of maize with lucern. In an intercropping study on maize with French bean, cowpea, field bean and pole bean, Sannagoudar and Murthy (2018) reported that the paired row planting (30/90 x 30 cm) of maize produced higher plant height, leaf number, leaf area and dry matter production over normal planting with and without intercrops.

While studying the skip row planting in maize, Mesfin *et al*. (2014) noted that there was no significant difference in plant height between skipping a row of maize, skipping a pair of rows and planting all rows or planting of intercrops.

Replacement series studies in maize based intercropping system by Banik and Sharma (2009) indicated significant difference in root length of legume intercrop wherein the baby corn and groundnut planted in 2:1 and 2:2 ratio produced the higher root length in groundnut.

2.2.2 Effect of planting geometry on yield and yield attributes

In an intercropping study on maize with two different varieties of cowpea and four different row spacing and population, Fawusi and Wanki (1982) reported that number of cobs per m^2 increased with increasing population but the average number of kernels per cob got decreased, and there was significant effect on grain yield by increasing population with or without intercrop. Prasad and Brook (2005) reported that in a maize + soybean intercropping system, the grain yield of maize increased with increase in population but the yield of soybean was reduced with increase in population of maize by 53-59 per cent. As reported by Thavaprakaash *et al.* (2005), yield attributes such as cob length, cob width and cob weight of baby corn showed significant increase due to wider row spacing of 60 cm x 19 cm than 45 cm x 20 cm spacing, but the number of cobs was unaffected in a baby corn + vegetable intercropping system. When baby corn was intercropped with fenugreek and fodder cowpea under different planting geometries, the wider row spacing of 75 cm x 16 cm recorded 6.7 per cent higher green cob yield than narrow row spacing of 60 cm x 20 cm as reported by Rathika (2013).

While studying the effect of skip row planting patterns in maize, Lyon *et al.* *(*2009) reported that skip row planting with 30-inch row spacing resulted in higher grain yield than the standard row planting in adverse climatic conditions in dry land areas. According to Dolijanovic *et al*. (2013), alternate row or skip row planting was more favorable for the yield of maize crop than the strip planting in maize and soybean intercropping system. Mesfin *et al*. (2014) observed that when short duration pulse French bean (*Phaseolus vulgaris* L.) was planted in skip row, there was 20 per cent increase in the productivity of system and skipping alternate rows showed no difference in grain yield and yield components of maize compared to full population when there was a moisture stress.

In paired row arrangement more intercrops are accommodated by reducing the row spacing of main crop. Paired row planting of maize with four rows of green gram resulted in higher grain yield and stover yield of maize which was 10.5 per cent higher than normal planting of maize with two rows of green gram and 22.3 per cent higher than the sole crop (Latha and Prasad, 2008). In an intercropping study with baby corn and field pea in paired row and 1:1 row planting, Devi and Singh (2017) reported similar yield in paired row planting, 1:1 row planting and sole cropping of baby corn, but the green stover yield was higher in sole crop. The paired row planting however had no effect on number of cobs per plant in this trial. While investigating the effect of intercropping maize with French bean, cowpea, field bean and pole bean, Sannagoudar and Murthy (2018) reported that the paired row planting (30/90 x 30 cm) of maize produced higher grain and stover yield over normal planting with and without intercrops

In a replacement series study, Willey and Osiru (1972) reported that when one third of maize was replaced by beans (2:1 ratio), the yield loss in maize was well compensated by beans and caused a non significant yield reduction in baby corn but when two third of maize was replaced by beans (1:2 ratio), the bean population could not compensate the maize yield loss due to the lower yield potential of beans. Banik and Sharma (2009) reported a higher relative yield loss for intercrops than baby corn under 2:1 and 2:2 row ratios and the yield loss was higher in soybean followed by black gram, green gram and groundnut. Rani *et al*. (2015) observed higher baby corn equivalent yields when vegetable cowpea was intercropped with baby corn in 2:1 ratio over other vegetables like coriander and radish. In a recent study, Huang *et al.* (2019) reported that 2:1 row planting produced higher grain yield of maize which did not significantly differ from sole crop of maize but superior than 2:2 row planting of maize and soybean.

2.2.3 Effect of planting geometry on light interception

Andrade *et al*. (2002) reported that the radiation interception increased in response to narrow row (35 cm x 70 cm) spacing and the percentage grain yield increase in response to reduced row spacing was significantly and inversely proportional to wider row spacing (50 cm x 70 cm) in maize. According to Prasad and Brook (2005), as the row spacing was increased from 0.75 m to 1.00 m in a maize + soybean intercropping system, the light interception by the intercrop increased with increase in the overall yield. In this study, the sole crop of soybean was found to be very effective at intercepting light from 84 DAS onwards, compared to sole crop of maize. In another study, Rathika *et al.* (2013) reported that the light interception was higher when wider row spacing of 75 cm with intercrops was adopted in baby corn based intercropping system. In this study, the light interception was the highest at 25 DAS and 45 DAS with fenugreek and fodder cowpea respectively. In an experiment conducted to study the light use efficiency, productivity and profitability of maize and soybean intercropping system as influenced by planting geometry and row proportion, Yogesh *et al.* (2014) reported higher light interception by crop canopy in paired row planting of baby corn (45/180 cm) with six rows of soybean.

2.2.4 Effect of planting geometry in nutrient uptake

Dalal (1974) reported that maize intercropped with pigeon pea either as a mixed stand or in alternate rows recorded lower uptake of nitrogen, potassium, phosphorus, calcium and magnesium compared to the pure stand of both maize and pigeon pea due to reduced dry matter yield. Increased uptake of N (190.2 kg ha^{-1}), P (24.5 kg ha^{-1}) and K (375.5 kg ha^{-1}) in baby corn due to wider row spacing of 60 cm x 19 cm was reported by Thavaprakaash and Velayudham (2007) in a baby corn based intercropping system with amaranthus and green gram as intercrops. Aravinth *et al.* (2011) observed that the baby corn spaced at 60 cm x 15 cm recorded higher uptake of N (160.6 kg ha^{-1}), P (22.2 kg ha^{-1}) and K (184.4 kg ha^{-1}) than 45 cm x 25 cm spacing in summer season and intercropping with pulses however did not affect the nutrient uptake. In another intercropping trial on baby corn with fenugreek and fodder cowpea, significantly higher uptake of N, P and K (161.4, 22.3 and 184.6 kg ha^{-1}, respectively) were observed with wider row spacing of 75 cm compared to 60 cm spacing (Rathika, 2013).

2.2.5 Effect of planting geometry in soil properties

While studying the effect of different planting geometries in maize + cowpea intercropping systems, Dahmardeh *et al*. (2010) reported higher soil N under 100 per cent population of maize + 100 per cent population of cowpea compared to other proportions of maize and cowpea, and the soil N content was found to increase with increase in population of cowpea. Rathika (2013) observed variation with respect to N availability in baby corn based intercropping system with fenugreek and fodder cowpea. In this trial, wider row spacing (75 cm x 16 cm) had low soil available N content of 173.7 kg ha^{-1} over 60 cm x 20 cm (181.5 kg ha^{-1}) after the experiment, which was due to the vigorous growth of baby corn under wider spacing. Fenugreek and fodder cowpea as intercrops produced higher soil N than sole crop of baby corn while the available P and K did not show any variation in case of intercrops or planting geometry.

2.2.6 Effect of planting geometry on crop competition indices

Planting geometry was found to influence the competition indices in maize based cropping systems as reported by several investigators. Rajshekhar *et al*. (2004) reported that the paired row planting of maize with lucern produced higher maize equivalent yield. Ullah *et al.* (2007) reported that maize intercropped at 90 cm double row strips with soybean recorded highest land equivalent ratio (LER) of 1.62 and maize intercropped at 135 cm double row strips with mung bean recorded the lowest LER (0.91). The results also indicated that intercropping of maize with soybean produced higher land use efficiency than mono-cropping of maize. In another intercropping study on maize with black gram, green gram and sesame in paired row planting with one or two rows of intercrop, Kumar *et al*. (2014) reported that paired row planting of maize with one row of green gram produced higher LER (1.24), maize equivalent yield and relative crowding coefficient. However paired row planting of maize with two rows of black gram registered the higher monetary advantage index (MAI).

The competition indices showed variation with respect to crop geometry in baby corn based intercropping systems with short duration intercrops. Thavaprakaash *et al.* (2005) noted a higher baby corn equivalent yield in intercropping system with short duration crops compared to the sole crop, which was solely due to the higher corn yield under wider row spacing. Banik and Sharma (2009) reported higher competitive ratio, LER and relative crowding coefficient of baby corn under 2:1 ratio than 2:2 ratio planting with legumes. In this study, the baby corn equivalent yield recorded was higher in 2:2 ratio planting compared to 2:1 row planting with different legumes. Rani *et al*. (2015) observed that when baby corn was intercropped with vegetable cowpea in 2:1 ratio, higher baby corn equivalent yield (BCEY) and net returns were obtained compared to intercropping with coriander or radish. In another intercropping study, Sharma and Banik (2015) recorded higher land equivalent ratio (LER), monetary advantage index (MAI), area time equivalent ratio (ATER) and baby corn equivalent yield (BCEY) when baby corn was intercropped with pea in 2:2 ratio compared to intercropping with other crops such as lentil, groundnut and chickpea in 2:2 or 2:1 ratio. Devi and Singh (2017) reported a higher LER of 1.61 in paired row planting of baby corn and field pea, compared to sole cropping or 1:1 row planting.

2.2.7 Effect of planting geometry on economics of cultivation

A study conducted by Ullah *et al.* (2007) indicated that the double row strips of maize at 90 cm spacing intercropped with soybean resulted in the highest income compared to double row strips of 135 cm spacing intercropped with soybean and mung bean. In an intercropping trial on maize with black gram, green gram and sesame, Kumar *et al*. (2014) reported that the paired row planting of maize with one row of green gram produced higher net returns (₹ 20320 ha^{-1}) and benefit: cost ratio (1.77) than other intercropping systems. Devi and Singh (2017) observed that planting two rows of field pea in between the paired rows of baby corn (30/60) produced higher net returns and benefit: cost ratio than 1:1 row planting and sole cropping. In an intercropping trial on sweet corn with leafy vegetables, Chaudhari *et al.* (2018) reported that paired row (40/80 cm) planting of sweet corn accommodating amaranthus in between gave higher benefit: cost ratio, gross income, and net returns as compared to other intercrops like spinach, mustard, radish, and coriander.

Banik and Sharma (2009) reported higher net returns and benefit: cost ratio for intercropping legumes in 2:1 and 2:2 ratios with baby corn and the baby corn + groundnut produced the highest economic benefit. When French bean was intercropped with baby corn in 1:1 and 2:2 row proportions, it resulted in higher net returns and benefit: cost ratio as reported by Nataraj *et al.* (2011). When baby corn was intercropped with vegetable cowpea in 2:1 ratio, it recorded the highest benefit: cost ratio (2.42) and net returns compared to other crops such as radish, okra and coriander (Rani *et al.,* 2015).

The review of related literature works indicated the influence of intercropping systems under different crop geometries on growth and growth attributes, yield attributes and yield, soil chemical properties, competition indices and economics of cultivation of main crop and intercrops.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study entitled "Intercropping vegetables in baby corn (*Zea mays* L.)'' was conducted at College of Agriculture, Vellayani during 2018-20. The objective of the study was to investigate the feasibility of intercropping vegetables like cowpea and amaranthus in baby corn and to find the effect of crop geometry on growth, yield, productivity and economics of intercropping system. The materials used and the methods adopted for the study were described in this chapter.

3.1 EXPERIMENTAL SITE

The field experiment was conducted in block D of Instructional farm, College of Agriculture, Vellayani, Thiruvananthapuram. The experimental site was located at a latitude of N $08^0$25'49.6632" and longitude of E $76^0$59'24.954" and at an altitude of 29 m above mean sea level.

3.1.1 Soil

Composite soil samples were taken from the field before the experiment and analysed for its mechanical composition and chemical properties. The mechanical composition and chemical properties of soil are given in Table 1 and 2 respectively.

The soil was sandy clay loam lateritic belonging to the order Oxisol with very strong acidity, normal electrical conductivity and was medium in organic carbon and available nitrogen, while high in available phosphorus and potassium.

Table 1. Mechanical properties of the soil of the experimental site

SlNo.	Fraction	Content (per cent)	Methods used
1	Sand	52.39	Bouyoucos hydrometer method (Bouyoucos, 1962)
2	Silt	24.45	
3	Clay	19.42	

Table 2. Chemical properties of the soil of the experimental site

Parameter	Content	Rating	Methods used
Soil reaction(pH)	4.8	Very strongly acidic	1:2.5 soil water solution using pH meter with glass electrode (Jackson,1973)
Electrical conductivity (dSm^{-1})	0.13	Normal	Digital conductivity meter (Jackson,1973)
Organic carbon (%)	1.14	Medium	Walkley and Black rapid titration method (Jackson,1973)
Available N (kg ha^{-1})	363.78	Medium	Alkaline permanganate method (Subbiah and Asija,1956)
Available P (kg ha^{-1})	62.50	High	Bray colorimetric method (Jackson,1973)
Available K (kg ha^{-1})	392.00	High	Ammonium acetate method (Jackson,1973)

3.1.2 Climate and season

The field experiment was conducted during the summer season of 2019 (March to May). The standard week wise weather data on minimum and maximum temperatures, relative humidity, bright sunshine hours and rainfall during the cropping period were collected from the class B Agromet Observatory of Department of Agricultural Meteorology, College of Agriculture, Vellayani and are given in Appendix I and graphical illustration of weekly weather data are depicted in Fig 1.

The mean maximum temperature and mean minimum temperature ranged from 34.1-35.2 ^{0}C and 24.4 ^{0}C-26.2 ^{0}C respectively, mean maximum relative humidity ranged between 78.6-85.7 per cent and minimum relative humidity ranged between 59.0-67.3 per cent. A total rainfall of 33.5 mm was received during the cropping season.

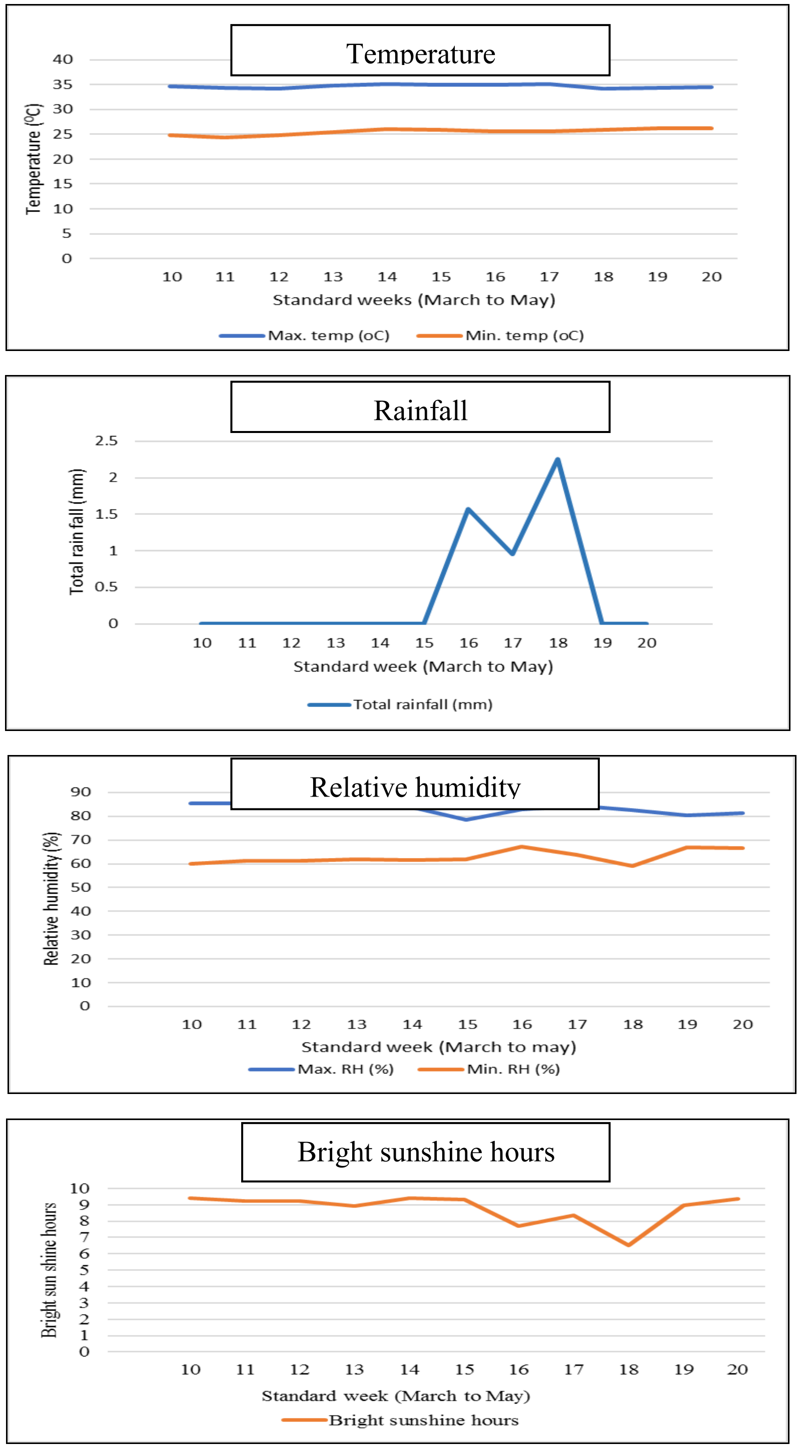

Fig. 1: Weather parameters during the cropping period

3.1.3 Cropping history of the experimental plot

The field was cultivated with vetiver and left fallow for three months before the conduct of the experiment.

3.2 MATERIALS

3.2.1 Crops and varieties

Baby corn, variety G 5414 was raised as main crop. Cowpea variety Bhagyalakshmi and amaranthus variety Arun were raised as intercrops in various planting geometries. Varietal features of the crops are presented in Table 3.

Table 3. Important varietal features of crops raised in the experiment

Varietal features	Baby corn	Cowpea	Amaranthus
Variety	G 5414	Bhagyalakshmi	Arun
Duration (days)	50-55	60	45
Type and colour of seeds/leaves	Uniform sized creamy/light yellow	Brown coloured with creamy yellow marks	Red leaves
Releasing agency	Syngenta seed Co. Ltd.	KAU	KAU
Cost of seed (₹ per kg)	650	1000	1750
Nature of variety	Baby corn hybrid	Bush type vegetable cowpea	Red colour variety

3.2.2 Manures and fertilizers

Well decomposed farm yard manure (FYM) containing 0.52 per cent N, 0.56 per cent P_2O_5, and 0.33 per cent K_2O was used as the source of organic manure. Urea (46 per cent N), Rajphos (20 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) were used as chemical sources of nitrogen, phosphorus and potassium respectively.

3.3 METHODS

3.3.1 Design and layout

Design : Randomized Block Design

Treatments : 9

Replications : 3

Plot size : 9.0 m x 4.0 m

Baby corn and vegetable intercrops were planted in different crop geometries and two additional replications were maintained for destructive sampling.

3.3.1.1 Treatments

T_1- baby corn + cowpea (skip row)

T_2- baby corn + amaranthus (skip row)

T_3- baby corn + cowpea (paired row)

T_4- baby corn + amaranthus (paired row)

T_5- baby corn + cowpea (2:1 ratio)

T_6- baby corn + amaranthus (2:1 ratio)

T_7- sole crop of baby corn

T_8- sole crop of cowpea

T_9- sole crop of amaranthus

3.3.2 Crop management

3.3.2.1 Land preparation

The experimental area was ploughed with a power tiller and brought to fine tilth with the help of a cultivator. Bunds were taken to separate the experimental plots. Lime was applied during final land preparation and FYM was incorporated 10 days after lime application. Ridges and furrows were taken in the plots according to the crop geometry and spacing of main crops and intercrops as per the treatments. All the management practices were done as per KAU package of practices recommendations (KAU, 2016).

3.3.2.2 Planting

Baby corn was planted at a spacing of 45 cm x 20 cm (Scaria, 2016) and cowpea and amaranthus were planted at a spacing of 30 cm x 15 cm and 30 cm x 20 cm, respectively as per the cropping geometries according to the treatments. Baby corn seeds and cowpea seeds were dibbled and amaranthus seedlings were transplanted (15 DAS) as per the spacing requirements. Baby corn was sown on ridges while the intercrops were planted in furrows between ridges. The treatment wise plant population is indicated in Appendix III.

3.3.2.3 Application of manures and fertilizers

Application of manures and fertilizers were separately done for main crop and intercrops. For baby corn, cowpea and amaranthus, FYM @ 12.5 t ha^{-1}, 20 t ha^{-1} and 25 t ha^{-1}, respectively were separately applied during seed bed preparation to the ridges (main crop) and furrows (intercrops). The fertilizer recommendation adopted for baby corn was 135:65:45 kg NPK ha^{-1} (Mavarkar, 2016). The N and K were given in 2 split doses ½ as basal + ½ at 25 days after sowing (DAS) and the full P was given as basal dose in baby corn. A quantity of 20:30:10 kg $N:P_2O_5:K_2O$ ha^{-1} were applied to cowpea wherein half the dose of N and full dose of P and K were applied as basal dose and remaining dose of N was top dressed 20 DAS. For amaranthus, 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1} was applied wherein half the dose of N and full dose of P and K were applied as basal dose and remaining dose of N was top dressed after the first harvest (KAU, 2016).

3.3.2.4 Weeding and earthing up

Weeding of the plot was done twice at 21 and 40 DAS and earthing up was done at 45 DAS.

3.3.2.5 Irrigation

The crop was irrigated frequently from the day of sowing till 15 days after planting. Subsequent irrigation was given as and when required.

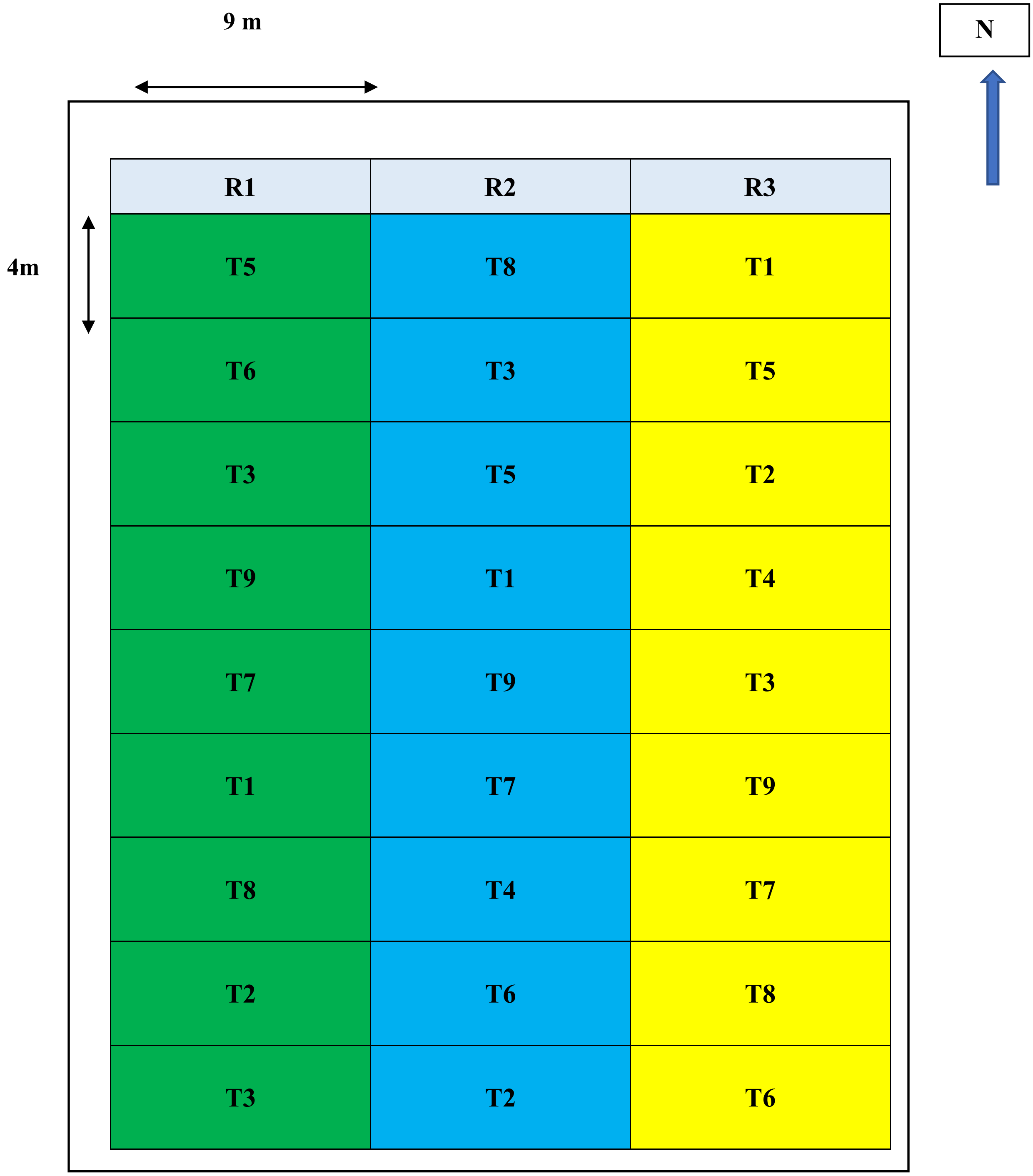

Fig 2. Layout of the experimental plot

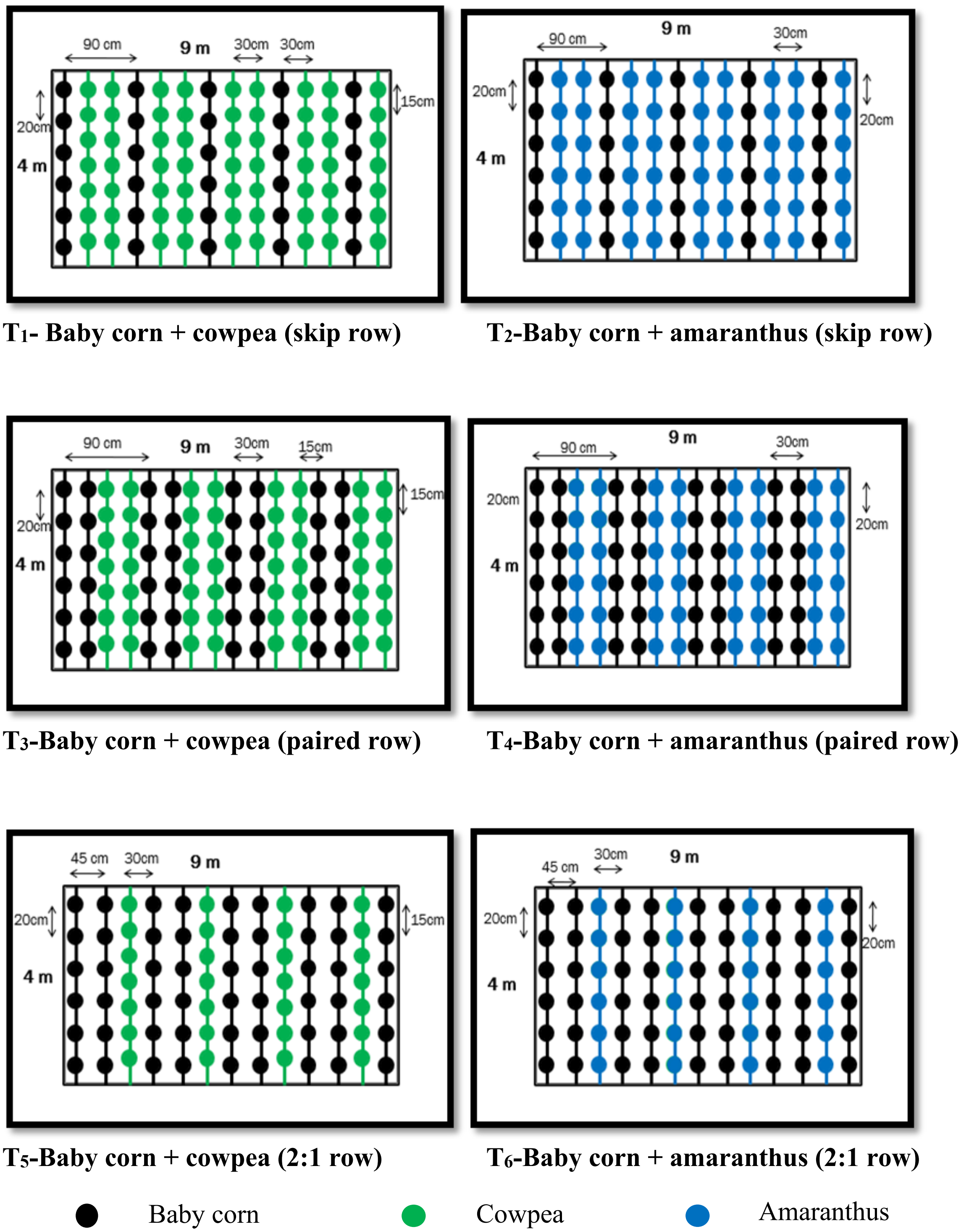

Fig 3 . Schematic representation of planting geometry

3.3.2.6 De-tasseling

To avoid pollination followed by fertilization, the male inflorescence (tassel) of baby corn plant was removed at 40-45 DAS.

3.3.2.7 Harvest

Harvesting of baby corn was done at 2-3 days after emergence of silk as immature unfertilized cobs. Cowpea pods were harvested 35 days after planting onwards at subsequent intervals as vegetable cowpea. The first cut of amaranthus was taken on 20 days after transplanting and second cut at 40 days after transplanting.

3.4 OBSERVATIONS

3.4.1 Growth and growth attributes

Five representative plants were tagged from each plot and observations were taken from the tagged plants. Boarder plants were excluded from taking observations.

3.4.1.1 Baby corn

3.4.1.1.1 Plant height

The plant height was taken from the ground level to the uppermost fully opened leaf up to the flowering stage and after flowering stage plant height was recorded from the ground level to the basal end of tassel at 15, 30 and 45 days after emergence (DAE), and expressed in cm.

3.4.1.1.2 Leaves per plant

Number of fully opened functional leaves of baby corn was counted at an interval of 15 days from the day of seedling emergence.

3.4.1.1.3 Leaf area index

Leaf area index was calculated as per the formula suggested by Balakrishnan *et al.* (1987). The length of the fully opened leaf was measured from base to tip and the breadth was taken at the widest point of leaf lamina. The LAI was recorded at 15, 30 and 45 DAS.

$$LAI = \frac{L \times B \times N \times K}{\text{Plant spacing (cm)}}$$

L – Length of leaf

B – Breadth of leaf

N – Number of leaves per plant

K – Constant (0.796)

3.4.1.1.4 Days to 50 per cent tasseling

Number of days was counted when 50 per cent of plants reached tasseling stage from the date of sowing

3.4.1.1.5 Days to 50 per cent silking

The number of days was counted when 50 per cent of plants reached silking stage from date of sowing.

3.4.1.1.6 Days to maturity

Number of days required by the plant from sowing to the harvestable maturity of the cob as baby corn was noted.

3.4.1.1.7 Days to harvest from tasseling

The number of days taken from tasseling to harvesting of baby corn was recorded.

3.4.1.1.8 Number of harvests

The number of times the baby cobs were harvested from each plot was recorded.

3.4.1.1.9 Total dry matter production

Five plants were uprooted at the time of harvest and dried under shade and then oven dried at $60 \pm 5^{0}C$ till a constant weight was obtained. The total dry matter production was expressed as kg ha^{-1}

3.4.1.1.10 Rooting depth

Rooting depth of main crop and intercrops were measured by uprooting the crops at the time of final harvest.

3.4.1.1.11 Root volume

Rooting volume of the main crop and intercrops were estimated at harvest by water displacement method.

3.4.1.2 Cowpea

3.4.1.2.1 Plant height

The plant height was measured from the ground level to the tip of the growing point from five observational plants at 15, 30 and 45 DAE and the average was worked out and expressed in cm.

3.4.1.2.2 Number of primary branches

Number of primary branches per plant was counted at 15, 30 and 45 DAE from the sample plants and the mean was taken.

3.4.1.2.3 Leaf area index

Leaf area of observational plants was measured from each plot at 30 DAS and leaf area index was calculated by the formula

$$LAI = \frac{L \times B \times N \times K}{\text{Spacing (cm)}}$$

L - Length of leaf

B- Breadth of leaf

N - Number of leaves per plant

K - Constant (0.75) (Olal, 2015)

3.4.1.2.4 Total dry matter production

Five sample plants were selected randomly and uprooted at harvest. The plants were dried under shade and then oven dried at 60±5°C till a constant weight was obtained and the total dry matter production was expressed as kg ha^{-1}.

3.4.1.2.5 Rooting depth

Five sample plants were uprooted and the rooting depth was measured in cm and the mean value was calculated.

3.4.1.2.6 Root volume

The root volume was measured by water displacement method.

3.4.1.3 Amaranthus

3.4.1.3.1 Plant height

The height was measured from ground level to the growing tip and recorded in cm at the time of first harvest.

3.4.1.3.2 Leaf area index

Leaf area index of the crop was measured at the time of harvest using the following formula.

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Space occupied by the plant}}$$

$$\text{LAI} = \frac{\text{L x B x N x K}}{\text{Plant spacing (cm)}}$$

L – Length of leaf

B- Breadth of leaf

N – Number of leaves per plant

K – Constant (0.75)

3.4.1.3.3 Total dry matter production

Five sample plants were selected randomly and uprooted at harvest. The plants were dried under shade and then oven dried at 60±5°C till a constant weight was obtained and the total dry matter production was expressed as kg ha^{-1}

3.4.1.3.4 Rooting depth

Sample plants were uprooted at the time of final harvest and the rooting depth was measured in cm and the mean was calculated.

3.4.1.3.5 Root volume

Root volume was measured using water displacement method at the time of final harvest.

3.4.2 Yield attributes and yield

3.4.2.1 Baby corn

3.4.2.1.1 Cobs per plant

The number of baby cobs harvested per plant was recorded from five sample plants.

3.4.2.1.2 Cob length

The length of the cobs were measured from the tip to base of the cob and recorded in cm.

3.4.2.1.3 Cob girth

The girth was measured using a thread, at the center of the dehusked cobs of sample plants and the average value was expressed in cm.

3.4.2.1.4 Cob weight with husk

The weight of cob (with husk) of sample plants was taken from each plot and the mean was calculated and expressed in gram per cob

3.4.2.1.5 Cob yield with husk

The weight of baby corn with husk from each plot was recorded in kg and converted to t ha^{-1}.

3.4.2.1.6 Marketable cob yield

The outer layers of husk were removed and the weight of the corn was recorded as marketable baby cob yield and expressed in t ha^{-1}

3.4.2.1.7 Cob- corn ratio

The ratio of husked baby corn (cob) weight to the dehusked baby cob (corn) weight was calculated.

3.4.2.1.8 Green stover yield

After harvesting green cobs, the plants were cut immediately from each plot and the fresh weight was recorded in kg and it was converted to t ha^{-1}.

3.4.2.2 Cowpea

3.4.2.2.1 Number of pods per plant

Number of pods per plant was recorded from the sample plants and the average was taken.

3.4.2.2.2 Length of pod

The length of pod was measured from the sample plants in cm and the average length was calculated.

3.4.2.2.3 Pod yield per plant

The mean pod yield per plant was recorded from the sample plants and expressed in g per plant.

3.4.2.2.4 Mean pod weight per plant

The mean pod yield per plant was recorded and the number of pods obtained per plant was taken from the sample plants and the mean pod weight was calculated.

3.4.2.2.5 Pod yield per ha

The yield obtained from the net plot area was recorded and converted to t ha^{-1}.

3.4.2.3 Amaranthus

3.4.2.3.1 Yield per plant

The yield of amaranthus was recorded as green leaf yield from sample plants and the average was taken and expressed in g.

3.4.2.3.2 Yield per ha

Amaranthus was harvested from the net plot area, yield recorded and converted to t ha^{-1}.

3.4.3 Pest and disease incidence in main and intercrops

The incidence of pest and disease were noted. However, mild incidence was noticed and hence scoring was not done.

3.4.4 Light interception by crop canopies

The light interception was measured as per the procedure outlined by Thavaprakaash and Velayudham (2008). The incident light above the canopy was measured by holding the sensor above the canopy in each plot using Lux meter HI 97500. The light transmitted through the canopy was measured by holding the sensor below the row and across the row and the mean value was taken. Observations were taken at 30 DAS. The percentage of light intercepted by the crop canopy was calculated by the formula,

$$PLI = \frac{LI - LT}{LI} \times 100$$

PLI : Percentage of light intercepted

LI : Light incident above the canopy

LT : Light transmitted by below the crop canopy

For measuring the light interception by the intercropping system, lux meter readings were taken from three positions, viz., upper, middle and lower canopy in the plot and mean values were worked out for light incident above main crop canopy and intercrop canopy (LI) and light incident below main crop canopy and intercrop canopy (LT) as per the procedure outlined by Tejaswitha (2016).

3.5 PLANT ANALYSIS

3.5.1 Baby corn

3.5.1.1 Crude protein content

The crude protein content of the cob and the stover was calculated by multiplying the N content by the factor 6.25 (Simpson *et al*., 1965).

3.5.1.2 Starch content

Starch content of the cob was estimated using anthrone reagent following the procedure of Sadasivam and Manickam (1996).

3.5.1.3 Total soluble sugar

The total soluble sugar in the baby corn cob was estimated using hand refractometer and expressed in ^{0}brix (Shobha *et al*., 2010)

3.5.1.4 Ascorbic acid

Ascorbic acid content of the baby cob was estimated by titrimetric method outlined by Sadasivam and Manickam (1996) and expressed as mg per 100 g on fresh weight basis.

3.5.1.5 Uptake of N, P and K at harvest

The N, P and K uptake of the crop was calculated by estimating N, P and K content of the cob and stover separately and multiplying with the dry matter production and expressed in kg ha^{-1}.

3.5.1.5.1 Uptake of N

The nitrogen content was analysed by using the modified microckjeldahl method suggested by Jackson (1973). The nitrogen content was then multiplied with total dry matter production to obtain the uptake and expressed in kg ha^{-1}.

3.5.1.5.2 Uptake of P

The phosphorus content was analysed by vanadomolybdate phosphoric yellow colour method (Piper, 1966) and the uptake was determined by multiplying it with total dry matter production.

3.5.1.5.3 Uptake of K

The potassium content was analysed by using flame photometer method (Piper, 1966) and the uptake was determined by multiplying it with total dry matter production.

3.5.2 Cowpea

3.5.2.1 Crude protein content of pod

The crude protein content of the pod was calculated by multiplying the N content by the factor 6.25 (Simpson *et al*., 1965).

3.5.2.2 Uptake of N, P and K at harvest

The N, P and K uptake of the crop was calculated by estimating the N, P and K content of the plant and pods separately and multiplying with the dry matter production and expressed in kg ha^{-1}.

3.5.2.2.1 Uptake of N

The nitrogen content was analysed by using the modified microckjeldahl method suggested by Jackson (1973). The nitrogen content was then multiplied with total dry matter production to obtain the uptake and expressed in kg ha^{-1}

3.5.2.2.2 Uptake of P

The phosphorus content was analysed by vanadomolybdate phosphoric yellow colour method (Piper, 1966) and the uptake was determined by multiplying it with total dry matter production.

3.5.2.2.3 Uptake of K

The potassium content was analysed by using flame photometer method and the uptake was determined by multiplying it with total dry matter production (Piper, 1966).

3.5.3 Amaranthus

3.5.3.1 Crude protein content

The crude protein content of the amaranthus was calculated by multiplying the N content by the factor 6.25 (Simpson *et al*., 1965).

3.5.3.2 Uptake of N, P and K at harvest

The N, P and K uptake of the crop was calculated by estimating N, P and K content of the plant and multiplying with dry matter production and expressed in kg ha^{-1}.

3.5.3.2.1 Uptake of N

The nitrogen content was analysed by using the modified microckjeldahl method suggested by Jackson (1973). The nitrogen content was then multiplied with total dry matter production to obtain the uptake and expressed in kg ha^{-1}

3.5.3.2.2 Uptake of P

The phosphorus content was analysed by vanadomolybdate phosphoric yellow colour method (Piper, 1966) and the uptake was determined by multiplying it with total dry matter production.

3.5.3.2.3 Uptake of K

The potassium content was analysed by using flame photometer method and the uptake was determined by multiplying it with total dry matter production (Piper, 1966).

3.6 COMPETITION INDICES

3.6.1 Land equivalent ratio (LER)

The land equivalent ratio (LER) denotes the relative land area under sole crop required to give the same yield as obtained under a mixed or an intercropping system at the same level of management. The LER was calculated by the formula given by Willey (1979).

$$LER = \frac{Y_{bv}}{Y_{bb}} + \frac{Y_{vb}}{Y_{vv}} = LER_b + LER_v$$

Where, Y_{bb} and Y_{vv} were the yields of baby corn and vegetables as sole crops and Y_{bv} and Y_{vb} were the yields of baby corn and vegetables as intercrops, respectively.

3.6.2 Relative crowding coefficient (RCC)

The relative crowding coefficient (RCC) is a measure of the relative dominance of one species over the other in an intercropping system. The RCC was calculated by the formula given by De Wit (1960).

$$K = K_b \times K_v$$

K = RCC of the intercropping system

K_b = RCC of baby corn

K_v = RCC of vegetables

Where, $K_b = \dfrac{Y_{bv} \times Z_{vb}}{[(Y_{bb} - Y_{bv}) \times Z_{bv}]}$

$K_v = \dfrac{Y_{vb} \times Z_{bv}}{[(Y_{vv} - Y_{vb}) \times Z_{vb}]}$

Where, Y_{bb} and Y_{vv} were the yields of baby corn and vegetables as sole crops and Y_{bv} and Y_{vb} were the yields of baby corn and vegetables as intercrops, respectively. The Z_{bv} and Z_{vb} were the proportions of baby corn and vegetables in the mixture.

3.6.3 Aggressivity (A)

Aggressivity (A) is a measure of competitive ability of component crops which indicates how much the relative yield increase in component 'a' is greater than that of component 'b'. The aggressivity of intercropping systems (A_{bv} and A_{vb}) were calculated by the formula suggested by Mc Gilchrist (1965).

1) $A_{bv} = (Y_{bv} / Y_{bb} \times Z_{bv}) - (Y_{vb} / Y_{vv} \times Z_{vb})$

2) $A_{vb} = (Y_{vb} / Y_{vv} \times Z_{vb}) - (Y_{bv} / Y_{bb} \times Z_{bv})$

$$A_{bv} = \frac{Y_{bv}}{Y_{bb} \times Z_{bv}} - \frac{Y_{vb}}{Y_{vv} \times Z_{vb}}$$

$$A_{vb} = \frac{Y_{vb}}{Y_{vv} \times Z_{vb}} - \frac{Y_{bv}}{Y_{bb} \times Z_{bv}}$$

Where,

- A_{bv} and A_{vb} were the aggressivity of baby corn with respect to vegetables and aggressivity of vegetables with respect to baby corn respectively
- Y_{bv} and Y_{vb} were the yields of baby corn and vegetables respectively under intercropping.
- Y_{bb} and Y_{vv} were the yields of baby corn and vegetables respectively as sole crops.
- Z_{bv} and Z_{vb} were the proportions of baby corn and vegetables respectively in the mixture.

3.6.4 Monetary advantage index (MAI)

The monetary advantage index (MAI) quantifies the monetary advantage of intercropping system over sole cropping. The MAI was calculated by the formula suggested by Willey (1979)

$$\text{MAI} = (\text{Value of combined intercrop yield}) \times \frac{(\text{LER-1})}{\text{LER}}$$

3.6.5 Baby corn equivalent yield (BEY)

The yield of intercrops cowpea and amaranthus were converted into equivalent yield of baby corn based on the price of the produce and the baby corn equivalent yield of the intercropping system was calculated by the following formula

$$\text{BEY} = \text{Baby corn yield} + \frac{(\text{Intercrop yield} \times \text{price})}{\text{Price of baby corn}}$$

(Reddy and Reddy, 2016)

3.7 SOIL ANALYSIS

Soil samples were collected from each plot after the experiment and were analysed.

3.7.1 pH

The pH of the soil sample was found out by diluting with water in the ratio 1:2.5 and analysing using pH meter (Jackson, 1973)

3.7.2 Electrical conductivity (EC)

The EC of the soil samples were estimated by using conductivity meter and expressed in dSm^{-1} (Jackson, 1973).

3.7.3 Organic carbon

The organic carbon content in the soil sample was estimated using Walkley and Black rapid titration method (Jackson, 1973) and expressed in percentage.

3.7.4 Available N

Available nitrogen content of soil sample was analysed using alkaline permanganate method suggested by Subbiah and Asija (1956) and expressed in kg ha^{-1}.

3.7.5 Available P

Available P content of soil sample was analysed by using bray colorimetric method (Jackson, 1973) and expressed in kg ha^{-1}.

3.7.6 Available K

Available potassium content was estimated by extracting the soil sample with neutral normal ammonium acetate and estimated using flame photometer (Jackson, 1973) and expressed in kg ha^{-1}

3.8 ECONOMIC ANALYSIS

Economics of cultivation was worked out by taking into account the cost of inputs and prevailing market price of baby corn, cowpea and amaranthus during the cropping period as given in Appendix II.

3.8.1 Net returns

Net returns was calculated using the following formula and was expressed in ₹ ha^{-1}.

Net returns = Gross returns - Total cost of cultivation

3.8.2 Benefit : cost ratio (BCR)

The benefit: cost ratio was calculated as follows.

$$BCR = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Total cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.9 STATISTICAL ANALYSIS

Data generated were statistically analysed by using Analysis of Variance technique (ANOVA) suggested by Panse and Sukhatme (1985) as applied to Randomised Block Design. For the statistical analysis of intercrops, data from two additional replications were also included for satisfying the degrees of freedom. The significance was tested using F test (Snedecor and Cochran, 1967). Critical difference was worked out at 5 per cent level of probability, wherever the treatment differences were found significant.

RESULTS

4. RESULTS

The study entitled "Intercropping vegetables in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani during 2018-20. The aim of the study was to investigate the feasibility of intercropping cowpea and amaranthus in baby corn and to find out the effect of crop geometry on growth, yield, productivity and economics of the intercropping systems. The results of the experiment are presented in this chapter.

4.1 GROWTH AND GROWTH ATTRIBUTES OF BABY CORN BASED INTERCROPPING SYSTEMS WITH VEGETABLES

4.1.1 Growth and growth attributes of main crop -baby corn

The growth and growth attributes of baby corn are presented below.

4.1.1.1 Plant height

The result of the effect of baby corn based intercropping systems with vegetables on plant height of baby corn is presented in Table 4.

Different intercropping systems with baby corn and vegetables did not have any significant effect on plant height of main crop baby corn at 15, 30 and 45 DAE.

4.1.1.2 Leaves per plant

The result of the effect of intercropping vegetables on number of leaves per plant of main crop baby corn is given in Table 5.

Different intercropping treatments could not significantly affect the number of leaves per plant of baby corn.

Table 4. Effect of baby corn and vegetable intercropping systems on plant height of baby corn, cm

Treatments	Plant height		
	15 DAE	30 DAE	45 DAE
T_1 -baby corn + cowpea (skip row)	27.56	109.16	211.30
T_2-baby corn + amaranthus (skip row)	25.90	114.13	206.02
T_3-baby corn + cowpea (paired row)	27.39	124.06	206.43
T_4-baby corn + amaranthus (paired row)	27.13	126.86	212.00
T_5-baby corn + cowpea (2:1 ratio)	26.20	116.79	220.00
T_6-baby corn + amaranthus (2:1 ratio)	25.84	99.40	209.76
T_7-sole crop of baby corn	28.51	117.02	216.26
SEm (±)	0.72	7.59	5.18
CD (0.05)	NS	NS	NS

Table 5. Effect of baby corn and vegetable intercropping systems on number of leaves per plant of baby corn.

Treatments	Number of leaves per plant		
	15 DAE	30 DAE	45 DAE
T_1 -baby corn + cowpea (skip row)	4.93	6.93	10.20
T_2-baby corn + amaranthus (skip row)	6.86	6.86	10.06
T_3-baby corn + cowpea (paired row)	5.00	7.00	10.13
T_4-baby corn + amaranthus (paired row)	4.86	6.86	10.33
T_5-baby corn + cowpea (2:1 ratio)	4.73	6.73	10.26
T_6-baby corn + amaranthus (2:1 ratio)	4.60	6.60	10.13
T_7-sole crop of baby corn	4.80	6.80	10.13
SEm (±)	0.79	0.17	0.09
CD (0.05)	NS	NS	NS

4.1.1.3 Leaf area index

The result of the effect of baby corn based intercropping systems with vegetables on leaf area index of baby corn is detailed in Table 6.

Leaf area index was not influenced by the intercropping systems at any growth stage.

4.1.1.4 Days to 50 per cent tasseling

The result of the effect of baby corn and vegetable intercropping systems on days to 50 per cent tasseling in baby corn is indicated in Table 7.

Different intercropping systems with vegetables could not affect the days to 50 per cent tasseling in baby corn.

4.1.1.5 Days to 50 per cent silking

The result of the effect of baby corn based intercropping systems with vegetables on days to 50 per cent silking in baby corn is shown in Table 7.

The intercropping treatments did not significantly influence the days to 50 per cent silking in baby corn.

4.1.1.6 Days to maturity

The result of the effect of vegetable intercropping on days to maturity of main crop baby corn is detailed in Table 7.

None of the treatments could significantly influence the number of days taken for maturity of baby corn.

4.1.1.7 Days to harvest from tasseling

The result of the effect of baby corn and vegetable intercropping systems on number of days from tasseling to harvest of baby corn is presented in Table 8.

Table 6. Effect of baby corn and vegetable intercropping systems on leaf area index of baby corn.

Treatments	Leaf area index		
	15 DAE	30 DAE	45 DAE
T_1 -baby corn + cowpea (skip row)	0.19	3.13	6.20
T_2-baby corn + amaranthus (skip row)	0.18	3.23	6.30
T_3-baby corn + cowpea (paired row)	0.21	3.85	6.27
T_4-baby corn + amaranthus (paired row)	0.23	3.36	6.42
T_5-baby corn + cowpea (2:1 ratio)	0.17	3.23	6.31
T_6-baby corn + amaranthus (2:1 ratio)	0.15	2.65	6.06
T_7-sole crop of baby corn	0.19	2.97	5.92
SEm (±)	0.02	0.24	0.32
CD (0.05)	NS	NS	NS

Table 7: Effect of baby corn and vegetable intercropping systems on days to 50 per cent tasseling, 50 per cent silking and days to maturity in baby corn

Treatments	Days to 50 per cent tasseling	Days to 50 per cent silking	Days to maturity
T_1 -baby corn + cowpea (skip row)	48.66	50.66	53.33
T_2-baby corn + amaranthus (skip row)	48.66	50.66	53.66
T_3-baby corn + cowpea (paired row)	49.33	51.33	54.66
T_4-baby corn + amaranthus (paired row)	48.66	51.66	54.00
T_5-baby corn + cowpea (2:1 ratio)	48.66	50.66	53.66
T_6-baby corn + amaranthus (2:1 ratio)	48.33	51.00	53.66
T_7-sole crop of baby corn	49.33	51.66	54.66
SEm (±)	0.33	0.36	0.41
CD (0.05)	NS	NS	NS

The days taken from tasseling to harvesting of baby corn was not significantly influenced by the intercropping systems.

4.1.1.8 Number of harvests

The result of the effect of baby corn based intercropping systems with vegetables on number of harvests in baby corn is shown in Table 8.

The intercropping treatments did not have any significant effect on number of harvests in baby corn.

4.1.1.9 Total dry matter production

The result of the influence of baby corn based intercropping systems with vegetables on total dry matter production of baby corn at harvest is given in Table 9.

The total dry matter production of baby corn was significantly influenced by the intercropping systems. Paired row planting of baby corn with cowpea (T_3) registered the highest dry matter yield of 24453 kg ha^{-1} which was significantly superior to planting baby corn and amaranthus in 2:1 ratio (T_6), planting baby corn with cowpea in 2:1 ratio (T_5), skip row planting of baby corn with amaranthus (T_2) and skip row planting of baby corn with cowpea (T_1) which produced a dry matter yield of 19518, 18463, 16836 and 15283 kg ha^{-1}, respectively. The treatment T_3 was however on par with T_4 (paired row planting of baby corn with amaranthus) and T_7 (sole cropping of baby corn) which recorded a total dry matter production of 23571 kg ha^{-1} and 23274 kg ha^{-1}, respectively.

4.1.1.10 Rooting depth (at harvest)

The result of the effect of baby corn and vegetable intercropping systems on rooting depth of baby corn at harvest is presented in Table 10.

Rooting depth of baby corn at harvesting stage was not significantly influenced by the treatments.

Table 8. Effect of baby corn and vegetable intercropping systems on days to harvest from tasseling and number of harvests in baby corn

Treatments	Days to harvest from tasseling	Number of harvests
T_1 -baby corn + cowpea (skip row)	4.66	3.00
T_2-baby corn + amaranthus (skip row)	5.00	3.00
T_3-baby corn + cowpea (paired row)	5.33	3.66
T_4-baby corn + amaranthus (paired row)	5.33	3.66
T_5-baby corn + cowpea (2:1 ratio)	5.00	3.33
T_6-baby corn + amaranthus (2:1 ratio)	5.33	4.00
T_7-sole crop of baby corn	5.33	3.66
SEm (±)	0.42	0.26
CD (0.05)	NS	NS

Table 9. Effect of baby corn and vegetable intercropping systems on total dry matter production of baby corn at harvest, kg ha^{-1}

Treatments	Total dry matter production
T_1 -baby corn + cowpea (skip row)	15283
T_2-baby corn + amaranthus (skip row)	16836
T_3-baby corn + cowpea (paired row)	24453
T_4-baby corn + amaranthus (paired row)	23571
T_5-baby corn + cowpea (2:1 ratio)	18463
T_6-baby corn + amaranthus (2:1 ratio)	19518
T_7-sole crop of baby corn	23274
SEm (±)	980
CD (0.05)	3052

Table 10. Effect of baby corn and vegetable intercropping systems on rooting depth and root volume of baby corn at harvest

Treatments	Rooting depth (cm)	Root volume (cm^3)
T_1 -baby corn + cowpea (skip row)	33.13	55.33
T_2-baby corn + amaranthus (skip row)	32.76	55.00
T_3-baby corn + cowpea (paired row)	32.73	66.66
T_4-baby corn + amaranthus (paired row)	32.66	58.16
T_5-baby corn + cowpea (2:1 ratio)	32.83	54.33
T_6-baby corn + amaranthus (2:1 ratio)	33.13	60.16
T_7-sole crop of baby corn	32.50	72.33
SEm (±)	1.31	5.85
CD (0.05)	NS	NS

Table 11. Effect of baby corn and cowpea intercropping systems on plant height of cowpea, cm

Treatments	Plant height		
	15 DAE	30 DAE	45 DAE
T_1 -baby corn + cowpea (skip row)	19.20	52.06	101.75
T_3 -baby corn + cowpea (paired row)	18.14	55.93	104.10
T_5 -baby corn + cowpea (2:1 ratio)	16.39	49.53	80.55
T_8 - sole crop of cowpea	17.80	51.13	108.55
SEm (±)	0.91	2.26	4.03
CD (0.05)	NS	NS	14.245

4.1.1.11 Root volume (at harvest)

The result of the effect of baby corn and vegetable intercropping systems on root volume of baby corn at harvest is indicated in Table 10.

Root volume of baby corn was unaffected by the treatments. But a slightly higher root volume was recorded in sole crop of baby corn (72.33 cm^3) compared to that under intercropping.

4.1.2 Growth and growth attributes of intercrop –cowpea

The growth parameters such as plant height, number of primary branches, leaf area index, total dry matter production, rooting depth and root volume of cowpea as an intercrop in baby corn are described hereunder.

4.1.2.1 Plant height

The results of the effect of intercropping systems on plant height of cowpea as an intercrop in baby corn are presented in Table 11.

Different intercropping treatments did not have any influence on plant height of cowpea at 15 and 30 DAE. However, at 45 DAE, the plant height of cowpea was significantly affected by the treatments.

The sole cropping of cowpea recorded the highest plant height (108.55 cm) and was on par with the intercropping treatments, T_3 (baby corn + cowpea in paired row) and T_1 (baby corn + cowpea in skip row) which registered a plant height of 104.10 cm and 101.75 cm, respectively. However, a significant reduction was observed in plant height when cowpea was planted with baby corn in 2:1 ratio (80.55 cm) in T_5 and all the other treatments were significantly superior to T_5 with respect to plant height.

4.1.2.2 Number of primary branches

The results of the effect of intercropping vegetable cowpea in baby corn on number of primary branches of cowpea are shown in the Table 12.

Intercropping of cowpea in baby corn had no significant effect on the number of primary branches of cowpea at 15 or 30 DAE. However, at 45 DAE the treatments could significantly influence the branching of cowpea. The sole crop of cowpea produced the highest number of primary branches at 45 DAE (3.33) which was significantly superior to all intercropping treatments involving cowpea such as T_3 (paired row planting of cowpea in baby corn), T_1 (skip row planting of cowpea in baby corn) and T_5 (planting baby corn and cowpea in 2:1 ratio) which were on par each other.

4.1.2.3 Leaf area index (30 DAS)

The results of effect of intercropping vegetable cowpea in baby corn on leaf area index of cowpea at 30 DAS are presented in Table 13.

The leaf area index of cowpea was significantly influenced by the treatments. The sole crop of cowpea recorded the highest (3.46) leaf area index (LAI) compared to its cultivation under intercropping and was significantly superior to T_1 (skip row planting of cowpea in baby corn)-2.71, T_3 (paired row planting of cowpea in baby corn)-2.25 and T_5 (planting baby corn and cowpea in 2:1 ratio)-1.80. However, the intercropping system T_1 was significantly superior to T_3 and T_5, while T_3 was statistically superior to T_5. A noticeable reduction in LAI was observed in T_5 wherein baby corn and cowpea were intercropped in 2:1 ratio.

4.1.2.4 Total dry matter production

The results of the effect of intercropping baby corn and vegetable cowpea on total dry matter production of cowpea are depicted in Table 14.

The total dry matter production of cowpea was significantly higher with the sole crop (6564.01 kg ha^{-1}) compared to its cultivation as intercrop and there was a drastic reduction in the dry matter production under intercropping situation. However, among different intercropping systems, the higher total dry matter production of cowpea was

Table 12. Effect of baby corn and cowpea intercropping systems on number of primary branches of cowpea.

Treatments	Number of primary branches		
	15 DAE	30 DAE	45 DAE
T_1 -baby corn + cowpea (skip row)	1.33	2.00	3.03
T_3 -baby corn + cowpea (paired row)	1.00	2.20	3.10
T_5 -baby corn + cowpea (2:1 ratio)	1.00	2.00	3.00
T_8 - sole crop of cowpea	1.00	2.00	3.33
SEm (±)	0.16	0.05	0.06
CD (0.05)	NS	NS	0.215

Table 13. Effect of intercropping baby corn and cowpea on the leaf area index of cowpea

Treatments	Leaf area index (30 DAS)
T_1 -baby corn + cowpea (skip row)	2.71
T_3 -baby corn + cowpea (paired row)	2.25
T_5 -baby corn + cowpea (2:1 ratio)	1.80
T_8 - sole crop of cowpea	3.46
SEm (±)	0.05
CD (0.05)	0.180

recorded (1851.66 kg ha^{-1}) in T_1 (skip row planting) which was on par with T_3 (paired row planting -1690.68 kg ha^{-1}). The treatment T_1 was superior to T_5, which produced a dry matter yield of 920.68 kg ha^{-1} which in turn did not significantly vary from T_3 with respect to dry matter production at harvest.

4.1.2.5 Rooting depth (at final harvest)

The results of effect of intercropping cowpea in baby corn on rooting depth of cowpea at final harvest are indicated in Table 15.

Different intercropping systems significantly influenced the rooting depth of cowpea at the time of final harvest. The sole crop of cowpea (T_8) registered higher rooting depth of 27.13 cm which was on par with T_1 (skip row planting) recording a rooting depth of 26.33 cm. Both T_8 and T_1 were superior to the other two intercropping treatments T_3 (paired tow planting) and T_5 (2:1 ratio planting) producing a rooting depth of 24.16 cm and 23.16 cm, respectively which did not vary each other.

4.1.2.6 Root volume (at final harvest)

The results of effect of intercropping treatments on root volume of cowpea as intercrop are presented in Table 15.

The sole crop of cowpea (T_8) recorded the higher root volume (9.40 cm^3), which was on par with skip row planting of baby corn and cowpea (T_1-8.66 cm^3). The T_1 in turn was superior to T_5 (baby corn and cowpea planting in 2:1 ratio) treatment with respect to root volume (6.80 cm^3) which in turn produced significantly higher value compared to T_3 (5.50 cm^3).

Table 14. Effect of intercropping baby corn and cowpea on total dry matter production of cowpea, kg ha^{-1}

Treatments	Total dry matter production
T_1 -baby corn + cowpea (skip row)	1851.66
T_3 -baby corn + cowpea (paired row)	1690.68
T_5 -baby corn + cowpea (2:1 ratio)	920.68
T_8 - sole crop of cowpea	6564.01
SEm (±)	236.65
CD (0.05)	834.850

Table 15. Effect of intercropping baby corn and cowpea on rooting depth and root volume of cowpea at harvest

Treatments	Rooting depth (cm)	Root volume (cm^3)
T_1 -baby corn + cowpea (skip row)	26.33	8.66
T_3 -baby corn + cowpea (paired row)	24.16	5.50
T_5 -baby corn + cowpea (2:1 ratio)	23.16	6.80
T_8 - sole crop of cowpea	27.13	9.50
SEm(±)	0.51	0.32
CD (0.05)	1.816	1.148

4.1.3. Growth and growth attributes of intercrop –amaranthus

The results of growth parameters such as plant height, leaf area index, total dry matter production, rooting depth and root volume of amaranthus as an intercrop in baby corn are presented below.

4.1.3.1 Plant height

The result of the effect of intercropping amaranthus in baby corn on plant height of amaranthus at the time of harvest is presented in Table 16.

Single harvest of amaranthus was taken in case of intercropping treatments while two harvests were taken from sole crop of amaranthus (T_9). Therefore, the plant height measured at the I^{st} harvest was considered for all the treatments.

The plant height of amaranthus was significantly influenced by the treatments. The sole crop (T_9) registered higher value for plant height (60.86 cm) but was on par with skip row planting of baby corn and amaranthus (T_2) which recorded a plant height of 60.53 cm and paired row planting of baby corn and amaranthus (T_4) producing a plant height of 50.46 cm. The treatments T_9 and T_2 were significantly superior to T_6 which produced shorter plants (40.13 cm) which in turn was on par with T_4 (paired row planting).

4.1.3.2 Leaf area index (LAI)

The result of effect of intercropping amaranthus with baby corn on LAI of amaranthus at the time of first harvest is shown in Table 16.

The LAI of amaranthus was significantly influenced by intercropping and sole cropping. The sole crop of amaranthus (T_9) produced the highest LAI of 1.78 which was superior to all other treatments. Among intercropping systems, T_2 (skip row planting) produced higher LAI of 0.89 which was significantly higher than that recorded with T_4 -

Table 16. Effect of intercropping amaranthus in baby corn on plant height and leaf area index of amaranthus at first harvest

Treatments	Plant height (cm)	Leaf area index
T_2- baby corn + amaranthus (skip row)	60.53	0.89
T_4- baby corn + amaranthus (paired row)	50.46	0.61
T_6- baby corn + amaranthus (2:1 ratio)	40.13	0.34
T_9- sole crop of amaranthus	60.86	1.78
SEm (±)	3.05	0.03
CD (0.05)	10.779	0.120

Table 17. Effect of intercropping amaranthus in baby corn on total dry matter production of amaranthus, kg ha^{-1}

Treatments	Total dry matter production
T_2- baby corn + amaranthus (skip row)	1431.73
T_4- baby corn + amaranthus (paired row)	659.70
T_6- baby corn + amaranthus (2:1 ratio)	499.70
T_9- sole crop of amaranthus	2980.10
SEm (±)	39.34
CD (0.05)	138.809

paired row planting (0.61) and T_6 - planting base crop and intercrop in 2:1 ratio (0.34). However, the treatment T_4 was found to be superior to T_6.

4.1.3.3 Total dry matter production

The result of effect of intercropping amaranthus in baby corn on total dry matter production of amaranthus at harvest is given in Table 17.

The total dry matter production of amaranthus was significantly influenced by the treatments. The sole crop of amaranthus (T_9) had the highest dry matter production

(2980.10 kg ha^{-1}) which was superior to all other treatments. Among different intercropping systems, T_2 (skip row planting) recorded a dry matter production of 1431.73 kg ha^{-1} which was significantly higher than that recorded with other treatments such as T_4 (paired row planting)-659.70 kg ha^{-1} and T_6 (planting baby corn and amaranthus in 2:1 ratio)- 499.70 kg ha^{-1}. The treatment T_4 was however significantly superior to T_6 wherein a drastic reduction in dry matter production was observed.

4.1.3.4 Rooting depth (at final harvest)

Rooting depth of amaranthus as influenced by intercropping with baby corn is detailed in Table 18. The rooting depth of amaranthus did not show significant variation with respect to different treatments.

4.1.3.5 Root volume (at final harvest)

Rooting volume of amaranthus as influenced by intercropping with baby corn is presented in Table 18.

Root volume of amaranthus was not significantly affected by different treatments. However, the root volume of sole crop of amaranthus was comparatively higher than that of intercrops.

Table 18. Effect of intercropping amaranthus in baby corn on rooting depth and root volume of amaranthus at final harvest

Treatments	Rooting depth (cm)	Root volume (cm^3)
T_2- baby corn + amaranthus (skip row)	30.50	8.66
T_4- baby corn + amaranthus (paired row)	21.83	6.00
T_6- baby corn + amaranthus (2:1 ratio)	23.33	5.33
T_9- sole crop of amaranthus	30.53	12.00
SEm(±)	2.51	1.41
CD (0.05)	NS	NS

Table 19. Effect of baby corn and vegetable intercropping systems on cobs per plant, cob length and cob girth of baby corn

Treatments	Cobs per plant	Cob length (cm)	Cob girth (cm)
T_1 -baby corn + cowpea (skip row)	3.38	11.54	4.96
T_2-baby corn + amaranthus (skip row)	3.12	11.47	4.66
T_3-baby corn + cowpea (paired row)	2.63	12.42	5.04
T_4-baby corn + amaranthus (paired row)	2.64	11.83	4.77
T_5-baby corn + cowpea (2:1 ratio)	2.45	11.27	4.83
T_6-baby corn + amaranthus (2:1 ratio)	2.42	11.52	5.15
T_7-sole crop of baby corn	2.49	12.51	5.27
SEm(±)	0.12	0.76	0.38
CD (0.05)	0.366	NS	NS

4.2 YIELD ATTRIBUTES AND YIELD OF BABY CORN BASED INTERCROPPING SYSTEMS WITH VEGETABLES

4.2.1 Yield attributes and yield of main crop- baby corn

Effect of intercropping on yield attributes and yield of baby corn is presented below.

4.2.1.1 Cobs per plant

The result of the effect of baby corn based intercropping systems with vegetables on number of cobs per plant of baby corn is presented in Table 19.

The number of cobs per plant was significantly influenced by intercropping. T_1 (baby corn + cowpea in skip row) and T_2 (baby corn + amaranthus in skip row) treatments recorded significantly higher number of cobs per plant (3.38 and 3.12, respectively) compared to other treatments and were on par each other. There was no significant difference between the number of cobs produced by other treatments including the sole cropping.

4.2.1.2 Cob length

The result of the effect of baby corn based intercropping systems with vegetables on baby corn cob length is given in Table 19.

Different intercropping systems did not have any significant effect on cob length of main crop baby corn.

4.2.1.3 Cob girth

The result of the effect of intercropping vegetables with baby corn on cob girth of baby corn is shown in Table 19.

Different intercropping systems could not influence the cob girth of baby corn.

4.2.1.4 Cob weight with husk

The result of the effect of intercropping vegetables in baby corn on cob weight with husk of baby corn is presented in Table 20.

The cob weight with husk of baby corn significantly differed with the treatments. Paired row planting of baby corn with cowpea (T_3) registered significantly higher cob weight with husk of 49.5 g compared to all other treatments except T_4 (paired row planting of baby corn with amaranthus) and T_4 which recorded a cob weight with husk of 48.0 g was on par with T_3. The treatment T_4 however did not significantly vary from T_1 and T_2 (skip row planting of cowpea or amaranthus with baby corn) which produced a cob weight with husk value of 47.00 and 46.66 g, respectively. All other treatments (T_5, T_6 and T_7) produced statistically similar values (46.00, 46.16 and 46.16 g, respectively) which were on par with T_1 and T_2.

4.2.1.5 Cob yield with husk

The result of the effect of baby corn and vegetable intercropping systems on cob yield with husk of baby corn is given in Table 20.

The cob yield with husk was significantly influenced by the treatments. Paired row planting of baby corn with cowpea (T_3) produced the highest cob yield with husk (11.39 t ha^{-1}) which was significantly superior to all other treatments including the sole crop (10.27 t ha^{-1}). The treatment T_3 was followed by T_4 (planting of baby corn and amaranthus in paired row) in case of cob yield with husk production (10.72 t ha^{-1}) which in turn was on par with the sole crop of baby corn (T_7- 10.27 t ha^{-1}). The treatments T_3, T_4 and T_7 were however superior to all other treatments viz., T_1, T_2, T_5 and T_6 in terms of production of cob yield with husk (8.20, 7.25, 8.96 and 8.82 t ha^{-1}, respectively). T_1 was however significantly superior to T_2, while T_5 was on par with T_6.

Table 20. Effect of baby corn and vegetable intercropping systems on baby corn cob weight with husk, cob yield with husk and marketable cob yield

Treatments	Cob weight with husk (g)	Cob yield with husk (t ha^{-1})	Marketable cob yield (t ha^{-1})
T_1 -baby corn + cowpea (skip row)	47.00	8.20	2.54
T_2-baby corn + amaranthus (skip row)	46.66	7.25	2.25
T_3-baby corn + cowpea (paired row)	49.50	11.39	3.53
T_4-baby corn + amaranthus (paired row)	48.00	10.72	3.32
T_5-baby corn + cowpea (2:1 ratio)	46.00	8.96	2.78
T_6-baby corn + amaranthus (2:1 ratio)	46.16	8.82	2.73
T_7-sole crop of baby corn	46.16	10.27	3.18
SEm (±)	0.54	0.21	0.07
CD (0.05)	1.683	0.663	0.206

Table 21. Effect of baby corn and vegetable intercropping systems on cob- corn ratio and green stover yield of baby corn.

Treatments	Cob-corn ratio	Green stover yield (t ha^{-1})
T_1 -baby corn + cowpea (skip row)	3.62	23.50
T_2-baby corn + amaranthus (skip row)	3.92	27.66
T_3-baby corn + cowpea (paired row)	3.40	39.33
T_4-baby corn + amaranthus (paired row)	3.37	38.16
T_5-baby corn + cowpea (2:1 ratio)	3.94	32.00
T_6-baby corn + amaranthus (2:1 ratio)	3.95	32.50
T_7-sole crop of baby corn	3.54	38.00
SEm (±)	0.13	2.39
CD (0.05)	0.430	7.451

4.2.1.6 Marketable cob yield

The result of the effect of intercropping baby corn and vegetables on marketable cob yield of baby corn is detailed in Table 20.

Marketable cob yield of baby corn was significantly influenced by the intercropping treatments. T_3 (baby corn + cowpea in paired row) recorded the highest marketable cob yield of 3.53 t ha^{-1} which was significantly superior to all other treatments including the sole crop of baby corn (T_7) and was followed by T_4 (baby corn + amaranthus in paired row) which however was on par with the sole crop (T_7) producing a marketable cob yield of 3.32 and 3.18 t ha^{-1}, respectively. Both T_4 and T_7 were statistically superior to the treatments in which cowpea or amaranthus were planted in 2:1 ratio with baby corn ie. T_5 and T_6 recording a marketable baby corn yield of 2.78 and 2.73 t ha^{-1}, respectively which were on par each other. The treatment T_6 in turn did not differ from T_1 in which baby corn and cowpea were planted in skip row (marketable cob yield 2.54 t ha^{-1}). Skip row planting of amaranthus with baby corn (T_2) resulted in the lowest marketable cob yield of 2.25 t ha^{-1}.

4.2.1.7 Cob-corn ratio

The result of the effect of baby corn and vegetable intercropping systems on cob-corn ratio of baby corn is shown in Table 21.

Cob- corn ratio of baby corn was significantly influenced by the intercropping treatments. The treatment T_4 (paired row planting of baby corn and amaranthus) recorded lower cob-corn ratio of 3.37 which was on par with T_3 (baby corn + cowpea in paired row-3.40) and were significantly lower than T_6 (baby corn + amaranthus in 2:1 ratio), T_5 (baby corn + cowpea in 2:1 ratio) and T_2 (baby corn + amaranthus in skip row) which recorded cob-corn ratio of 3.95, 3.94 and 3.92, respectively. However, T_1 (baby corn + cowpea in skip row) and T_7 (sole crop of baby corn) recorded comparatively higher cob-corn ratio 3.62 and 3.54 respectively which were on par with T_4 and T_3.

4.2.1.8 Green stover yield

The result of the effect of baby corn based intercropping systems with vegetables on green stover yield of baby corn is presented in Table 21

Green stover yield of baby corn was influenced by the treatments. The treatment T_3 (paired row planting of baby corn and cowpea) produced the highest green stover yield (39.33 t ha^{-1}) which was significantly higher than the green stover yield produced in T_2 (skip row planting of baby corn and amaranthus-27.66 t ha^{-1}) and T_1 (skip row planting of baby corn and cowpea- 23.5 t ha^{-1}) which did not vary each other. T_3 was however, on par with T_4 (baby corn+ amaranthus in paired row), T_7 (sole crop of baby corn), T_6 (baby corn+ amaranthus in 2:1 row) and T_5 (baby corn + cowpea in 2:1 ratio) which produced a green stover yield of 38.16, 38.00, 32.5 and 32.00 t ha^{-1}, respectively which were on par each other.

4.2.2 Yield attributes and yield of intercrop - cowpea

4.2.2.1 Number of pods per plant

The results of the effect of intercropping systems on number of pods per plant in intercrop cowpea is detailed in Table 22.

The treatments could significantly influence the number of pods per plant of cowpea. There was a significant reduction in the number of pods per plant in all the intercropping treatments compared to sole cropping of cowpea and the sole crop (T_8) recorded the highest number of pods per plant (10.53) which was significantly superior to all other treatments viz., skip row planting of cowpea with baby corn (T_1), paired row planting of cowpea with baby corn (T_3) and planting of baby corn and cowpea in 2:1 ratio (T_5) which recorded 6.26, 5.06 and 4.73 number of pods per plant, respectively. The intercropping treatments T_1, T_3 and T_5 were however on par each other.

4.2.2.2 Length of pod

The results of the effect of intercropping systems on pod length of cowpea is presented in Table 22.

Intercropping cowpea with baby corn had no significant influence on the length of pod in cowpea.

4.2.2.3 Mean pod weight

The results of the effect of intercropping systems on mean pod weight of cowpea is given in Table 22.

Different intercropping treatments did not affect the mean pod weight of cowpea.

4.2.2.4 Pod yield per plant

The results of the effect of baby corn and cowpea intercropping systems on pod yield per plant of cowpea is shown in Table 23.

Intercropping of baby corn and cowpea under different planting patterns significantly influenced the pod yield per plant of cowpea. The pod yield per plant was significantly reduced in all the intercropping treatments compared to sole crop of cowpea. The highest pod yield per plant was recorded with sole crop of cowpea (T_8- 63.00 g) which was significantly superior to the intercropping treatments T_1 (baby corn and cowpea in skip row), T_3 (baby corn and cowpea in paired row) and T_5 (planting baby corn and cowpea in 2:1 ratio) which produced a pod yield of 35.94, 31.29 and 27.66 g per plant, respectively. Among the intercropping treatments, T_1 was on par with T_3 which in turn did not vary from T_5.

4.2.2.5 Pod yield per ha

The results of the effect of baby corn and cowpea intercropping systems on pod yield per ha of cowpea is indicated in Table 23.

Table 22. Effect of baby corn and cowpea intercropping systems on number of pods per plant, length of pod and mean pod weight of cowpea

Treatments	Number of pods per plant	Length of pod (cm)	Mean pod weight (g)
T_1 -baby corn + cowpea (skip row)	6.26	17.85	5.72
T_3 -baby corn + cowpea (paired row)	5.06	17.95	6.20
T_5 -baby corn + cowpea (2:1 ratio)	4.73	17.22	5.46
T_8 - sole crop of cowpea	10.53	18.96	5.72
SEm (±)	0.62	0.66	0.33
CD (0.05)	2.214	NS	NS

Table 23. Effect of baby corn and cowpea intercropping systems on pod yield per plant and pod yield per ha of cowpea.

Treatments	Pod yield per plant (g)	Pod yield per ha (t)
T_1 -baby corn + cowpea (skip row)	35.94	2.17
T_3 -baby corn + cowpea (paired row)	31.29	2.01
T_5 -baby corn + cowpea (2:1 ratio)	27.66	1.62
T_8 - sole crop of cowpea	63.00	6.53
SEm (±)	2.11	0.08
CD (0.05)	7.475	0.285

Pod yield per ha of intercrop cowpea was significantly influenced by intercropping. The highest pod yield per ha was recorded in sole crop of cowpea (T_8 - 6.83 t ha^{-1}) which was significantly superior to all the intercropping treatments. There was a marked reduction in the pod yield per ha in case of intercropping treatments T_1 (baby corn and cowpea in skip row-2.17 t), T_3 (baby corn and cowpea in paired row-2.01 t) and T_5 (planting baby corn and cowpea in 2:1 ratio-1.62 t), where T_1 and T_3 were found to be on par each other and both were superior to T_5.

4.2.3 Yield attributes and yield of intercrop- amaranthus

4.2.3.1 Yield per plant

The results of the effect of baby corn and amaranthus intercropping systems on yield per plant of amaranthus is given in Table 24.

The sole crop of amaranthus (T_9) produced the highest per plant yield of 96.00 g which was on par with T_2 (skip row planting with baby corn-91.13 g). However these treatments were significantly superior to T_4 (30.0 g) and T_6 (26.60 g) which were on par each other.

4.2.3.2 Yield per ha

The results of the effect of intercropping baby corn with amaranthus on yield per ha of amaranthus is detailed in Table 24.

Intercropping treatments could significantly influence the yield per ha of amaranthus as an intercrop. There was a severe reduction in the yield under intercropping situation compared to sole cropping. In case of sole crop of amaranthus, two harvests were taken while only one harvest was taken from the intercrop treatments. Sole crop of amaranthus registered the highest per ha yield of 10.91 t ha^{-1} which was significantly superior to the intercropping treatments T_2 (skip row planting of baby corn and amaranthus-5.24 t), T_4 (paired row planting of baby corn and amaranthus-2.41 t) and T_6

Table 24. Effect of baby corn and amaranthus intercropping systems on yield per plant and yield per ha of amaranthus.

Treatments	Yield per plant (g)	Yield per ha (t)
T_2- baby corn + amaranthus (skip row)	91.13	5.24
T_4 - baby corn +amaranthus (paired row)	30.00	2.41
T_6- baby corn + amaranthus (2:1 row)	26.60	1.83
T_9- sole crop of amaranthus	96.00	10.91
SEm (±)	3.63	0.14
CD (0.05)	12.819	0.508

Table 25. Effect of intercropping vegetables in baby corn on light interception by crop canopy of baby corn at 30 DAS, per cent.

Treatments	Light interception
T_1 -baby corn + cowpea (skip row)	77.36
T_2-baby corn + amaranthus (skip row)	75.84
T_3-baby corn + cowpea (paired row)	85.54
T_4-baby corn + amaranthus (paired row)	85.07
T_5-baby corn + cowpea (2:1 ratio)	84.35
T_6-baby corn + amaranthus (2:1 ratio)	84.65
T_7-sole crop of baby corn	85.06
SEm (±)	0.52
CD (0.05)	1.616

DAS- Days after sowing

(planting baby corn and amaranthus in 2:1 ratio-1.83 t). The intercropping treatment T_2 was superior to T_4 which in turn produced higher per ha yield compared to T_6.

4.3. PEST AND DISEASE INCIDENCE IN MAIN CROP AND INTERCROPS

Pest and disease incidence were not observed in main crop baby corn. However, mild attack of pod borer (*Lampiedes boeticus*) was observed in intercrop cowpea and was controlled by spraying of flubendiamide 39.5 SC @ 2 ml per 10 L of water. In amaranthus mild incidence of leaf blight attack was noticed in the later stages of growth and *Pseudomonas fluorescens* @ 20 g per litre of water was sprayed as a control measure.

4.4 LIGHT INTERCEPTION BY CROP CANOPY

4.4.1 Light interception by main crop and intercrops

4.4.1.1 Light interception by main crop- baby corn

Result of the effect of intercropping vegetables in baby corn on light interception by baby corn at 30 DAS is presented in Table 25.

Light interception by baby corn showed significant variation under different planting geometries with vegetables. Light interception by the crop canopy was the highest in baby corn (85.54 per cent) under paired row planting with cowpea (T_3) which was on par with T_4 (paired row planting of baby corn with amaranthus- 85.07 per cent), T_7 (sole cropping of baby corn- 85.06 per cent), T_6 (planting baby corn and amaranthus in 2:1 ratio-84.65 per cent) and T_5 (planting baby corn and cowpea in 2:1 ratio-84.35 per cent). All these treatments were significantly superior to T_1 (skip row planting of baby corn and cowpea- 77.36 per cent) and T_2 (skip row planting of baby corn and amaranthus- 75.84 per cent) with respect to light interception which in turn were on par each other.

Table 26. Effect of intercropping baby corn and cowpea on light interception by cowpea at 30 DAS, per cent

Treatments	Light interception
T_1 -baby corn + cowpea (skip row)	88.68
T_3-baby corn + cowpea (paired row)	88.25
T_5-baby corn + cowpea (2:1 ratio)	86.93
T_8- sole crop of cowpea	90.26
SEm (±)	0.43
CD (0.05)	1.530

DAS- Days after sowing

Table 27. Effect of intercropping baby corn and amaranthus on light interception by amaranthus at 30 DAS, per cent

Treatments	Light interception
T_2-baby corn + amaranthus (skip row)	83.99
T_4-baby corn + amaranthus (paired row)	82.99
T_6-baby corn + amaranthus (2:1 ratio)	84.47
T_9-sole crop of amaranthus	87.02
SEm (±)	1.06
CD (0.05)	NS

4.4.1.2 Light interception by intercrop- cowpea

Result of the effect of intercropping cowpea in baby corn on light interception by cowpea at 30 DAS is presented in Table 26.

The sole crop of cowpea (T_8) intercepted significantly higher amount of solar radiation (90.26 per cent) compared to the intercropping treatments such as skip row planting of cowpea and baby corn (T_1- 88.68 per cent), paired row planting of cowpea and baby corn (T_3-88.25 per cent) and planting baby corn and intercrop cowpea in 2:1 ratio (T_5- 86.93 per cent). The T_1 and T_3 treatments were on par each other with respect to light interception while T_5 did not differ from T_3.

4.4.1.3 Light interception by intercrop- amaranthus

Result of the effect of intercropping amaranthus in baby corn on light interception by amaranthus at 30 DAS is presented in Table 27.

The light interception by crop canopy of amaranthus was unaffected by different planting geometries as treatments.

4.4.2 Light interception by intercropping systems

Result of the effect of intercropping vegetables in baby corn on light interception by the intercropping systems at 30 DAS is shown in Table 28.

Cropping system wise analysis of the light interception indicated significant variation with respect to the treatments. Sole cropping of cowpea (T_8) recorded the highest value for light interception (90.26 per cent) which was significantly superior to all other treatments and was followed by T_9 (sole cropping of amaranthus) registering a value of 87.01 per cent which was on par with T_3 (paired row planting of cowpea- 86.89 per cent) and T_5 (planting baby corn and cowpea in 2:1 ratio-85.64 per cent) and significantly superior to T_7 (sole crop of baby corn-85.06 per cent), T_6 (planting baby

Table 28. Effect of intercropping vegetables in baby corn on light interception by the intercropping systems at 30 DAS, per cent

Treatments	Light interception
T_1 -baby corn + cowpea (skip row)	83.02
T_2-baby corn + amaranthus (skip row)	79.91
T_3-baby corn + cowpea (paired row)	86.89
T_4-baby corn + amaranthus (paired row)	84.03
T_5-baby corn + cowpea (2:1 ratio)	85.64
T_6-baby corn + amaranthus (2:1 ratio)	84.56
T_7-sole crop of baby corn	85.06
T_8- sole crop of cowpea	90.26
T_9-sole crop of amaranthus	87.01
SEm (±)	0.53
CD (0.05)	1.587

Table 29. Effect of baby corn and vegetable intercropping systems on crude protein content in cob and stover of baby corn, per cent

Treatments	Crude protein content (cob)	Crude protein content (stover)
T_1 -baby corn + cowpea (skip row)	10.15	5.36
T_2-baby corn + amaranthus (skip row)	9.91	5.25
T_3-baby corn + cowpea (paired row)	9.21	5.25
T_4-baby corn + amaranthus (paired row)	9.45	5.13
T_5-baby corn + cowpea (2:1 ratio)	10.50	4.66
T_6-baby corn + amaranthus (2:1 ratio)	9.91	4.08
T_7-sole crop of baby corn	9.80	4.78
SEm (±)	0.77	0.45
CD (0.05)	NS	NS

corn and amaranthus in 2:1 ratio-84.56 per cent), T_4 (paired row planting of baby corn and amaranthus- 84.03 per cent), T_1 (skip row planting of baby corn and cowpea-83.02 per cent) and T_2 (skip row planting of baby corn and amaranthus- 79.91 per cent). Light intercepted by T_5 (baby corn + cowpea in 2:1 ratio-85.64 per cent) was statistically similar to the value recorded with sole crop of baby corn (T_7- 85.06 per cent) and planting baby corn and amaranthus in 2:1 ratio (T_6 - 84.56 per cent). Light interception value registered with T_6 (baby corn + amaranthus in 2:1 ratio) was however statistically similar to that recorded with T_4 (baby corn + amaranthus in paired row-84.03 per cent) and T_1 (baby corn + cowpea in skip row-83.02 per cent). Light interception was significantly reduced with skip row planting of intercrops viz., T_1 (baby corn + cowpea in skip row-83.02 per cent) and T_2 (baby corn + amaranthus in skip row-79.91 per cent) compared to sole crop of baby corn (T_7-85.06 per cent), cowpea (T_8-90.26 per cent) or amaranthus (T_9- 87.01 per cent).

4.5 PLANT ANALYSIS

4.5.1 Main crop-baby corn

4.5.1.1 Crude protein content (cob and stover)-baby corn

The result of the effect of intercropping vegetables on crude protein content in cob and stover of main crop baby corn is presented in Table 29.

The intercropping treatments did not significantly influence the crude protein content in cob and stover of baby corn.

4.5.1.2 Starch content-baby corn

The result of the effect of intercropping vegetables on starch content of main crop baby corn is indicated in Table 30.

Starch content of baby corn was not significantly influenced by intercropping systems.

Table 30. Effect of baby corn and vegetable intercropping systems on starch content, total soluble sugars and ascorbic acid content of baby corn cob

Treatments	Starch content (per cent)	Total soluble sugar (°Brix)	Ascorbic acid (mg $100g^{-1}$)
T_1 -baby corn + cowpea (skip row)	8.36	7.66	5.51
T_2-baby corn + amaranthus (skip row)	8.91	7.33	6.00
T_3-baby corn + cowpea (paired row)	8.71	6.66	6.25
T_4-baby corn + amaranthus (paired row)	8.64	6.33	6.42
T_5-baby corn + cowpea (2:1 ratio)	8.75	6.00	6.01
T_6-baby corn + amaranthus (2:1 ratio)	8.29	7.66	5.84
T_7-sole crop of baby corn	8.66	6.33	5.43
SEm (±)	0.13	0.50	0.60
CD (0.05)	NS	NS	NS

Table 31. Effect of baby corn and vegetable intercropping systems on N, P and K uptake of baby corn, kg ha^{-1}

Treatments	N uptake	P uptake	K uptake
T_1 -baby corn + cowpea (skip row)	161.45	14.97	211.27
T_2-baby corn + amaranthus (skip row)	167.78	14.73	215.81
T_3-baby corn + cowpea (paired row)	239.94	24.44	335.27
T_4-baby corn + amaranthus (paired row)	230.56	22.48	306.90
T_5-baby corn + cowpea (2:1 ratio)	178.15	17.27	250.85
T_6-baby corn + amaranthus (2:1 ratio)	168.63	15.66	271.26
T_7-sole crop of baby corn	218.01	18.98	291.18
SEm (±)	15.36	1.84	13.77
CD (0.05)	47.868	5.736	42.901

4.4.1.3 Total soluble sugar-baby corn

The result of the effect of intercropping vegetables on total soluble sugar of main crop baby corn is given in Table 30.

Intercropping of baby corn and vegetables could not significantly influence the total soluble sugar content of baby corn.

4.5.1.4 Ascorbic acid-baby corn

The result of the effect of intercropping vegetables on ascorbic acid content of baby corn cob is shown in Table 30.

Different intercropping treatments of baby corn with vegetables did not have any significant effect on ascorbic acid content of baby corn cob.

4.5.1.5 Uptake of N, P, and K-baby corn

4.5.1.5.1 Uptake of N

The result of the effect of intercropping vegetables on N uptake by main crop baby corn is given in Table 31,

Uptake of N by baby corn significantly varied with treatments. N uptake (239.94 kg ha^{-1}) was higher in T_3 (baby corn + cowpea in paired row) which was on par with T_4 (baby corn + amaranthus in paired row), and T_7 (sole crop of baby corn) with 230.56 kg ha^{-1} and 218.01 kg ha^{-1}, respectively. Treatments T_3 and T_4 were significantly superior to T_5, T_6, T_2 and T_1 with N uptake value of 178.15, 168.63, 167.78 and 161.45 kg ha^{-1}, respectively. However, 2:1 row planting of baby corn with cowpea (T_5 - N uptake 178.15 kg ha^{-1}) was statistically similar to sole crop of baby corn (T_7 - N uptake 218.01 kg ha^{-1}).

4.5.1.5.2 Uptake of P

The result of the effect of intercropping vegetables on P uptake by main crop baby corn is presented in Table 31.

Different intercropping systems of baby corn and vegetables significantly influenced the uptake of P by baby corn. The P uptake was higher (24.44 kg ha^{-1}) in T_3 (baby corn + cowpea in paired row) which was on par with T_4 (baby corn + amaranthus in paired row) and T_7 (sole crop of baby corn) with P uptake value of 22.48 and 18.98 kg ha^{-1}, respectively. However the treatments T_5 (baby corn + cowpea in 2:1 ratio), T_1 (baby corn + cowpea in skip row), T_2 (baby corn + amaranthus in skip row) and T_6 (baby corn + amaranthus in 2:1 ratio) which registered P uptake values of 17.27, 14.97, 14.73 and 15.66 kg ha^{-1}, respectively did not statistically differ from sole crop of baby corn (T_7- 18.98 kg ha^{-1}).

4.5.1.5.3 Uptake of K

The result of the effect of intercropping vegetables on K uptake by main crop baby corn is shown in Table 31.

The K uptake by the main crop baby corn was significantly affected by different intercropping treatments. Paired row planting of baby corn with cowpea (T_3) registered higher K uptake of 335.27 kg ha^{-1}and was on par with T_4 (306.9 kg ha^{-1}) and were significantly superior to all other treatments. The treatment T_4 (baby corn + amaranthus in paired row) which recorded a K uptake of 306.90 kg ha^{-1} was on par with T_7 (sole crop of baby corn) and T_6 (baby corn + amaranthus in 2:1 ratio) with K uptake values of 291.18 and 271.26 kg ha^{-1} respectively. Treatment T_5 (baby corn + cowpea in 2:1 ratio) with K uptake value of 250.85 kg ha^{-1} was statistically similar to sole crop of baby corn (T_7- 291.18 kg ha^{-1}) and planting baby corn and amaranthus in 2:1 ratio (T_6 -271.26 kg ha^{-1}). Uptake of potassium by baby corn in skip row planting with amaranthus (T_2-215.81 kg ha^{-1}) or cowpea (T_1-211.27 kg ha^{-1}) were on par with T_5 (baby corn + cowpea in 2:1 ratio-250.85 kg ha^{-1}) and also did not vary each other.

4.5.2 Intercrop - Cowpea

4.5.2.1 Crude protein –cowpea pod

The result of the effect of intercropping vegetable cowpea in baby corn on crude protein content of cowpea pod is presented in Table 32.

Intercropping of cowpea in baby corn did not have any significant effect on crude protein content of cowpea pod.

4.5.2.2 Uptake of N, P, and K at harvest-cowpea

4.5.2.2.1 Uptake of N

The result of the effect of intercropping vegetable cowpea in baby corn on uptake of nitrogen is shown in Table 33.

Intercropping of cowpea with baby corn had significant influence on N uptake of cowpea. The sole crop of cowpea registered the highest N uptake of 155.52 kg ha^{-1} which was more than three times the uptake recorded with the intercropping systems and was significantly superior to all intercropping treatments. Among intercropping treatments, T_1 (baby corn + cowpea in skip row) recorded a higher N uptake (42.79 kg ha^{-1}) and was on par with T_3 (40.82 kg ha^{-1}). Intercropping cowpea with 2:1 ratio of row planting in baby corn (T_5) recorded the lowest N uptake (24.70 kg ha^{-1}) among all treatments but was found to be on par with treatment T_3 (baby corn + cowpea in paired row).

4.5.2.2.2 Uptake of P - cowpea

The result of the effect of intercropping vegetable cowpea in baby corn on P uptake is presented in the Table 33.

Intercropping of cowpea in baby corn had significant influence on P uptake of cowpea. The P uptake was the highest in sole crop of cowpea (15.14 kg ha^{-1}) which was significantly superior to all intercropping treatments. Among intercropping treatments, T_1 (baby corn + cowpea in skip row) recorded higher P uptake (7.94 kg ha^{-1}) and this was on par with all other intercropping treatments such as T_3 (baby corn + cowpea in paired

Table 32. Effect of baby corn and cowpea intercropping systems on crude protein content of cowpea pod, per cent

Treatments	Crude protein
T_1 -baby corn + cowpea (skip row)	21.00
T_3 -baby corn + cowpea (paired row)	20.88
T_5 -baby corn + cowpea (2:1 ratio)	22.28
T_8 - sole crop of cowpea	21.70
SEm (±)	0.89
CD (0.05)	NS

Table 33. Effect of baby corn and cowpea intercropping systems on N, P and K uptake by cowpea, kg ha^{-1}

Treatments	N uptake	P uptake	K uptake
T_1 -baby corn + cowpea (skip row)	42.79	7.94	30.26
T_3 -baby corn + cowpea (paired row)	40.82	3.90	25.70
T_5 -baby corn + cowpea (2:1 ratio)	24.70	2.52	14.14
T_8 - sole crop of cowpea	155.52	15.14	96.19
SEm (±)	4.67	1.78	3.18
CD (0.05)	16.476	6.306	11.224

row) and T_5 (baby corn + cowpea in 2:1 ratio) which registered P uptake values of 3.90 and 2.52 kg ha^{-1}, respectively.

4.5.2.2.3 Uptake of K - cowpea

The result of the effect of intercropping vegetable cowpea in baby corn on K uptake by cowpea is given in Table 33.

Intercropping cowpea in baby corn did significantly influence the K uptake by cowpea. The sole crop of cowpea (T_8) registered the highest K uptake of 96.19 kg ha^{-1} which was significantly superior to all other treatments. Among intercropping treatments, T_1 (baby corn + cowpea in skip row) recorded the next higher K uptake of 30.26 kg ha^{-1} which was on par with T_3 (baby corn + cowpea in paired row-25.70 kg ha^{-1}), but significantly superior to T_5 (baby corn + cowpea in 2:1 ratio) with an uptake value of 14.14 kg ha^{-1}. The treatment T_3 (baby corn + cowpea in paired row) was also significantly superior to T_5 (baby corn + cowpea in 2:1 ratio) which recorded the lowest K uptake.

4.5.3 Intercrop -amaranthus

4.5.3.1 Crude protein content-amaranthus

The result of the effect of intercropping amaranthus in baby corn on crude protein content of amaranthus is given in Table 34.

Intercropping of amaranthus with baby corn did not affect the crude protein content of amaranthus.

4.5.3.2 Uptake of N, P and K at harvest- amaranthus

4.5.3.2.1 Uptake of N

The result of effect of intercropping amaranthus in baby corn on N uptake is given in Table 35.

The sole crop of amaranthus (T_9) had the highest N uptake of 49.37 kg ha^{-1} which was significantly superior to all other intercropping treatments. Treatment T_9 was followed by T_2 (baby corn + amaranthus in skip row) and it recorded a higher N uptake of

22.72 kg ha^{-1} which was significantly superior to T_4 (baby corn + amaranthus in paired row-12.08 kg ha^{-1}) followed by T_6 (baby corn + amaranthus in 2:1 ratio-8.81 kg ha^{-1}). Treatments T_4 and T_6 were however on par each other.

4.5.3.2.2 Uptake of P

The result of the effect of intercropping amaranthus in baby corn on P uptake is presented in Table 35.

Intercropping amaranthus in baby corn significantly affected the P uptake of amaranthus. The sole crop of amaranthus recorded the highest P uptake of 12.53 kg ha^{-1} which was significantly superior to all other treatments. Among intercropping treatments, T_2 (baby corn + amaranthus in skip row) registered higher P uptake (6.07 kg ha^{-1}) which was on par with T_4 (3.01 kg ha^{-1}) but superior to T_6 (2.11 kg ha^{-1}). The treatments T_4 (baby corn + amaranthus in paired row) and T_6 (baby corn + amaranthus in 2:1 ratio) were however on par each other.

4.5.3.2.3 Uptake of K

The result of the effect of intercropping amaranthus in baby corn on K uptake of amaranthus is given in Table 35.

The sole crop of amaranthus (T_9) had a higher K uptake of 49.77 kg ha^{-1} which was significantly superior to all other treatments. Among intercropping treatments, T_2 (baby corn + amaranthus in skip row) recorded higher K uptake (25.86 kg ha^{-1}) and was significantly higher than the uptake registered with T_4 (baby corn + amaranthus in paired row) followed by T_6 (baby corn + amaranthus in 2:1 ratio) which recorded K uptake value of 13.73 and 8.16 kg ha^{-1}, respectively.

Table 34. Effect of intercropping amaranthus in baby corn on crude protein content of amaranthus, per cent

Treatments	Crude protein
T_2- baby corn + amaranthus (skip row)	9.91
T_4- baby corn + amaranthus (paired row)	11.43
T_6- baby corn + amaranthus (2:1 ratio)	11.08
T_9- sole crop of amaranthus	10.38
SEm (±)	0.64
CD (0.05)	NS

Table 35. Effect of intercropping amaranthus in baby corn on N, P and K uptake of amaranthus, kg ha^{-1}

Treatments	N uptake	P uptake	K uptake
T_2- baby corn + amaranthus (skip row)	22.72	6.07	25.86
T_4- baby corn + amaranthus (paired row)	12.08	3.01	13.73
T_6- baby corn + amaranthus (2:1 ratio)	8.81	2.11	8.16
T_9- sole crop of amaranthus	49.37	12.53	49.77
SEm (±)	1.86	1.02	1.28
CD (0.05)	6.590	3.601	4.522

4.6. COMPETITION INDICES

Different competition indices like land equivalent ratio (LER), relative crowding coefficient (RCC), monetary advantage index (MAI) and baby corn equivalent yield (BEY) were computed in the present study and were not statistically analysed.

4.6.1 Land equivalent ratio (LER)

Result of the effect of intercropping systems with baby corn and vegetables on LER is presented in Table 36.

The LER of all intercropping systems recorded values higher than one which indicated an yield advantage over sole cropping of baby corn and vegetables. Intercropping of baby corn with cowpea in paired row planting (T_3) showed higher LER of 1.42 followed by paired row planting of baby corn with amaranthus (T_4) with a value 1.26. Next higher LER was recorded with T_2 (baby corn + amaranthus in skip row) followed by T_1 (baby corn + cowpea in skip row), T_5 (baby corn + cowpea in 2:1 ratio) and T_6 (baby corn + amaranthus in 2:1 ratio) with LER 1.18, 1.13, 1.12 and 1.01, respectively.

4.6.2 Relative crowding coefficient (RCC)

Results of the effect of intercropping systems with baby corn and vegetables on relative crowding coefficient (RCC) are given in Table 37.

The RCC value of baby corn was found to be higher than that of vegetables which indicated that the baby corn was a dominant crop over vegetables in all intercropping treatments. Baby corn expressed the highest RCC in paired row planting with amaranthus (T_4 -23.84) followed by paired row planting with cowpea (T_3 -12.81). The RCC of the

Table 36. Effect of intercropping systems with baby corn and vegetables on land equivalent ratio (LER).

Treatments	LER_b	LER_v	LER
T_1 -baby corn + cowpea (skip row)	0.797	0.331	1.13
T_2-baby corn + amaranthus (skip row)	0.706	0.48	1.18
T_3-baby corn + cowpea (paired row)	1.107	0.308	1.42
T_4-baby corn + amaranthus (paired row)	1.043	0.212	1.26
T_5-baby corn + cowpea (2:1 ratio)	0.872	0.248	1.12
T_6-baby corn + amaranthus (2:1 ratio)	0.858	0.147	1.01
T_7- sole crop of baby corn	1	-	1
T_8- sole crop of cowpea	-	1	1
T_9-sole crop of amaranthus	-	1	1

LER_b – Land equivalent ratio of baby corn
LER_v – Land equivalent ratio of vegetables
LER – Land equivalent ratio of intercropping system
$LER = LER_a + LER_b$

Table 37: Effect of intercropping systems with baby corn and vegetables on relative crowding coefficient (RCC)

Treatments	K_b	K_v	K (RCC)
T_1 -baby corn + cowpea (skip row)	9.86	0.20	1.97
T_2-baby corn + amaranthus (skip row)	4.80	0.46	2.21
T_3-baby corn + cowpea (paired row)	12.81	0.36	4.61
T_4-baby corn + amaranthus (paired row)	23.84	0.28	6.68
T_5-baby corn + cowpea (2:1 ratio)	4.19	0.54	2.26
T_6-baby corn + amaranthus (2:1 ratio)	3.03	0.40	1.21

K_b – RCC of baby corn
K_v – RCC of vegetables
$K - K_b \times K_v$

system was the highest (6.68) with T_4 followed by T_3 (4.61), T_5 (2.26), T_2 (2.21) and T_1 (1.97).

4.6.3 Aggressivity

Results of the effect of intercropping vegetables in baby corn on aggressivity of component crops are shown in Table 38.

The aggressivity values indicate the competitive ability of component crops in an intercropping system. Aggressivity value of baby corn in all intercropping system was positive which indicated the dominant nature of baby corn over the component crops. The aggressivity of baby corn over vegetables was more pronounced in skip row planting of baby corn and cowpea (T_1) with a value of 2.33. In skip row planting and paired row planting, baby corn expressed a higher dominance over the component crop when it was grown with cowpea (A_{bv} value 2.33 and 1.94 for T_1 and T_3 respectively). In case of 2:1 row planting, the dominance of baby corn was more apparent when it was intercropped with amaranthus (A_{bv} – 0.79).

4.6.4 Monetary advantage index (MAI)

Results on the effect of intercropping vegetables in baby corn on monetary advantage index (MAI) of the intercropping systems are presented in Table 38.

The MAI was the highest (95503) with paired row planting of baby corn with cowpea (T_3) indicating the monetary advantage of the system and was followed by T_4 (baby corn and amaranthus in paired row), T_2 (baby corn and amaranthus in skip row), T_1 (baby corn and cowpea in skip row), T_5 (baby corn and cowpea in 2:1 ratio) and T_6 (baby corn and amaranthus in 2:1 ratio) with MAI values 66339, 45006, 28483, 27664 and 6500, respectively.

Table 38. Effect of intercropping vegetables in baby corn on aggressivity of component crops and the monetary advantage index (MAI)

Treatments	A_{bv}	A_{vb}	MAI
T_1 -baby corn + cowpea (skip row)	2.33	-2.33	28483
T_2-baby corn + amaranthus (skip row)	1.40	-1.40	45006
T_3-baby corn + cowpea (paired row)	1.94	-1.94	95503
T_4-baby corn + amaranthus (paired row)	1.64	-1.64	66339
T_5-baby corn + cowpea (2:1 ratio)	0.75	-0.75	27664
T_6-baby corn + amaranthus (2:1 ratio)	0.79	-0.79	6500

A_{bv} – Aggressivity of baby corn with respect to vegetables
A_{vb} – Aggressivity of vegetables with respect to baby corn

Table 39. Effect of baby corn and vegetable intercropping systems on baby corn equivalent yield (BEY), kg ha^{-1}

Treatments	Baby corn equivalent yield (kg ha^{-1})
T_1 -baby corn + cowpea (skip row)	9933
T_2-baby corn + amaranthus (skip row)	11452
T_3-baby corn + cowpea (paired row)	12999
T_4-baby corn + amaranthus (paired row)	12661
T_5-baby corn + cowpea (2:1 ratio)	10263
T_6-baby corn + amaranthus (2:1 ratio)	10285
T_7-sole crop of baby corn	10278
T_8-sole crop of cowpea	5225
T_9-sole crop of amaranthus	8733

4.6.5 Baby corn equivalent yield (BEY)

Results on effect of baby corn and vegetable intercropping systems on baby corn equivalent yield (BEY) is presented in Table 39. The highest baby corn equivalent yield (12999 kg ha^{-1}) was obtained with paired row planting of baby corn with cowpea (T_3) and was followed by T_4 (baby corn and amaranthus in paired row), T_2 (baby corn and amaranthus skip row), T_6 (baby corn and amaranthus in 2:1 ratio), T_7 (baby corn sole crop), T_5 (baby corn and cowpea in 2:1 ratio) and T_1 (baby corn and cowpea in skip row), with BEY values 12661, 11452, 10285, 10278, 10263 and 9933 kg ha^{-1}, respectively. Sole crop of amaranthus (T_9) and cowpea (T_8) expressed lower BEY of 8733 kg ha^{-1} and 5225 kg ha^{-1}, respectively.

4.7 SOIL ANALYSIS

4.7.1 Soil pH

The result of the effect of intercropping vegetables in baby corn on soil pH after the experiment is indicated in Table 40.

Intercropping vegetables and baby corn did not have any significant effect on soil pH after the experiment.

4.7.2 Electrical conductivity

The result of effect of intercropping vegetables in baby corn on electrical conductivity of soil after the experiment is presented in Table 40.

The treatments could not significantly affect the electrical conductivity of soil after the experiment.

4.7.3 Organic carbon

The result of effect of intercropping vegetables in baby corn on organic carbon content of soil after the experiment is given in Table 40.

Table 40. Effect of intercropping vegetables and baby corn on soil pH, EC and organic carbon content of soil after the experiment

Treatments	pH	EC (dSm^{-1})	Organic carbon (per cent)
T_1 -baby corn + cowpea (skip row)	4.73	0.14	1.37
T_2-baby corn + amaranthus (skip row)	4.66	0.14	1.52
T_3-baby corn + cowpea (paired row)	4.80	0.13	1.30
T_4-baby corn + amaranthus (paired row)	4.40	0.15	1.60
T_5-baby corn + cowpea (2:1 ratio)	4.90	0.13	1.39
T_6-baby corn + amaranthus (2:1 ratio)	4.50	0.14	1.45
T_7-sole crop of baby corn	4.76	0.15	1.17
T_8- sole crop of cowpea	5.06	0.15	1.43
T_9-sole crop of amaranthus	4.46	0.13	1.57
SEm (±)	0.304	0.008	0.130
CD (0.05)	NS	NS	NS

EC- Electrical conductivity

Table 41. Effect of intercropping baby corn and vegetables on available N, P and K status of soil after the experiment, kg ha^{-1}

Treatments	Available N	Available P	Available K
T_1 -baby corn + cowpea (skip row)	317.78	78.94	199.62
T_2-baby corn + amaranthus (skip row)	296.87	78.07	194.91
T_3-baby corn + cowpea (paired row)	301.05	78.07	157.09
T_4-baby corn + amaranthus (paired row)	321.96	77.44	164.19
T_5-baby corn + cowpea (2:1 ratio)	317.78	76.82	184.87
T_6-baby corn + amaranthus (2:1 ratio)	271.78	77.32	202.75
T_7-sole crop of baby corn	313.60	79.19	177.93
T_8- sole crop of cowpea	367.96	78.75	225.19
T_9- sole crop of amaranthus	376.32	77.19	241.50
SEm (±)	27.57	1.91	25.21
CD (0.05)	NS	NS	NS

None of the intercropping treatments could significantly influence the organic carbon content of soil after the experiment.

4.7.4 Available nutrient status of soil after the experiment

Effect of intercropping vegetables and baby corn available N, P and K status of soil after the experiment is presented hereunder.

4.7.4.1 Available N

Result on the effect of intercropping vegetables in baby corn on available N status of soil after the experiment is given in Table 41. Intercropping of vegetables in baby corn did not have significant effect on available N content of soil after the experiment.

4.7.4.2 Available P

Results on the effect of intercropping vegetables in baby corn on available P status of soil after the experiment is shown in Table 41.

Available soil P content after the experiment was not influenced by different treatments. However, there was a general increase in the available P content of soil compared to initial status.

4.7.4.3 Available K

Results on the effect of intercropping vegetables in baby corn on available K status of soil after the experiment is presented given in Table 41.

Intercropping vegetables in baby corn did not influence the available K status of soil after the experiment.

4.8 ECONOMIC ANALYSIS

4.8.1 Total cost of cultivation

The result of the effect of baby corn based intercropping systems with vegetables on total cost of cultivation is presented in Table 42.

The cost of cultivation was found to be higher in intercropping than the sole cropping. The total cost of cultivation was the lowest for sole crop cowpea (₹ 64225 ha^{-1}) followed by sole crop of amaranthus (₹ 81946 ha^{-1}) which was followed by sole crop of baby corn (₹ 89751 ha^{-1}). Among intercropping treatments, cost of cultivation was the lowest for T_1 (baby corn + cowpea in skip row- ₹ 94892 ha^{-1}) which was followed by T_5 (baby corn + cowpea in 2:1 row- ₹ 95070 ha^{-1}), T_6 (baby corn + amaranthus in 2:1 row-₹ 101978 ha^{-1}), T_3 (baby corn + cowpea in paired row- ₹ 102138 ha^{-1}), T_2 (baby corn+ amaranthus in skip row- ₹ 109700 ha^{-1}) and T_4 (paired row planting of baby corn with amaranthus-₹ 109954 ha^{-1})

4.8.2 Net income

The result of the effect of baby corn based intercropping systems with vegetables on net income of cultivation is presented in Table 43.

Economic analysis indicated that the paired row planting of baby corn with cowpea (T_3) recorded with highest net income (₹ 222830 ha^{-1}) and was followed by the treatment T_4 (paired row planting of baby corn and amaranthus -₹ 206559 ha^{-1}), T_2 (baby corn + amaranthus in skip row- ₹ 176603), T_7 (sole crop of baby corn- ₹ 167192), T_6 (baby corn + amaranthus in 2:1 ratio- ₹ 155142 ha^{-1}), T_1 (baby corn + cowpea in skip row-₹ 153441 ha^{-1}), T_9 (sole crop of amaranthus- ₹ 136374 ha^{-1}) and T_8 (sole crop of cowpea - ₹ 66408 ha^{-1}). All the sole cropping treatments except baby corn recorded lower net income compared to the intercropping treatments.

4.8.2 Benefit: cost ratio (BCR)

The result of the effect of baby corn based intercropping systems with vegetables on benefit: cost ratio (BCR) is presented in Table 43.

Intercropping vegetables in baby corn expressed BCR greater than one. Paired row planting of baby corn with cowpea (T_3) recorded the highest BCR of 3.18 followed

Table 42. Effect of intercropping baby corn and vegetables on total cost of cultivation, ₹ ha^{-1}

Treatments	Total cost of cultivation
T_1 -baby corn + cowpea (skip row)	94892
T_2-baby corn + amaranthus (skip row)	109700
T_3-baby corn + cowpea (paired row)	102138
T_4-baby corn + amaranthus (paired row)	109954
T_5-baby corn + cowpea (2:1 ratio)	95070
T_6-baby corn + amaranthus (2:1 ratio)	101978
T_7-sole crop of baby corn	89751
T_8-sole crop of cowpea	64225
T_9-sole crop of amaranthus	81946

Table 43. Effect of intercropping baby corn and vegetables on net income and benefit: cost ratio (BCR) of cultivation

Treatments	Net income (₹ ha^{-1})	BCR
T_1 -baby corn + cowpea (skip row)	153441	2.62
T_2-baby corn + amaranthus (skip row)	176603	2.61
T_3-baby corn + cowpea (paired row)	222830	3.18
T_4-baby corn + amaranthus (paired row)	206559	2.88
T_5-baby corn + cowpea (2:1 ratio)	161513	2.70
T_6-baby corn + amaranthus (2:1 ratio)	155142	2.52
T_7-sole crop of baby corn	167192	2.86
T_8-sole crop of cowpea	66408	2.03
T_9-sole crop of amaranthus	136374	2.66

by the paired row planting of baby corn with amaranthus (T_4-BCR 2.88). This was followed by sole crop of baby corn (T_7) with a BCR of 2.86. Planting of baby corn with cowpea in 2:1 row ratio (T_5) resulted in a BCR of 2.70 and was followed by T_9 (sole crop of amaranthus), T_1 (skip row planting of baby corn with cowpea), T_2 (skip row planting of baby corn with amaranthus), T_6 (2:1 row planning of baby corn with amaranthus) and T_8 (sole crop cowpea) with BCR of 2.66, 2.62, 2.61, 2.52 and 2.03, respectively. The BCR was lower in case of sole cropping compared to intercropping except in case of sole crop of baby corn.

DISCUSSION

5. DISCUSSION

The study entitled "Intercropping vegetables in baby corn (*Zea mays* L.)" was conducted at College of Agriculture, Vellayani during 2018-20 to investigate the feasibility of intercropping cowpea and amaranthus in baby corn and to find out the effect of crop geometry on growth, yield, productivity and economics of the intercropping systems. The results of the experiment are briefly discussed in this chapter.

5.1 GROWTH AND GROWTH ATTRIBUTES

5.1.1 Main crop - baby corn

Paired row planting of baby corn with cowpea produced higher dry matter yield (Fig.4) though it did not differ statistically from the paired row planting with amaranthus or sole crop of baby corn. Optimum plant population of baby corn was maintained under sole cropping as well as in paired row planting, which was higher than the population in other intercropping systems. Relationship between the plant population and dry matter production is well known. As reported by Tajul *et al*. (2013) in maize, the dry matter production is a function of photosynthetic surface which increases with increase in population density. The higher dry matter acquisition in paired row planting with intercrops or under sole crop might be due to the higher assimilation of photosynthates on account of increased photosynthetic surface, consequent to the higher population density. Similar trend was reported by Rajshekhar *et al.* (2004) and Sannagoudar and Murthy (2018) in maize + legume intercropping systems.

5.1.2 Intercrop - cowpea

Growth attributes of cowpea such as plant height (Fig. 5), number of primary branches, LAI (Fig. 6), root volume and rooting depth (Fig. 7), and dry matter production were reduced under intercropping which clearly indicated the competition and dominance of baby corn over cowpea. Among intercropping treatments, the skip row planting performed better with respect to LAI, rooting depth, root volume and dry matter production compared to other intercropping treatments. Maize being a C_4 plant, is highly competitive with its intercrops and this competition is more pronounced in case of solar radiation and soil factors. Vegetable cowpea variety raised in the experiment had a bushy stature and maize which is taller would have caused shading on the intercropped cowpea thus reducing the photosynthetic rate (Palaniappan and Sivaraman, 1996), which might have reflected in its growth attributes. However, the competitive ability of baby corn for solar radiation would have been reduced under skip row planting since the population maintained was low and spacing between two rows of baby corn was wide (90 cm), compared to other intercropping treatments. This in turn might have improved the growth attributes of cowpea when grown in skip row with baby corn. Better light interception by cowpea under skip row planting with baby corn as indicated in Table 26 also supports this argument. Reduction in the growth and growth attributes of cowpea in maize + legume intercropping systems and better performance of the sole crop were previously reported by Alla *et al.* (2014) and Yadav and Dawson (2015).

5.1.3 Intercrop - amaranthus

As in case of cowpea, there was a drastic reduction in plant height (Fig. 8), LAI (Fig.8), total dry matter production, rooting depth and root volume of amaranthus under intercropping compared to sole crop. Sole crop of amaranthus recorded higher values for all growth parameters compared to intercropping systems. According to Wadud *et al*. (2002), any reduction in the photosynthetically active radiation (PAR) negatively influenced the growth and growth attributes of red amaranthus and with increase in shade, the growth of the crop showed a decreasing trend and hence found to be not suitable under shaded conditions. As explained earlier, the competition exhibited by baby corn for solar radiation would have resulted in penetration of less radiation deep into the canopy (Palaniappan and Sivaraman, 1996) which would have reduced the light available for photosynthesis affecting the growth of amaranthus negatively.

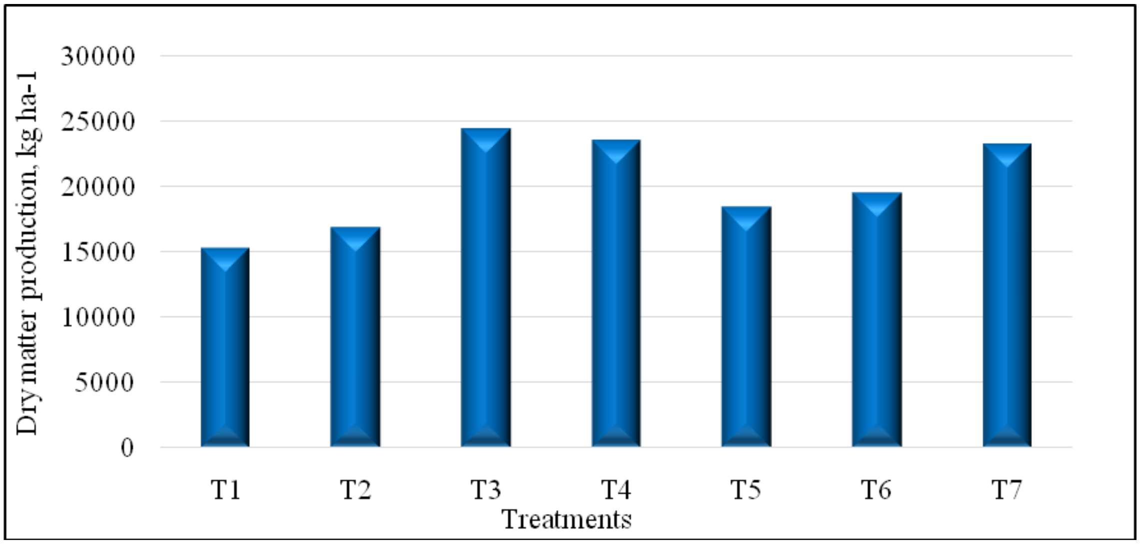

Fig 4. Effect of intercropping systems on total DMP of baby corn, kg ha^{-1}

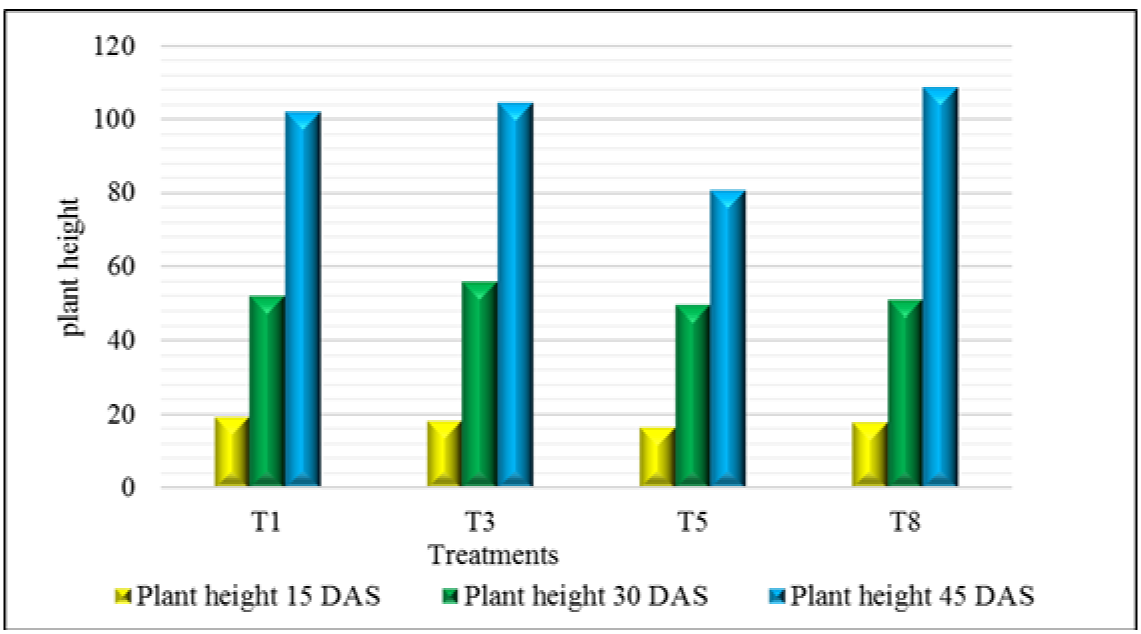

Fig 5. Effect of intercropping systems on plant height of cowpea, cm

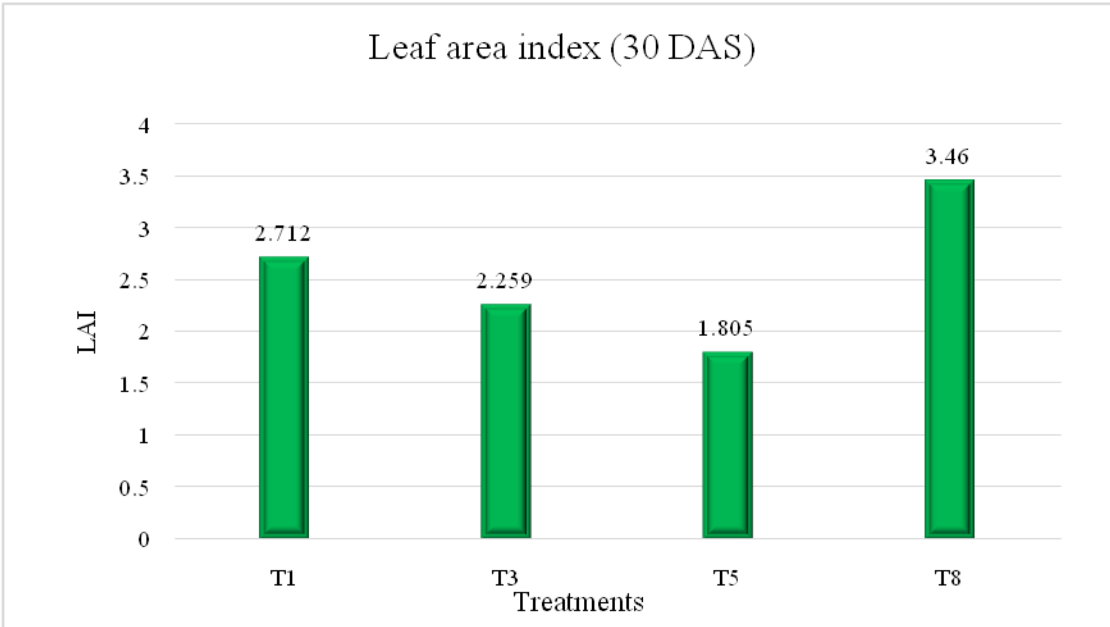

Fig 6. Effect of intercropping systems on leaf area index of cowpea

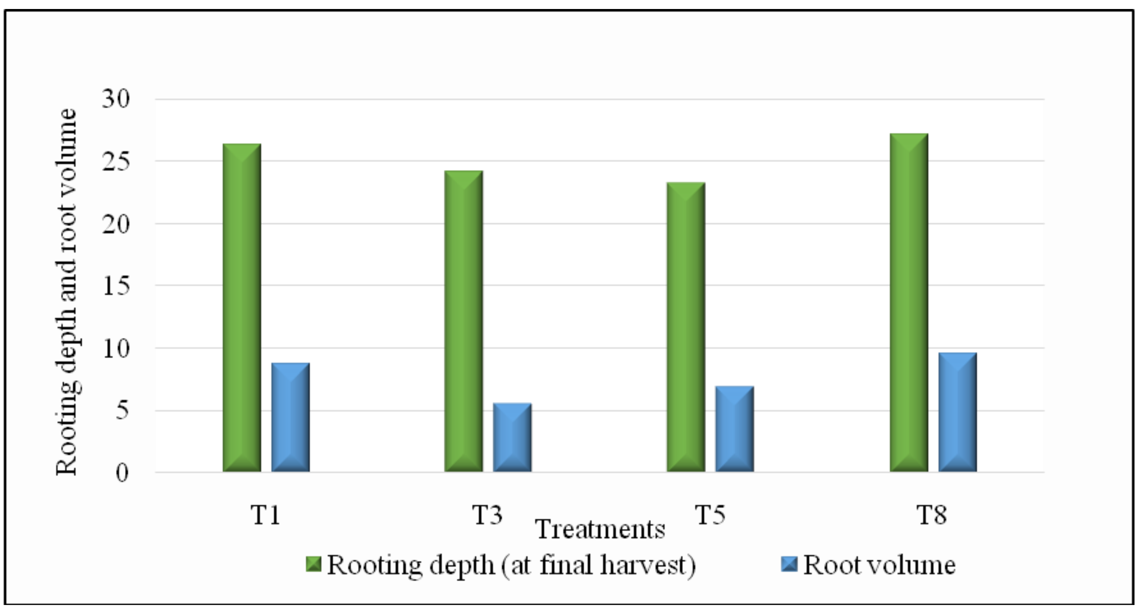

Fig 7. Effect of intercropping systems on rooting depth (cm) and root volume (cm^3) of cowpea at final harvest

However, among the intercropping systems, the skip row planting of amaranthus produced higher LAI and dry matter production and was on par with sole crop with respect to plant height. The wider spacing between baby corn rows coupled with lower plant population would have moderated the competition of baby corn for light, which in turn could have improved the dry matter accumulation and growth parameters of amaranthus under skip row planting. Higher light interception at 25 DAS resulting from wider row spacing, in baby corn + leafy vegetable intercropping system was previously reported by Rathika *et al*. (2013).

5.2 YIELD ATTRIBUTES AND YIELD

5.2.1 Main crop - baby corn

The number of cobs per plant was significantly influenced by intercropping. Planting baby corn with cowpea or amaranthus in skip row produced more number of cobs per plant compared to other treatments. Wider row spacing might have contributed to better resource utilization and reduced competition among plants, resulting in better yield attributes. Production of more cobs per plant with lower population of baby corn was previously reported by Ravichandran *et al.* (2016).

Intercropping had significant influence on baby corn yield with paired row planting of cowpea producing higher cob weight with husk, cob yield with husk (Fig. 9), marketable cob yield (Fig. 9) and green stover yield (Fig. 10). Lower cob-corn ratio which is an indication of higher economic yield was observed when cowpea or amaranthus was intercropped with baby corn in paired row. The favourable influence of paired row planting on yield attributes and yield of baby corn could be attributed to the higher light interception and accumulation of more dry matter in the sink. Furthermore, when a legume and non legume are involved in an intercropping system, a portion of the

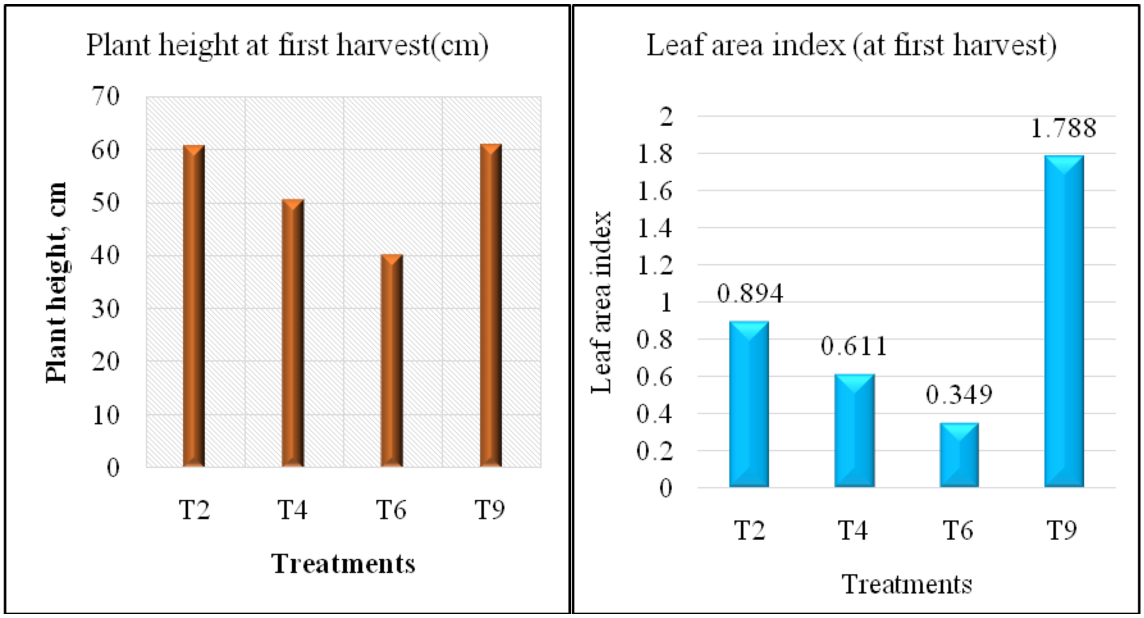

Fig 8. Effect of intercropping systems on plant height and LAI of amaranthus

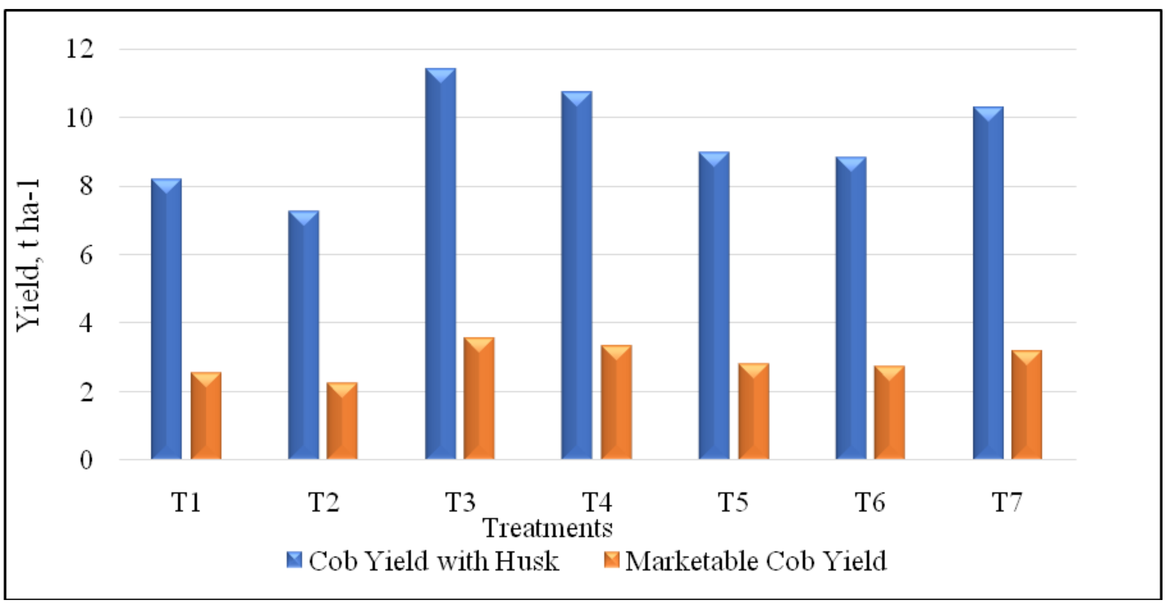

Fig. 9: Effect of intercropping systems on cob yield with husk and marketable cob yield of baby corn, t ha^{-1}

N fixed in the root nodule of the legume may become available to the non legume component (Ofori and Stern, 1987) and the baby corn would have been benefitted from this kind of legume effect which would have reflected on its yield. Favourable influence of paired row planting with legume was previously pointed out by Reddy *et al.* (2009) in baby corn and cowpea intercropping system and Sharma *et al.* (2016) in baby corn + black gram + green gram intercropping system.

5.2.2 Intercrop - cowpea

Following the trend in growth and growth attributes, there was significant reduction in the yield attributes and yield of cowpea under intercropping situation and the number of pods per plant, pod yield per plant (Fig. 11) and pod yield per ha (Fig. 11) were significantly higher in sole crop of cowpea. Shading effect of tall growing baby corn plants is evident from the low light interception by the intercropping systems (Table 26). Shading by the taller component in an intercropping system reduces the photosynthetic rate in shorter component and less radiation deep in the canopy also results in less energy to drive the process of transpiration and sensible heat exchange with the atmosphere as pointed out by Palaniappan and Sivaraman (1996), and this would have caused a reduction in the yield attributes and yield of cowpea under intercropped situation.

Another school of thought is that when a non legume is combined with legume in an intercropping system, the vigorously growing non legume will be absorbing large amount of nutrients from soil, and the legume may be deprived of its nutrient share (Snaydon and Harris, 1981). This argument is supported by the uptake pattern of cowpea in this study (Table 33) wherein low nutrient uptake was observed under intercropping situation. The nutrient supplementation index proposed by Wahua (1983) predicted the requirement of an additional 9.7 per cent more nitrogen in maize and cowpea mixture than that required by the sole crop of maize, which points out the additional nutrient requirement for cowpea when intercropped with more competitive crops like maize.

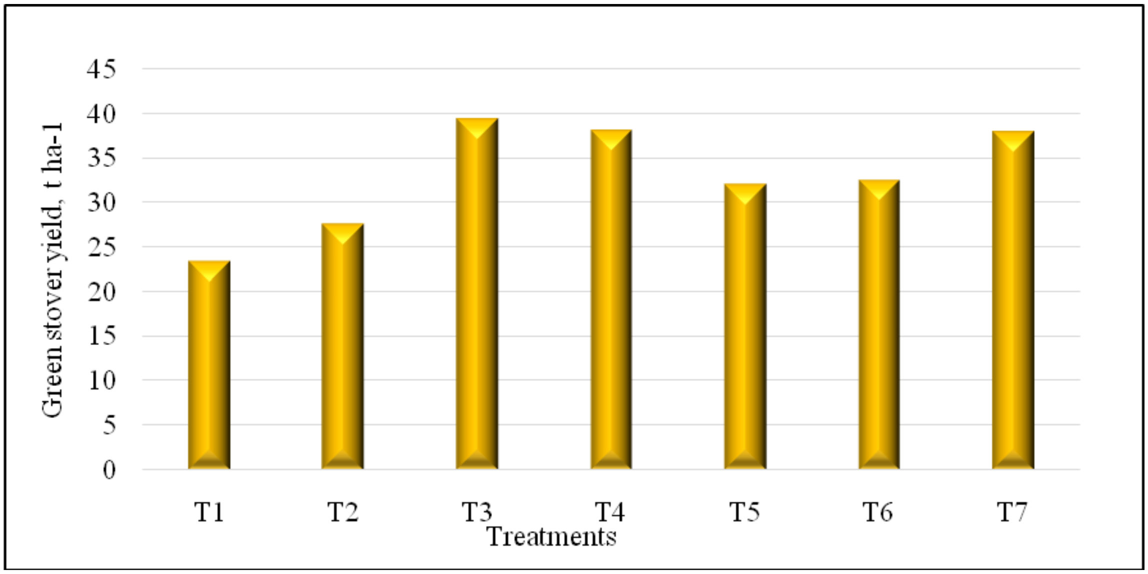

Fig 10. Effect of intercropping systems on green stover yield of baby corn, t ha^{-1}

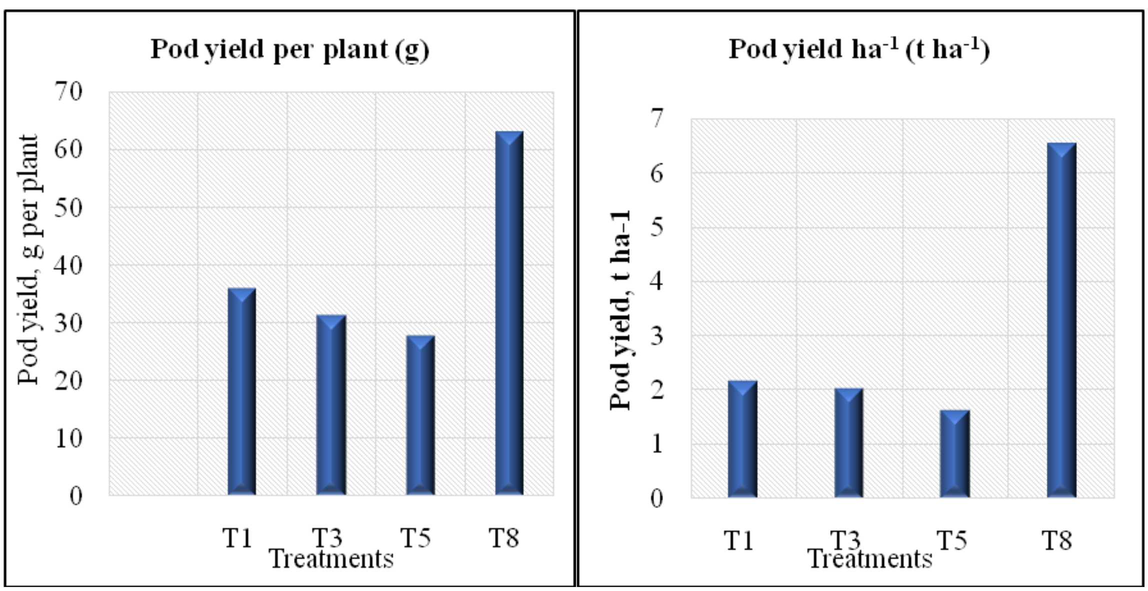

Fig 11. Effect of intercropping systems on pod yield per plant and pod yield per ha of cowpea

However, in the present study, both main crop and intercrops were given recommended dose of nutrients separately and no additional quantity was provided, and hence competition for nutrients can also be considered as a reason for low yield of cowpea under intercropping situation. Intercropping maize with cowpea resulting in yield reduction in cowpea was previously reported by Alla *et al*. (2014).

Among intercropping treatments, the skip row planting with baby corn produced comparatively higher number of pods per plant, pod yield per plant and pod yield per ha. As observed in case of growth and growth attributes, the competition exhibited by baby corn especially for light was comparatively lower on account of low population density and wider spacing in skip row planting and this would have favourably influenced the growth and yield of cowpea.

5.2.3 Intercrop - amaranthus

As in case of cowpea, the yield attributes and yield of amaranthus were severely reduced when grown as an intercrop in baby corn and the sole crop produced the highest per plant yield (Fig. 12) and per ha yield (Fig. 12). In case of sole crop, two harvests were taken while only one harvest was taken from the intercrop treatments. Shading effect of the tall growing main crop could be considered as the major reason for poor performance of amaranthus under intercropping situation. Moreover, in amaranthus, reduction in the growth and growth attributes will be directly reflected on the yield, as biomass yield is taken as the economic yield. Reduction in the leaf number, leaf weight, stem weight and leaf yield of amaranthus with more than 10 per cent reduction in photosynthetically active radiation due to shading was previously reported by Wadud *et al*. (2002).

However, the skip row planting of baby corn and amaranthus produced higher per plant yield and per ha yield, wherein the per plant yield was comparable with the yield produced by the sole crop of amaranthus. In skip row, plant population of amaranthus was comparatively higher and that of baby corn was lower which might have reduced the shading effect of baby corn. The higher plant population of amaranthus would have resulted in higher biomass yield, thus directly contributing to the higher yield in skip row planting.

5.3 LIGHT INTETRCEPTION

Light interception by baby corn was higher when it was intercropped with vegetables in paired row or in 2:1 planting ratio or when maintained as a sole crop (Fig. 13) which could be a direct effect of better canopy formation due to higher population density and narrow spacing (in case of paired row planting) between baby corn rows, leading to harvesting of more solar radiation. Positive relationship between maize canopy structure and light interception was previously pointed out by Liu *et al*. (2011). However, in skip row planting of baby corn with vegetables, there was a reduction in the light interception by baby corn. In skip row planting, 50 per cent of the sole crop population was maintained for baby corn, while 62.5 per cent and 66.7 per cent of sole crop population respectively were maintained for cowpea and amaranthus (Appendix III). Wider spacing (90 cm) between two rows of baby corn in this planting geometry (Fig. 3) coupled with low population density would have permitted the transmission of more light to the canopy beneath, which in turn might have been intercepted by the intercrops. This otherwise explains the better growth and yield response of intercrops and moderate reduction in the yield of main crop baby corn under skip row planting system.

Analysis of the light interception pattern of intercrops in different planting geometries in comparison with their sole crops revealed that the interception was higher in sole crop of cowpea which might be due to the higher LAI of cowpea under sole cropping. Cowpea intercepted more light under paired row and skip row intercropping system with baby corn (Fig. 14) compared to 2:1 row planting of baby corn with cowpea and corresponding values of LAI were also higher for paired row and skip row planting (Table 13).

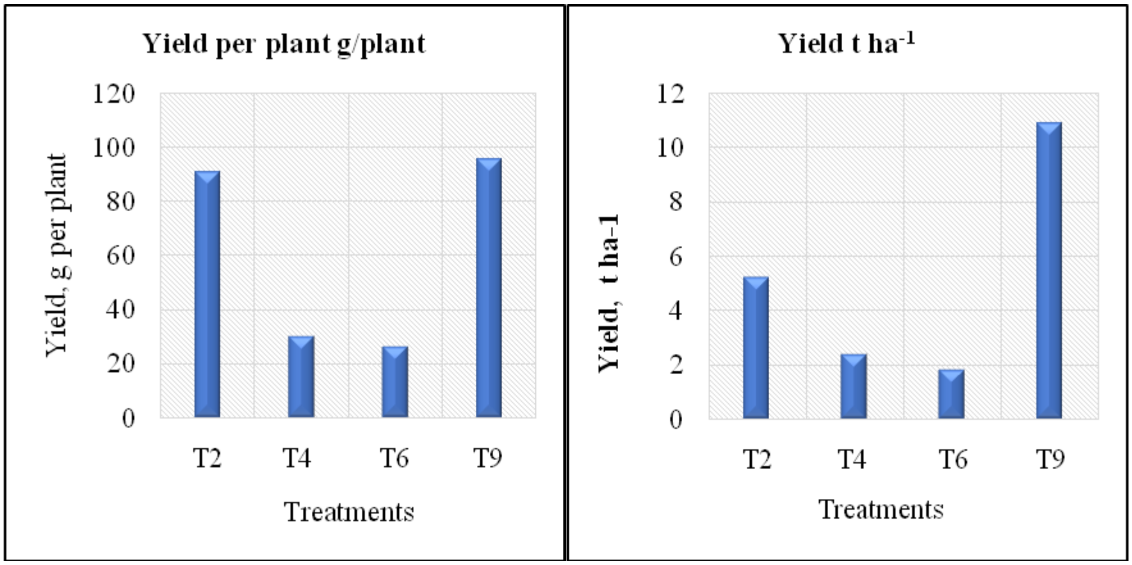

Fig 12. Effect of intercropping systems on yield per plant and per ha^{-1} in amaranthus

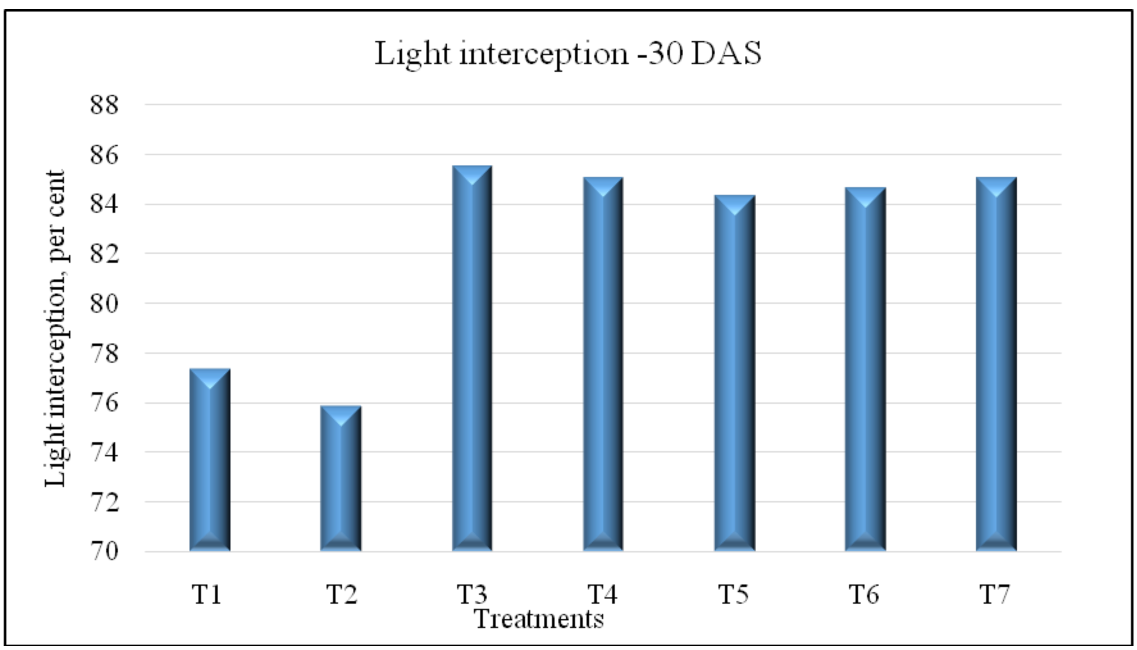

Fig 13. Effect of intercropping systems on light interception by baby corn, per cent

The relationship between LAI and light interception has been elaborated by Palaniappan and Sivaraman (1996), and in their opinion, the LAI is an important biophysical index for assessing the quantity of photosynthetically active radiation (PAR) absorbed in plant canopies and the instantaneous PAR absorbed by a crop canopy depends on LAI along with other parameters like flux density, zenith and azimuth positions of sun. Therefore, higher leaf area development and better canopy formation could be attributed towards the higher light interception by cowpea in skip and paired row planting with baby corn. Similar trend was reported by Thavaprakaash and Velayudham (2008) in baby corn.

Cropping system wise analysis of light interception indicated the superiority of sole crop of cowpea followed by amaranthus in harvesting solar radiation and the percentage of light intercepted by sole crop of baby corn was lower than that by the intercrops (Fig. 15) under sole cropping. The light interception by the paired row planting and 2:1 row planting of baby corn and cowpea were also better than the sole crop of baby corn. The difference in the system wise light interception could be considered as a reflection of the variation in leaf morphology, orientation and phyllotaxy of the component crops. Maize which is a cereal has large leaves, linear in shape and the leaf arrangement is distichous. The leaf angle, leaf orientation and leaf azimuth of the canopy structure which varies with varieties decide the efficiency of light interception in maize (Liu *et al*., 2011). In cowpea, leaves are compound, large in size with two asymmetrical side leaflets and one symmetrical central leaflet (Pottorff *et al*., 2012) and this kind of leaf structure supports quick canopy formation under favourable growing conditions, which would have favoured the interception of more solar radiation compared to its cereal component crop, when raised as sole crop or in cropping systems.

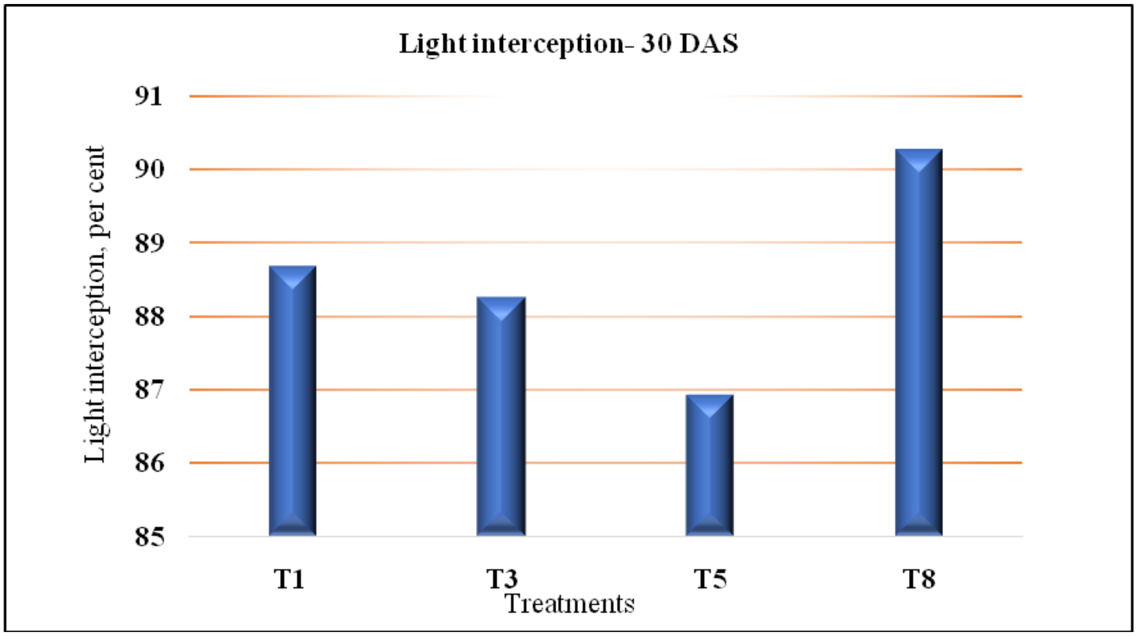

Fig 14. Effect of intercropping systems on light interception by cowpea, per cent

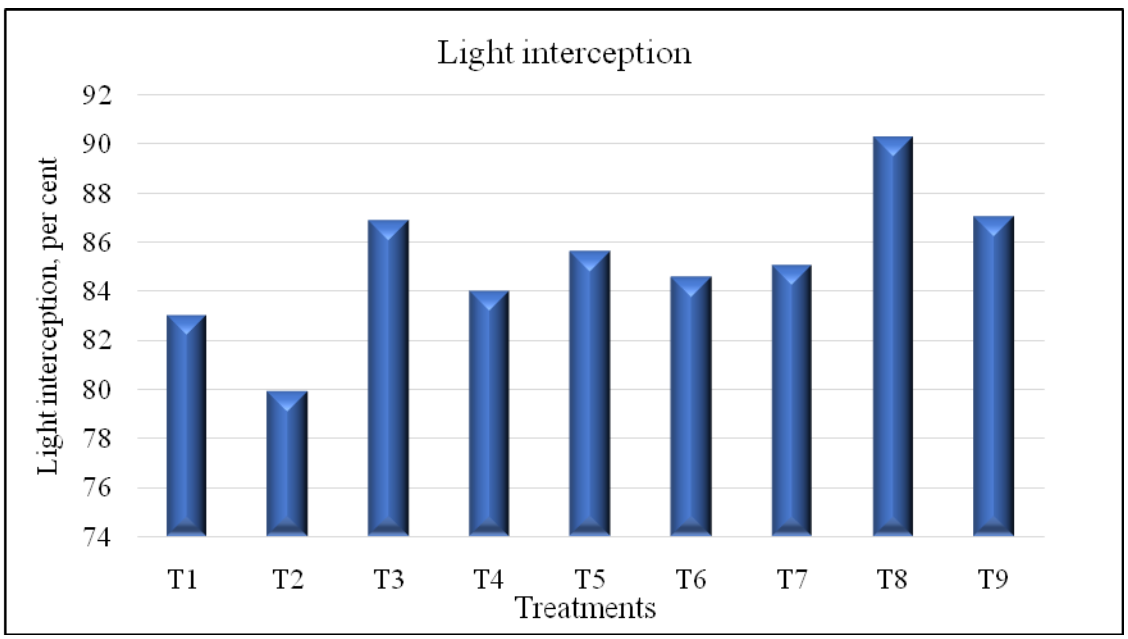

Fig 15. Intercropping system wise light interception at 30 DAS, per cent

5.4 NUTRIENT UPTAKE

Uptake of N, P and K by baby corn significantly varied with the treatments and were higher when planted with cowpea in paired row system (Fig. 16). In case of N and P uptakes, the paired row planting was equally effective as the sole crop of baby corn. The same population of baby corn under sole cropping was maintained under paired row planting also and it resulted in higher dry matter production (Table 9) and consequently, in higher uptake. Similar finding was reported by Ofori and Stern (1986) in maize and cowpea intercropping system.

In case of intercrops, N, P and K uptakes were higher in sole crop of cowpea and amaranthus compared to the intercropping systems, which also could be considered as a direct effect of higher dry matter yield. However, the skip row planting was found to favour the uptake of nutrients by intercrops compared to other cropping geometries and this might have been due to reduced competition for resources such as nutrients on account of low population density and wider spacing of baby corn, and also due to the higher population density of intercrops in that system. Similar observations on skip row planting were made by Gou *et al*. (2018) in maize and wheat intercropping system.

5.5. COMPETITION INDICES

The value of land equivalent ratio (LER) was more than one in all the intercropping systems (Fig. 17). The LER represents the land required for sole crops to produce the yield achieved in the intercropping mixture and the LER value more than one indicates an overall biological advantage of intercropping (Palaniappan and Sivaraman, 1996). Therefore the LER value >1 observed under the intercropping situation in the study revealed the yield advantage of growing vegetables as intercrops with baby corn over sole cropping of baby corn and vegetables. Among different intercropping systems, the paired row planting of cowpea with baby corn had the highest LER (1.42). The LER of the intercropping system is calculated by adding the LER values of main crop and intercrops. All the yield parameters of baby corn such as cob weight with husk, cob yield with husk and marketable cob yield were higher in paired row planting of baby corn with cowpea which was also reflected on its LER value (LER_b) and the LER value of intercropping system as a whole (total LER). This is in agreement with the findings of Filho (2000) who concluded that maize was the main component in deciding the productivity of maize + cowpea intercropping system as evident from its higher partial LER value. Increased land use efficiency and LER value for maize and cowpea intercropping system was previously reported by Lateef *et al*. (2015).

Baby corn had higher relative crowding coefficient (K_b) in paired row planting with amaranthus followed by cowpea and the higher RCC of baby corn than intercrops indicated higher competitive ability over the intercrops. Higher plant population of baby corn maintained in paired row might have been contributed to its greater competitive ability in the intercropping system. Similar result was reported by Ghanbari *et al*. (2010) who observed higher RCC of baby corn compared to vegetables, in baby corn and vegetable intercropping system.

Aggressivity value of baby corn was positive in all intercropping systems (Fig. 17) which indicated the dominant nature of baby corn over other component crops. The overall competitive ability of baby corn on vegetables was found to be more pronounced in skip row planting with cowpea. Positive aggressivity value of maize over cowpea and negative aggressivity value of cowpea were previously reported by Saudy and Bagoury (2014) in maize and cowpea intercropping system.

The paired row planting of baby corn with cowpea resulted in the highest monetary advantage index (MAI) and baby corn equivalent yield (BEY). The MAI is an indicator of the economic feasibility of intercropping system and BEY evaluates the economic benefit of the intercropping system by converting yield of intercrops into equivalent yield of baby corn based on the price. Higher yield potential of baby corn expressed in paired row planting with cowpea would have contributed to the monetary benefit in terms MAI and BEY. This is in agreement with the findings of Alla *et al*. (2014) and Rani *et al*. (2015) in baby corn.

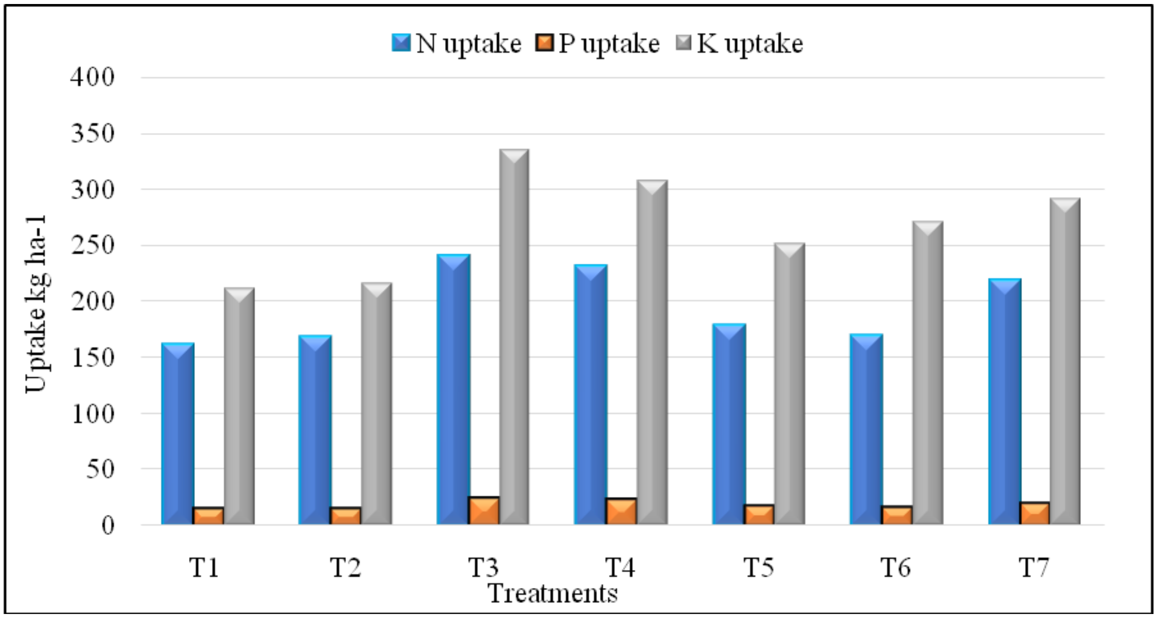

Fig 16. Effect of intercropping systems on N, P and K uptake of baby corn, kg ha^{-1}

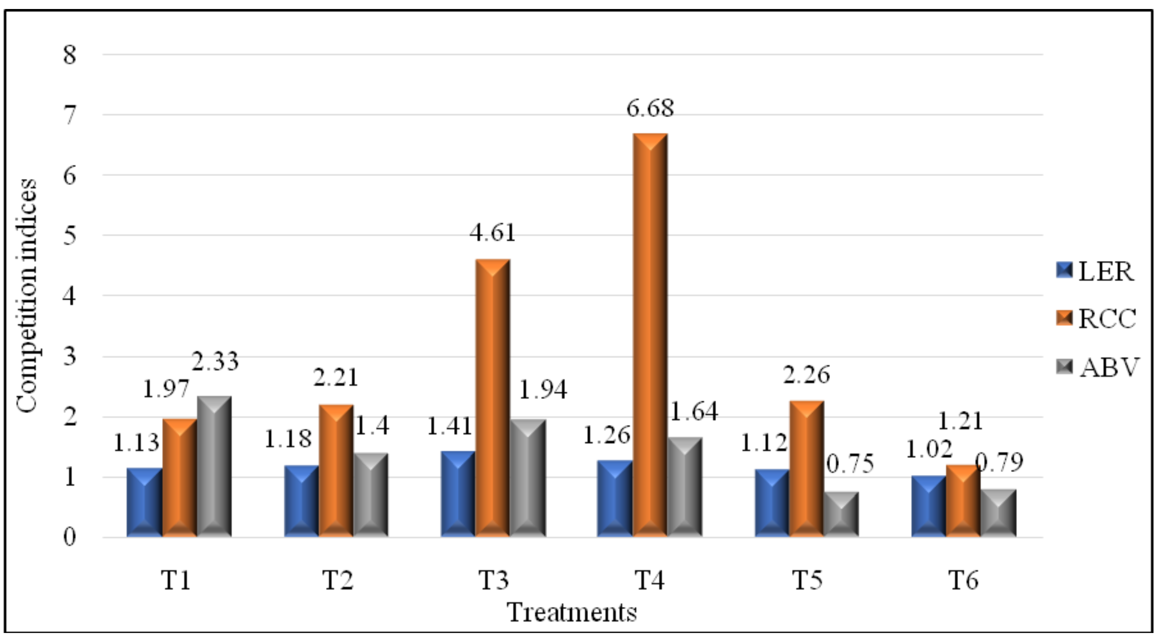

Fig 17. Effect of intercropping systems on land equivalent ratio, relative crowding coefficient and aggressivity

5.6 SOIL PROPERTIES

The soil of the intercropped plots was analysed for pH, EC, organic carbon and nutrients N, P and K before and after the experiment. There was no significant variation in soil parameters among treatments. But an increase in available P status of soil was observed in all the treatment plots after the experiment compared to the initial value. According to Koo *et al*. (2005), maize roots have the ability for rhizodeposition and organic acids such as malic, malonic, acetic, citric, fumaric, succinic, lactic, tartaric and oxalic acids are released to the rhizosphere through root exudation, which play a major role in solubilisation of mineral nutrients such as phosphorus. The increased availability of P in soil after cultivating baby corn could be therefore considered as an indirect effect of rhizodeposition by maize. Similar results were reported by Lalati *et al*. (2014).

5.7 ECONOMICS OF CULTIVATION

Economic analysis of the intercropping systems revealed that the benefit: cost ratio (BCR) obtained from different planting geometries of baby corn with cowpea were found to be higher than that produced by growing baby corn with amaranthus, which indicated the suitability of cowpea as an intercrop in baby corn compared to amaranthus. The paired row planting of baby corn with cowpea produced the highest net income and BCR (Fig. 18). As opined by Filho (2000), in maize and cowpea intercropping system, maize decides the productivity of the system and yield attributes and yield of baby corn were the highest when it was intercropped with cowpea and this in turn would have reflected on the net income and BCR generated. Profitability of intercropping vegetable cowpea with baby corn was reported earlier by Reddy *et al.* (2009) and Rani *et al*. (2015).

Total cost of cultivation of intercropping systems were however higher than that of the sole crops and was the lowest with sole crop of baby corn. Intercropping of cowpea or amaranthus needed more labour and management practices compared to sole crops, which would have increased the cost of cultivation. However, the higher yield of component crops especially the main crop obtained from the intercropping systems would have compensated the higher cost of cultivation making these more economically viable and profitable than the sole cropping. This is in agreement with the findings of Adhikary *et al*. (2015) who reported that baby corn and vegetable based intercropping systems were more productive and profitable than sole cropping of baby corn.

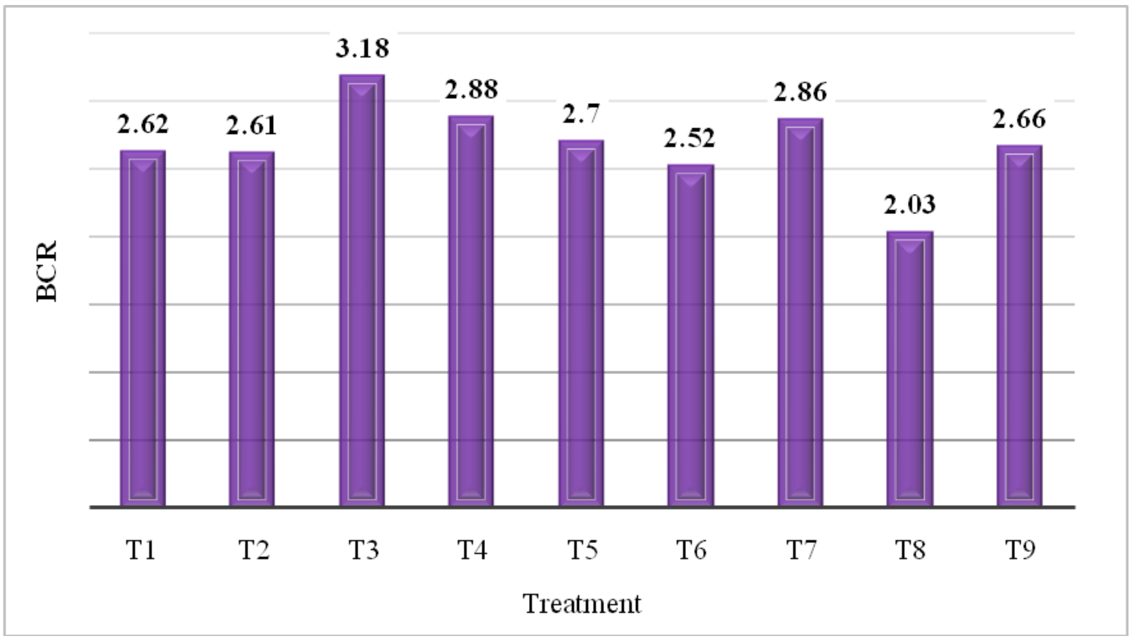

Fig 18. Effect of intercropping systems on benefit: cost ratio

The results of the study revealed that vegetable cowpea is more suitable than amaranthus for intercropping with baby corn and intercropping vegetables in baby corn is more productive and profitable than sole cropping of baby corn. The paired row planting of baby corn with cowpea was identified as the best intercropping system in this study, with respect to yield, baby corn equivalent yield, monetary advantage index, net income and benefit: cost ratio.

SUMMARY

6. SUMMARY

The study entitled "Intercropping vegetables in baby corn (*Zea mays* L.)'' was conducted at College of Agriculture, Vellayani during 2018-20 to investigate the feasibility of intercropping vegetables (cowpea and amaranthus) in baby corn and to find out the effect of crop geometry on growth, yield, productivity and economics of intercropping systems.

The experiment was laid out in Randomized Block Design with 3 replications. Baby corn (var. G 5414) was raised as main crop and cowpea (var. Bhagyalakshmi) and amaranthus (var. Arun) were raised as intercrops in various cropping geometries. The treatments consisted of different planting geometries of baby corn with cowpea and amaranthus as intercrops along with sole crop treatments, viz., T_1- baby corn + cowpea (skip row), T_2- baby corn + amaranthus (skip row), T_3- baby corn + cowpea (paired row), T_4- baby corn + amaranthus (paired row), T_5- baby corn + cowpea (2:1 ratio), T_6- baby corn + amaranthus (2:1 ratio), T_7- sole crop of baby corn, T_8- sole crop of cowpea and T_9- sole crop of amaranthus. The salient results of the experiment are summarized below.

The results of the study revealed that the intercropping treatments could influence the growth and growth attributes of main crop baby corn and intercrops cowpea and amaranthus. The total dry matter production at harvest of baby corn was significantly influenced by the intercropping systems and the paired row planting with cowpea (T_3) registered the highest dry matter yield of 24453 kg ha^{-1} which was significantly superior to all other treatments except T_4 (paired row planting of baby corn with amaranthus- 23571 kg ha^{-1}) and T_7 (sole cropping of baby corn-23274 kg ha^{-1}).

The sole crop of cowpea recorded the highest plant height (108.55cm) at 45 DAE which was on par with all other intercropping treatments except T_5 (planting baby corn and cowpea in 2:1 ratio), wherein a significant reduction in plant height (80.55 cm) was observed. Number of primary branches per plant at 45 DAE was reduced in intercropping treatments compared to sole crop of cowpea (3.33), but no variation was observed among intercropping systems. The sole crop of cowpea recorded the highest LAI (3.46) compared to intercropping systems. However, the intercropping system T_1 (skip row planting of cowpea in baby corn) with LAI 2.71 was significantly superior to T_3 (paired row planting of cowpea in baby corn-LAI 2.25) and T_5 (baby corn + cowpea in 2:1 ratio-LAI 1.80). The total dry matter production of cowpea was significantly higher (6564.01 kg ha^{-1}) under sole cropping compared to intercropping. However, among different intercropping systems, the highest total dry matter production was recorded (1851.66 kg ha^{-1}) with T_1 (skip row planting) which was on par with T_3 (paired row planting). The sole crop of cowpea (T_8) registered the highest rooting depth (27.13 cm) and volume (9.40 cm^3), which was on par with T_1 (skip row planting) recording a rooting depth of 26.33 cm and root volume of 8.66 cm^3.

The results of growth parameters of the intercrop amaranthus revealed that the sole crop (T_9) produced taller plants with the highest plant height (60.86 cm) at harvest but was on par with the skip row planting of baby corn and amaranthus (T_2) and paired row planting of baby corn and amaranthus (T_4) producing the plant height 60.53 cm and 50.46 cm, respectively. The LAI of amaranthus at the time of first harvest was significantly influenced by the intercropping and sole cropping. The T_9 (sole crop of amaranthus) produced the highest LAI of 1.78 which was superior to all other treatments. Among intercropping systems, the T_2 (skip row planting) produced higher LAI of 0.89 which was significantly higher than that recorded with T_4 - paired row planting (0.61) and T_6 - planting base crop and intercrop in 2:1 ratio (0.34). The total dry matter production of amaranthus was significantly influenced by the treatments. The sole crop of amaranthus (T_9) had the highest dry matter production (2980.10 kg ha^{-1}) which was superior to all other treatments. Among different intercropping systems, the T_2 (skip row planting) recorded a dry matter production of 1431.73 kg ha^{-1} and was superior to other treatments.

The intercropping systems with different planting geometries could influence the yield attributes and yield of main crop baby corn. The T_1 (baby corn + cowpea in skip row) and T_2 (baby corn + amaranthus in skip row) recorded significantly higher number of cobs per plant (3.38 and 3.12, respectively) than other treatments.

The paired row planting of baby corn with cowpea (T_3) registered significantly higher cob weight with husk of 49.5 g compared to all other treatments except T_4 (paired row planting of baby corn with amaranthus-48.0 g) which was on par with T_3. Paired row planting of baby corn with cowpea (T_3) produced the highest cob yield with husk (11.39 t ha^{-1}) and marketable cob yield (3.53 t ha^{-1}) and was significantly superior to all other treatments including the sole crop. The paired row planting of baby corn and amaranthus (T_4) recorded the lowest cob-corn ratio of 3.37 which was on par with paired row planting of baby corn and cowpea (T_3- 3.40). The treatment T_3 (paired row planting of baby corn and cowpea) produced the highest green stover yield of 39.33 t ha^{-1} which was significantly higher than T_2 (skip row planting of baby corn and amaranthus-27.66 t ha^{-1}) and T_1 (skip row planting of baby corn and cowpea-23.5 t ha^{-1}) but was statistically similar to all other treatments.

Analysis of yield attributes of intercrop cowpea revealed that there was a significant reduction in the number of pods per plant in all the intercropping treatments compared to the sole crop (10.53) which was superior to all other treatments. The pod yield per plant was also significantly reduced in all the intercropping treatments and the highest pod yield per plant was recorded with sole crop of cowpea (T_8- 63.00 g) which was significantly superior to the intercropping treatments. Among intercropping treatments, T_1 (baby corn and cowpea in skip row-35.94 g per plant) was on par with T_3 (baby corn and cowpea in paired row) which in turn did not vary from T_5 with respect to pod yield per plant. Highest pod yield per ha was recorded with the sole crop of cowpea (T_8 - 6.83 t ha^{-1}) which was significantly superior to all the intercropping treatments. There was a marked reduction in the pod yield per ha in case of intercropping treatments and T_1 (baby corn and cowpea in skip row-2.17 t) and T_3 (baby corn and cowpea in paired row-2.01 t) were found to be on par each other and were superior to T_5.

Analysis of yield parameters of amaranthus revealed that the sole crop (T_9) produced the highest yield per plant (96.00 g) which was significantly higher than the value recorded with T_4 (paired row planting of baby corn and amaranthus-30.00 g) and T_6 (planting baby corn and amaranthus in 2:1 ratio-26.60 g) which were on par each other. The skip row planting of baby corn and amaranthus (T_2) however produced higher per plant yield (91.13 g) which was on par and comparable with the yield produced by the sole crop of amaranthus. There was a severe reduction in the amaranthus yield under intercropping situation compared to sole cropping. In case of sole crop, two harvests were taken while only one harvest was taken from the intercrop treatments. Sole crop of amaranthus registered the highest per ha yield of 10.91 t ha^{-1} which was significantly superior to the intercropping treatments. The intercropping treatment T_2 (5.24 t) was superior to T_4 which in turn produced higher per ha yield compared to T_6.

Light interception by the crop canopy at 30 DAS was the highest in baby corn (85.54 per cent) under paired row planting with cowpea (T_3) which was on par with all other treatments except T_1 (77.36 per cent) and T_2 (75.84 per cent). The sole crop of cowpea (T_8) intercepted significantly higher amount of solar radiation (90.26 per cent) compared to the intercropping treatments while in amaranthus no variation in light interception with respect to treatments was noticed.

Analysis of nutrient uptake of main crop baby corn at harvest showed higher N uptake (239.94 kg ha^{-1}) when the crop was grown with cowpea in paired row (T_3) but was on par with T_4 (in paired row with amaranthus- 230.56 kg ha^{-1}) and T_7 (sole crop of baby corn-218.01 kg ha^{-1}). The P uptake of baby corn also showed similar trend wherein the T_3 recorded the highest uptake (24.44 kg ha^{-1}) which did not statistically differ from T_4 (22.48 kg ha^{-1}) and T_7 (18.98 kg ha^{-1}). A near similar trend was noticed in case of K uptake also wherein the treatment T_3 recorded the highest K uptake (335.27 kg ha^{-1}) and was on par with T_4 (306.9 kg ha^{-1}).

The sole crop of cowpea registered the highest N, P and K uptake (155.52, 15.14 and 96.19 kg ha^{-1}, respectively), which were more than three times that recorded under intercropping systems. Among intercropping treatments, planting cowpea in skip row with baby corn recorded (T_1) higher N uptake (42.79 kg ha^{-1}) and it did not differ from planting in paired row with baby corn (T_3- 40.82 kg ha^{-1}). Same trend was noticed in case of P uptake wherein T_1 had the higher uptake (7.94 kg ha^{-1}) but was on par with all other intercropping treatments. The T_1 resulted in higher K uptake also (30.26 kg ha^{-1}), and was on par with T_3 (25.70 kg ha^{-1}). A drastic reduction in the nutrient uptake was noticed in case of planting baby corn and cowpea in 2:1 ratio.

The results of the nutrient uptake by intercrop amaranthus revealed that the sole crop (T_9) recorded the highest N, P and K uptake of 49.37, 12.53 and 49.77 kg ha^{-1}, respectively. Among intercropping treatments, the T_2 had higher N, P and K uptake (22.72, 6.07 and 25.86 kg ha^{-1}, respectively)

Different competition indices computed in the study were land equivalent ratio (LER), relative crowding coefficient (RCC), aggressivity, monetary advantage index (MAI) and baby corn equivalent yield (BEY). The LER of each intercropping system recorded values higher than one which indicated the yield advantage over sole cropping. Intercropping baby corn with cowpea in paired row planting (T_3) had the highest LER of 1.42. The RCC value of baby corn (K_b) was found to be higher than that of vegetables which indicated its dominance over vegetables in all intercropping systems. Baby corn expressed the highest RCC value when grown in paired row with amaranthus (T_4 -23.84). Aggressivity values of baby corn (A_{bv}) in all intercropping systems were positive which indicated the dominant nature of baby corn over the intercrops. The aggressivity of baby corn over vegetables was more pronounced in skip row planting with cowpea (T_1-2.33). The MAI was the highest (95503) in paired row planting of baby corn with cowpea (T_3) indicating the monetary advantage of the system. The highest BEY was recorded (12999 kg ha^{-1}) in T_3 (paired row planting of baby corn with cowpea) and was followed by T_4

(baby corn and amaranthus in paired row). Sole crop of amaranthus (T_9) and cowpea (T_8) expressed lower BEY of 8733 kg ha^{-1} and 5225 kg ha^{-1}, respectively.

The cost of cultivation of intercropping was found to be higher than that of sole crop and the total cost of cultivation was the lowest for sole crop cowpea (₹ 64225 ha^{-1}) and was the highest for paired row planting of baby corn with amaranthus (T_4- ₹ 109954 ha^{-1}). Economic analysis indicated that the paired row planting of baby corn with cowpea (T_3) recorded with highest net income (₹ 222830 ha^{-1}). All the sole crop treatments except baby corn recorded lower net income compared to the intercropping treatments. Intercropping vegetables in baby corn expressed BCR greater than one. Paired row planting of baby corn with cowpea (T_3) recorded the highest BCR of 3.18.

The results of the study revealed that cowpea is more suitable as an intercrop in baby corn in comparison with amaranthus. Paired row planting of baby corn with cowpea was found to be the best intercropping system based on growth, yield, productivity, monetary benefit in terms of baby corn equivalent yield, monetary advantage index and the economics of cultivation.

FUTURE LINE OF WORK

- Suitability of intercropping more short duration vegetable crops in baby corn may be studied.
- Examining the possibilities of introducing the cultivation of baby corn in homesteads is another future area of study
- Measures to improve the performance of intercrops through modified agro techniques could be tried to develop more suitable intercropping systems with better productivity of all the component crops.

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INTERCROPPING VEGETABLES IN BABY CORN (*Zea mays* L.)

By

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ABSTRACT

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ABSTRACT

The study entitled "Intercropping vegetables in baby corn (*Zea mays* L.)'' was conducted at College of Agriculture, Vellayani, Thiruvananthapuram during 2018-20 to investigate the feasibility of intercropping vegetables (cowpea and amaranthus) in baby corn and to find the effect of crop geometry on growth, yield, productivity and economics of intercropping systems.

The field experiment was conducted during March to May 2019 and was laid out in Randomized Block Design with 3 replications. Baby corn (var. G 5414) was raised as main crop and cowpea (var. Bhagyalakshmi) and amaranthus (var. Arun) were raised as intercrops in various cropping geometries. The treatments consisted of different planting geometries of baby corn with cowpea and amaranthus as intercrops along with sole crop treatments, viz., T_1- baby corn + cowpea (skip row), T_2- baby corn + amaranthus (skip row), T_3- baby corn + cowpea (paired row), T_4- baby corn + amaranthus (paired row), T_5- baby corn + cowpea (2:1 ratio), T_6- baby corn + amaranthus (2:1 ratio), T_7- sole crop of baby corn, T_8- sole crop of cowpea and T_9- sole crop of amaranthus.

The results indicated that intercropping cowpea or amaranthus in baby corn had significant influence on the growth and yield of both main crop and intercrops. The cob yield with husk (11.39 t ha^{-1}), marketable cob yield (3.53 t ha^{-1}) and cob weight with husk (49.50 g) of baby corn were found to be significantly higher in T_3 compared to other treatments including sole crop of baby corn. The number of cobs per plant recorded was the highest in T_1 which did not differ from T_2. Cob-to corn ratio of baby corn was significantly lower in treatments T_4 and T_3. The highest dry matter production (24453 kg ha^{-1}) and green stover yield (39.33 t ha^{-1}) of baby corn were recorded in T_3 which was on par with T_7.

Growth and yield of intercrops were significantly reduced under intercropping. Sole crop of cowpea (T_8) produced higher number of primary branches, LAI, total dry matter production, root volume, root depth, number of pods per plant, pod yield per plant and pod yield per ha compared to intercropping systems. Sole crop of amaranthus (T_9) also produced significantly higher LAI, total dry matter production, yield per plant and yield per ha when compared to intercropping systems. The light interception by the crop canopy of baby corn was found to be the highest in T_3. Higher uptake of N, P and K were recorded in intercropping treatment T_3 (growing baby corn and cowpea in paired row). The sole cropping of intercrops however resulted in the highest N, P and K uptake compared to the intercropping.

Analysis of competitive indices of intercropping system revealed that the land equivalent ratio (LER), baby corn equivalent yield (BEY) and monetary advantage index (MAI) were the highest in T_3. The positive aggressivity value (A_{bv}) and higher relative crowding coefficient of baby corn (K_b) indicated the competitive nature and dominance of baby corn over intercrops. The paired row planting of baby corn with cowpea (T_3) produced the highest net returns (₹ 222830 ha^{-1}) and benefit: cost ratio (3.18).

The results of the study indicated that compared to amaranthus, vegetable cowpea was more suitable for intercropping with baby corn. Paired row planting of baby corn with cowpea (T_3) was found to be the best intercropping system considering the planting geometry in terms of baby corn equivalent yield, monetary advantage index, net income and benefit: cost ratio.

APPENDIX I

STANDARD WEEK WISE METEOROLOGICAL DATA DURING THE CROPPING PERIOD (March – May, 2019)

Standard week	Mean temperature (ºC)		Total rainfall (mm)	Mean RH (%)		Bright sunshine hours
	Max.	Min.		Max.	Min.	
10 (5Mar.–11Mar.)	34.6	24.8	0.0	85.4	60.0	9.4
11 (12 Mar. – 18Mar.)	34.4	24.4	0.0	85.3	61.3	9.2
12 (19 Mar. – 25Mar.)	34.2	24.8	0.0	84.9	61.3	9.2
13 (26 Mar. – 1 Apr.)	34.8	25.4	0.0	85.7	61.9	8.9
14 (2 Apr. – 8 Apr.)	35.2	26.0	0.0	83.7	61.6	9.4
15 (9 Apr. – 15 Apr.)	35.0	25.9	0.0	78.6	61.9	9.3
16 (16 Apr. – 22 Apr.)	34.9	25.6	1.6	82.8	67.3	7.7
17 (23 Apr. – 29 Apr.)	35.1	25.6	1.0	84.6	63.7	8.4
18 (30 Apr. – 6 May.)	34.1	25.9	2.3	82.7	59.0	6.5
19 (7 May – 13 May)	34.3	26.2	0.0	80.3	66.9	8.9
20 (14 May – 20 May)	34.5	26.2	0.0	81.3	66.7	9.4

Source :Agromet observatory, Department of Agricultural Meteorology, College of Agriculture, Vellayani

APPENDIX II

AVERAGE INPUT COST AND MARKET PRICE OF PRODUCE

Items	Cost (₹)
Inputs	
Labour wages	
Men	700 day^{-1}
Women	500 day^{-1}
FYM	800 t^{-1}
Urea	8 kg^{-1}
Muriate of potash	23 kg^{-1}
Rajphos	15 kg^{-1}
Lime	18 kg^{-1}
Baby corn seed	650 kg^{-1}
Amaranthus seed	1750 kg^{-1}
Cowpea seed	1000 kg^{-1}
Produce	
Baby corn	25 kg^{-1}
Amaranthus	20 kg^{-1}
Cowpea	20 kg^{-1}

APPENDIX III

PLANT POPULATION OF BABY CORN AND INTERCROPS IN TREATMENTS- Plants per Ha

Treatments	Baby corn	Cowpea	Amaranthus
T_1 -baby corn + cowpea (skip row)	55,555	138,888	-
T_2-baby corn + amaranthus (skip row)	55,555	-	111,108
T_3-baby corn + cowpea (paired row)	111,111	138,888	-
T_4-baby corn + amaranthus (paired row)	111,111	-	111,108
T_5-baby corn + cowpea (2:1 ratio)	88,886	55,554	-
T_6-baby corn + amaranthus (2:1 ratio)	88,886	-	44,443
T_7-sole crop of baby corn	111,111	-	-
T_8- Sole crop of cowpea	-	222,222	-
T_9-Sole crop of amaranthus	-	-	166,666

APPENDIX IV

TREATMENT WISE COST OF CULTIVATION, ₹ ha^{-1}

Particulars	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**
Land preparation	4000	4000	4000	4000	4000	4000	4000	4000	4000
Lime	4500	4500	4500	4500	4500	4500	4500	4500	4500
Plant protection	2000	2000	2000	2000	2000	2000	1250	2000	2500
Labour cost- Men	28,000	42,000	24,500	38500	24500	38500	28000	14000	28,000
-Women	19,000	25,000	17,500	17500	22500	17500	20000	12500	15,000
Baby corn seed	6,500	6,500	13,000	13,000	10,400	10,400	13,000	-	-
Cowpea/Amaranthus seed	10,000	1,750	11000	1,750	4,500	875	-	10,000	2,625
Fertilizer	6892	9950	11638	14704	8670	10203	10251	3225	7821
FYM	14,000	14,000	14,000	14000	14000	14000	8750	14000	17500
TOTAL	**94892**	**109700**	**102138**	**109954**	**95070**	**101978**	**89751**	**64225**	**81946**

Plate 1: General view of the experimental field

Plate 2: General view of the field before and after sowing

Plate 3: T_1- Baby corn + cowpea in skip row

Plate 4: T_2- Baby corn + amaranthus in skip row

Plate 5: T_3 – Baby corn + cowpea in paired row

Plate 6: T_4- Baby corn + amaranthus in paired row

Plate 7: T_5 – Baby corn + cowpea in 2:1 row

Plate 8: T_6 – Baby corn + amaranthus in 2: 1 row

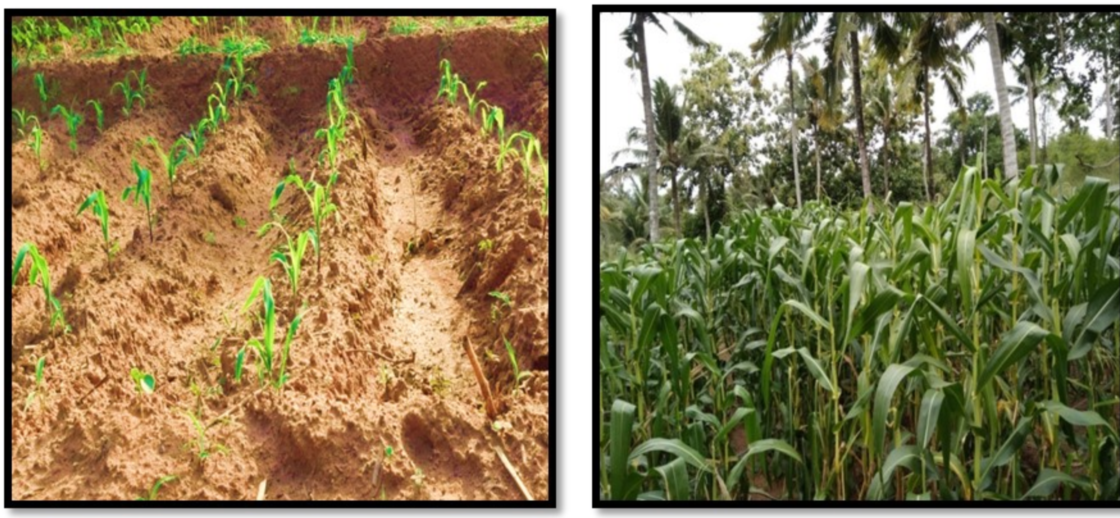

Plate 9: T_7- Sole crop of baby corn

Plate 10: T_8- Sole crop of cowpea

Plate 11: T_9- Sole crop of Amaranthus

Plate 12: Tasseling and silking of baby corn