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Effect of baby corn-vegetable intercropping systems on light interception by canopy and competition indices

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ABSTRACT

A study was conducted to investigate the feasibility of intercropping vegetables (cowpea and amaranthus) in baby corn and to find out the effect of intercropping and cropping geometry on light interception and competition indices of the intercropping systems at College of Agriculture (KAU), Vellayani, Thiruvananthapuram, Kerala during summer 2019. The light interception by the crop canopy of baby corn was the highest in paired row planting of baby corn with cowpea (85.54%). A significant reduction of light interception was observed in skip row planting of baby corn with cowpea and amaranthus. Analysis of competitive indices in intercropping systems revealed that the paired row planting of baby corn with cowpea recorded the highest land equivalent ratio (LER) of 1.42. The positive aggressivity (A_{bv}) value and higher relative crowding coefficient (RCC) of baby corn (K_b) indicated the competitive nature and dominance of baby corn over intercrops. Study revealed that the intercropping baby corn with vegetables was feasible and resulted in yield advantage than the sole cropping of baby corn. The paired row planting of baby corn with cowpea had higher light interception and more intercropping advantage with respect to the competition indices.

Keywords: Baby corn; planting geometry; intercropping; light interception; competition indices

INTRODUCTION

Maize (*Zea mays* L) is the third most important cereal crop next to rice and wheat and many speciality corn types have been evolved recently for diversification and value addition of maize. The term baby corn refers to young cobs of maize harvested within 2 to 3 days of silk emergence and is a delicious and nutritive vegetable fetching very high price both in national and international markets. Diversification of agriculture is necessary for meeting the increased demand of food and the nutritional requirement through enhanced food production. Intercropping is a way to increase diversity in an agricultural system which enhances the productivity besides providing the potential risk of monoculture.

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 per unit area. Light intercepted by the canopy of baby corn and the intercrops affect the productivity of the system and the adoption of proper planting geometry and choice of intercrop help in better resource utilization especially light. Cowpea is considered as a suitable intercrop in cropping systems due to its N-fixing ability and less competitive nature. The short duration leafy vegetable, amaranthus is another choice for intercropping which can yield well under different agro-climatic conditions.

MATERIAL and METHODS

The field experiment was conducted at College of Agriculture (KAU), Vellayani, Thiruvananthapuram, Kerala during summer 2019. The experiment was conducted in the garden land of instructional farm which is situated at a latitude of N 08°25’49.6632" and longitude of E76°59’24.954" and at an altitude of 29 m amsl. The soil was sandy clay loam lateritic belonging to the order oxisol with very strong acidity, normal electrical conductivity and was rich in organic carbon. The soil was medium in available nitrogen and potassium and high in available phosphorus. The mean maximum and minimum temperature ranged from 30.1 to 34.5°C and 23.7 to 26.7°C respectively.

The experiment was conducted in randomized block design with 3 replications with a plot size of 9.0 x 4.0 m. Two additional replications were maintained for statistical analysis of intercrops. 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 used were 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. Baby corn, cowpea and amaranthus were planted at a spacing of 45 x 20 cm (Scaria 2016), 30 x 15 cm and 30 x 20 cm respectively. In paired row planting, main crop (baby corn) was planted at 30/60 x 20 cm spacing.

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 and the percentage of light intercepted by the crop canopy was calculated by the formula:

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

where 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).

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}= Yield of baby corn and vegetables as sole crops respectively, Y_{bv} and Y_{vb}= Yield of baby corn and vegetables as intercrops respectively

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):

$$K = K_b \times K_v$$

where K= RCC of the intercropping system, K_b= RCC of baby corn, K_v= RCC of vegetables

$$\text{where } K_b = \frac{Y_{bv} \times Z_{vb}}{[(Y_{bb} - Y_{bv}) \times Z_{bv}]},$$

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

where Y_{bb} and Y_{vv}= Yield of baby corn and vegetables as sole crops respectively, Y_{bv} and Y_{vb}= Yield of baby corn and vegetables as intercrops respectively, Z_{bv} and Z_{vb}= Proportions of baby corn and vegetables in the mixture respectively

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

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

where A_{bv} and A_{vb}= Aggressivity of baby corn with respect to vegetables and aggressivity of vegetables with respect to baby corn respectively, Y_{bv} and Y_{vb}= Yield of baby corn and vegetables as intercrops respectively, Y_{bb} and Y_{vv}= Yield of baby corn and vegetables as sole crops respectively, Z_{bv} and Z_{vb}= Proportions of baby corn and vegetables in the mixture respectively

RESULTS and DISCUSSION

Data given in Table 1 show that light interception by the crop canopy at 30 DAS was the highest in baby corn (85.54%) under paired row planting with cowpea (T_3) which was on par with all other treatments except planting baby corn and cowpea in skip row, T_1 (77.36%) and baby corn and amaranthus in skip row, T_2 (75.84%). Higher light interception of baby corn under paired row planning with cowpea 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 the 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 intercrops, wider spacing (90 cm) between two rows of baby corn was maintained compared to the normal row spacing of 45 cm. This 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.

The sole crop of cowpea (T_8) intercepted significantly higher amount of solar radiation (90.26%) compared to the intercropping treatments. The sole crop of cowpea was devoid of competition from the tall growing maize. The taller component in an intercropping system permits the passage of less amount of radiation deep in the canopy as pointed out by Palaniappan and Sivaraman (1996) and this would have reduced the light interception by cowpea under intercropped situation.

Cropping system-wise analysis of light interception indicated that the sole crop of cowpea (T_8) recorded the highest value of light interception (90.26%) which was significantly superior to all other treatments followed by sole crop of amaranthus (T_9) registering a value of 87.01 per cent which was statistically similar to paired row planting of baby corn with cowpea, T_3 (86.89%) and planting baby corn and cowpea in 2:1 ratio, T_5 (85.64%). The percentage of light intercepted by sole crop of baby corn was however lower than the sole crops of intercrops.

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 vary 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

Table 1. Effect of intercropping vegetables in baby corn on light interception by component crops and intercropping systems at 30 DAS

Treatment	Per cent light interception			
	Baby corn	Cowpea	Amaranthus	Cropping system
T_1	77.36	88.68	-	83.02
T_2	75.84	-	83.99	79.91
T_3	85.54	88.25	-	86.89
T_4	85.07	-	82.99	84.03
T_5	84.35	86.93	-	85.64
T_6	84.65	-	84.47	84.56
T_7	85.06	-	-	85.06
T_8	-	90.26	-	90.26
T_9	-		87.02	87.01
SEm±	0.519	0.434	1.057	0.53
$CD_{0.05}$	1.616	1.530	NS	1.587

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, NS: Non-significant 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.

Light interception in cropping system was significantly reduced with skip row planting viz baby corn + cowpea in skip row, T_1 (83.02%) and baby corn + amaranthus in skip row, T_2 (79.91%) compared to sole cropping of baby corn, T_7 (85.06%), cowpea, T_8 (90.26%) or amaranthus T_9 (87.01%).

In skip row planting a wider spacing was maintained between the baby corn rows and the population density was also lower than the sole crop of baby corn which would have resulted in sparse canopy formation in the upper strata resulting in reduction in the light interception by the main crop. Furthermore the light which might have filtered down to the deeper layers of the canopy would not have been harvested by the intercrops due to the growth suppression on account of competitive effect of baby corn in the system. Higher competitive ability of baby corn over vegetable intercrops was previously reported by Ghanbari et al (2010).

The data in Table 2 depict that the value of land equivalent ratio (LER) was more than one in all the intercropping systems. 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 in growing vegetables as intercrops with baby corn over sole cropping of baby corn and vegetables.

Intercropping of baby corn with cowpea in paired row planting (T_3) had the highest LER of 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 Abd El-Lateef et al (2015).

The RCC value of baby corn (K_b) was found to be higher than that of vegetables which indicated that it was a dominant crop over vegetables in all intercropping treatments. Baby corn expressed the highest RCC value when grown in paired row with amaranthus, T_4 (23.84). Higher plant population of baby corn maintained in paired row might have contributed to its greater competitive ability in the intercropping

Table 2. Effect of baby corn and vegetable intercropping systems on LER, RCC and aggressivity

Treatment	LER	K_b	K_v	RCC	A_{bv}	A_{vb}
T_1	1.13	9.86	0.20	1.96	2.33	-2.33
T_2	1.19	4.80	0.46	2.22	1.40	-1.40
T_3	1.42	12.81	0.36	4.56	1.94	-1.94
T_4	1.27	23.84	0.28	6.78	1.64	-1.64
T_5	1.12	4.19	0.54	2.26	0.75	-0.75
T_6	1.03	3.03	0.40	1.22	0.79	-0.79
T_7	1	-	-	-	-	-
T_8	1	-	-	-	-	-
T_9	1	-	-	-	-	-

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, LER: Land equivalent ratio, RCC: Relative crowding coefficient, K_b: RCC of baby corn, K_v: RCC of vegetables, A_{bv}: Aggressivity of baby corn on vegetables, A_{vb}: Aggressivity of vegetables on baby corn system. Similar results were 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 (A_{bv}) in all intercropping systems was positive which indicated the dominant nature of baby corn over the component crop. The aggressivity of baby corn over vegetables was more pronounced in skip row planting with cowpea (2.33). Positive aggressivity value of maize over cowpea and negative aggressivity value of cowpea were previously reported by Saudy and El-Bagoury (2014) in maize and cowpea intercropping system.

The study revealed that the sole crop of cowpea was more efficient in harvesting the solar radiation than baby corn or amaranthus. Though cowpea had inherent potential to harvest more light, its light interception capacity was reduced under intercropping with baby corn due to competition for light by tall growing maize. Cropping system-wise analysis revealed that the paired row planting of baby corn with cowpea had relatively higher light interception and in skipped row planting, the light interception was drastically reduced.

The value of land equivalent ratio (LER) was more than one in all the intercropping systems and the paired row planting of baby corn and cowpea recorded the highest LER indicating the intercropping advantage over other systems. The RCC value of baby corn (K_b) was found to be higher than that of vegetables which indicated its dominance. Aggressivity value of baby corn (A_{bv}) in all intercropping systems was positive which also indicated the dominating nature of baby corn over vegetables under intercropping situation.

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