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Agronomy

Biological Efficiency of Legume Intercrops in Baby Corn (*Zea Mays* L.)

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Abstract

Field experiments were conducted at the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore to study the effect of crop geometry, intercropping and topping on the productivity and biological efficiency of baby corn. Crop geometry (60 x 20 cm and 75 x 16 cm) and intercropping (baby corn alone, baby corn + fenugreek (greens), baby corn + fodder cowpea) were assigned to main plots. Four topping practices (detasseling alone, topping beyond 9th, 10th and 11th internodes) was allotted to sub plots. The results revealed that baby corn raised at 75 x 16 cm produced higher green cob yield over 60 x 20 cm. Intercropping systems did not have positive influence on yield of baby corn. The highest green cob yield was obtained with topping beyond 10th internode. Higher baby corn equivalent yield (BEY) was obtained with baby corn + fenugreek grown under 75 cm row spacing combined with topping beyond 10th internode. Biological use efficiency as measured by the indices like LER, AHER, LEC, MER and RNRI were higher with baby corn + fenugreek grown under 75 cm row spacing combined with topping beyond 10th internode. However, baby corn intercropped with fodder cowpea at 75 cm row spacing combined with topping beyond 10th internode registered the higher ATER than the other treatment combinations.

Highlights

Baby corn + fenugreek grown raised at 75 cm row spacing with topping beyond 10th internode recorded higher BEY, LER, AHER, LEC, MER and RNRI.

Keywords: Baby corn, crop geometry, intercropping, topping, biological efficiency, green cob yield, baby corn equivalent yield

Baby corn has the versatility to become commercial crop of this century. Baby corn is gained popularity as a vegetable being a rich source of phosphorus, iron, vitamin A and C, high fibre content and no cholesterol (Nataraj *et al.,* 2011). Being a non conventional vegetable crop, it contributes towards employment through value addition and also food processing. Optimum crop geometry is one of the important factors for higher production by efficient utilization of underground resources and also harvesting as much as solar radiation and in turn better photosynthate formation.

Intercropping ensures efficient utilization of light and other resources, reduces soil erosion, suppresses weed growth and thereby helps to maintain greater stability in crop yields (Kamanga *et al.,* 2010). It also guarantees

greater land occupancy and thereby higher net returns. Hence, it is also necessary to select a suitable intercrop with higher productivity and profitability of baby corn in intercropping situation. Growing of short duration leguminous crops like fodder cowpea (Purushotham *et al*., 2003) and fenugreek (Kumar *et al*., 2006) as intercrops in various cereals and millets have been well documented for its higher system productivity. Topping is an important agro-technique to induce better cob development by removal of terminal portion from the uppermost node. However, it is essential to know the correct stage of the crop when topping has to be done. Hence, sowing of baby corn at optimum crop geometry with suitable legume intercrops followed by topping at correct stage are required to be found for higher productivity and to improve biological efficiency of baby corn. But, information on these aspects in baby corn is lacking and so the present study was undertaken.

Materials and Methods

Field experiments were conducted at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore during *kharif,* 2006 and 2007. The experimental site is located at 11° N latitude, 77° E longitude and at an altitude of 426.7 m above MSL. The experiments were laid out in split plot design with three replications. The main plot treatments comprised of crop geometry (60 x 20 cm and 75 x 16 cm) and intercropping systems (baby corn alone, baby corn + fenugreek (greens), baby corn + fodder cowpea). Topping practices (detasseling alone, topping beyond 9^{th}, 10^{th} and 11^{th} internodes) were assigned to sub plots. Detasseling was done as and when emergence of tassel i.e., normally at 52-55 DAS. Topping refers to nipping or the removal of terminal portion from the uppermost node to induce better cob development and to avoid fertilization of the cob. Topping beyond 9^{th}, 10^{th} and 11^{th} internodes were done at 47, 50 and 52-55 DAS respectively.

Table 1. Influence of crop geometry, intercropping and topping practices on green cob yield and baby corn equivalent yield (BEY)

Treatments	Green cob yield (kg ha^{-1})			BEY (kg ha^{-1})		
	2006	2007	Pooled	2006	2007	Pooled
Crop geometry						
S_1 - 60 x 20 cm	7270	6566	6918	8534	7762	8118
S_2 - 75 x 16 cm	7777	6980	7379	8918	7969	8494
SEd	137	111	118	115	102	121
CD (P=0.05)	274	223	236	230	204	243
Intercropping systems						
C_1 - Baby corn alone	7578	6788	7183	7638	6863	7251
C_2 - Baby corn + fenugreek (greens)	7610	6847	7229	10564	9457	10011
C_3 - Baby corn + fodder cowpea	7383	6683	7033	7976	7177	7577
SEd	163	135	140	132	116	141
CD (P=0.05)	NS	NS	NS	264	232	283
Topping practices						
T_1 - Detasseling alone	7109	6370	6740	8446	7592	8019
T_2 - Beyond 9^{th} internode	7756	7018	7387	4909	8019	8464
T_{3-} Beyond 9^{th} internode	7951	7183	7567	8993	8090	8542
T_4 - Beyond 11^{th} internode	7256	6520	6888	8555	7651	8103
SEd	223	205	212	168	155	174
CD (P=0.05)	457	416	435	336	312	348

Interaction is not significant

The soil of the experimental field was sandy clay loam in texture belonging Typic Ustochrepts with alkaline pH; low in organic carbon (0.35 and 0.39%) and available nitrogen (232.5 and 242.6 kg ha^{-1}), medium in available phosphorus (14.2 and 16.5 kg ha^{-1}) and high in potassium (470.0 and 446.8 kg ha^{-1}) during both the years respectively. The baby corn composite $COBC_1$, CO_2 of fenugreek (greens) and CO(FC) 8 of fodder cowpea varieties were used under this study.

The cobs from net area of each plot were harvested separately, weighed and recorded as green cob yield (kg ha^{-1}). Baby corn equivalent yield (BEY) was worked out based on the formulae evolved by Verma and Modgal (1983). Fenugreek plants from the net plot were pulled off manually, roots were washed with water, weighed and expressed as kg ha^{-1}. The cowpea plants were harvested from the net plot area weighed and expressed the fodder yield as kg ha^{-1}.

Intercropping efficiency was evaluated by comparing the productivity of a given area of intercropping with that of sole crops using competition functions described below.

$$\text{Land Equivalent Ratio (LER)} = \sum_{i=1}^{n} \left(Y_i^I / Y_i^M \right)$$

Where, n - 1, 2, 3 …n, Total nuber of crops in association, Y_i^I - Yield of i in intercropping, and Y_i^M - Yield of i in sole cropping (Mead and Willey (1980). In the present study, $S_1C_1T_1$ treatment was taken as the yield of baby corn in sole cropping.

$$\text{Area Time Equivalency Ratio (ATER)} = \frac{(LER_a \times t_a) + (LER_b \times t_b)}{T}$$

Where, LERa - LER of baby corn, LERb - LER of intercrops, t_a - Duration of baby corn (days), t_b - Duration of intercrop (days), and T - Duration of the intercropping system (days) (Hiebsch and Mc Collum , 1987), Here also, the baby corn yield in the statement $S_1C_1T_1$ was taken as the yield of baby corn in sole cropping.

Area Harvest Equivalency Ratio (AHER) =

$$\sum_{i=1}^{n} (Y_i^I / Y_i^M ni)$$

Where, n - 1, 2, 3 . . . n, Total number of crops in association, Y_i^I - Yield of crop i in intercropping, Y_i^M - Yield of crop i in sole cropping, and ni - Total number of possible harvests of crop i that could be obtained during the full intercrop period, if crop i was monocropped (Balasubramanian and Sukayanka, 1990)

Land Equivalent Coefficient (LEC) = $LER_a \times LER_b$

Where, LERa - LER of baby corn, and LERb - LER of intercrops (Adetiloye *et al.*, 1983)

Monetary Equivalent Ratio (MER) = (ra + rb + rc) / Ra
Where, ra = Pa x ya, rb = Pb x yb, rc = Pc x yc, Ra = Pa x Ya

Where, ra, rb and rc are the monetary returns of baby corn, fenugreek and fodder cowpea (*Kharif*, 2006 and 2007), respectively under intercropping; Pa, Pb and Pc are the current market prices per unit weight of above respectively; ya, yb and yc are the intercrop yields of the above crops and Ya is the sole crop yield of baby corn obtained in the treatment $S_1C_1T_1$. Ra is the monetary returns of baby corn under sole cropping. This was calculated based on gross returns as well as net returns (Adetiloye and Adekunle, 1989).

Relative Net Returns Index (RNRI) =

$$\frac{(PiYi) + (PjYj) \pm Dij}{(P \times Yii)}$$

Where, Yi - Yield of the i^{th} major crop ha^{-1}, Yj - Yield of the j^{th} intercrop ha^{-1}, Pi - Unit price of the product of i^{th} major crop, Pj - Unit price of the product of j^{rh} intercrop,
Yii - Yield of i^{th} sole crop ha^{-1} and Dij - Differential cost of cultivation of ij^{th} crop combination in comparison to i^{th} sole crop (Jain and Rao, 1980).

Table 2. Yield (kg ha^{-1}) of intercrops as influenced by crop geometry, intercropping systems and topping practices of baby corn

Treatments	Kharif, 2006	Kharif, 2007
$S_1C_2T_1$	3300	2990
$S_1C_2T_2$	3375	3035
$S_1C_2T_3$	3350	3105
$S_1C_2T_4$	3285	3075
$S_1C_3T_1$	10723	9686
$S_1C_3T_2$	10672	9850
$S_1C_3T_3$	10863	9728
$S_1C_3T_4$	10772	9658
$S_2C_2T_1$	3410	3150
$S_2C_2T_2$	3550	3100
$S_2C_2T_3$	3485	3213
$S_2C_2T_4$	3350	3118
$S_2C_3T_1$	11645	10736
$S_2C_3T_2$	11726	10893
$S_2C_3T_3$	11796	10770
$S_2C_3T_4$	11685	10845
Sole C_2	4630	4163
C_3	16535	15352

Data not statistically analysed

Crop geometry	Intercropping systems	Topping practices
S_1 - 60 x 20 cm	C_1 - Baby corn alone	T_1 - Detasseling alone
S_2 - 75 x 16 cm	C_2 - Baby corn + fenugreek (greens)	T_2 - Topping beyond 9th internode
	C_3 - Baby corn + fodder cowpea	T_3 - Topping beyond 10th internode
		T_4 - Topping beyond 11th internode

Results and Discussion

Green cob yield

Crop geometry had a positive influence on green cob yield of baby corn (Table 1). Baby corn grown at wider row (75` x 16 cm) spacing produced 7.0 and 6.3 per cent higher cob yield over narrow row (60 x 20 cm) spacing during 2006 and 2007, respectively. Pooled analysis showed that wider row spacing recorded 6.7 per cent higher green cob yield than narrow row spacing. This increase in yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop. This corroborates with the findings of and Maddonni *et al.,* (2006) in maize and Thavaprakaash and Velayutham (2009) in baby corn.

There was no significant response on cob yield of baby corn due to intercropping systems. This might be due to short duration, short plant stature, non-bushiness and also neither complementary nor competitive nature of intercrops did not influence growth parameters of main crop. Similar results have been reported earlier by Tiwari *et al*., (2002) and Thavaprakaash and Velayutham (2008).

Among all the topping treatments, topping beyond 10th internode was significantly superior and produced higher green cob yield as compared to topping beyond 9th internode. The lowest green cob yield was registered with detasseling alone. Topping beyond 10th internode recorded 11.8 and 12.8 per cent higher cob yield during 2006 and 2007 respectively over detasseling alone. Based on pooled analysis, the yield increase due to topping beyond 10th and 9th internode over detasseling alone was 12.3 and 9.6 per cent, respectively. The possible reasons for this enhanced yield might be due to greater functioning of remaining leaves by arresting unnecessary growth, decreased mutual shading of leaves, higher light interception leading to increased photosynthesis and CO_2 exchange rate, nutrient uptake, decreased competition between the tassel and ear for available plant nutrients, diverting plant nutrients to the reproductive part which aids in better source-sink relationship and better cob development. The present results are in agreement with the findings of Esechie and Al-Alawi (2002) in maize.

Baby corn equivalent yield (BEY)

Higher BEY was obtained in wider row (76 x 16 cm) than narrow row (60 x 20 cm) crop geometry (Table 1). Pooled mean was also in the similar trend. Wider row spacing recorded 4.0 per cent increased BEY when compared to narrow row spaced baby corn. Between intrcrops, baby corn + fenugreek registered higher BEY than baby corn + fodder cowpea intercropping system during both the years. Pooled analysis showed that baby

Table 3. Effect of crop geometry, intercropping systems and topping practices on LER, ATER, AHER, LEC, Gross and net return based MER and RNRI of baby corn based intercropping systems

Treatments	Kharif **2006**							Kharif **2007**						
	LER	**ATER**	**AHER**	**LEC**	**Gross return based MER**	**Net return based MER**	**RNRI**	**LER**	**ATER**	**AHER**	**LEC**	**Gross return based MER**	**Net return based MER**	**RNRI**
$S_1C_1T_1$	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00
$S_1C_1T_2$	1.08	1.08	1.08	-	1.08	1.10	1.08	1.08	1.08	1.08	-	1.02	1.03	1.03
$S_1C_1T_3$	1.11	1.11	1.11	-	1.11	1.14	1.11	1.13	1.13	1.13	-	1.03	1.04	1.04
$S_1C_1T_4$	1.03	1.03	1.03	-	1.03	1.04	1.03	1.05	1.05	1.05	-	1.01	1.01	1.01
$S_1C_2T_1$	1.73	1.32	1.73	0.72	1.36	1.47	1.38	1.74	1.33	1.74	0.74	1.32	1.43	1.34
$S_1C_2T_2$	1.90	1.48	1.90	0.85	1.50	1.65	1.52	1.82	1.40	1.82	0.80	1.35	1.46	1.38
$S_1C_2T_3$	1.90	1.49	1.90	0.85	1.51	1.66	1.53	1.94	1.51	1.94	0.89	1.37	1.48	1.39
$S_1C_2T_4$	1.74	1.33	1.74	0.73	1.37	1.48	1.39	1.79	1.35	1.79	0.77	1.34	1.44	1.36
$S_1C_3T_1$	1.64	1.46	1.64	0.64	1.05	1.05	1.06	1.64	1.47	1.64	0.64	1.05	1.05	1.06
$S_1C_3T_2$	1.71	1.54	1.71	0.69	1.12	1.14	1.14	1.71	1.53	1.71	0.68	1.07	1.07	1.09
$S_1C_3T_3$	1.75	1.57	1.75	0.71	1.13	1.16	1.15	1.73	1.56	1.73	0.70	1.08	1.09	1.10
$S_1C_3T_4$	1.66	1.48	1.66	0.66	1.06	1.06	1.07	1.65	1.48	1.65	0.64	1.05	1.05	1.07
$S_2C_1T_1$	1.01	1.03	1.01	-	1.04	1.05	1.04	1.02	1.02	1.02	-	1.02	1.03	1.02
$S_2C_1T_2$	1.22	1.26	1.22	-	1.20	1.27	1.21	1.17	1.17	1.17	-	1.05	1.05	1.05
$S_2C_1T_3$	1.26	1.29	1.26	-	1.25	1.33	1.25	1.27	1.27	1.27	-	1.05	1.07	1.06
$S_2C_1T_4$	1.07	1.10	1.07	-	1.08	1.10	1.08	1.07	1.07	1.07	-	1.03	1.03	1.03
$S_2C_2T_1$	1.85	1.43	1.85	0.82	1.48	1.62	1.49	1.85	1.40	1.85	0.82	1.36	1.48	1.38
$S_2C_2T_2$	2.00	1.57	2.00	0.94	1.59	1.78	1.62	1.93	1.49	1.93	0.88	1.38	1.50	1.40
$S_2C_2T_3$	2.04	1.60	2.04	0.98	1.63	1.83	1.65	2.06	1.61	2.06	0.99	1.40	1.53	1.42
$S_2C_2T_4$	1.85	1.43	1.85	0.81	1.50	1.65	1.51	1.88	1.44	1.88	0.85	1.36	1.48	1.38
$S_2C_3T_1$	1.76	1.57	1.76	0.74	1.11	1.14	1.13	1.74	1.55	1.74	0.73	1.07	1.08	1.09
$S_2C_3T_2$	1.84	1.65	1.84	0.80	1.20	1.24	1.22	1.84	1.65	1.84	0.80	1.10	1.11	1.12
$S_2C_3T_3$	1.86	1.67	1.86	0.82	1.22	1.27	1.24	1.87	1.68	1.87	0.82	1.11	1.12	1.12
$S_2C_3T_4$	1.78	1.59	1.78	0.76	1.14	1.17	1.15	1.76	1.57	1.76	0.75	1.08	1.09	1.09

Data not statistically analysed

Crop geometry	Intercropping systems	Topping practices
S_1 - 60 x 20 cm S_2 - 75 x 16 cm	C_1 - Baby corn alone C_2 - Baby corn + fenugreek (greens) C_3 - Baby corn + fodder cowpea	T_1 - Detasseling alone T_2 - Topping beyond 9th internode T_3 - Topping beyond 10th internode T_4 - Topping beyond 11th internode

corn intercropped with fenugreek recorded 38.1 per cent higher BEY over sole baby corn. This could be justified that additional yield obtained from the intercrops and higher market value for fenugreek. Kumar and Singh (2002) reported that the maize grain equivalent yield was the highest with maize + fenugreek intercropping over sole maize. This corroborates with the findings of Bali Reddy *et al.*, (2009) in baby corn + vegetable cowpea intercropping and Nataraj *et al.*, (2011) in baby corn + french bean intercropping.

Intercrops yield

Intercrop yields were higher under 75 cm row spacing when compared to 60 cm spacing (Table 2). There was little / no competition between the base crop of baby corn and the associated intercrop during the growth period. Availability of light, moisture and nutrients in adequate amounts resulted in enhanced plant height, LAI and TDMP which in turn improved the yield of intercrops. However, the highest growth and yield of intercrops were recorded when grown as sole crop. This is in consonance with the results of Thavaprakaash *et al.,* (2005) in baby corn + *Amaranthus* intercropping system and Muhammad Azim Khan *et al.*, (2012) in maize + mungbean intercropping system.

Topping practices did not influence on any of the growth and yield parameters of intercrops because topping treatments were imposed only after 45 DAS.

Biological efficiency of intercropping systems

LER, LEC, AHER, ATER, gross and net return based MER, and RNRI as influenced by crop geometry, intercropping systems and topping practices (Table 3).

Land equivalent ratio (LER) is the tool to assess the biological efficiency of intercropping system. Among the different treatment combinations, the higher LER value (2.04 and 2.06 during 2006 and 2007, respectively) was recorded in baby corn + fenugreek intercropping system at 75 cm row spacing along with topping beyond 10th internode ($S_2C_2T_3$) during both the years of study, respectively. Similar trend was also observed with LEC, AHER, gross and net return based MER and RNRI. This falls in line with the findings of Thavaprakaash *et al.*, (2005) in baby corn + *Amaranthus* intercropping system

Baby corn intercropped with fodder cowpea at 75 cm row spacing combined with topping beyond 10th internode ($S_2C_3T_3$) registered the higher ATER (1.67 and 1.68 during 2006 and 2007, respectively) as compared to other treatment combination. This is in consistent with the findings of Muhammad Azim Khan *et al.*, (2012) in maize + mungbean intercropping system.

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