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Examination of system productivity and profitability of baby corn based vegetable intercropping systems

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ABSTRACT

The experiment was conducted in lower Gangetic alluvial zone of India at district seed farm (A-B Block), Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during autumn-winter season, 2012 and 2013. Experiment was conducted with the objectives to study the system productivity, profitability and interpretation of different intercropping systems of baby corn and vegetables. Baby corn was taken as the base crop and it was intercropped with vegetables such as tomato, chilli, brinjal and pea. Significantly highest baby corn equivalent yield (BEY) was exhibited by baby corn + pea (115 q ha^{-1}) followed by baby corn + brinjal (110.5 q ha^{-1}), baby corn + tomato (108.5 q ha^{-1}) however, baby corn + chilli (91.4 q ha^{-1}) was decreased in respect of sole baby corn (103.3 q ha^{-1}). All the intercrop treatments recorded land equivalent ratio (LER) more than 1 and highest LER was observed for baby corn + pea (1.52) intercropping system. Highest benefit cost ratio (B:C) was observed in baby corn + pea (3.66) intercropping followed by baby corn + brinjal (2.78), baby corn + tomato (2.62) and baby corn + chilli (2.40). Highest monetary advantage index (MAI) was found for baby corn + pea (30753.4) intercropping system stating that it was the most profitable among all the intercropping treatments. In respect of relative crowding co-efficient (RCC), total K_t values ranged from 2.87-13.47 suggesting yield advantage through intercropping. Positive aggressivity values of baby corn (A_b) were showing that baby corn dominated the vegetable intercrops. Higher CR_b values (4.65-10.65) than CR_v (0.1-0.22) pointed out the higher competitive ability of the baby corn for resources than vegetable intercrops. From this study it was found that baby corn based vegetable intercropping systems were productive and profitable than sole cropping of baby corn and among all the intercropping treatments baby corn + pea intercropping system was established as the most productive and profitable than other systems.

Keywords: Baby corn, competition indices, intercropping, productivity, vegetables

Bay corn (*Zea mays var. rugosa*) is best suitable for intercropping system as it is a short duration crop, requires limited space due to single stem upright growing habit rather than spreading. It is a commercial crop that fetches high return to the farmers and gaining importance among farming community for past few years. The edible portion of baby corn is unfertilized ovary *i.e.*, the cobs are to be harvested before pollination and fertilization. Increasing the living standards of people and shift in food habit from non vegetarian to vegetarian makes popularity of baby corn cultivation (Rathika *et al.,* 2013). The delicate sweet flavour and crisp nature contributes to its increasing popularity in several countries as a common ingredient of Manchurian (Chinese) and various fancy dishes and may also be eaten raw (Reddy *et al.,* 2009). Being a C_4 plant is an efficient converter of absorbed nutrients into food. Baby corn is rich in folate, and a good source of several other nutrients (Aravinth *et al.,* 2011). Thailand and China are the world leaders in baby corn production. Baby corn cultivation is now picking up in some states of India (Natraj *et al.,* 2011).

Intercropping is an intensive cropping system that is intended to increase production per unit area and time (Adhikary *et al*.,1991, 2005). It is more productive system and a less risky technology (Kamanga *et al.,* 2010). It is productive through judicious utilization of resources *viz.,* light, space, water and nutrients. It avoids risk as failure in one crop can be compensated from the yield of another crop. Moreover, intercropping with legumes is a key component in nutrient management in organic farming, where fossil fuel based and synthetic chemicals are not allowed (Machado, 2009).

Earlier some intercropping works based on baby corn were done in Thailand by Sayampol and Changsalak in 1999 (Prodhan *et al.,* 2009). In India, later on few works were done in this aspect like baby corn with cowpea, peas and beans (Reddy *et al.,* 2009; Prodhan *et al.,* 2009; Natraj *et al.,* 2011), tomato (Upadhyay *et al.,* 2010) and leafy vegetables (Thavaprakash and Velayudam, 2007; Prodhan *et al.,* 2009). But, none of it studied in detail about the profitability and competition indices of baby corn based intercropping system. It is clear that cereal legume intercropping has been the most successful cropping system so far.

Legumes have been the common intercrops in any intercropping system owing to their short duration, N-fixing ability etc. Even though non leguminous vegetables require longer duration than legumes and are non-N-fixers, they can also be suitable as intercrops because of their high profitability and higher yields. The limited availability of literature suggests that very few works have been done by using vegetables as intercrops like tomato (Upadhyay *et al.,* 2010; Sangakkara *et al.,* 2012), okra (Alabi and Esobhawan, 2006), leafy

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vegetables (Thavaprakash and Velayudam, 2007; Prodhan *et al.,* 2009) and long duration tuber crops (Sangakkara *et al.,* 2012) as intercrops. The current experiment was conducted with the objectives to evaluate the system productivity, profitability and competition indices interpretation of intercropping systems. To achieve these objectives, baby corn was used as the base crop and intercropped with vegetables such as tomato, chilli, brinjal and pea.

Keeping these points in view, in this experiment baby corn was taken as the base cop and it was intercropped with tomato, brinjal, chilli and pea to study the productivity, profitability and competition indices of intercropping systems in detail.

The experiment was carried out at district seed farm (A-B Block), BCKV, Nadia, West Bengal during *autumn* winter season, 2012 and 2013 in randomized block design with four replications. In general the soil nutrients of the experimental plots were: total N (6.06%), available P (18.27 kg ha^{-1}), available K (126.52 kg ha^{-1}) and Organic carbon (0.63%). The experimental site belongs to lower Gangetic Alluvial Zone of India and climate is humid subtropical having annual rainfall 1300-1500 mm. Treatments include both sole cropping of all crops and their respective intercrop with baby corn. Baby corn was grown as base crop whereas pea, brinjal, chilli and tomato were grown as intercrops in between the rows of baby corn. Baby corn was grown at 60 x30 cm spacing in case of sole crop whereas in intercropping system it was grown at 30:180 cm spacing in paired rows. The space between two paired rows was 180 cm. Pea, brinjal and tomato were grown at 30 x10, 60 x 60 and 60 x 60 cm respectively, in both sole and intercropping system. Chilli was grown at 60 x 30 cm spacing as sole crop and 45 x 30 cm spacing as intercrop. Therefore the row arrangement in intercropping treatments was as follows, baby corn + pea (2:5), baby corn + brinjal (2:2), baby corn + chilli (2:6) and baby corn + tomato (2:2). Seeds of baby corn and pea were dibbled at the rate of 2-3 seeds $hole^{-1}$ and seedlings of tomato, brinjal and chilli were transplanted at 30 DAS in between the paired rows of baby corn. Organic manure (vermicompost) @ 50 q ha^{-1} was applied at the time of land preparation. Chemical fertilizer as basal dose @ 20:60:40 kg ha^{-1} ($N:P_2O_5:K_2O$) was applied at the time of sowing and 20 kg N ha^{-1} was applied as top dressing at knee-high stage of baby corn. Standard cultural practices were followed and irrigation was given as per requirement. The most important operation in baby corn production technology is the avoidance of pollination. If the silk is pollinated, the kernels start developing within hours and the cob becomes hard (Reddy *et al.,* 2009). Therefore, detasseling was done as soon as the tassels appeared. The market value of the crops per kilogram used in calculating the profitability indices was as follows: baby corn- 80 INR, tomato- 35 INR, chilli- 25 INR, brinjal- 25 INR and pea- 15 INR.

Yield data were collected from whole plot and converted into hectare to determine the production and subjected to calculate different competition indices for system productivity evaluation. To examine the intercropping advantage or disadvantage over sole cropping and best found intercropping system different competition indices and competition functions were calculated such as baby corn equivalent yield (BEY) was calculated as per formula given by Verma and Modgal (1983), land equivalent ratio (LER) was calculated as per Willey (1979), area time equivalent ratio (ATER) was calculated according to the formula given by Hiebsch and Macollam (1980), actual yield loss (AYL), intercropping advantage (IA) and monetary advantage index (MAI) were calculated as per Banik (1996), Banik *et al.* (2000) and Ghosh (2004) respectively. The competition indices like relative crowding co-efficient (RCC), aggressivity (A), and competition ratio (CR) were calculated as per formula given by De Wit (1960), McGilchrist (1965) and Willey and Rao (1980) respectively. 'b' and 'v' denotes baby corn and vegetable, respectively in all cases of this article.

Productivity and profitability

BEY and B:C ratio of intercropping system were presented in table-1. All the intercropping treatments except baby corn + chilli (91.4 q ha^{-1}) produced higher baby corn equivalent yield (BEY) than sole baby corn (103.3 q ha^{-1}). No significant difference was found in baby corn equivalent yield however, highest was exhibited by baby corn + pea (115 q ha^{-1}) followed by baby corn + brinjal (110.5 q ha^{-1}), baby corn + tomato (108.5 q ha^{-1}) proving the more productivity of intercropping over sole cropping. Higher B:C ratios were exhibited by intercropping treatments than that of sole cropping treatments. Significantly highest B:C ratio was observed in baby corn + pea (3.66) and baby corn + brinjal (2.78) intercropping system although baby corn + tomato (2.62) and baby corn + chilli (2.40) exhibited higher than sole baby corn (2.13). Similarly Prodhan *et al.* (2009) observed higher net returns for baby corn + spinach and baby corn + pea.

LER, ATER values were presented in table 2 and they indicate the yield advantage per unit area in an intercropping system over sole cropping providing that all other things being equal (Adhikary *et al*., 1991,2005; Adhikary and Sarkar, 2000; Dariush *et al.,* 2006). All the intercrop treatments recorded LER values more than 1 depicting the yield advantage in intercropping over sole cropping. Among all intercropping treatments highest LER value was observed for baby corn + pea (1.52) *i.e.* 52% more area was required to produce same combined yield as in intercropping system when these two crops are grown separately. This was followed by baby corn + chilli (1.21) and baby corn + brinjal (1.16). Lowest LER value was observed for baby corn + tomato (1.07) intercropping system. Higher LER values for maize + legume (beans) intercropping system than maize + tomato and maize + tuber crops were previously observed by Sangakkara *et al.* (2012).

Table1: Baby corn equivalent yield and benefit:cost ratio of intercropping system

Treatments	BEY (q ha^{-1})	B:C ratio
Baby corn	103.3	2.13
Tomato	98.6	1.40
Chilli	9.00	1.26
Brinjal	100.2	1.32
Pea	48.90	2.12
Baby corn + tomato	108.5	2.62
Baby corn + chilli	91.40	2.40
Baby corn + brinjal	110.5	2.78
Baby corn + pea	115.0	3.66
SE m(±)	**6.69**	**0.21**
LSD (0.05)	**20.2**	**0.64**

Table 2 : Land equivalent ratio and area time equivalent ratio of intercropping system

Treatments	LER	ATER
Baby corn + tomato	1.07	1.19
Baby corn + chilli	1.21	1.36
Baby corn + brinjal	1.16	1.33
Baby corn + pea	1.52	1.63

Highest ATER value was observed for baby corn + pea (1.63) showing an advantage of 63% while other intercropping systems: baby corn + chilli (1.36) baby corn + brinjal (1.33) and baby corn + tomato (1.19) showed an advantage of 36%, 33% and 19% respectively over sole cropping. Area time equivalent ratio provides more realistic comparison of the yield advantage of intercropping over monocropping in terms of time taken by component crops in the intercropping systems (Adhikary *et al*., 2005 and Aasim *et al.,* 2008).

AYL, IA and MAI of intercropping system were presented in table 3. Highest reduction of 125% in yield was observed for pea followed by 56% for chilli, 54% for tomato and 50% for brinjal when intercropped with baby corn. This further indicated that pea was less resistant to yield loss than chilli, tomato and brinjal when intercropped with baby corn. However, positive values of the total AYL_t made a picture of gain in combined yield of components in intercropping system when compared to the sole crop components. Baby corn + chilli intercropping system had highest gain in yield (310%) followed by baby corn + brinjal (260%), baby corn + tomato (231%) and baby corn + pea (195%). Positive AYL_b values were a sign of gain in yield in baby corn when compared with sole baby corn. Negative AYL_v values of vegetables were a sign of reduction or loss in the yields of intercrops when compared with sole crops. Partial actual yield loss also represents the proportionate yield loss or gain of each species grown as intercrops compared to pure stand (Dhima *et al.,* 2007; Aasim *et al.,* 2008).

Intercropping advantage (IA) is another index, which indicates proportionate loss or gain of intercrops in terms of money when compared with the particular sole crop. The positive IA_b values were suggesting an advantage for baby corn whereas negative IA_v values were advocating disadvantage for vegetable intercrops. The positive values of total IA were meant that there was an advantage in intercropping than sole cropping and the baby corn component compensated the loss in vegetable component. Monetary advantage index (MAI) is the real index that gives information on economic advantage of intercropping system as it utilizes LER values besides economic value of crops. Highest MAI was found for baby corn + pea (30753.4) intercropping system stating that it was the most profitable among all intercropping treatments and it was also evidenced by B:C ratio analysis. According to Ghosh (2004), this higher MAI was probably due to higher LER, RCC and CR. This was followed by baby corn + chilli (13059.6), baby corn + brinjal (12012.2). On the other hand, baby corn + tomato was the least profitable intercropping system with a low (5856.8) MAI value. Higher economic gain for maize + legume intercropping was previously observed by Ghosh (2004); Adhikary *et al*., (2005) and Yilmaz *et al.* (2008).

Competition indices

RCC, aggressivity and CR of intercropping system were presented in table 4. The partial (K_b) values of bay corn (12.9-61.1) were greater than 1 indicating an advantage in yield for baby corn. But, the partial K_v values of vegetables (0.1-0.8) were less than 1 depicting a disadvantage or potential reduction in yield when compared to sole cropping. However, the total K_t values were greater than one for all the intercropping systems (2.87-13.47) signifying yield advantage of intercropping systems over sole cropping probably because of the compatible and complementary nature of the intercrops. It further indicated that baby corn was

Table 3: AYL, IA and MAI of intercropping system

Treatments	AYL			IA			MAI
	AYL_b	AYL_v	AYL_t	IA_b	IA_v	Ia_t	
Baby corn + tomato	2.85	-0.54	2.31	22834.3	-1902.0	20932.3	5856.8
Baby corn + chilli	3.66	-0.56	3.10	29296.9	-1400.0	27896.9	13059.6
Baby corn + brinjal	3.10	-0.50	2.60	24798.0	-1497.8	23300.3	12012.2
Baby corn + pea	3.20	-1.25	1.95	25604.2	-1874.1	23730.1	30753.4

Note: *AYL_b, IA_b- actual yield loss and intercropping advantage of baby corn; AYLv, IAv- actual yield loss and intercropping advantage of vegetables; AYL_t, IA_t- total actual yield loss and total intercropping advantage.*

Table 4: RCC, aggressivity and CR of intercropping system

Treatments	RCC			Aggressivity		CR	
	K_b	K_v	K_t	A_b	A_v	CR_b	CR_v
Baby corn + tomato	12.9	0.2	2.87	0.034	-0.034	8.62	0.12
Baby corn + chilli	61.1	0.1	7.36	0.042	-0.042	10.65	0.10
Baby corn + brinjal	55.3	0.2	13.23	0.036	-0.036	8.19	0.12
Baby corn + pea	15.1	0.8	13.47	0.033	-0.033	4.65	0.22

Note: *K_b, A_b, CR_b- RCC, aggressivity, CR of baby corn; K_v, A_v, CR_v- RCC, aggressivity, CR of vegetables; K_t- total RCC.*

more competitive than vegetables and intercropping with vegetables did not have any negative effect on baby corn. K value greater than1 indicates a yield advantage and less than 1 indicates disadvantage; whereas K value equals to 1, there is no yield advantage or disadvantage (Yilmaz *et al.,* 2008).

Aggressivity (A) is often used to determine the competitive relationship between two crops used in the mixed cropping (Yilmaz *et al.,* 2008). The positive aggressivity values of baby corn (A_b) and negative aggressivity values of vegetables were showing that baby corn dominated the vegetable intercrops among all the intercropping systems. Moreover, the lesser numerical values of aggressivity indicated that there was no greater difference between actual and expected yields. Competitive ratio (CR) is also a measure of competitive ability of the component crops in an intercropping system and is also a better index as compared with RCC and aggressivity (Willey and Rao, 1980). CR also followed the similar trend like A. Higher CR_b values (4.65-10.65) than CR_v (0.1-0.22) pointed out the higher competitive ability of the baby corn for resources than vegetable intercrops. This might be the reason for considerable yield reduction in intercrops when compared to respective sole crops which was specified by the lower K_v values (<1).

Among all the intercropping treatments baby corn + pea intercropping system was established from this study as the most productive and profitable than other systems as it had the high BEY, B:C ratio and MAI. Baby corn was found to be dominant and more competitive than the vegetables. This could be proved by high K_b, CR_b values. All the vegetable intercrops were less competitive than baby corn and had almost similar competitive ability. Though productivity of vegetables was reduced with intercropping, the loss in yield was compensated by the gain in yield of baby corn. So, it could be concluded that baby corn based vegetable intercropping systems were productive and profitable than sole cropping of baby corn.

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