Asian Journal of Agricultural Research 1 (1): 10-16, 2007
ISSN 1819-1894

Effect of Crop Geometry, Intercropping Systems and INM Practices on Cob Yield and Nutrient Uptake of Baby Corn

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Abstract: Field experiments were conducted at Eastern Block farm, Tamil Nadu Agricultural University, Coimbatore during kharif 2002 (June to September) and summer 2003 (February to May) seasons to study the impact of varied crop geometry, short duration intercrops and INM practices on production potential of baby corn based intercropping systems. Two crop geometry levels (45×25 cm and 60×19 cm) and two short duration intercrops (*Amaranthus* and green gram) along with control (no intercrops) were taken in main plot. Recommended dose of fertilizers (100% NPK-N_1) along with three INM practices [50% NPK + FYM + *Azospirillum* + phosphobacteria (N_2), 50% NPK + poultry manure + *Azospirillum* + phosphobacteria (N_3) and 50% NPK + goat manure + *Azospirillum* + phosphobacteria (N_4)] were assigned to subplot in a split plot design. The trial was replicated thrice. The experimental results revealed that crop geometry and INM treatments significantly influenced on nutrient uptake of baby corn. Baby corn spaced at 60×19 cm recorded higher uptake of N, P and K as compared with 45×25 cm spacing. Intercropping systems did not influence the nutrient uptake. All the INM practices showed higher NPK uptake than N_1. Among the three INM practices, the treatments N_3 and N_4 recorded significantly higher values than N_2. Almost similar results were obtained in green cob yield of baby corn. BEY was higher with S_2 than S_1. Intercropped baby corn produced higher BEY than sole baby corn. The treatments N_3 and N_4 recorded significantly more BEY values as compared to N_2 and N_1. The correlation between NPK uptake and baby corn yields was positive and significant, however, between BEY and nutrient uptake was not significant during both the seasons.

Key words: Cob yield, nutrient uptake, INM practices, crop geometry, baby corn

INTRODUCTION

With the advancement of science and technology, rise in standard of living, populist measures like supply of rice and wheat through public distribution system, supply at subsidized rate, there is a change in traditional usage of maize as food and increase in consumption of green ears as food, especially in and around cities and towns. The sweet succulent and delicious baby corn is a medium plant type and provides green ears within 65-75 days after sowing (Thavaprakaash *et al*., 2006). As it is a new plant type, there is an urgent need to find out suitable agro-techniques for higher production and ultimately higher income of farmers.

Crop geometry is one of the important factors, which has to be maintained optimum level to harvest maximum solar radiation and utilizes the soil resources effectively. Though the spacing requirement of grain and fodder maize has been standardized, the information on the influence of spacing on yield and quality of baby corn composite that too under intercropping situation is lacking. Though the duration of baby corn ends within 65-75 days, until that it enters its reproductive phase

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(45-55 days after sowing) the resources *viz.*, space, light, moisture and nutrients are un/under utilized. Such resources could effectively be utilized by mixing short duration intercrops, which complete their life cycle within 50 days. Short duration vegetables grown in-between the agricultural crops is the recent advancement to fulfill the requirement of vegetables without any reduction of agricultural area. Performance of *Amaranthus* as intercrop under different cropping situations is well documented (Amma and Ramdas, 1991). Intercropping of legumes with corn is well compatible and profitable cropping system (Shivey and Singh, 2000). Integration of organics with bio-fertilizers is the need of the day to maintain the soil health and quality of the produce. Baby corn is a high value crop and quality is the prime factor than quantity, integration of organics and bio-fertilizers assumes significance. Judicious combination of organic manures (Suri *et al.*, 1997) or bio-fertilizers *viz.*, *Azospirillum* (Rai and Gaur, 1982) and phosphobacteria (Datta *et al.*, 1992) along with inorganic fertilizers not only reduces the quantity of chemical fertilizers but also improve the yield and quality of crop produce. Information on the optimum crop geometry to explore the available resources, suitable intercrops for higher income per unit area and unit time and effect of organic manures in combination with inorganic and bio-fertilizers on baby corn yield and quality is meagre. Hence, the present study was planned and undertaken.

MATERIALS AND METHODS

The field experiments were conducted during kharif 2002 (June to September) and summer 2003 (February to May) seasons at Eastern Block farm, Tamil Nadu Agricultural University, Coimbatore. The experimental site is located at 11°N latitude, 77°E longitude with an altitude of 426.7 m above MSL. The soil of the experimental area was sandy clay loam (*Typic Ustropept*) with alkaline pH; low in organic carbon (0.31 and 0.30%) and available N (246.5 and 239.7 kg ha^{-1}), medium in available P (11.9 and 13.0 kg ha^{-1}) and high in available K (400.8 kg ha^{-1} each) during kharif 2002 and summer 2003 seasons, respectively. The baby corn composite COBC 1, *Amaranthus* cv. CO 5 and green gram cv. Pusa bold were chosen for the study.

The experiments were laid out in split plot design with three replications on a gross plot size of 5.4×4.0 m and a net plot size of 4.5×3.0 m. Two factors *viz.*, crop geometry with two levels (45×25 cm and 60×19 cm) and intercropping systems (sole baby corn, baby corn + *Amaranthus* and baby corn + green gram) in main plot and integrated nutrient management practices with four levels [N_1 - 100% of the recommended dose of NPK (150:60:40 kg ha^{-1}) of baby corn; N_2 - 50% NPK of baby corn + FYM + *Azospirillum* + phosphobacteria; N_3 - 50% NPK of baby corn + Poultry manure + *Azospirillum* + phosphobacteria; N_4 - 50% NPK of baby corn + Goat manure + *Azospirillum* + phosphobacteria] were assigned in sub plots. Before sowing, furrows were formed in the beds as per the spacing treatments. The baby corn seeds were pre-treated with fungicide (Carbendazim at the rate of 2 g kg^{-1} of seeds), sown in the furrows and covered with soil. Furrows were formed in-between the two baby corn rows and the intercrops were sown. Green gram seeds were hand dibbled at a spacing of 10 cm. *Amaranthus* seeds were mixed with sand at 1:5 ratio and sown in furrows as solid sowing. Organic manures were applied as per the treatment (on equal N basis) and incorporated in the soil uniformly. Bio-fertilizers (*Azospirillum* and phosphobacteria) at the rate of 2kg ha^{-1} were mixed along with well-powdered FYM and spread uniformly as per the treatment. Recommended dose of nitrogen (150 kg ha^{-1}) as Urea, phosphorus (60 kg ha^{-1}) as Single super phosphate and potassium (40 kg ha^{-1}) as Muriate of potash were applied as per the treatment schedule. Fifty per cent of N and K fertilizers along with full dose of P were applied as basal. Remaining half of the N and K were applied as top dressing at 25 DAS. All the agronomic practices were carried out uniformly to raise the crop.

The oven dried plant samples of baby corn at harvest were chopped and ground in Wiley mill and was analyzed for available N, P_2O_5 and K_2O. The nutrient values obtained as percentage in the analysis were computed to kg ha^{-1} by multiplying with the corresponding DMP obtained for each treatment. Nitrogen content in the plant sample was estimated by micro-kjeldahl method as per the procedure given by Bremner (1965). This was expressed as percentage on dry weight basis and computed to kg ha^{-1}. Total phosphorus content was estimated by using triple acid digestion extract using photoelectric calorimeter with blue filter as described by Jackson (1973). The amount of phosphorus content was determined by referring to a standard curve and the uptake computed was expressed in kg ha^{-1}. Total potassium uptake in the plant sample was estimated from triple acid extract using flame photometer (Jackson, 1973) and the uptake was expressed in kg ha^{-1}.

Harvested cobs from the net plot were weighed and cob yield was recorded from individual plots and expressed in kg ha^{-1}. Baby corn equivalent yield was worked out based on the formulae evolved by Verma and Modgal (1983). The data were subjected to statistical analysis as suggested by Gomez and Gomez (1984). Correlation analysis made between cob yield and BEY with uptake of nutrients.

RESULTS AND DISCUSSION

Nutrient Uptake

In general, the nutrient uptake was higher during kharif 2002 than summer 2003 season (Table 1). Crop geometry significantly altered the NPK uptake to during both the seasons. During kharif 2002 season, higher uptake of N (190.2 kg ha^{-1}), P (24.5 kg ha^{-1}) and K (375.5 kg ha^{-1}) was recorded at 60×19 cm spacing as compared to 45×25 cm spacing level. This was true with summer 2003 season also. Higher dry matter accumulation at 60 cm wider row spacing leading to higher uptake of N. Generally, when the uptake of N is more, the crop would have a tendency to absorb more P and K. Sukanya (1997) also obtained the increased uptake of NPK under wider spacing of baby corn.

Nutrient uptake by baby corn was not influenced by the intercrops during all the seasons of study. Nutrients in the soil were not much depleted by the intercrops since they were harvested before 45 DAS. This might be the reason for non-significant results of nutrient uptake of baby corn.

Table 1: Influence of crop geometry, intercropping systems and INM practices on nutrient uptake (kg ha^{-1}) of baby corn

	Kharif 2002			Summer 2003		
Treatment	N	P	K	N	P	K
Crop geometry						
S_1	183.9	22.8	364.2	170.3	19.7	345.8
S_2	190.2	24.5	375.5	180.5	21.9	357.5
SED	1.1	0.1	2.2	1.0	0.1	2.0
CD (p = 0.05)	2.4	0.3	4.8	2.3	0.3	4.6
Intercropping						
C_1	187.4	23.6	370.0	175.0	21.7	352.1
C_2	187.2	23.5	368.3	175.9	21.5	354.0
C_3	186.6	23.8	371.3	175.3	21.8	348.9
SED	1.3	0.2	2.6	1.3	0.2	2.5
CD (p = 0.05)	NS	NS	NS	NS	NS	NS
INM						
N_{11}	177.5	21.5	353.1	163.8	19.7	335.0
N_2	184.8	23.3	366.7	173.1	21.2	351.2
N_3	192.7	25.0	379.5	182.1	22.8	359.8
N_4	193.4	24.8	380.1	182.7	22.6	360.7
SED	2.5	0.3	4.9	2.3	0.3	4.6
CD (p = 0.05)	5.0	0.6	9.8	4.7	0.7	9.3

Interaction: Absent, Crop geometry, S_1-45×25 cm, S_2-60×19 cm

NS: Non-Significant, Intercropping system, C_1-Baby corn alone, C_2-Baby corn + *Amaranthus*, Baby corn + Green gram,

Integrated Nutrient Management Practices
N_1-Recommended inorganic fertilizers to baby corn
N_2-50% NPK of baby corn + FYM + *Azospirillum* + Phosphobacteria
N_3-50% NPK of baby corn + Poultry manure + *Azospirillum* + C_3-Phosphobacteria
N_4-50% NPK of baby corn + Goat manure + *Azospirillum* + Phosphobacteria

The effect of INM practices on nutrient uptake was significant during all of the seasons. During summer 2003 season, the highest nutrient removal *viz.*, N (192.7 kg ha^{-1}), P (25.0 kg ha^{-1}) and K (379.5 kg ha^{-1}) was noted due to the combined effect of inorganic, poultry manure and bio-fertilizers (*Azospirillum* + phosphobacteria) (N_3) application and was comparable with N_4 (50% NPK + goat manure + *Azospirillum* + phosphobacteria). Incorporation of FYM in addition to inorganic and bio-fertilizers (*Azospirillum* + Phosphobacteria) (N_2) registered lower uptake than N_3 and N_4 whereas superior over N_1. The results were similar during summer season too. This was due to the increased DMP of baby corn crop, which in turn increased NPK uptake. The built up of vigorous growth and higher photosynthetic rate, led to better uptake of nutrients by the crop. Improvement of nutrient uptake due to organic manures was reported by Cooperband *et al*. (2002). Singh and Totawat (2002) observed the enhanced nutrient uptake due to bio-fertilizer application.

Green Cob Yield

Irrespective of the treatments, green cob yields were higher (7243 to 8037 kg ha^{-1}) during kharif 2002 season as compared with summer 2003 (7109-7521 kg ha^{-1}) season (Table 2).

Crop geometry led substantial increase in green cob yield of baby corn. Baby corn raised at 60×19 cm (S_2) produced higher cob yields over S_1 (45×25 cm). The percentage of increase of S_2 over S_1 was 10.9 and 10.6 during kharif 2002 and summer 2003 seasons, respectively. The results of pooled analysis also in the same trend where the increase was 10.7%. The increase might be due to the effective utilization of applied nutrients increased sink capacity and higher nutrient uptake of crop. The yield potential of baby corn is decided by the growth and yield components. This was reflected in the present study. Khafi *et al*. (2000) reported higher yields of bajra under wider spacing.

Table 2: Cob yield, fodder yield and baby corn equivalent yield of baby corn as influenced by crop geometry, intercropping systems and INM practices

	Baby corn yield (kg ha^{-1})			Fodder yield (t ha^{-1})		BEY (kg ha^{-1})		
Treatments	Kharif 2002	Summer 2003	Pooled	Kharif 2002	Summer 2003	Kharif 2002	Summer 2003	Pooled
Crop geometry								
S_1	6877	5340	6104	32.7	30.0	8870	8183	8526
S_2	7666	5333	6584	35.1	33.0	9507	8450	8979
SED	218	57	121	0.49	0.33	52	49	55
CD (p = 0.05)	485	127	127	1.10	0.74	115	109	121
Intercropping								
C_1	7124	5384	6250	34.0	31.8	8049	7306	7677
C_2	7348	5372	6361	34.1	31.6	9805	8817	9310
C_3	7349	5402	6374	33.6	31.6	9712	8827	9269
SED	266	70	145	0.60	0.41	63	60	64
CD (p = 0.05)	NS	NS	NS	NS	NS	141	133	151
INM								
N_1	6801	5173	5986	31.8	29.7	8690	8097	8393
N_2	7012	5167	6090	31.7	30.4	9380	8129	8752
N_3	7707	5598	6651	36.0	33.5	9248	8525	8885
N_4	7668	5608	6588	36.1	33.2	9436	8515	8980
SED	298	110	186	0.79	0.60	121	109	127
CD (p = 0.05)	604	222	376	161	1.21	246	222	255

Interaction: Absent 1. *Kharif* 2002 2. Summer 2003

Crop geometry	Intercropping system	Integrated Nutrient Management Practices
S_1-45×25 cm	C_1-Baby corn alone	N_1-Recommended inorganic fertilizers to baby corn
S_2-60×19 cm	C_2-Baby corn + *Amaranthus*	N_2-50% NPK of baby corn + FYM + *Azospirillum* + Phosphobacteria
	C_3-Baby corn + Green gram	N_3-50% NPK of baby corn + Poultry manure + *Azospirillum* + Phosphobacteria
		N_4-50% NPK of baby corn + Goat manure + *Azospirillum* + Phosphobacteria

No significant response was observed on green cob yield due to the intercropping systems during the study. Non-significant results obtained in growth and yield characters ultimately reflected in the green cob yield of baby corn. Tiwari *et al*. (2002) obtained non-significant results due to intercropping systems.

Synergistic effect of baby corn green cob yield due to INM treatments was recorded during both seasons. Combined application of inorganic and bio-fertilizers (*Azospirillum* and phosphobacteria) along with poultry manure (N_3) produced higher cob yield (8037 and 8004 kg ha^{-1}) than FYM (N_2) incorporated with inorganic and bio-fertilizers (7243 kg ha^{-1}) and inorganic fertilizers (N_1) alone (7335 and 719 kg ha^{-1}) during kharif 2002 season. Same trend also noticed during summer 2003 and pooled mean data. Application of poultry manure increased the P availability (More and Ghonshikar, 1988) through the formation soluble complex with organic legends increased the P uptake. Transformation from existing solid phase of K to a soluble metal complex increased the K uptake (Das *et al*., 1991). Considerable amount of N present in the manures and narrow C:N ratio accelerated the N release (Bishnoi and Bajwa, 1994). Fixation of atmospheric N and secretion of growth promoting substances of *Azospirillum* and increased bacterial efficiency by phosphobacteria (Datta and Banik, 1997) combined together might have increased the growth and yield parameters and ultimately yield of baby corn. Yield increase due to poultry manure (Reddy and Reddy, 1999), sheep/goat manure (Ramesh, 1998), bio-fertilizers (Mishra *et al*., 1998) were reported earlier.

Baby Corn Equivalent Yield

In general, the baby corn equivalent yield (BEY) was higher during kharif 2002 season than summer 2003 season (Table 2).

During kharif 2002 season, wider row crop geometry (S_2) registered higher BEY (9507 kg ha^{-1}) than at 45×25 cm (8870 kg ha^{-1}). This was true with summer 2003 season. The pooled mean was also in the similar trend where the yield increase was 9.5%. Increased BEY was due to higher yield of baby corn recorded under S_2. Singh (2000) reported higher maize equivalent yield at 60 cm row spacing.

The effect of intercropping systems on BEY was significant during both seasons. Sole baby corn (S_1) registered lower BEY (8049 and 7306 kg ha^{-1} during kharif 2002 and summer 2003 season, respectively) as compared with intercropped baby corn (C_2 and C_3). Pooled data also follow the same trend where 21.3 and 20.7% increase over C_1 was recorded in C_2 and C_3. Additional yield obtained from the intercrops without much reduction of main crop yield improved the BEY. Similarly, increased equivalent yield of main crop by addition of intercrops *viz.*, *Amaranthus* (Amma and Ramdas, 1991) and green gram (Shivey and Singh, 2000) under varied component crops was reported earlier. Tiwari *et al*. (2002) reported that leafy vegetables did not show any adverse effect on growth and development of main crop, which might be attributed to the fact that *Amaranthus* is shallow rooted, and short-stature and short duration. This is true with the present investigation, where both the intercrops were shallow rooted and did not compete with baby corn.

The INM practice exhibited a positive response on BEY. During kharif 2002 season, compensation of 50% NPK by organic manure (poultry manure and goat manure) and bio-fertilizers (*Azospirillum* + phosphobacteria) (N_3 and N_4) recorded significantly superior BEY (9248 and 9436 kg ha^{-1}, respectively) over N_2 (50% NPK + FYM + *Azospirillum* + phosphobacteria) and N_1 (100 % NPK alone). N_1 and N_2 remained at par. Similar trend was also noted in summer 2003 season and pooled mean data. Higher yields of baby corn and non-reduction of intercrop yields under these treatments had influenced on the improvement of BEY. Singh *et al.* (1997) reported similar findings of increased Maize Equivalent Yield (MEY) due to the addition of organic manures to inorganic fertilizers.

Correlation Analysis

Correlation between NPK uptake and baby corn yield was positive and significant during both the seasons. During Kharif 2002 season, the correlation values were 0.861*, 0.865* and 0.849* for upake of N, P and K, respectively. Similarly, the correlation relationship of N, P and K uptake during summer 2003 season were 0.752*, 0.751* and 0.821*, respectively. This relationship clearly indicated the importance of NPK uptake for higher production of baby corn.

CONCLUSION

Thus, the present investigation revealed that raising baby corn at 60 cm row spacing intercropped with coriander and radish intercrops under INM practices (50% NPK + poultry/goat manure + *Azospirillum* + Phosphobacteria) would produce maximum baby corn and intercrops yields and higher BEY.

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