https://doi.org/10.29321/MAJ.10.A01335

Madras Agric. J. 92 (7-9) : 407-414 July-September 2005

Study of crop geometry, intercropping systems and nutrient management practices on weed density and yield in baby corn based intercropping systems

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Abstract : Field experiments were conducted in Tamil Nadu Agricultural University, Coimbatore during *Kharif* 2002 and summer 2003. The experimental soil was sandy clay loam with alkaline pH. The experiments were laid out in split plot design with three replications. The main pot consisted of two factors viz., crop geometry [45 x 25 cm (S_1) and 60 x 19 cm (S_2)] and intercropping systems [baby corn alone (C_1), baby corn + radish (C_2) and baby corn + coriander (C_3)]. Four integrated nutrient management practices (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 to sub plots. The experimental results revealed that weed population and weed DMP were higher with S_2 than S_1. Sole crop situation resulted higher weed population and weed DMP than intercropped baby corn. Baby corn with inorganic fertilizer recorded the lowest weed population and weed DMP than INM treated baby corn. The results were reverse for Weed Smothering Efficiency. Green cob yield of baby corn was higher (7976 and 7519 kg ha^{-1}) with S_2 than S_1. Intercropping systems failed to influence the green cob yield. Combined use of a half NPK with poultry or goat manures along with bio-fertilizers (*Azospirillum* and Phosphobacteria) has produced significantly higher baby corn yield as compared to N_2 and N_1 during both the seasons.

Key words : Baby corn, Crop geometry Green cob yield, Integrated Nutrient Management, Intercropping systems, Weed dynamics.

Introduction

Maize is the third most important cereal crop of India as well as the world. It is used both as food for human and feed for livestock especially poultry industry. In late 1970's people in USA and western countries started to consume raw cobs called baby corn. Change in foot habit from non-vegetarian to vegetarian aggravated the consumption of vegetables especially baby corn. Though the baby corn is more popular worldwide, agro-techniques to achieve higher production is the need of the day.

Space available to the individual plant is necessary to use the soil resources effectively and to harvest the maximum possible solar radiation to attain higher yield. Though the crop geometry levels to grain and fodder maize were well defined, such study is meagre in baby corn. Baby corn ends its life cycle within 75 days and enters its reproductive phase during 50-55 DAS. Natural resources viz., space, light, nutrients, moisture are under utilized. Such natural resources could effectively be used by introducing short duration vegetable like *Amaranthus* and pulse like green gram which complete their life cycle shortly and would not compete much with baby corn. Suitability of *Amaranthus* (Anitha *et al.*, 2001) and green gram (Shivay and Singh, 2000) as best intercrops was already proved in other crops. A very large number

Table 1. Weed population and weed DMP as influenced by crop geometry, intercropping systems and INM practices on baby corn

Treatment	Weed population				Weed DMP			
	Kharif 2002		Summer 2003		*Kharif* 2002		Summer 2003	
Crop Geometry								
S_1	1.52	0.98	1.49	0.85	1.18	1.44	1.29	1.27
	(33.2)	(9.5)	(30.9)	(7.1)	(15.0)	(27.8)	(19.5)	(18.5)
S_2	1.54	1.08	1.45	0.86	1.22	1.46	1.33	1.22
	(35.0)	(11.9)	(28.5)	(7.3)	(16.5)	(28.8)	(21.5)	(16.5)
SED	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.02	0.02	0.02	NS	0.02	0.02	0.02	0.02
Intercropping								
C_1	2.01	1.03	1.62	0.85	1.34	1.58	1.45	1.39
	(101.3)	(10.8)	(41.5)	(7.2)	(22.0)	(38.1)	(28.4)	(24.5)
C_2	1.30	0.99	1.39	0.86	1.02	1.45	1.12	1.22
	(20.0)	(9.8)	(24.6)	(7.3)	(10.5)	(28.5)	(13.2)	(16.5)
C_3	1.28	1.02	1.40	0.86	1.24	1.32	1.36	1.13
	(19.0)	(10.5)	(24.9)	(7.3)	(17.5)	(21.0)	(23.1)	(13.5)
SED	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.03	0.02	0.03	NS	0.02	0.02	0.02	0.02
INM								
N_1	2.01	1.03	1.62	0.85	1.34	1.58	1.45	1.39
	(101.3)	(10.8)	(41.5)	(7.2)	(22.0)	(38.1)	(28.4)	(24.5)
N_2	1.30	0.99	1.39	0.86	1.02	1.45	1.12	1.22
	(20.0)	(9.8)	(24.6)	(7.3)	(10.5)	(28.5)	(13.2)	(16.5)
N_3	1.28	1.02	1.40	0.86	1.24	1.32	1.36	1.13
	(19.0)	(10.5)	(24.9)	(7.3)	(17.5)	(21.0)	(23.1)	(13.5)
N_4	1.28	1.02	1.40	0.86	1.24	1.32	1.36	1.13
	(19.0)	(10.5)	(24.9)	(7.3)	(17.5)	(21.0)	(23.1)	(13.5)
SED	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02
CD (P=0.05)	0.04	NS	0.04	NS	0.03	NS	0.04	NS

Interaction : Absent

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

Note : Fig. in paranthesis indicate transformed values

Table 1. Weed smothering efficiency as influenced by crop geometry, intercropping systems and INM practices on baby corn

Treatment	*Kharif* 2002		Summer 2003	
	25 DAS	45 DAS	25 DAS	45 DAS
$S_1C_2N_1$	12.3	9.0	12.4	11.5
$S_1C_2N_2$	14.4	8.2	12.6	11.4
$S_1C_2N_3$	12.0	8.2	12.0	14.3
$S_1C_2N_4$	13.9	9.8	15.1	13.3
$S_1C_3N_1$	8.5	16.6	8.2	17.3
$S_1C_3N_2$	9.6	18.6	7.1	17.1
$S_1C_3N_3$	9.6	16.5	9.5	17.5
$S_1C_3N_4$	8.5	15.3	8.7	18.2
$S_2C_2N_1$	12.4	10.0	12.1	12.8
$S_2C_2N_2$	10.7	8.8	10.9	10.9
$S_2C_2N_3$	11.4	7.0	13.0	10.9
$S_2C_2N_4$	10.8	6.3	15.3	11.4
$S_2C_2N_1$	8.9	16.9	8.7	20.6
$S_2C_2N_2$	8.9	17.5	8.0	19.0
$S_2C_2N_3$	8.6	14.6	11.3	14.1
$S_2C_2N_4$	8.4	13.9	10.1	18.2

of evidences (Nanjundappa *et al.,* 2000) confirm the fact that judicious combination of inorganic fertilizers and organic manures brings about favourable as well as desirable results in terms of yield levels of crops, improved qualities of crop produces and fertility built up of soils. Bio-fertilizers in combination with inorganic fertilizers and organic manures are the way to sustain in crop production. *Azospirillum* is the bio-fertilizer used for maize and satisfies 20-25 per cent of nitrogen requirement (Rai and Gaur, 1982) where as Phosphobacteria, a phosphate solubilizing microorganisms will make available phosphate sources from the un available form (Datta *et al.,* 1992). Information on the optimum crop geometry to explore the available resources, suitable intercrops for higher income per unit area and effect of organic manures in combination with inorganic and bio-fertilizers on baby corn yield and weed dynamics is meagre. Hence, this study has been contemplated.

Materials and methods

Field experiments were conducted during *Kharif* 2002 (June-September) and summer 2003 (February -May) seasons at Eastern Block farm of 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 alkalin 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

Table 3. Yielf of baby corn as influenced by crop geometry, intercropping systems and INM practices

Treatments	Green cob yield (kg ha^{-1})			BEY		
	Kharif 2002	Summer 2003	Pooled	*Kharif* 2002	Summer 2003	Pooled
Crop Geometry						
S_1	7333	7116	7222	8870	8183	8526
S_2	7976	7519	7747	9507	8450	8979
SED	107	83	91	52	49	55
CD (P=0.05)	239	185	190	15	109	121
Intercropping						
C_1	7749	7306	7527	8049	7306	7677
C_2	7759	7317	7437	9805	8817	9310
C_3	7656	7331	7493	9712	8827	9269
SED	132	102	110	63	60	64
CD (P=0.05)	NS	NS	NS	141	133	115
INM						
N_1	7335	7109	7221	8690	8097	8393
N_2	7243	7126	7184	9380	8129	8752
N_3	8037	7516	7777	9248	8525	8885
N_4	8004	7521	7760	9436	8515	8980
SED	202	130	151	121	109	127
CD (P=0.05)	409	263	309	246	222	255

Interaction : Absent

Crop geometry
S_1 - 45 x 25 cm
S_2 - 60 x 19 cm

Intercropping system
C_1 = Baby corn alone
C_2 = Baby corn + Radish
C_3 = Baby corn + Coriander

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* + Phosphobacteria
N_4 - 50% NPK of baby corn + Goat manure + *Azospirillum* + Phosphobacteria

seasons. The baby corn composite, COBC1 and *Amaranthus* cv. CO 5 and green gram cv. Pusa chetki were chosen for the study.

The experiments were laid out in split plot design with three replications. Two factors *viz.*, crop geometry with two levels (45 x 25 cm and 60 x 19 cm) intercropping systems (sole baby corn, baby corn + *Amaranthus* and baby corn + green gram) were included 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. Baby corn seeds were pre-treated with fungicide (Carbendazim @ 2g kg^{-1} of seeds), sown in the furrows and covered with soil. 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 furrow in solid rows. Organic manures were applied as per the treatment (on equal N basis) and incorporated in to the soil uniformly. Bio-fertilizers (*Azospirillum* and Phosphobacteria) @ 2kg ha^{-1} were mixed along with well-powered FYM and spread uniformly as per the treatment. Recommended dose of nitrogen (150 kg ha^{-1}) as Urea, 60 kg ha^{-1} of phosphorus as Single super phosphate and 40 kg ha^{-1} of potassium 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.

Weed count was taken at 25 and 50 DAS during both the seasons and weed-smothering efficiency was worked out. The total weed count was recorded by using $0.25m^2$ quadrate at five places in each plot and expressed as number of m^{-2} quadrate at five places in each plot and expressed as number m^{-2} as suggested by Burnside and Wicks (1965). Weeds present in five quadrates were removed, air-dried and then oven dried at 75°C till a constant weight was attained. The dry weight of weed recorded and expressed in ka ha^{-1}. From this Weed Smothering Efficiency was computed using the formula.

$$WSE (\%) = \frac{Mdw - Idw}{Mdw} \times 100$$

Where, Mdw - Mean dry weight of weeds in pure crop plot,

Idw - Mean dry weight of weeds in intercropped plot.

Harvested cobs from the net plot were weighed and expressed in kg ha^{-1}.

From the net plot, green gram pods were harvested, sun dried, weighed and expressed as ka ha^{-1}. *Amaranthus* greens yield was expressed in kg ha^{-1}. Baby corn Equivalent Yield (BEY) 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).

Results and Discussion

Weeds dynamics

In general, weed population and weed DMP was higher during *kharif* 2002 season (Table 1). At 25 DAS, weed density was more than compared to 45 DAS, whereas the results were reverse with weed DMP. Except at 45 DAS during summer 2003, weed density did vary with two crop geometry levels. During *kharif* 2002 season, S_2 registered higher weed population (1.54 and 1.08 at 25 and 45 DAS respectively) than S_1. Similarly crop geometry levels considerably influenced the weed DMP in baby corn based intercropping systems. Baby corn raised at 45 x 25 cm (S_1) suppressed the DMP of weeds as compared to 60 x 19 cm (S_2) during both the seasons. Wider spacing (S_2) recorded higher Weed Smothering Efficiency than narrow row spacing. Under 60 cm spacing higher weed DMP could be due to more space and light availability which might have allowed vigorous weed growth and in turn increased the weed DMP.

Intercropping systems had shown adverse effect on weed population and weed DMP than sole baby corn during both the seasons. With regard to weed population, intercropping systems reduced the weed density during both the seasons except at 45 DAS during summer 2003 season. All the intercropping systems improved WSE. During *kharif* 2002 season, at 25 DAS higher WSE was noted in baby corn + *Amaranthus* (C_2) than baby corn + green gram (C_3). This could be due availability of space and light under 60 cm spacing which might have allowed vigorous growth of weeds and in turn increased the weed DMP. Intercropping treatments recorded lesser number of weeds and weed DMP when compared to sole baby corn. This could be attributed to complete coverage and high plant density available in intercropping system which caused severe competition with the weeds and reduced the weed growth. The present results are in agreement with the observations made by Thakur (1994). Shetty and Rao (1981) reported that intercropping minimized the weed infestation without any detrimental effect on the yield of sorghum and red gram. Velayutham *et al* (2002) also opined that intercrops provide efficient coverage of land resulting in suppression of weed growth.

The INM practices exhibited significant difference on weed population over seasons. During *kharif* 2002, the weed density was lower (1.44) at 25 DAS with inorganic fertilizers (N_1) alone than 50 per cent NPK + organic manures + bio-fertilizers (*Azospirillum* + Phosphobacteria) (N_3 and N_4) treatment (1.54 to 1.57 at 25 DAS). The results were repetitive during rest of the seasons. However, at 45 DAS the results were not varied significantly. Almost similar results were obtained with weed DMP and reverse with WSE. This may be due to the presence of weed seeds in the organic manures and got germinated in the field and increased the population and DMP of weeds under INM treatments.

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 to 7521 kg ha^{-1}) (Table 3). In both the seasons, crop geometry led substantial increase in green cob yield of baby corn. Baby corn raised at 60 x 19 cm (S_2) produced higher cob yields over S_1 (45 x 25 cm). The percentage of increase of S_2 over S_1 was 9.2 and 9.5 during *kharif* 2002 and summer 2003 seasons respectively. The results of pooled analysis also follow the same trend where the increase was 9.3 per cent. The increase was due to the effective utilization of applied nutrients increased 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) also reported higher yields of maize under wider spacing.

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

The INM treatments had synergistic effect on green cob yield of baby corn during both the seasons. Combined application of inorganic and bio-fertilizers (*Azospirillum* and Phospobacteria) along with either poultry manure or goat manure (N_3 and N_4) produced higher cob yield (8037 and 8004 kg ha^{-1}) and (7516 and 7521 kg ha^{-1}) than FYM (N_2) incorporated with inorganic and bio-fertilizers (7243 and 7126 kg ha^{-1}) and inorganic fertilizers (N_1) alone (7335 and 7104 kg ha^{-1}) during *kharif* 2002 and summer 2003 seasons respectively. Same trend also noticed with pooled mean data. Application of poultry manure increased the P availability in turn 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 also narrow C:N ratio accelerated the N release (Bishnoi and Bajwa, 1994). Fixation of atmospheric N and secretion of growth promoting substances by *Azospirillum* increased bacterial efficiency by Phosphobacteria (Datta and Banik, 1997) combined together 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) was also reported earlier.

Baby corn Equivalent Yield

In general, Baby corn Equivalent Yield (BEY) was higher during *kharif* 2002 season than summer 2003 season.

During *kharif* 2002 season, wider (60 x 19 cm) crop geometry (S_2) registered higher BEY (9507 kg ha^{-1}) than at 45 x 25 cm (8870 kg ha^{-1}). This was true with summer 2003 season also. The pooled mean was also in the similar trend where the yield increase was 9.5 per cent. Increased BEY was solely due to higher yield of baby corn recorded under S_2. Singh (2000) also reported higher maize equivalent yield at 60 cm row spacing.

The effect of intercropping systems on BEY was significant during both the seasons. Sole baby corn (S_1) registered lower BEY (8049 and 7306 during *kharif* 2002 and summer 2003 season respectively) as compared to intercropped baby corn (C_2 and C_3). Pooled data also follow the same trend where 21.3 and 20.7 per cent increase over C_1 was recorded in C_2 and C_3. Additional yield obtained from the intercrops without reducing the main crop yield improved the BEY. Similarly, increased equivalent yield of main crop by addition of intercrops *viz., Amaranthus* (Anitha *et al.,* 1999) and green gram (Shivay 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 may 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 are shallow rooted and did not compete with baby corn.

The INM practice exhibited a positive response on BEY during the course of investigation. During *kharif* 2002 season, compensation of 50 per cent NPK by organic manure (poultry manure and goat manure) and bio-fertilizers (*Azospirillum* + Phosphobacteria) (N_3 and N_4) recorded significantly superior BEY (9248 adn 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 also pooled mean data. Higher yields of baby corn and non-reduction of intercrop yields under these treatments had influenced BEY. Singh *et al.* (1997) reported similar findings of increased Maize Equivalent Yield (MEY) due to the addition of organic manures to inorganic fertilizers.

In the light of the above results, it can be interpreted that crop geometry failed to influence weed dynamics. Whereas, introduction of intercrops reduced the weed population and increased the WSE. It also revealed that raising of baby corn at 60 cm row spacing with *Amaranthus* and green gram intercrops by following INM practices (50% NPK + poultry / goat manure + Azospirillum + Phosphobacteria) would produce maximum baby corn yield and also higher BEY and in turn increase the over all productivity of the system.

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(Received : December 2004 Revised : December 2005)