RESEARCH ARTICLE

EFFECT OF PLANTING GEOMETRY AND INTERCROPPING BASED STRATEGY ON PRODUCTIVITY AND FALL ARMYWORM MANAGEMENT IN WINTER MAIZE (*ZEA MAYS* L.)

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Abstract: A field experiment to explore the potential of maize and legume based intercropping systems under different treatments conducted during *Rab*i season of 2020-21 to evaluate the effect of eight treatments via. maize sole (70 x20 cm), maize + fenugreek (1:1), maize + coriander (1:1), maize + garlic (1:1), maize sole (50/90 cm), paired row maize + fenugreek (2:2) (50/90 cm), paired row maize + coriander (2:2) (50/90 cm) and paired row maize + garlic (2:2) (50/90 cm) on productivity and fall army worm management which were laid out in factorial block design with 3 replications. Row arrangement system significantly influenced the growth and yield of maize and paired row system was found superior over regular row. All the intercropping systems significantly influenced growth and yield attributing features of maize and where maize + coriander intercropping was superior over maize + fenugreek, maize + garlic and sole maize for yield attributes and cob and grain yield of maize. While, maximum system productivity was obtained in paired row which was found significantly superior over regular row and maize + garlic intercropping was significantly superior over maize + fenugreek, maize + coriander and sole maize. The lowest FAW damage was also recorded with the paired row over the regular row. The maize + coriander intercropping system recorded minimum FAW damage over the rest of the intercropping system. Paired row + garlic had higher net return and B: C ratio found statistically comparable with paired row + fenugreek.

Keywords: Maize, Intercropping, System productivity, B:C ratio, Fall armyworm

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal food crops in the world with highest production and productivity when compare to others cereals. This crop possesses versatility and also has wider adaptability under varied agro-climatic condition and usually grown in more than 166 counties across world including tropical, sub-tropical and temperate region. Globally, maize is also known as "**Queen of cereals"** because it has the highest genetic yield potential among the cereals. Agricultural production depends on various factors and any set back in these factors severely affects the yield of crop. The farming practices that use the ecology of the farm to correct resource and pest imbalances, intercropping is a prime example of such a practice.There are many established and speculated advantages for intercropping system such as more grain yields, higher land use efficiency and increase in soil fertility by the component legume crops. The main advantage for the use of legumes in intercropping and mixed cropping is as the saving of N-fertilizer. To popularize maize and avoid competition with other crops, intercropping is a good technique where farmers may produce maize with other crops (pulses, oilseeds, vegetables etc.). Pulses can mobilize organic phosphorous in both soil cultures and hydroponic, leading to a site-specific facilitation in utilization of organic phosphorous in intercropping (Li *et al*., 2004). In the tropical and sub-tropical regions, cereal-legumes intercropping are the most popular practices because of its many additional advantages (Willey, 1979 a). Intercropping becomes more productive and economic when both the crops differ with genetic makeup, photosynthetic pathway, growth habit, growth duration and demand of different growth resources.

Plant protection is the most necessary factors manipulating production of crop, eco-environment and sustainability in agricultural production. Insects are one which affects productivity and sustainability of agricultural production. Intercropping is practice of growing to or more crops at the same time during same growing season on the same piece of land. In India insects alone are responsible for one-fifth reduction in crop production. Fall armyworm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera), is an invasive polyphagous destructive insect pest reported causing economic loss to maize across the globe (Clark *et al*. 2007; Nabity *et al*. 2011).It is an economically important pest that attacks maize and other graminaceous crops throughout much of its native tropical and sub-tropical America. Its host range however includes almost 100 recorded plant species in 27 families (Pogue, 2002). The fall armyworm larvae feed on young leaf whorls, ears and tassels causing substantial damage to maize, occasionally resulting in total yield loss. The adoption and expansion of monocultures has decreased the abundance and activity of natural enemies by destruction of critical food resources and

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overwintering sites. The farming practices that use the ecology of the farm to correct resource and pest imbalances, intercropping is a prime example of such a practice. The use of intercropping systems provides an option for insect management for organic farmers that are limited in their chemical use. Additionally, intercropping systems can be attractive to conventional growers as a cost-effective insect control solution.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* seasons 2020-21 at the Research farm, Raj Mohini Devi College of Agriculture & Research Station, Ambikapur (Chhattisgarh), which is situated at 23^0 10' N latitude, 83°15' E longitude and at an altitude of 623 meters above the mean sea level. The soil of experimental field was sandy loam in texture with pH of 5.7, organic carbon 0.56%, 234 kg/ha available N, 8.4 kg/ha P_2O_5 and 268 kg/ha K_2O. The meteorological data recorded at meteorological observatory of the station indicated that rainfall received during the crop seasons was 802 mm. The experiment was laid out in factorial block design with three replications. There were 08 treatments, consisting of Maize sole (70 x 20 cm), Maize + Fenugreek (1:1), Maize + Coriander (1:1), Maize + Garlic (1:1), Maize sole (50/90 cm), Paired row Maize + Fenugreek (2:2) (50/90 cm), Paired row Maize + Coriander (2:2) (50/90 cm) and Paired row Maize + Garlic (2:2) (50/90 cm). The recommended doses of fertilizers were applied for sole and for intercrops as per row ratio. The recommended doses of fertilizers for babycornwas150-80-60 kg N-P_2O_5- K_2O /ha and nitrogen as per treatment was applied in three splits. Half dose of nitrogen along with full dose of phosphorous and potassium was applied at the time of sowing of maize. Remaining nitrogen was top dressed in two equal splits at Knee high stage (30 DAS) and tasseling stage (50 DAS) in all treatments of maize. Coriander and garlic intercrops, fertilizer as recommended for intercrops. And as Fenugreek is leguminous, so full dose of recommended fertilizers were applied as basal. Maize var. NK 30, fenugreek var. PEB, Garlic var. Local and Coriander var. G-ground were sown during second week of November 2020. Maize and intercrops (fenugreek, garlic and coriender) varieties were sown manually at varying row spacing as per treatments. Gap filling and thinning were done within 10 days after sowing to maintain the optimum plant population. Five plants were tagged randomly from each plot for recording of growth and yield attributes. Cobs were harvested when matureand same were counted weighed dehusked and grain yield was recorded.Gross returns, net returns and benefit: cost ratios were calculated on the basis of prevailing market price of inputs and produce. To compute the productivity of system maize-equivalent yield (MEY) was obtained by dividing the economic value of the produce (yield of produce x price of produce) with the price of maize. All data obtained in the inter cropping were statistically analyzed using *F*- test, the procedure given by Gomez & Gomez (1984), critical difference (CD) values at P= 0.05 were used to determine the significance of differences between means.

RESULTS AND DISCUSSION

Yield attributes

Different row arrangements significantly affected the yield attributes of maize. (Table 1). Higher yield attributes, *viz* length of cob, girth of cob, number of kernals row^{-1} and number of kernel rows cob^{-1}were recorded under paired row which was superior over regular row. Also different intercropping system significantly affected the yield attributes of maize, where maize + coriander intercropping recorded maximum cob lengthand number of kernals row^{-1} which was significantly superior over maize + fenugreek, maize + garlicand sole maize.The maximum cob girth and number of kernel rows cob^{-1}was recorded with maize + coriander which was at par with maize + fenugreek, maize + garlicbut significantly superior over sole maize.

The increased in yield attributes ofmaize might have occurred owing to the improved due to symbiotic nitrogen fixation by legumes and its subsequent transfer to maize which was also evident from the higher growth attributes. The more congenial environment under paired row planting might have increased the maize as well as intercrops to avail the natural resources like soil, water and light which might have resulted in taller plants and ultimately more dry matter accumulation and yield attributing features. Similar results were also reported by Kheroar and Patra (2014).

Cob yield and grain yield

Different row arrangements significantly influenced the cob yield and grain yield of maize. The highest cob yield and grain yield of maize was recorded in paired row which was significantly superior over regular row. Also different intercropping influenced significantly the cob yield and grain yield of maize i.e. maximum cob yield and grain yield was obtained with maize + coriander which was at par maize + fenugreek but significantly superior maize + garlic and sole maize.

System productivity

Maximum system productivity (6488.5 kg ha^{-1}) was recorded with paired row which was found significantly superior over regular row (5811.0 kg ha^{-1}). Different intercropping system also had significant effect on system productivity. Maximum system productivity (7832.2 kg ha^{-1}) was recorded with maize + garlic which were significantly superior overmaize + fenugreek (7290.1 kg ha^{-1}), maize +

coriander (5929.6 kg ha^{-1}) and sole maize (3466.9 kg ha^{-1}).

Interaction effect of row arrangements and intercrops on system productivity revealed that paired row with maize + garlic had maximum grain yield (8154.7 kg ha^{-1}), which was significantly superior over rest of treatment combinations (Table 3).Maize in paired rows intercropped registered higher growth characters, dry matter accumulation and yield attributes and yield. Added to this the intercrop yield which is the bonus and converted to maize equivalent yield and the total yield of maize. Similar results were also reported by Tripathi *et al*. (2010).

FAW damage

Minimum FAW damage (32.5 %) was recorded with paired row which was found significantly superior over regular row (37.4 %). Different intercropping system also had significant effect on FAW damage (%). Minimum FAW damage (25.4 %) was recorded with maize + coriander which were found significantly superior over maize + fenugreek (32.1 %), maize + garlic (29.8%) and sole maize (42.4 %).

Intercropping systems for insect pest control includes the planting of a crop that has a repellent effect, an attractant effect, or a combination of the two, on a targeted insect in close proximity to a crop that has the potential to be attacked by the insect. For this reason, adoption of suitable intercropping combination is necessary in present time to tackle the agro ecosystems from vulnerable to pest outbreaks and other environmental problems. The successful use of intercropping to manage pests depends on a thorough knowledge of insect ecology and crop characteristics.Similar results were also reported by Rao *et al*. (2012).

Economics

Paired rowrecorded higher net return significantly superior over regular row (Table 2). The maximum net return was accrued with maize + garlic which were at par with maize + fenugreek and both of these treatments were significantly superior over maize + coriander and sole maize.

Numerically the highest B: C ratio (2.22) was obtained from paired row which was significantly superior over regular row (1.87). Significant influence on B:C ratio was recorded due to intercrops. Amongst different rates of nutrients maize + fenugreek proved best as maximum B:C ratio (2.65) which was at par with maize + garlic (2.50) but significantly superior over maize + coriander (1.20). Minimum B:C ratio was recorded with sole maize (0.79) (Table 2).

The practical utility of any treatment can be best judged because of net return and B: C ratio. Paired row + garlic had higher net return and B: C ratio found statistically comparable with paired row + fenugreek this was because of more net returns than the money spent in crop production under these treatments. These results are found to be in close conformity with Acharya *et al*. (2004).

Table 1. Yield and yield attributes of maize as influenced by row arrangements and intercrops.

Treatments		Yield attributes				Yield	
		Cob length (cm)	Cob girth (cm)	No. of kernels row^{-1}	No. of kernel rows cob^{-1}	Cob yield (Kg ha^{-1})	Grain yield (Kg ha^{-1})
Row arrangements (R)							
R$_1$	*Regular (1:1 at 70 X 20 cm)*	17.7	15.2	35.0	14.4	4787.3	3764.6
R$_2$	Paired (2:2 at 50 X 90 cm)	18.6	16.0	36.1	14.8	5416.4	4227.5
Sem±		0.2	0.12	0.3	0.2	146.2	116.3
C.D. (P=0.05)		0.6	0.4	0.9	NS	443.7	352.8
Intercrops (I)							
I$_0$	Maize alone	17.5	15.2	34.5	14.1	4546.0	3466.9
I$_1$	Maize + Garlic	18.0	15.4	34.8	14.4	4606.9	3625.0
I$_2$	Maize + Coriander	19.1	15.9	37.3	15.0	5758.7	4522.8
I$_3$	Maize + Fenugreek	18.2	15.6	35.5	14.8	5495.7	4369.6
Sem±		0.3	0.2	0.4	0.21	206.8	164.5
C.D. (P=0.05)		0.8	0.5	1.3	0.64	627.5	498.9

Table 2. System productivity, economics and FAW damage% as influenced by row arrangements and intercrops.

		System Productivity (Kg ha^{-1})	**Net return (₹ ha^{-1})**	**B:C ratio**	**FAW damage (%)**
Row arrangements (R)					
R_1	*Regular (1:1 at 70 X 20 cm)*	5811.0	75071.0	1.87	37.4
R_2	Paired (2:2 at 50 X 90 cm)	6448.5	87915.9	2.22	32.5
Sem±		127.4	2398.4	0.06	0.6
C.D. (P=0.05)		386.3	7275.4	0.18	1.7
Intercrops (I)					
I_0	Maize alone	3466.9	71406.8	31468.6	42.4
I_1	Maize + Garlic	7832.2	152146.2	108627.6	39.8
I_2	Maize + Coriander	5929.6	118255.2	81838.1	25.4
I_3	Maize + Fenugreek	7290.1	143323.1	104039.6	32.1
Sem±		180.1	3391.8	0.09	0.8
C.D. (P=0.05)		546.3	10289.0	0.26	2.4

Table 3. Interaction effect between row arrangements and intercrops on system productivity (kg ha^{-1})

Treatments	**Row arrangements**	
Intercrops	System productivity (kg ha^{-1})	
	Regular (1:1 at *70 X 20 cm)*	Paired (2:2 at 50 X 90 cm)
Maize alone	3272.4	3661.5
Maize + Garlic	7509.7	8154.7
Maize + Coriander	5476.7	6382.6
Maize + Fenugreek	6985.0	7595.3
SEm±	55.1	
CD (P=0.05)	161.7	

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