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Role of Border and Barrier Crops for the Management of Important Chilli (*Capsicum annuum* L.) Pests

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Field experiments were conducted during *kharif* 2010-11 and 2011-12 at Agricultural Research Station, UAS, Dharwad, Karnataka, South India to assess the effect of border and barrier cropping for the management of chilli pests. Chilli as border and barrier crop with South African tall maize and sweet sorghum was found to be superior over sole crop by recording the lowest population of sucking pests, leaf curl index, larval population of *H. armigera*, fruit damage and significantly higher growth parameters as well as dry chili yield (3.95 and 3.89q/ ha) with a net return of Rs 19,528/- and C:B ratio 1: 2.56. Activity of predators such as coccinellids and chrysopids were found to be greatly distributed in plots having border and barrier crops.

Key words : Border and Barrier cropping, Fruit borer damage, *Helicoverpa armigera*, Leaf curl index, Predators, Sucking pests

Chilli (*Capsicum annuum* L.) is a tropical and subtropical spice and vegetable grown all over India. Chilli constitutes about 20 per cent of Indian spice exports in quantity and about 14 per cent in value. Globally India is the largest producer and consumer of chilli. Among the states, Andhra Pradesh is the largest producer of chilli in India. In Karnataka thrips, mites, aphids and whiteflies have been identified as sucking pests of chilli, of which leaf curl caused by mite and thrips are very serious (Saumya and Giraddi, 2007). Besides, a number of viruses are transmitted by aphids, whiteflies *etc*, which result into a complex murda (Gundannavar *et al*., 2007). The yield losses due to these pests are estimated to be 50 per cent (Hosmani, 2007). The loss caused by the thrips is reported to range from 50 to 90 per cent (Borah, 1987) and by fruit borers up to 90 per cent (Reddy and Reddy, 1999).

Massive application of insecticides not only leaves harmful residues in the food chain, but also causes effects on non-target organisms and environment, pest resurgence and development of resistance in insects. Pesticide residues in chilli are also of great concern from the point of domestic consumption and exports. With this background experiments were conducted to assess the influence of border and barrier crops on the activity of sucking pests, pod borer and natural enemies populations in order to minimize insecticides applications.

Materials and Methods

Field experiments were carried out for two seasons to know the effect of border and barrier cropping system on the activities of insect pests of chilli during *kharif* 2010-11 and 2011-12. The experiment was laid out at Agricultural Research Station, UAS, Dharwad in deep black cotton soil. The treatment details includes; T_1 - Sole crop, T_2 - Border crop with south African tall maize, T_3 - Barrier crop with South African tall maize, T_4 - Border and barrier crop with South African tall maize, T_5 - Border crop with sweet sorghum, T_6 - Barrier crop with sweet sorghum and T_7 - Border and barrier crop with sweet sorghum.

Chilli seedlings (var. Byadagi kaddi) were transplanted during 3rd and 1st week of July 2010-11 and 2011-12, respectively in plots of size 5.4 X 4.8 m. with spacing of 60 X 60 cm. Each plot had a density of 72 hills with two plants per hill. The seeds of African tall maize and sorghum (var.SSV-74) were sown at the time of chilli transplanting all around the main crop. All management practices were followed as per recommended package of practices (www.uasd.edu.in) except the plant protection measures against target pests.

Observations of sucking pests

The population count of aphids and thrips were taken at 30, 60 and 90 days after transplanting (DAT) in each plant from five randomly selected samples. The population count of mite was taken at 60 and 90 DAT. The top six leaves in each selected plant were collected and observed by using binocular microscope by following destructive sampling procedure. Ten plants were selected randomly in each plot and scored for leaf curl index (LCI) at 70 and 100 DAT visually following 0-4 scale (Niles, 1980).

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Assessment of larval population of* H. armigera *and fruit damage

The observations on larval population of chilli fruit borer, *H. armigera* were made on five randomly selected plants from each treatment at 60, 90 and 120 DAT. The per cent fruit damage was worked out by counting total number of fruits and damaged ones per plant on five randomly selected samples in each treatment at every picking.

Population of natural enemies

Population count of both grubs and adults of *Chilonomus sexmaculatus* and chrysopids, *Chrysoperla zastrow sillemi* were recorded in each treatment on five randomly selected plants at 60 and 90 DAT by following the standard procedures for ecological studies (Daniel *et al*., 2008)

Plant height and fruit yield

Plant hieght of chilli were recorded at 90 DAT. Green chillies were harvested from five randomly selected plants in each plot as well as from entire plot, separately. Yield per plant and per plot was also recorded during each picking. Totally four pickings were done to record the total and average yield. Based on the yield per plot, per hectare yield in guntas was calculated. Dry chilli yield was obtained from the green chilli yield as per the procedure (Gundannavar *et al.*, 2007), with the ratio of conversion of green chilli to dry chilli being 10:1. Cost effectiveness of each treatment was assessed based on net returns and the B:C ratio was worked out. The data on mean population of sucking pests, natural enemies and fruit borer were transformed to square root values and the per cent damage was transformed to arcsine values and subjected to one way ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Sucking pest density

Data on aphid population in different treatments ranged from 0.22 to 0.47 and 0.19 to 0.38 during 2010-11 and 2011-12, respectively. Chilli with South Africal tall maize as border and barrier crop registered significantly less number of aphids (0.22 and 0.19 during 2010-11 and 2011-12, respectively). Moderate pest activity was recorded in chilli crop having sweet sorghum as border and barrier crop, while chilli as sole crop recorded significantly more number of aphids (0.47 and 0.38/ leaf) during 2010-11 and 2011-12, respectively. Pooled analysis of the data also indicated similar trend (Table 1). Significantly least level of thrips population (0.28/ leaf) was registered during 2010-11, in chilli South African tall maize as border and barrier crop. Contrarily, higher number of thrips were found in sole crop (0.60/leaf). All the treatments except chilli as sole crop recorded significantly lower number of thrips. Similar trend was noticed during 2011-12 (Table 1).

Table 1. Population of sucking pests and leaf curl index in chilli border and barrier cropped with different crops

Treatment	Aphid count (No./leaf)			Thrips count (No./leaf)			Mite count (No./leaf)			Leaf curl index		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 - Chilli- sole crop	0.47a	0.38a	0.45a	0.60a	0.71a	0.67a	0.89a	0.91a	0.91a	1.46a	1.37a	1.44a
	(1.19)	(1.12)	(1.17)	(1.27)	(1.34)	(1.32)	(1.44)	(1.45)	(1.45)	(1.71)	(1.67)	(1.70)
T_2 - Chilli + border crop with	0.31c	0.25c	0.27bc	0.45bc	0.41c	0.43bc	0.65bc	0.63c	0.63c	0.56b	0.59b	0.58b
South African tall maize	(1.06)	(1.00)	(1.03)	(1.17)	(1.17)	(1.17)	(1.31)	(1.29)	(1.29)	(1.25)	(1.27)	(1.26)
T_3 - Chilli + barrier cropp with	0.33c	0.29b	0.31b	0.46bc	0.47bc	0.47b	0.65bc	0.66bc	0.66bc	0.49c	0.44c	0.47c
South African tall maize	(1.07)	(1.04)	(1.06)	(1.18)	(1.19)	(1.19)	(1.31)	(1.31)	(1.31)	(1.20)	(1.16)	(1.18)
T_4 – Chilli+ border and barrier crop	0.22e	0.19d	0.20d	0.28d	0.23d	0.24d	0.41d	0.39d	0.39d	0.36d	0.29d	0.31d
with South African tall maize	(0.99)	(1.00)	(1.00)	(1.14)	(1.12)	(1.12)	(1.23)	(1.21)	(1.21)	(1.10)	(1.04)	(1.06)
T_5 – Chilli + border crop with	0.38b	0.37a	0.38ab	0.59a	0.56b	0.57ab	0.74b	0.71b	0.73b	0.51c	0.47c	0.49c
sweet sorghum	(1.12)	(1.11)	(1.12)	(1.23)	(1.25)	(1.23)	(1.36)	(1.34)	(1.35)	(1.21)	(1.19)	(1.20)
T_6 – Chilli + barrier crop with	0.30d	0.31ab	0.36ab	0.55ab	0.59b	0.57ab	0.75b	0.73b	0.75b	0.64b	0.65b	0.65b
sweet sorghum	(1.05)	(1.06)	(1.10)	(1.23)	(1.27)	(1.25)	(1.37)	(1.35)	(1.37)	(1.30)	(1.31)	(1.31)
T_7 - Chilli + border and barrier	0.25de	0.22cd	0.24c	0.41c	0.35cd	0.38c	0.46c	0.42cd	0.45d	0.39d	0.31d	0.33cd
crop with sweet sorghum	(1.00)	(0.97)	(0.99)	(1.14)	(1.13)	(1.12)	(1.25)	(1.22)	(1.23)	(1.12)	(1.06)	(1.08)
CV	10.10	9.65	8.38	10.40	12.36	13.33	8.65	11.29	8.63	5.89	6.36	5.92
S. Em±	0.02	0.03	0.01	0.03	0.04	0.04	0.03	0.04	0.03	0.03	0.04	0.05
C.D. at 5%	0.05	0.09	0.04	0.09	0.11	0.12	0.11	0.13	0.10	0.08	0.11	0.15

Figures in parenthesis are arc sine transformed values
In a column means followed by the same alphabet did not differ significantly by DMRT (p=0.05)

Results on mite population indicated that chilli with South African tall maize as border and barrier crop had recorded significantly less number of mites (0.41 and 0.39 mites/leaf) during 2010-11 and 2011-12, respectively. All the treatments except sole crop recorded significantly less number of mites (Table 1). Similar pattern of treatment significance was noticed in pooled analysis also. Observations on LCI revealed that chilli with South African tall maize as border and barrier crop had recorded significantly less leaf curl score (0.36 and 0.29 during 2010-11 and 2011-12, respectively). All treatments were found to be significantly superior over control recording lower levels of LCI.

Since, aphids, thrips, mites and whiteflies are soft bodied, small and fragile insects, they may be easily dispersed from one place to another through wind currents. When borders and barriers are used around and within the main crop, dispersal of these insects may be physically prevented due to thick

plant canopy, thus may prevent or reduce the spread of the sucking pests. Besides, border and barrier crops may also promote build up of natural enemies by providing sufficient food (eg. Nector, pollen etc.), which in turn reduce the pest population on the main crop. Tatagar *et al.* (2011) also reported that chilli crop bordered with two rows of maize would record the least leaf curl damage due to the presence of lower number of thrips and mites. Shivaprasad *et al.* (2011) who concluded that lower level of leaf curl index as a consequence of lower populations of thrips and mite. Border or barrier crop with fodder or grain sorghum also increased predator population when compared to chilli as sole crop.

H. armigera

Fruit borer larval density in different treatments varied from 0.28 to 0.48 and 0.31 to 0.61/plant during 2010-11 and 2011-12, respectively (Table 2). Chilli with South African tall maize as border and barrier crop recorded significantly less number of fruit borer (0.28 and 0.31 during 2010-11 and 2011-12, respectively) followed by chilli sweet sorghum as border and barrier crop (0.31 and 0.34/plant). Maximum fruit borer larvae of 0.48 and 0.61/plant was registered in sole crop during 2010-11 and 2011-12, respectively. Pooled data also recorded similar pattern of treatment significance. Chilli South African tall maize as border and barrier crop recorded significantly less fruit borer damage (3.49 and 3.44%), which was on par with chilli sweet sorghum as border and barrier crop (3.60 and 3.78 %) during 2010-11 and 2011-12 respectively. Lower activity of fruit borer in chilli could be attributed to the presence of certain volatile substance secreted by border and barrier crop plants, that might restrict colonization on main crop. Further, border and barrier cropping system may help in habitat manipulation to maintain the eco-balance and provide favourable conditions for natural enemies of fruit borer. Similar results were reported by Nelson and Natarajan (1994) and Dhandapani *et al.* (2003) in chilli and tomato, respectively.

Table 2. Population of chilli fruit borer, fruit damage percent and natural enemies in chilli border and barrier cropped with different crops

Treatment	Fruit borer (larvae/plant)			Fruit damage (%)			Coccinellids/plant			Chrysopids/plant		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 - Chilli- sole crop	0.48a	0.61a	0.57a	5.37a	5.12a	5.20a	0.95d	0.92d	0.94d	1.21cd	1.31d	1.24d
	(1.19)	(1.28)	(1.25)	(13.36)	(13.01)	(13.11)	(1.47)	(1.48)	(1.47)	(1.60)	(1.64)	(1.61)
T_2 - Chilli + border crop with South African tall maize	0.34c	0.39c	0.37bc	3.64cd	3.66d	3.65cd	1.51b	1.53ab	1.53b	1.76ab	1.80ab	1.78ab
	(1.08)	(1.12)	(1.11)	(10.89)	(10.93)	(10.97)	(1.73)	(1.74)	(1.74)	(1.83)	(1.84)	(1.83)
T_3 - Chilli + barrier cropp with South African tall maize	0.36c	0.41c	0.38b	3.64cd	3.72cd	3.68cd	1.53b	1.54ab	1.54ab	1.80a	1.86a	1.83a
	(1.10)	(1.14)	(1.11)	(10.89)	(11.04)	(10.97)	(1.74)	(1.74)	(1.74)	(1.84)	(1.86)	(1.85)
T_4 – Chilli+ border and barrier crop with South African tall maize	0.28d	0.31d	0.29c	3.49d	3.44d	3.45d	1.71a	1.65a	1.67a	1.87a	1.91a	1.88a
	(1.03)	(1.06)	(1.04)	(10.66)	(10.66)	(10.66)	(1.81)	(1.78)	(1.79)	(1.87)	(1.88)	(1.87)
T_5 – Chilli + border crop with sweet sorghum	0.41b	0.48b	0.45ab	3.87c	3.98c	3.92c	1.31c	1.29c	1.28c	1.40c	1.61c	1.51c
	(1.14)	(1.19)	(1.17)	(11.30)	(11.45)	(11.30)	(1.65)	(1.64)	(1.64)	(1.68)	(1.77)	(1.73)
T_6 – Chilli + barrier crop with sweet sorghum	0.45a	0.50b	0.47a	4.38b	4.29b	4.34b	1.35c	1.28c	1.32c	1.44c	1.52c	1.48c
	(1.17)	(1.21)	(1.19)	(12.02)	(11.88)	(11.96)	(1.66)	(1.63)	(1.65)	(1.70)	(1.73)	(1.72)
T_7 - Chilli + border and barrier crop with sweet sorghum	0.31cd	0.34d	0.33bc	3.60d	3.78cd	3.62cd	1.65a	1.63a	1.63a	1.91a	1.96a	1.95a
	(1.06)	(1.08)	(1.07)	(10.85)	(10.93)	(10.85)	(1.79)	(1.78)	(1.78)	(1.88)	(1.90)	(1.90)
CV	6.12	9.02	6.40	6.02	5.89	6.35	5.40	9.78	5.39	8.72	5.25	6.42
S. Em±	0.01	0.02	0.06	0.13	0.15	0.15	0.04	0.08	0.04	0.08	0.05	0.06
C.D. at 5%	0.04	0.06	0.15	0.39	0.47	0.46	0.14	0.24	0.14	0.25	0.16	0.19

Figures in parenthesis are arc sine transformed values
In a column means followed by the same alphabet did not differ significantly by DMRT (p=0.05)

Predators

During 2010-11, the population of *C. sexmaculatus* ranged from 0.95 to 1.71 per plant. Significantly higher number of *C. sexmaculatus* (1.71 per plant) was noticed in chilli South African tall maize as grown with border and barrier crop when compared to sole crop (0.95/plant). During both the years, significantly more number of chrysopids was noticed in chilli cropped with sweet sorghum as border and barrier crop (1.91 and 1.96/plant) when compared to rest of the treatments (Table 2).

Plant height (cm)

During the both the years plant height of chilli ranged from 52.30 to 76.30 cm, when grown with South African tall maize as border and barrier crop (Table 3). These findings provide strong base to conclude that border and barrier crop of maize and sweet sorghum all along chilli field as border and barrier crops contributed significant role in preventing pest dispersal and conserving and enhancing the population of predators throughout the cropping period and thereby reducing pest load on chilli crop. These results are in agreement with the findings of Shivaprasad *et al*. (2011) in chilli, Srinivas and Lawande (2002) in onion and Hook and Fererers (2006) and Fererers (2000) in maize.

Yield (q/ha)

Significantly higher dry chilli yield (4.01 and 3.87q/ha on 2010-11 and 2011-12, respectively) was registered in chilli with South African tall maize as border and barrier crop (T4) and significantly less dry chilli yield (1.86 and 1.81q/ha) in sole crop (Table 3).

The highest net return (Rs. 19,528/-) was recorded in chilli with South African tall maize as border and barrier crop (C:B ratio of 1: 2.56), while, the control plot recorded a net return of Rs. 3654/-

Table 3. Effect of different border and barrier crops on chilli plant height, dry chilli yield and cost economics

Treatments	Plant height (cm)			Dry chilli yield (q/ha)			Gross Returns (`/ha)	Total cost of production (`/ha)	Net Returns (`/ha)	C:B ratio
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled				
T_1 - Chilli- sole crop	52.30c	55.50bc	54.10bc	1.86d	1.81d	1.83d	15006	11352	3654	1:1.32
	(7.73)	(7.95)	(7.87)							
T_2 - Chilli + border crop with South African tall maize	65.20ab	67.80ab	66.30ab	3.28b	3.18b	3.21b	23698	11861	11837	1:1.99
	(8.57)	(8.73)	(8.63)							
T_3 - Chilli + barrier cropp with South African tall maize	61.60b	58.30bc	59.95b	2.82c	2.92bc	2.87b	22304	11793	10511	1:1.89
	(8.35)	(8.14)	(8.25)							
T_4 – Chilli+ border and barrier crop with South African tall maize	76.30a	79.20a	76.95a	4.01a	3.87a	3.95a	32062	12534	19528	1:2.56
	(9.23)	(9.40)	(9.28)							
T_5 – Chilli + border crop with sweet sorghum	62.50b	64.20b	63.45b							
	(8.41)	(8.51)	(8.47)	3.25b	3.08b	3.17b	23042	12151	10891	1:1.90
T_6 – Chilli + barrier crop with sweet sorghum	59.80bc	56.60bc	58.00b	2.92bc	2.82bc	2.85bc	20992	11983	9009	1:1.75
	(8.23)	(8.02)	(8.10)							
T_7 - Chilli + border and barrier crop with sweet sorghum	75.30a	77.70a	76.10a	3.88a	3.84a	3.89a	30832	12785	18047	1:2.41
	(9.18)	(9.31)	(9.21)							
CV	6.59	7.52	6.61	6.34	6.50	5.26				
S. Em±	3.95	4.35	4.62	0.16	0.16	0.13				
C.D. at 5%	10.18	11.97	12.41	0.48	0.39	0.40				

Figures in parenthesis are arc sine transformed values ; In a column means followed by the same alphabet did not differ significantly by DMRT (p=0.05); Market price: Chilli – Rs. 8200/q

only, with a C:B ratio of 1:1.32. Shivaprasad *et al*. (2010) also reported that dry chilli yield increased to the extent of 150 and 120 per cent in the leeward and windward direction of barrier crop, respectively when compared to sole crop. Anandam and Doraiswamy (2007) further observed that chilli mosaic disease transmitted by aphids could be effectively managed by barrier crops *viz*., maize, sorghum and sunflower. Among all the treatments tried, maize or sorghum as a barrier crop with recommended insecticidal sprays to chilli crop was found to be better and effective in reducing the pest spread and thereby increasing yield.

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