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Impact of Cowpea-maize Intercropping and Bio-rational Product on Fall Armyworm, *Spodoptera frugiperda* (JE Smith) in Fodder Maize

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ABSTRACT

Background: A recent occurrence of fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith) a new invasive pest in Africa attained epidemic form in 2016. Consequently, researchers probed various ecofriendly methods to manage the pest. The effect of intercropping cowpea [*Vigna unguiculata* (L.) Walp.] with fodder maize (*Zea mays* L.) on the incidence of FAW was investigated.

Methods: The maize fodder was protected against FAW by intercropping with cowpea along with a biorational product, Brahamastra and compared with the recommended insecticide used to manage the insect by conducting field experiments during *kharif* 2020, 2021 and 2022 comprising the eight treatments *viz*. T1: Maize + Cowpea 1:1 ratio (unsprayed); T2: Maize + Cowpea 1:1 ratio (coragen @ 100 ml ha^{-1}); T3: Maize + Cowpea 1:1 ratio (brahamastra @ 12.5 litre ha^{-1} sprayed); T4: Maize sole (brahamastra @ 7.5 litre ha^{-1} sprayed); T5: Maize sole (brahamastra @ 10.0 litre ha^{-1} sprayed); T6: Maize sole (Brahamastra @ 12.5 litre ha^{-1} sprayed); T7: Maize sole (coragen 18.5 SC @ 100 ml ha^{-1} sprayed as standard check) and T8: Maize sole (Unsprayed). The plot size for each treatment was 500 m^2, demarcating 5 × 4 m^2 for sampling with three replications in a completely randomized design (CRBD).

Result: The treatments, Maize + Cowpea (1:1 row) (Coragen @ 100 ml ha^{-1} sprayed) and Maize sole (Coragen @ 100 ml ha^{-1} sprayed) though had significantly the lowest pooled pest incidence and the highest per cent reduction over control (PROC), the bio-rational applied on maize + Cowpea (1:1 row) (brahamastra @ 12.5 litre ha^{-1} sprayed) encounted the lowest pest incidence, the highest PROC combined with the highest fodder yield and economic returns without any statistical singnificant difference with Maize + Cowpea (1:1 row) (unsprayed).

Key words: Brahamastra, Coragen, Fall armyworm, Impact, Incidence, Maize-cowpea intercropping, PROC.

INTRODUCTION

A recent occurrence of fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith) a new invasive pest in Africa had attained epidemic form in 2016 drawing the attention of whole farming and scientific community. Since then it moved across the continent and into the Asia. Its larvae feed over the immature leaf whorls, ears and tassels in maize crop thereby causing considerable defoliation due to their veracious feeding behaviour with abundant faecal material left on the plant. The crop growth and development get eventually halted thereby causing no cob or tassle production (Raddy, 2019). Baudron *et al.* (2019) reported 11.57 per cent yield loss of maize due to the pest incidence ranging from 26.4-55.9 per cent. Potential sustainable pest management strategies include intercropping systems and use of beneficial microbes and botanical pesticides (Cook *et al*., 2004; Dalvi *et al*., 2011; Stockstand, 2017). Intercropping constitutes push-pull systems involving companion plants that act as the “push” component for pests, or planting companion plants at the boarders of main crops to act as the “pull” component (Khan *et al*., 2007; Cook *et al*., 2007; Midega *et al*., 2018). The use of synthetic insecticides as the sole control measure is unsustainable due to their high cost, increased pesticide resistance, pest resurgence and risks to human health and the environment.

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MATERIALS AND METHODS

Experimental site

The field trials of fodder maize (variety J 1006) were conducted at research area located at Integrated Farming System (IFS), School of Organic Farming in Punjab Agricultural University at Ludhiana in Punjab state.

Crop cultivation

The single cut maize fodder crop (variety J 1006) was raised during the *kharif* season in the year 2020, 2021 and 2022 on flat field in June, 2020, 2021 and 2022 by applying all farm inputs as per as per PAU package of practices for kharif crops (Anonymous, 2022).

Experimental treatments

In the experiment, maize plants were protected against fall armyworm using cowpea as an intercrop in a steady maize population. A total of eight treatments were designed with three replications each *viz*. T1: Maize + Cowpea 1:1 ratio (unsprayed); T2: Maize + Cowpea 1:1 ratio (coragen @ 100 ml ha^{-1} sprayed); T3: Maize + Cowpea 1:1 ratio (brahamastra @ 12.5 litre ha^{-1} sprayed); T4: Maize sole (Brahamastra @ 7.5 litre ha^{-1} sprayed); T5: Maize sole (Brahamastra @ 10.0 litre ha^{-1} sprayed); T6: Maize sole (Brahamastra @ 12.5 litre ha^{-1} sprayed); T7: Maize sole (Coragen 18.5 SC @ 100 ml ha^{-1} sprayed as standard check) and T8: Maize sole (Unsprayed). Of the plot size for each treatment 500 m^2, an area of 5 × 4 m^2 was demarcated for sampling.

Data recording on pest incidence

A systematic random sampling method was considered for selecting the maize samples from the assigned plots. Two sprays of the bio-rational products (Including chemical standard check) were applied, first at two weeks after sowing (WAS) and second application two weeks after first spray. The incidence of fall armyworm was recorded as per cent numbers of plants damaged by the pest as 2, 3, 4, 5, 6 and 7 WAS besides pre spray. The phytotoxic effects of the treatments were also noted down. The fodder crop was harvested at after eight weeks of sowing and fodder yield was recorded.

Experiment set up and statistical design

The experiment was set up in a randomized full block design using the CPCS 1 program (Cheema and Singh, 1990).

RESULTS AND DISCUSSION

Fortunately no phytotoxicity was observed in any of the treatments indicating the suitability of the inputs used.

FAW infested plants

The differences for pooled FAW infested plants in the treated and untreated plots being non-significant before first spray on maize fodder during 2020, 2021 and 2022 (Table 1-3). On pooled mean basis, T2: Maize + Cowpea (1:1 row) (Coragen @ 100 ml ha^{-1} sprayed) performed better with the lowest FAW infested plants, *i.e*., 6.80, 5.20 and 4.00 per cent and the highest PROC, *i.e*., 82.74, 86.17 and 89.11 per cent during 2020, 2021 and 2022, respectively. It was statistically at par with and T7: Maize sole (Coragen @ 100 ml ha^{-1} sprayed as standard check). Among other treatments, T6: Maize + Cowpea (1:1 row) (brahamastra @ 12.5 litre ha^{-1} sprayed) showed the lowest FAW infested plants, *i.e*., 17.60, 16.13 and 14.60 per cent and, the highest PROC, *i.e*., 55.33, 57.10 and 60.25 per cent during 2020, 2021 and 2022, respectively. It was statistically at par with T1: Maize + Cowpea (1:1 row) (unsprayed) (Table 1-3).

Fodder yield

In Table 4, the treatment, T2: Maize + Cowpea (1:1 row) (coragen @ 100 ml ha^{-1} sprayed) recorded the highest pooled fodder yield (432.56 q ha^{-1}) which was statistically at par with T7: Maize sole (Coragen @ 100 ml ha^{-1} sprayed) (429.28 q ha^{-1}). Among various bio-rational treatments, T3: Maize + Cowpea (1:1 row) (Brahamastra @ 12.5 litre ha^{-1} sprayed) yielded more fodder (406.78 q ha^{-1}) and was statistically at par with T1: Maize + Cowpea (1:1 row) (Unsprayed) (402.00 q ha^{-1}) and T6: Maize sole (Brahamastra @ 12.5 litre ha^{-1} sprayed) @ 395.83 q ha^{-1}). The fodder yield in T6: Maize sole (Brahamastra @ 12.5 litre ha^{-1} sprayed) was statistically at par with T4: Maize sole (Brahamastra @ 7.5 litre ha^{-1} sprayed) and T5: Maize sole (Brahamastra @ 10.0 litre ha^{-1} sprayed) (Table 4).

Economic returns

In Table 5, the treatment, T2: Maize + Cowpea (1:1 row) (Coragen @ 100 ml ha^{-1} sprayed) resulted in the highest economic returns (Rs. 23623.75 ha^{-1}) closely followed by T2: Maize sole (Coragen @ 100 ml ha^{-1} sprayed as standard check) (Rs.23213 ha^{-1}). Among the various bio-rational treatments, there was not much difference between economic returns in T1: Maize + Cowpea (1:1 row) (Unsprayed) and T3: Maize + Cowpea (1:1 row) intercropping (Brahamastra @ 12.5 litre ha^{-1} 100 ml ha^{-1} sprayed), *i.e*., Rs.22603.75 and 21638.75 ha^{-1}. It was followed by Maize sole (Brahamastra @ 12.5 litre ha^{-1} sprayed) (Rs. 20270.00 ha^{-1}).

Also, results of current investigations are in line with those of Chabi *et al*. (2005) who found the incidence of stem borer pests in the humid forest areas of Cameroon to be low in maize intercropped with cassava, cowpea and soybean than when monocropped. Current investigations for reduction of FAW with maize + cowpea intercropping was in full agreement with the findings by Hailu *et al.* (2018) who reported that intercropping maize with edible legumes could also reduce the abundance of FAW and stemborer compared to the mono-cropped maize. Harrison *et al*. (2019) also supported current investigations by reporting intercropping with appropriately selected companion plants as one of the important alternative to reduce the FAW incidence. Observations made by Firake (2019) that maize intercropping with legume crops (Maize + pigeonpea/black gram/mungbean) was effective to control FAW have supported the present studies. Findings by Tanyi *et al.* (2020) have also supported the present investigations by reporting beans push cropping systems in maize fields as viable sustainable alternative control measures for invasive FAW.

Table 1: Evaluation of cowpea intercropping and brahamastra for the management of fall armyworm on fodder maize (2020).

Treatment	Spray ha^{-1}	*Fall armyworm incidence (%)												
		2 WAS (BS)	3 WAS	PROC	4 WAS	PROC	5 WAS	PROC	6 WAS	PROC	7 WAS	PROC	Pooled mean	Pooled PROC
T1: Maize + Cowpea (1:1 row)	Unsprayed	9.33	9.00 (17.43)	54.24	16.33 (28.81)	46.15	20.67 (26.55)	54.07	24.33 (29.54)	52.29	22.33 (28.18)	56.21	18.40 (25.11)	53.30
T2: Maize + Cowpea (1:1 row)	Coragen @ 100 ml	9.00	2.33 (8.74)	88.14	8.00 (16.40)	73.63	6.67 (14.92)	85.19	10.00 (18.41)	80.39	7.00 (15.31)	86.27	6.80 (14.78)	82.74
T3: Maize + Cowpea (1:1 row)	Brahamastra @ 12.5 litre	8.67	8.00 (16.40)	59.32	15.00 (22.75)	50.55	19.33 (26.08)	57.04	23.67 (29.08)	53.59	22.00 (27.94)	56.86	17.60 (24.47)	55.33
T4: Maize sole	Brahamastra @ 7.5 litre	9.00	11.33 (19.66)	42.37	20.67 (27.02)	31.87	24.67 (29.75)	45.19	27.33 (31.51)	46.41	26.00 (30.64)	49.02	22.00 (27.22)	44.16
T5: Maize sole	Brahamastra @ 10.0 litre	9.00	10.67 (19.02)	45.76	20.00 (26.54)	34.07	24.00 (29.31)	46.67	26.33 (30.86)	48.37	25.33 (30.21)	50.33	21.27 (27.20)	46.02
T6: Maize sole	Brahamastra @12.5 litre	8.67	10.33 (18.71)	47.46	18.00 (25.08)	40.66	23.33 (28.85)	48.15	26.00 (30.64)	49.02	24.00 (29.32)	52.94	20.33 (26.53)	48.40
T7: Maize sole	Coragen @ 100 ml (Std ck)	8.67	2.67 (9.08)	86.44	7.67 (16.04)	74.73	6.67 (14.95)	85.19	8.00 (16.40)	84.31	7.67 (16.04)	84.97	6.54 (14.59)	83.40
T8: Sole maize	Unsprayed	9.00	19.67 (26.30)		30.33 (33.38)		45.00 (42.11)		51.00 (45.56)		51.00 (45.56)		39.40 (38.59)	
LSD (p=0.05)		NS	(2.04)		(2.30)		(2.01)		(1.60)		(2.05)		(2.55)	

Means of 3 replications; BS: Before spray; WAS: Week after sowing; Values in parentheses are arc sine transformed means.

Table 2: Evaluation of cowpea intercropping and brahamastra for the management of fall armyworm on fodder maize (2021).

Treatment	Spray ha^{-1}	*Fall armyworm incidence (%)												
		2 WAS (BS)	3 WAS	PROC	4 WAS	PROC	5 WAS	PROC	6 WAS	PROC	7 WAS	PROC	Pooled mean	Pooled PROC
T1: Maize + Cowpea (1:1 row)	Unsprayed	7.00	9.00 (17.43)	50.91	15.00 (22.75)	48.86	19.33 (26.07)	55.73	23.00 (28.64)	53.38	21.67 (27.69)	55.48	17.20 (24.25)	54.26
T2: Maize + Cowpea (1:1 row)	Coragen @ 100 ml	7.67	2.00 (7.94)	89.09	6.33 (14.56)	78.41	5.33 (13.33)	87.79	5.67 (13.72)	88.51	8.67 (17.11)	82.43	5.20 (12.84)	86.17
T3: Maize + Cowpea (1:1 row)	Brahamastra @ 12.5 litre	7.33	8.00 (16.40)	56.36	13.67 (21.67)	53.41	18.00 (25.09)	58.78	22.33 (28.17)	54.73	20.67 (26.99)	57.53	16.13 (23.40)	57.10
T4: Maize sole	Brahamastra @ 7.5 litre	8.00	11.67 (19.94)	36.36	19.33 (26.07)	34.09	23.33 (28.86)	46.56	26.00 (30.64)	47.30	25.00 (29.99)	48.63	20.67 (26.84)	45.03
T5: Maize sole	Brahamastra @ 10.0 litre	7.67	11.00 (19.35)	40.00	18.33 (25.33)	37.50	22.67 (28.41)	48.09	25.00 (29.98)	49.32	24.00 (29.32)	50.68	19.80 (26.21)	47.34
T6: Maize sole	Brahamastra @ 12.5 litre	7.67	10.00 (18.41)	45.45	16.67 (24.07)	43.18	22.00 (27.95)	49.62	24.67 (29.77)	50.00	22.67 (28.41)	53.42	18.80 (25.46)	50.00
T7: Maize sole	Coragen @ 100 ml (Std ck)	7.33	1.33 (6.53)	92.73	7.00 (15.31)	76.14	5.33 (13.33)	87.79	6.33 (14.56)	87.16	7.00 (15.31)	85.62	5.00 (12.53)	86.70
T8: Sole maize	Unsprayed	8.00	18.33 (25.33)		29.33 (32.74)		43.67 (41.34)		49.33 (44.60)		48.67 (44.22)		37.60 (37.50)	
LSD (p=0.05)		NS	(2.41)		(1.83)		(1.86)		(1.47)		(2.30)		(2.72)	

Means of 3 replications; BS: Before spray; WAS: Week after sowing; Values in parentheses are arc sine transformed means.

Table 3: Evaluation cowpea intercropping and brahamastra for the management of fall armyworm on fodder maize (2022).

Treatment	Spray ha^{-1}	*Fall armyworm incidence (%)												
		2 WAS (BS)	3 WAS	PROC	4 WAS	PROC	5 WAS	PROC	6 WAS	PROC	7 WAS	PROC	Pooled mean	Pooled PROC
T1: Maize + Cowpea (1:1 row)	Unsprayed	6.67	8.00 (16.34)	54.72	12.67 (20.80)	54.76	17.00 (24.33)	59.52	20.67 (27.02)	56.94	19.67 (26.27)	58.45	15.60 (22.99)	57.53
T2: Maize + Cowpea (1:1 row)	Coragen @ 100 ml	7.33	1.00 (4.62)	94.34	4.67 (12.45)	83.33	3.67 (11.01)	91.27	7.00 (15.31)	85.42	3.67 (10.95)	92.25	4.00 (11.13)	89.11
T3: Maize + Cowpea (1:1 row)	Brahamastra @ 12.5 litre	7.00	7.33 (15.65)	58.49	11.33 (19.65)	59.52	15.67 (23.30)	62.70	20.00 (26.54)	58.33	18.67 (25.55)	60.56	14.60 (22.16)	60.25
T4: Maize sole	Brahamastra @ 7.5 litre	6.67	9.33 (17.76)	47.17	17.00 (24.32)	39.29	21.00 (27.25)	50.00	24.00 (29.32)	50.00	23.00 (28.64)	51.41	18.87 (25.47)	48.63
T5: Maize sole	Brahamastra @ 10.0 litre	7.00	9.67 (18.04)	45.28	16.67 (24.08)	40.48	21.00 (27.25)	50.00	22.67 (28.41)	52.78	22.00 (27.96)	53.52	18.40 (25.17)	49.90
T6: Maize sole	Brahamastra @12.5 litre	7.33	8.33(16.75)	52.83	15.00 (22.77)	46.43	20.33 (26.79)	51.59	23.00 (28.64)	52.08	20.67 (27.02)	56.34	17.47 (24.40)	52.44
T7: Maize sole	Coragen @ 100 ml (Std ck)	7.33	2.00 (6.55)	88.68	5.33 (13.33)	80.95	3.00 (9.97)	92.86	5.33 (13.26)	88.89	4.33 (11.99)	90.85	4.00 (11.36)	89.11
T8: Sole maize	Unsprayed	7.00	17.67 (24.83)		28.00 (31.91)		42.67 (40.77)		48.00 (43.83)		47.33 (43.45)		36.73 (36.97)	
LSD (p=0.05)		NS	(4.18)		(1.59)		(1.47)		(1.70)		(2.38)		(2.86)	

Means of 3 replications; BS: Before spray; WAS: Week after sowing; Values in parentheses are arc sine transformed means.

Table 4: Effect of cowpea intercropping and brahamastra on fodder yield of maize.

Treatment	Spray ha^{-1}	Fodder yield (q ha^{-1})			
		2020	2021	2022	Pooled yield
T1: Maize + Cowpea (1:1 row)	Unsprayed	397.50	407.33	401.17	402.00
T2: Maize + Cowpea (1:1 row)	Coragen @ 100 ml	425.00	439.17	433.50	432.56
T3: Maize + Cowpea (1:1 row)	Brahamastra @ 12.5 litre	400.00	411.00	409.33	406.78
T4: Maize sole	Brahamastra @ 7.5 litre	382.50	396.33	396.17	391.67
T5: Maize sole	Brahamastra @ 10.0 litre	390.00	397.00	397.83	394.94
T6: Maize sole	Brahamastra @12.5 litre	389.00	399.00	399.50	395.83
T7: Maize sole	Coragen @ 100 ml (Std ck)	422.50	436.17	429.17	429.28
T8: Sole maize	Unsprayed	225.00	216.17	210.33	217.17
LSD (p=0.05)		16.45	4.88	3.79	8.59

Table 5: Economic returns for management of fall armyworm on fodder maize.

Treatment	Spray ha^{-1}	Yield (q ha^{-1})	Additional yield over control (q ha^{-1})	Gross returns (Rs./ha)	Cost of treatment (Rs./ha)	Net additional returns over control (Rs/ha)
T1: Maize + Cowpea (1:1 row)	Unsprayed	402.00	184.83	23103.75	500.00	22603.75
T2: Maize + Cowpea (1:1 row)	Coragen @ 100 ml	432.56	215.39	26923.75	3300.00	23623.75
T3: Maize + Cowpea (1:1 row)	Brahamastra @ 12.5 litre	406.78	189.61	23701.25	2062.50	21638.75
T4: Maize sole	Brahamastra @ 7.5 litre	391.67	174.50	21812.50	1250.00	20562.50
T5: Maize sole	Brahamastra @ 10.0 litre	394.94	177.77	22221.25	1500.00	20721.25
T6: Maize sole	Brahamastra @12.5 litre	395.83	178.66	22332.50	2062.50	20270.00
T7: Maize sole	Coragen @100 ml (Std ck)	429.28	212.11	26513.75	3300.00	23213.75
T8: Sole maize	Unsprayed	217.17	-	-	-	

Average price of maize fodder @ Rs.125/- per quintal; Preparation cost of Brahamastra @ Rs.20/litre; Cost of coragen @ Rs. 1400 per 100 ml.

The low incidence of FAW in maize-cowpea intercropping in present investigations is also in agreement with Bhagat *et al.* (2022) who reported maximum FAW reduction in maize when maize + cowpea grown regular in 1:1 row arrangement.

CONCLUSION

The results of the studies revealed that Maize + Cowpea (1:1 row) (Coragen @ 100 ml ha^{-1} sprayed) and Maize sole (Coragen @ 100 ml ha^{-1} sprayed) performed appreciably by suffering the lowest incidence pest and attaining the highest PROC and were also statistically at par with each other. A Devis scale based intensity of fall armyworm infested plants indicated significantly low level in Maize + Cowpea (1:1) (Brahamastra @ 12.5 litre ha^{-1} sprayed) which was statistically at par with Maize + Cowpea (1:1) intercropping (Unsprayed) among all the bio-rational treatments.

Considering the environmental safety and economics of crop production, maize intercropped with cowpea applied with brahamastra found to be judicial and sustainable way of fodder maize production.

Conflict of interest

All authors declared that there is no conflict of interest.

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