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DEVELOPMENT AND EVALUATION OF INTEGRATED PEST MANAGEMENT MODULE FOR CASTOR

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ABSTRACT : Field trials were conducted for three years during *kharif* season of 2014, 2015 and 2016 to evaluate the integrated pest management (IPM) module against major insect pests of castor in comparison with farmer's practice and untreated control. The results based on pooled data showed that the IPM module found to be the best in reducing the population of tobacco caterpillar (87.82 to 95.23% reduction over untreated control) and capsule borer damage (8.40% capsule damage) as compared to farmer's practice (58.65 to 71.22% reduction in tobacco caterpillar and 13.63% capsule damage). The IPM module provided 84.95 to 90.71% reduction in semilooper population and 97.17% reduction in leafhopper population and found on par with farmer's practice (94.19 to 99.11% reduction in semilooper population and 97.81% reduction in leafhopper population). IPM module recorded significantly more number of cocoons of larval parasitoids (*Snellenius maculipennis*) of semilooper and tobacco caterpillar (*Apanteles* sp.) as compared to farmer's practice. IPM module also resulted higher mean seed yield (1409 kg/ha), net returns (Rs. 22573/ha) and benefit cost ratio (1.84) as compared with farmer's practice (seed yield of 1225 kg/ha, net returns of Rs. 17003/ha and benefit cost ratio of 1.66). Hence, the IPM module consisting of application of *Bacillus thuringiensis* var. *kurstaki* against semilooper, monitoring of *S. litura* using pheromone trap, collection and destruction of gregarious stages of defoliators, ETL based application of flubendiamide 39.35 SC against lepidopteran defoliators and profenofos 50 EC against capsule borer and leafhopper can be used for effective, economic and eco-friendly management of insect pests in castor.

Key words : Castor, insect pests, IPM module, efficacy, economics.

INTRODUCTION

Castor (*Ricinus communis* L.) is known for its diversified uses in industrial, medical and agriculture sectors. India accounts for nearly 66.5 and 82.9 per cent of world's castor area and production, respectively. The current castor production in the country is 17.33 lakh tonnes from 11.05 lakh hectares with a productivity of 1568 kg/ha (DES, 2016). One of the major constraints in exploiting higher productivity in castor is the excessive damage caused by insect pests. Among them semilooper (*Achaea janata* L.), tobacco caterpillar (*Spodoptera litura* F.), capsule borer (*Conogethes punctiferalis* Guen.) and leafhopper (*Empoasca flavescens* F.) are of greater economic importance. The magnitude of the insect pest problem is quite high in Southern India where castor is grown mainly as rainfed crop, resulting in low seed yields. It is estimated that castor yields are reduced by 17.2 to 63.3% due to the insect pests during *kharif* season (Lakshminarayanana and Duraimurugan, 2014). So far, the use of organophosphorus has been the major approach for controlling the insect pests in castor. However, repeated applications of broad spectrum insecticides with similar mode of action may result in development of resistance in insects, pest resurgence and toxic effect on natural enemies. At present, the main aim in pest management is to bring down the insect pests population below Economic Threshold Level (ETL) rather than eradication. Hence, it is necessary to adopt holistic approach with IPM in order to avoid economic damage. In recent years, wide range of techniques such as biological and chemical methods have been developed for effective management of insect pests of castor. The microbial formulation *viz*., *Bacillus thuringiensis* var. *kurstaki* found effective in reducing semilooper (*A. janata*) population (Duraimurugan *et al*, 2015). The new molecule with novel mode of action *viz*., flubendiamide found very effective against lepidopteran pests in castor (Duraimurugan and Lakshminarayanana, 2014). So keeping in view the status of insect pests and their potential natural enemies, the present study was taken up to develop and evaluate an IPM module for management of insect pests of castor.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* season of the year 2014, 2015 and 2016 at Narkhoda Farm, ICAR-Indian Institute of Oilseeds Research, Hyderabad to evaluate IPM module in comparison with farmer's practice and untreated control as check. For the purpose, castor hybrid DCH-519 was raised in larger plots of 600 m^2 for each treatment with a spacing of 90 cm between rows and 90 cm between plants. The IPM module comprised of application of *Bacillus thuringiensis* var. *kurstaki* (Delfin WG™) @1g/l against semilooper once the larval population exceeds the ETL of 3-4 early instar larvae/plant, monitoring of *S. litura* using pheromone trap @ 4/acre, collection and destruction of gregarious stages of lepidopteran defoliators, application of flubendiamide 39.35 SC @ 0.2ml/l against lepidopteran defoliators at 25% foliage damage and profenofos 50 EC @ 1ml/l against capsule borer and leafhopper at 10% capsule damage or 10% hopper burn damage. Farmer's practice involved four sprays of acephate 75SP @ 1.5 g/l, while the crops were grown under unprotected conditions in untreated control. The insecticides in the treatments were applied with the help of knapsack sprayer and the spray volume was 500 l/ha. To avoid the drift of insecticide and to reduce the movement of pests and natural enemies from one plot to another, the plots were separated by a distance of 4 m. All the plots received recommended agronomic practices except the treatment operations. In each module, pretreatment and post treatment (3, 7 and 14 days after imposing treatments) populations of insect pests and natural enemies per plant were recorded on three plants in eight blocks of 50m^2 (each considered as one replication) and the mean insect or natural enemies numbers per plant was worked out. In each harvest, the data on total number of capsules and number of capsules damaged by the capsule borer was recorded from each block and then per cent capsule damage was worked out. The yield was recorded on each block individually by spike order (at the time of harvest of each primary, secondary and tertiary), which was converted to kg/ha for statistical interpretations. The economics of treatments was calculated. Treatment effects were analyzed using Randomized Block Design with eight replications. The data on numbers were transformed into square root values and per cent transformed into arc sine values and subjected to analysis of variance (ANOVA) through MSTAT-C software. Pooled analysis was carried out for three years.

RESULTS AND DISCUSSION

Effect of IPM module on the incidence of insect pests

Semilooper (*Achaea janata*), tobacco caterpillar (*Spodoptera litura*), capsule borer (*Conogethes punctiferalis*) and leafhopper (*Empoasca flavescens*) were recorded as major pests during all the three years. Sporadic incidence of hairy caterpillar, *Euproctis fraterna* Moore was recorded during *kharif* 2014 and 2016, while hairy caterpillar, *Ergolis* (*Ariadne*) *merione* (Cramer) was recorded during *kharif* 2015. During all the three years, similar type of pest succession was observed. Two peak incidence of semilooper was noticed during seedling and vegetative stages. Two peak incidence of tobacco caterpillar was observed during vegetative and reproductive stages. Incidence of capsule borer, leafhopper and hairy caterpillars was observed during reproductive stage. The results of pooled data of the three years (*kharif* 2014-16) on the effectiveness of IPM module along with farmer's practice and untreated control against the major insect pests are presented in Table 1. During seedling stage, semilooper was managed by application of *Btk* in IPM module and by applying acephate in farmer's practice. Farmer's practice was significantly superior in reducing semilooper incidence with minimum mean population of 0.27 larvae/plant as compared to 0.70 larvae/plant in IPM module. Per cent reduction in semilooper population over the untreated control was 94.19% in farmer's practice, whereas, it was 84.95% in IPM module. During vegetative stage, incidence of tobacco caterpillar and semilooper was managed by mechanical removal of gregarious stages of the larvae in IPM module and by applying acephate in farmer's practice. Mechanical removal in IPM module resulted in very good reduction in the population of *S. litura* larvae (mean population of 1.19 larvae/plant and 87.82% reduction over untreated control) as compared with acephate application in farmer's practice (mean population of 4.04 larvae/plant and 58.65% reduction over untreated control). Acephate application in farmer's practice found effective against semilooper (mean population 0.02 larvae/plant and 99.11% reduction over untreated control) as against IPM module with 0.21 larvae/plant and 90.71% reduction over untreated control. Flubendiamide and acephate was sprayed against *S. litura* during reproductive stage at 25% foliage damage in IPM module and farmer's practice, respectively. Spraying of flubendiamide against *S. litura* in IPM module registered significantly low mean population of 0.59 larvae/plant with 95.23% reduction over untreated control, while mean population of 3.56 larvae/plant and 71.22% reduction over control was recorded in farmer's practice. Profenofos in IPM module and acephate in farmers practice was sprayed against leafhopper, hairy caterpillars and capsule borer during reproductive stage. Both IPM module and farmer's practice were found to be on par in reducing the population of leafhopper (mean population of 0.53 and 0.41 leafhoppers/3 leaves/plant and 97.17% and 97.81% reduction over control, respectively) and hairy caterpillars (mean population of

Table 1 : Effect of IPM module against major insect pests in castor (Pooled mean of *kharif* 2014, 2015 and 2016).

Module	*Semilooper (No. of larvae/plant)						@Semilooper (No. of larvae/plant)					
	PTC	3 DAT	7 DAT	14 DAT	Mean	% Reduction	PTC	3 DAT	7 DAT	14 DAT	Mean	% Reduction
IPM	6.40(2.62)	1.25(1.31)	0.40(0.94)	0.46(0.97)	0.70	84.95	2.58(1.75)	0.28(0.88)	0.12(0.79)	0.22(0.85)	0.21	90.71
Farmer's practice	5.28(2.40)	0.53(1.01)	0.12(0.78)	0.17(0.81)	0.27	94.19	1.83(1.51)	0.03(0.73)	0.0(0.71)	0.04(0.73)	0.02	99.11
Untreated control	5.39(2.42)	5.83(2.51)	4.49(2.23)	3.62(2.03)	4.65	-	3.78(2.06)	2.88(1.83)	2.0(1.58)	1.90(1.55)	2.26	-
CD(P=0.05)	0.17	0.18	0.15	0.11	-	-	0.19	0.09	0.05	0.06	-	-
	@*Spodoptera litura* (No. of larvae/plant)						#*Spodoptera litura* (No. of larvae/plant)					
IPM	8.51(2.99)	1.9(1.55)	0.61(1.05)	1.07(1.25)	1.19	87.82	10.67(3.33)	0.85(1.16)	0.49(0.99)	0.44(0.97)	0.59	95.23
Farmer's practice	8.53(2.98)	3.96(2.11)	3.76(2.06)	4.39(2.20)	4.04	58.65	10.44(3.30)	4.13(2.15)	3.36(1.96)	3.20(1.92)	3.56	71.22
Untreated control	9.17(3.09)	10.56(3.32)	8.71(3.03)	10.04(3.22)	9.77	-	11.43(3.45)	14.11(3.81)	11.6(3.48)	11.4(3.45)	12.37	-
CD(P=0.05)	NS	0.15	0.18	0.19	-	-	NS	0.24	0.12	0.15	-	-
	$Hairy caterpillars (No. of larvae/plant)						$Leafhopper (No./3 leaves/plant)					
IPM	1.39(1.37)	0.10(0.77)	0.0(0.71)	0.0(0.71)	0.03	98.37	16.53(4.08)	0.72(1.10)	0.21(0.84)	0.65(1.07)	0.53	97.17
Farmer's practice	1.28(1.33)	0.12(0.79)	0.07(0.75)	0.04(0.73)	0.08	95.65	13.67(3.74)	0.50(1.10)	0.12(0.79)	0.61(1.05)	0.41	97.81
Untreated control	2.35(1.68)	2.57(1.75)	1.78(1.51)	1.18(1.29)	1.84	-	21.54(4.67)	21.85(4.71)	18.54(4.36)	15.72(4.02)	18.70	-
CD(P=0.05)	0.16	0.09	0.05	0.06	-	-	0.41	0.24	0.18	0.14	-	-

PTC – Pre treatment count; DAT-Days after treatment; Figures in parentheses are square root transformed values; *- Observations before and after application of Bt in IPM module and acephate in farmer's practice; @- Observations before and after mechanical control in IPM module and acephate application in farmer's practice; #- Observations before and after application of flubendiamide in IPM module and acephate in farmer's practice; $- Observations before and after application of profenofos in IPM module and acephate in farmer's practice.

0.03 and 0.08 larvae/plant and 98.37% and 95.65% reduction over control, respectively). IPM module was the best with reference to capsule borer recorded significantly lower infestation of 8.40% capsule damage as compared to farmer's practice (13.63%) and untreated control (21.07%) (Table 3).

Over reliance on chemical pesticides without regard to complexities of the agroecosystem has resulted in many problems like pest resistance to pesticides, secondary pest outbreak and pest resurgence besides increased plant protection expenses. IPM programmes are an attempt to promote favourable ecological, economic and sociological outcomes, which is accomplished by the best mix of pest control tactics together. In the present study, an IPM module has been developed based on effective non-chemical and chemical plant protection technologies identified in the recent years (Duraimurugan *et al*, 2014; Duraimurugan *et al*, 2015; Duraimurugan and Lakshminarayanana, 2014) and evaluated in castor. Results of present investigation revealed that the IPM module found to be best in reducing the population of *S. litura* and capsule borer damage as compared to farmer's practice and found on par with chemical intensive farmer's practice in reducing the population of semilooper, leafhopper and hairy caterpillars. The results were in accordance with the findings of Suganthy (2010), Hegde *et al* (2011), Rathod and Bhosle (2014a) who reported effective management of insect pests with IPM module as compared with the use of conventional insecticides in castor, groundnut and soybean, respectively. Ineffectiveness of farmer's practice against *S. litura* may be due to insecticide resistance in the insect to acephate commonly used by the farmer's (Chandrayudu *et al*, 2015).

Effect of IPM module on the occurrence of natural enemies

Statistical analysis revealed that among the treatments, untreated control was significantly superior in conserving larval parasitoids of semilooper, *Snellenius* (*Microplitis*) *maculipennis* and tobacco caterpillar, *Apanteles* sp. followed by IPM module (Table 2). Higher number of cocoons of *S. maculipennis* and *Apanteles* sp. was observed in untreated control (0.93 to 1.26 and 1.29 to 1.52 cocoons/plant, respectively) and IPM module (0.54 to 0.58 and 0.28 to 0.74 cocoons/plant, respectively) and which were lowest in farmer's practice (0.03 to 0.16 and 0.05 to 0.09 cocoons/plant). Significantly higher number of *S. maculipennis* and *Apanteles* sp.

Table 2 : Effect of IPM module on parasitoids of semilooper and tobacco caterpillar in castor (Pooled mean of *kharif* 2014, 2015 and 2016).

Module	***S. maculipennis parasitoid cocoon/plant**					**@S. maculipennis parasitoid cocoon/plant**				
	PTC	3 DAT	7 DAT	14 DAT	Mean	PTC	3 DAT	7 DAT	14 DAT	Mean
IPM	1.04(1.23)	0.89(1.17)	0.58(1.03)	0.28(0.88)	0.58	0.79(1.13)	0.47(0.98)	0.74(1.11)	0.42(0.95)	0.54
Farmer's practice	1.54(1.40)	0.35(0.92)	0.10(0.77)	0.04(0.73)	0.16	0.28(0.88)	0.10(0.77)	0.0(0.71)	0.0(0.71)	0.03
Untreated control	1.21(1.29)	1.35(1.35)	0.78(1.12)	0.67(1.07)	0.93	1.24(1.31)	1.42(1.37)	1.53(1.42)	0.83(1.15)	1.26
CD(P=0.05)	NS	0.10	0.14	0.12	-	0.11	0.12	0.10	0.07	-
	@Apanteles parasitoid cocoon/plant					**#Apanteles parasitoid cocoon/plant**				
IPM	0.81(1.14)	0.79(1.13)	0.82(1.14)	0.61(1.05)	0.74	0.78(1.12)	0.38(0.93)	0.28(0.88)	0.17(0.81)	0.28
Farmer's practice	0.60(1.04)	0.08(0.76)	0.0(0.71)	0.08(0.76)	0.05	0.75(1.11)	0.18(0.82)	0.06(0.74)	0.03(0.73)	0.09
Untreated control	1.57(1.42)	1.65(1.46)	1.68(1.47)	1.22(1.31)	1.52	1.19(1.30)	1.42(1.38)	1.47(1.40)	0.99(1.21)	1.29
CD(P=0.05)	0.20	0.11	0.11	0.10	-	0.15	0.10	0.10	0.10	-

PTC – Pre treatment count; DAT-Days after treatment; Figures in parentheses are square root transformed values; *- Observations before and after application of Bt in IPM module and acephate in farmer's practice; @- Observations before and after mechanical control in IPM module and acephate application in farmer's practice; #- Observations before and after application of flubendiamide in IPM module and acephate in farmer's practice.

Table 3 : Capsule damage, seed yield and economics of IPM module in castor (Pooled mean of *kharif* 2014, 2015 and 2016).

Module	Capsule damage due to capsule borer (%)	Seed yield (kg/ha)	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	BC ratio
IPM module	8.40 (15.78)*	1409	49327	26754	22573	1.84
Farmer's practice	13.63 (21.66)	1225	42875	25872	17003	1.66
Untreated control	21.07 (27.31)	877	30695	21272	9423	1.44
CD(P=0.05)	1.07	69.07	-	-	-	-

*Figures in parentheses are arc sine values.

cocoons in IPM module may be due to reduced use of chemical insecticides supplemented with biopesticide, *Btk* against semilooper during seedling stage and self-perpetuation of the parasitoids on the leftover population of the semilooper and tobacco caterpillar after mechanical removal. On the other hand, application of chemical insecticides in farmer's practice reduced the population of both insect pests and their parasitoids. The findings of the present investigation are more or less similar to those of Suganthy (2010) and Duraimurugan *et al* (2015), who observed higher population of the parasitoids in the treatments involving use of non-chemical approaches over foliar application of chemical insecticides.

Effect of IPM module on yield and economics

Significant impact of IPM module and farmer's practice over untreated control in consideration of yield was noted. IPM module exhibited higher mean seed yield (1409 kg/ha) followed by farmer's practice (1225 kg/ha) as against the lowest yield (877 kg/ha) in untreated control (Table 3). Net profit in IPM module was relatively higher (Rs. 22573/ha) than farmer's practice (Rs. 17003/ha). The IPM module registered the maximum benefit-cost of 1.84 as compared to farmer's practice (1.66) and untreated control (1.44) (Table 2). Earlier workers have also reported that IPM module provided higher net returns, yield and benefit cost ratio over the farmer's practices in castor (Basappa, 2007), groundnut (Hegde *et al*, 2011) and soybean (Rathod and Bhosle, 2014b). The results obtained in the study are in consonance with those previous workers.

Considering efficacy, economics and safety to natural enemies, the present study thus revealed that IPM module comprised of application of *Bacillus thuringiensis* var. *kurstaki* (Delfin WG™) @1g/l against semilooper once the larval population crosses the ETL of 3-4 early instar larvae/plant, monitoring of *S. litura* using pheromone trap @ 4/acre, collection and destruction of gregarious stages of lepidopteran defoliators, application of flubendiamide 39.35 SC @ 0.2ml/l against lepidopteran defoliators at 25% foliage damage and profenofos 50 EC @ 1ml/l against capsule borer and leafhopper at 10% capsule damage or 10% hopper burn damage can be used for effective management of insect pests in castor.

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