Assessment of avoidable yield losses due to insect pests in castor (*Ricinus communis* L.)

M LAKSHMINARAYANA AND P DURAIMURUGAN

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, Telangana

(Received: December, 2014; Revised: December, 2014; Accepted: December, 2014)

ABSTRACT

Field experiments were carried out to evaluate the avoidable yield losses caused by insect pests on three castor cultivars (DCH-519, DCH-177 and 48-1) during *kharif* and *rabi* seasons of 2012-13 and 2013-14. Semilooper, tobacco caterpillar, hairy caterpillar, capsule borer and leafhopper were recorded as major pests. However, the pest succession varied with the season. The results revealed that significantly lower infestation of insect pests was observed in protected plots over unprotected plots. Higher mean seed yield of 1996 kg/ha and 1596 kg/ha was recorded from protected plots, while seed yield of 1421 kg/ha and 750 kg/ha was recorded from unprotected plots during *kharif* 2012-13 and 2013-14, respectively. During *rabi* season, higher mean seed yield of 1050 kg/ha and 927 kg/ha was recorded in protected plots, while unprotected plots recorded seed yield of 542 kg/ha and 375 kg/ha during 2012-13 and 2013-14, respectively. The mean avoidable yield losses due to insect pests on castor cultivars ranged from 17.2 to 63.3 per cent during *kharif* season, while the loss was higher (22.5 to 89.4%) during *rabi* season. Among the cultivars, DCH-519 revealed minimum avoidable yield losses due to insect pests in both *kharif* and *rabi* seasons.

Keywords: Avoidable yield loss, Castor, Cultivars, Insect pests, Pest succession

Castor (*Ricinus communis* L.) is an industrially important oilseed crop of India. The crop is attacked by a number of insect pests which impose a great limitation in realizing the potential productivity. Among the insect pests, semilooper, tobacco caterpillar, leafhopper and capsule borer are of greater economic importance (Lakshminarayana *et al*., 2013). The magnitude of the insect pests problem is quite high in Southern India where castor is grown mainly as rainfed crop, while it is low in Gujarat and Rajasthan under irrigated conditions (Lakshminarayana, 2005). Development of Integrated Pest Management strategies for each agro-ecological zone to exploit full yield potential is the need of the day. Information on crop losses is prerequisite to determine the relative importance of pests and to provide a sound base for an integrated management schedule. Yield loss in castor due to defoliation by semilooper and capsule damage by capsule borer was worked out in South India (Anonymous, 2006; Rao *et al*., 2012). However, information on the yield loss due to insect pest complex as a whole in castor is scanty. Hence, the present study was undertaken with the main objective of generating data on the avoidable yield losses caused by insect pests during *kharif* and *rabi* seasons in castor.

MATERIALS AND METHODS

Field experiments were conducted at Research Farm, Directorate of Oilseeds Research, Hyderabad during *kharif* and *rabi* seasons of 2012-13 and 2013-14 with three castor cultivars *viz.*, DCH-519, DCH-177 and 48-1 under protected and unprotected conditions. Each cultivar was sown (I^{st} fortnight of July and October during *kharif* and *rabi* seasons, respectively) in two plots, each of size 100 m^2 with a spacing of 90 cm x 90 cm. All agronomic practices were followed as per the recommendations except for insect-pest management. Unprotected plots were kept free from insecticides and subjected to the natural infestation of the insect pests. Whereas, protected plots were treated with foliar application of monocrotophos 0.04% at 15-20 days intervals starting from seedling stage to the maturity stage of the crop. In each treatment, the plot was divided in to four blocks (each block of 25 m^2, considering each as one replicate) and the observations of insect pests were taken from five randomly selected plants in each block at fortnightly intervals. 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. Mean insect numbers and per cent damage across sampling intervals were determined to provide a single index of pest population for making comparison across treatments. The final pooled mean data was analyzed and presented. 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. Treatment effects were analyzed using Factorial Randomized Block Design with four replications. Following ANOVA, differences between datasets were determined using least significant difference at P=0.05 using

AGRES statistical software. The avoidable yield loss was calculated using the following formula:

$$\text{Per cent avoidable yield loss} = \frac{\text{Yield in protected crop - Yield in unprotected crop}}{\text{Yield in protected crop}} \times 100$$

RESULTS AND DISCUSSION

Data on the incidence of major insect pests and yield losses caused by them were assessed in three castor cultivars (DCH-519, DCH-177 and 48-1) during *kharif* 2012-13 and 2013-14 is presented in Tables 1 and 2. Semilooper (*Achaea janata*), tobacco caterpillar (*Spodoptera litura*), hairy caterpillar (*Euproctis fraterna*), capsule borer (*Conogethes punctiferalis*) and leafhopper (*Empoasca flavescens*) were recorded as major insect pests during *kharif* season. Incidence of semilooper and tobacco caterpillar was noticeable throughout the crop season. Capsule borer and leafhopper were observed during reproductive stage and remained active till crop maturation. Hairy caterpillar recorded as major pest during *kharif* 2013-14 and its incidence appeared during reproductive stage and continued throughout the growing season. Significantly less population of the insect pests on all three cultivars was registered in protected crop than in unprotected crop (Table 1). The mean population of semilooper (0.9 and 0.6 larvae/plant), *S. litura* (0.08 and 1.2 larvae/plant), leafhopper (19.3 and 12.4 leafhoppers/3 leaves/plant) and capsule borer (6.2 and 7.1% capsule damage) was low in protected plots as compared to unprotected plots (4.2 and 2.4 semilooper larvae/plant; 0.3 and 4.0 *S. litura* larvae/plant; 68.0 and 52.2 leafhoppers/3 leaves/plant; 8.1 and 15.8% capsule damage) during *kharif* 2012-13 and 2013-14, respectively. Similarly, mean population of hairy caterpillar recorded during *kharif* 2013-14 was low in protected plots (0.3 larvae/plant) as compared to untreated plots (0.9 larvae/plant).

Table 1 Population of insect pests on castor under protected and unprotected conditions during *kharif* (2012-13 and 2013-14)

Kharif (2012-13)

Cultivar	Semilooper (larvae/plant)$		*Spodoptera litura* (larvae/plant)$		Leafhopper (No./3 leaves/plant)$		Capsule damage (%)#	
	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
DCH-519	0.7 (1.1)	3.4 (1.9)	0.03 (0.7)[a]	0.1 (0.8)[a]	15.6 (4.0)	45.3 (6.7)	7.0 (15.3)	9.7 (18.1)
DCH-177	0.9 (1.2)	4.5 (2.2)	0.1 (0.8)[a]	0.3 (0.9)[b]	24.6 (4.9)	87.0 (9.2)	7.2 (15.6)	8.6 (17.0)
48-1	1.1 (1.3)	4.8 (2.3)	0.1 (0.8)[a]	0.6 (1.0)[b]	17.7 (4.3)	71.7 (8.5)	4.5 (12.1)	6.1 (14.3)
Mean	0.9 (1.2)[a]	4.2 (2.1)[b]	0.08 (0.8)[a]	0.3 (0.9)[b]	19.3 (4.4)[a]	68.0 (8.1)[b]	6.2 (14.3)[a]	8.1 (16.5)[b]

	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±
Plant Protection (P)	*	0.20	0.10	*	0.05	0.02	*	0.99	0.47	*	1.54	0.72
Cultivars (C)	NS	-	0.11	*	0.06	0.03	*	1.22	0.57	*	1.88	0.88
Interaction (PxC)	NS	-	0.16	*	0.08	0.04	NS	-	0.81	NS	-	1.25

Kharif (2013-14)

Cultivar	Semilooper (larvae/plant)$		*Spodoptera litura* (larvae/plant)$		Hairy caterpillar (larvae/plant)$		Leafhopper (No./3 leaves/plant)$		Capsule damage (%)#	
	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
DCH-519	0.7 (1.1)	2.8 (1.8)	0.9 (1.2)	4.6 (2.3)	0.2 (0.8)	0.7 (1.1)	6.2 (2.6)[a]	20.2 (4.5)[b]	6.8 (15.0)	16.6 (24.0)
DCH-177	0.2 (0.8)	2.3 (1.7)	1.2 (1.3)	3.6 (2.0)	0.3 (0.9)	0.7 (1.1)	16.4 (4.1)[b]	81.1 (9.0)[d]	7.9 (16.1)	17.2 (24.4)
48-1	0.8 (1.1)	2.0 (1.6)	1.4 (1.4)	3.7 (2.0)	0.3 (0.9)	1.3 (1.3)	14.7 (3.9)[b]	55.2 (7.4)[c]	6.7 (15.0)	13.7 (21.6)
Mean	0.6 (1.0)[a]	2.4 (1.7)[b]	1.2 (1.3)[a]	4.0 (2.1)[b]	0.3 (0.9)[a]	0.9 (1.2)[b]	12.4 (3.5)[a]	52.2 (7.0)[b]	7.1 (15.4)[a]	15.8 (23.3)[b]

	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±
Plant Protection (P)	*	0.15	0.07	*	0.17	0.08	*	0.11	0.05	*	0.53	0.25	*	2.26	1.06
Cultivars (C)	NS	-	0.09	NS	-	0.10	NS	-	0.06	*	0.65	0.30	NS	-	1.30
Interaction (PxC)	NS	-	0.13	NS	-	0.14	NS	-	0.09	*	0.91	0.43	NS	-	1.84

* - Significant; NS- Non Significant $Figures in the parentheses are square root transformed values; #Figures in parentheses are arc sin transformed values
In a column means followed by the same alphabet do not differ significantly by LSD (P=0.05)

Significantly higher seed yield was recorded in protected plots over unprotected plots during both *kharif* 2012-13 and 2013-14 (Table 2). The data revealed that a higher mean seed yield of 1775 to 2275 kg/ha with an average of 1996 kg/ha and 1484 to 1776 kg/ha with an average of 1596 kg/ha was recorded from protected plots, while the mean seed yield of 1075 to 1813 kg/ha with an average of 1421 kg/ha and 286 to 1298 kg/ha with an average of 750 kg/ha was recorded from unprotected plots during *kharif* 2012-13 and 2013-14, respectively. The avoidable yield losses due to

insect pests on different cultivars of castor ranged from 20.3 (DCH-519) to 44.5 per cent (DCH-177) with an average of 29.1 per cent and 12.5 (DCH-519) to 83.9 per cent (DCH-177) with an average of 50.9 per cent during *kharif* 2012-13 and 2013-14, respectively. On basis of pooled results of *kharif* 2012-13 and 2013-14, the avoidable yield losses due to insect pests on different cultivars of castor ranged from 17.2 (DCH-519) to 63.3 per cent (DCH-177) with an average of 39.5 per cent.

Table 2 Avoidable yield losses due to insect pests in castor during *kharif* (2012-13 and 2013-14)

Cultivar	*Kharif* 2012-13				*Kharif* 2013-14				Pooled Mean			
	Yield (kg/ha)			% avoidable loss	Yield (kg/ha)			% avoidable loss	Yield (kg/ha)			% avoidable loss
	Protected	Unprotected	Mean		Protected	Unprotected	Mean		Protected	Unprotected	Mean	
DCH-519	2275	1813	2044[a]	20.3	1484[b]	1298[c]	1391[a]	12.5	1880	1556	1718	17.2
DCH-177	1938	1075	1507[b]	44.5	1776[a]	286[e]	1031[b]	83.9	1857	681	1269	63.3
48-1	1775	1375	1575[b]	22.5	1528[b]	666[d]	1097[b]	56.4	1652	1021	1337	38.2
Mean	1996[a]	1421[b]	1709	29.1	1596[a]	750[b]	1193	50.9	1796	1086	1441	39.5
	F-test	CD at 5%	SEm±	-	F-test	CD at 5%	SEm±	-	F-test	CD at 5%	SEm±	-
Plant Protection (P)	*	212	99	-	*	106	50	-	*	126	59	-
Cultivars (C)	*	260	122	-	*	130	61	-	*	155	73	-
Interaction (PxC)	NS	-	172	-	*	183	86	-	*	219	103	-

* - Significant; NS- Non Significant

The incidence of insect pests during *rabi* season was found similar as *kharif* season and semilooper, tobacco caterpillar, hairy caterpillar, leafhopper and capsule borer were recorded as major insect pests during *rabi* season. However, variation in pest succession was observed during *rabi* season. Leafhoppers appeared in seedling stage and remained active till crop maturation. Tobacco caterpillar, semilooper and hairy caterpillar also appeared in seedling stage and remained active till vegetative stage. Capsule borer was observed during reproductive stage and continued throughout the season. The incidence of pests was found significantly lower in protected plots as compared to the untreated plots during both the years (Table 3). The mean population of leafhopper (27.4 and 14.1 leafhoppers/3 leaves/plant), *S. litura* (0.03 and 0.4 larvae/plant), semilooper (0.4 and 0.2 larvae/plant), hairy caterpillar (0.3 and 0.1 larvae/plant) and capsule borer (1.0 and 8.5% capsule damage) was low in protected plots as compared to unprotected plots (88.8 and 53.8 leafhoppers/3 leaves/plant; 0.3 and 1.7 *S. litura* larvae/plant; 1.2 and 1.2 semilooper larvae/plant; 1.8 and 1.2 hairy caterpillar larvae/plant; 2.5 and 14.1% capsule damage) during *rabi* 2012-13 and 2013-14, respectively.

Higher seed yield of 988 to 1100 kg/ha with an average of 1050 kg/ha and 686 to 1064 kg/ha with an average of 927 kg/ha was recorded in protected crops during *rabi* 2012-13 and 2013-14, respectively. Castor cultivars under unprotected conditions recorded minimum seed yield of 525 to 888 kg/ha with an average of 542 kg/ha and 0 to 762 kg/ha with an average of 375 kg/ha during *rabi* 2012-13 and 2013-14, respectively. Among the cultivars, yield of 48-1 and DCH-519 was maximum (1100 kg/ha and 1064 kg/ha) in protected conditions during *rabi* 2012-13 and 2013-14, respectively. Seed yield of DCH-177 was higher in protected conditions (988 kg/ha and 1030 kg/ha during *rabi* 2012-13 and 2013-14, respectively), while DCH-177 under unprotected conditions suffered heavy loss due to insect pests especially due to leafhopper resulted minimum seed yield of 213 kg/ha during *rabi* 2012-13 and complete failure of crop during *rabi* 2013-14. Among the castor cultivars, yield of DCH-519 was maximum under unprotected conditions (888 kg/ha and 762 kg/ha during *rabi* 2012-13 and 2013-14, respectively) (Table 4). The avoidable yield losses due to insect pests on different cultivars of castor ranged from 16.5 (DCH-519) to 78.4 per cent (DCH-177) with an average of 49.1 per cent and 28.4 (DCH-519) to 100 per cent (DCH-177) with an average of 58.5 per cent during *rabi* 2012-13 and 2013-14, respectively. Pooled means of the two years data revealed that the avoidable yield losses due to insect pests on different cultivars of castor ranged from 22.5 (DCH-519) to 89.4 per cent (DCH-177) with an average of 54.1 per cent.

The insect pest complex of crops has undergone a tremendous change during the last two decades due to change in cropping pattern, introduction of high yielding cultivars and insecticide application pattern (Kooner *et al.,* 2006). Some major pests have become insignificant, while others continue to remain serious. On the other hand, some species, which were of minor importance in the past, have become dominant pests, and others that were never reported have appeared. This kind of shift in the pest complex necessitates the continuous monitoring and review of the pest complex and their succession for developing effective pest management strategies. The incidence of major pests in castor recorded in the present study revealed that semilooper, *S. litura*, capsule borer and leafhopper continue to remain as major pests during *kharif* and *rabi* seasons. Similar findings were also reported by Lakshminarayana (2005) and Lakshminarayanamma *et al.* (2013). However, the status of red hairy caterpillar (*Amsacta* spp.) reported by

Basappa (2007) differed from the present study in which the pest was not observed during both *kharif* and *rabi* seasons. Similarly hairy caterpillar (*Euproctis fraterna*) reported as minor pest (Lakshminarayana, 2005) was observed as major pest in both seasons.

Reliable information on crop loss due to insect pests to establish the increased yield is obtainable when these agents are controlled at acceptable economic cost. Crop loss estimates are thus regarded as the best way to indicate to the farmer that the opportunities are gained when sound plant protection measures are applied (Kooner *et al*., 2006; Duraimurugan and Tyagi, 2012). Earlier, seed yield loss of 31.0 to 40.8 per cent due to defoliators *viz*., semilooper and *S. litura*, 12.9 to 20.3 per cent due to sucking pests (Anonymous, 1992) and 48.6 to 52.0 per cent due to capsule borer (Anonymous, 1991) were reported. The present study confirmed the significant impact of insect pests on castor yield which effected mean avoidable yield loss of 17.2 to 63.3 per cent during *kharif* and 22.5 to 89.4 per cent during *rabi*. The results also indicate that the cultivar DCH-519 revealed minimum seed yield loss due to insect pests in both *kharif* and *rabi* seasons as compared to other cultivars. This is in confirmation with the report of Lakshminarayana and Raoof (2005) who reported that the yield losses in castor varied widely with variety/hybrid. Therefore, the present study gives information on major insect pests of castor and avoidable yield losses due to the insect pests in different crop growing seasons. The information would enable us for developing effective pest management strategies and to harness best yield potential in castor.

Table 3 Population of insect pests on castor under protected and unprotected conditions during *rabi* (2012-13 and 2013-14)

Rabi (2012-13)

Cultivar	Leafhopper (No./3 leaves/plant)$		*Spodoptera litura* (larvae/plant)$		Semilooper (larvae/plant)$		Hairy caterpillar (larvae/plant)$		Capsule damage (%)#	
	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
DCH-519	20.3 (4.5)	78.3 (8.8)	0.0 (0.7)	0.4 (0.9)	0.6 (1.0)	1.4 (1.4)	0.2 (0.8)	1.6 (1.4)	1.4 (6.7)^{b}	4.1 (11.6)^{bc}
DCH-177	33.7 (5.8)	93.3 (9.6)	0.0 (0.7)	0.1 (0.8)	0.2 (0.8)	0.9 (1.2)	0.6 (1.0)	2.1 (1.6)	0.7 (4.7)^{a}	1.1 (6.0)^{a}
48-1	28.3 (5.3)	95.0 (9.7)	0.1 (0.8)	0.3 (0.9)	0.4 (0.9)	1.3 (1.3)	0.13 (0.8)	1.8 (1.5)	0.9 (5.3)^{ab}	2.4 (8.9)^{c}
Mean	27.4 (5.2)^{a}	88.8 (9.4)^{b}	0.03 (0.7)^{a}	0.3 (0.9)^{b}	0.4 (0.9)^{a}	1.2 (1.3)^{b}	0.3 (0.9)^{a}	1.8 (1.5)^{b}	1.0 (5.6)^{a}	2.5 (8.8)^{b}

	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±
Plant Protection (P)	*	0.79	0.37	*	0.06	0.03	*	0.14	0.07	*	0.12	0.06	*	1.09	0.51
Cultivars (C)	NS	-	0.46	*	0.07	0.04	NS	-	0.08	*	0.15	0.07	*	1.33	0.62
Interaction (PxC)	NS	-	0.64	NS	-	0.05	NS	-	0.12	NS	-	0.10	*	1.89	0.88

Rabi(2013-14)

Cultivar	Leafhopper (No./3 leaves/plant)$		*Spodoptera litura* (larvae/plant)$		Semilooper (larvae/plant)$		Hairy caterpillar (larvae/plant)$		Capsule damage (%)#	
	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
DCH-519	9.1 (3.1)^{a}	34.2 (5.9)^{c}	0.4 (0.9)^{a}	1.4 (1.4)^{c}	0.3 (0.9)^{ab}	0.9 (1.2)^{c}	0.1 (0.8)^{a}	0.2 (0.8)^{a}	10.9 (19.1)^{bc}	16.3 (23.7)^{d}
DCH-177	18.5 (4.3)^{b}	92.1 (9.6)^{d}	0.6 (1.0)^{ab}	2.9 (1.8)^{d}	0.2 (0.8)^{ab}	2.1 (1.6)^{d}	0.2 (0.8)^{a}	2.2 (1.6)^{c}	7.6 (16.0)^{ab}	-
48-1	14.6 (3.8)^{ab}	35.1 (5.9)^{c}	0.3 (0.9)^{a}	0.8 (1.1)^{b}	0.1 (0.8)^{a}	0.5 (1.0)^{b}	0.1 (0.8)^{a}	1.2 (1.3)^{b}	7.0 (15.3)^{a}	11.9 (20.0)^{c}
Mean	14.1 (3.7)^{a}	53.8 (7.1)^{b}	0.4 (0.9)^{a}	1.7 (1.4)^{b}	0.2 (0.6)^{a}	1.2 (1.3)^{b}	0.1 (0.8)^{a}	1.2 (1.4)^{b}	8.5 (16.8)^{a}	14.1 (21.9)^{b}

	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±	F-test	CD at 5%	SEm±
Plant Protection (P)	*	0.45	0.21	*	0.11	0.05	*	0.11	0.05	*	0.05	0.02	*	1.99	0.94
Cultivars (C)	*	0.55	0.26	*	0.13	0.06	*	0.13	0.06	*	0.06	0.03	*	2.44	1.15
Interaction (PxC)	*	0.77	0.36	*	0.19	0.09	*	0.18	0.09	*	0.09	0.04	*	3.45	1.62

* - Significant; NS- Non Significant $Figures in the parentheses are square root transformed values; #Figures in parentheses are arc sin transformed values

Table 4 Avoidable yield losses due to insect pests in castor during *rabi* (2012-13 and 2013-14)

Cultivar	*Rabi* 2012-13				*Rabi* 2013-14				Pooled Mean			
	Yield (kg/ha)			% avoidable loss	Yield (kg/ha)			% avoidable loss	Yield (kg/ha)			% avoidable loss
	Protected	Unprotected	Mean		Protected	Unprotected	Mean		Protected	Unprotected	Mean	
DCH-519	1063[a]	888[a]	976[a]	16.5	1064[a]	762[b]	913[a]	28.4	1064[a]	825[b]	945[a]	22.5
DCH-177	988[a]	213[c]	601[b]	78.4	1030[a]	0[d]	515[b]	100	1009[a]	107[d]	558[c]	89.4
48-1	1100[a]	525[b]	813[b]	52.3	686[b]	362[c]	524[b]	47.2	893[b]	444[c]	669[b]	50.3
Mean	1050[a]	542[b]	797	49.1	927[a]	375[b]	651	58.5	989[a]	459[b]	724	54.1
	F-test	CD at 5%	SEm±	-	F-test	CD at 5%	SEm±	-	F-test	CD at 5%	SEm±	-
Plant Protection (P)	*	151	71	-	*	93	44	-	*	57	27	-
Cultivars (C)	*	185	87	-	*	114	53	-	*	69	33	-
Interaction (PxC)	*	262	123	-	*	161	76	-	*	98	46	-

* - Significant; NS- Non Significant

REFERENCES

Anonymous 1991. *Annual Report 1990-91*. All India Coordinated Research Project on Castor, Directorate of Oilseeds Research, Hyderabad.

Anonymous 1992. *Annual Report 1991-92.* All India Coordinated Research Project on Castor, Directorate of Oilseeds Research, Hyderabad.

Anonymous 2006. *Research Achievements in Castor*. All India Coordinated Research Project on Castor, Directorate of Oilseeds Research, Hyderabad.

Basappa H 2007. Validation of integrated pest management modules for castor (*Ricinus communis*) in Andhra Pradesh. *Indian Journal of Agricultural Sciences*, **77**(6): 357-362.

Duraimurugan P and Tyagi K 2014. Pest spectra, succession and its yield losses in mungbean and urdbean under changing climatic scenario. *Legume Research*, **37**(2): 212-222.

Kooner B S, Cheema H K and Kaur R 2006. Insect pests and their management. *In: Advances in Mungbean and Urdbean*. pp. 335-401. Ali M and Shivkumar (Eds.), Indian Institute of Pulses Research, Kanpur.

Lakshminarayana M, Duraimurugan P and Vimala Devi P S 2013. Efficacy of microbial and botanical formulations for the management of lepidopteran pests infesting castor. *In: Proceedings of Fourth Biopesticide International Conference*, 28-30 November 2013 at St. Xavier's College, Palayamkottai, Tamil Nadu, India. pp.248-249.

Lakshminarayana M 2005. Studies on antixenosis in castor, *Ricinus communis* L. against major insect pests. *Indian Journal of Plant Protection*, **33**(2): 216-219.

Lakshminarayana M and Raoof M A 2005. *Insect Pests and Diseases of Castor and Their Management*. Directorate of Oilseeds Research, Hyderabad. pp.78.

Lakshminarayanamma V, Reddy D K and Reddy A V 2013. Management of lepidopteran pests through newer insecticides in castor. *Indian Journal of Plant Protection*, **41**: 25-29.

Rao M S, Rama Rao C A, Srinivas K, Pratibha G, Vidya Sekhar S M, Sree Vani G and Venkatswarlu B 2012. Intercropping for management of insect pests of castor, *Ricinus communis* in the semi-arid tropics of India. *Journal of Insect Science*, **12**: 1-10.