Indian Journal of Agricultural Sciences **79** (8): 620–3, August 2009

Effect of defoliation on seed yield of castor (*Ricinus communis*)

P LAKSHMAMMA[1] , M LAKSHMINARAYANA[2], LAKSHMI PRAYAGA[3], K ALIVELU[4] and C LAVANYA[5]

Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Andhra Pradesh 500 030

Received: 16 November 2008

ABSTRACT

Field investigation was carried out during 2005–07 to determine yield loss to different levels of defoliation at different growth stages in 'DCS 9'castor (*Ricinus communis* L.) Treatments consisted of 4 defoliation levels (25, 50, 75, and 100%) at primary, secondary and tertiary spike initiation stages along with control. Per cent defoliation affected was not exactly at the prescribed levels, but nearer to them. Number of leaves removed at 25% defoliation ranged from 3 to 6, at 50% from 5 to 11 at 75% from 7 to 17 and from 10 to 25 at 100% at different stages of defoliation. The actual defoliation was 23–32% for 25% defoliation, 50–55% for 50%, 58–71% for 75% defoliation at different stages of defoliation. With increase in per cent defoliation, there was significant reduction in seed yield. The reduction in seed yield ranged from 10 to 20%, 20 to 23%, 24 to 36% and 26 to 55% with 25, 50, 75 and 100% defoliation, respectively. On an average, defoliation at primary stage showed 21% yield reduction and at secondary stage showed 33% yield reduction. Tertiary stage defoliation showed 26% yield reduction. Defoliation at secondary spike initiation stage was found to be the most sensitive stage which reduced total seed yield. The practical information generated during the study could be utilized in designing the pest management strategies in castor.

Key words: Castor, Defoliation, Primary, Secondary, Tertiary spike initiation stages, Yield

Castor (*Ricinus communis* L.) is infested with a number of insect pests at different phenological stages of the crop in India. Heavy foliage loss from major defoliating insects, like semilooper, tobacco caterpillar, Bihar hairy caterpillar is very common and is quite high in South India, especially during rainy (*kharif*) season. Outbreaks of some of these pests cause significant damage and yield reduction to castor (Lakshminarayana and Raoof 2005). Because of its indeterminate growth habit, it is capable of recovering such damage. No research information is available on its ability to recover the extent of foliage loss due to insect damage so as to initiate appropriate and economic insect management strategies.

Assimilate availability and allocation to reproductive structures is primarily determined by leaf area and photosynthetic activity. The number of competing sinks is one of the most important factors affecting yield and its components. Defoliation decreases yield with reduced leaf area, light interception, photosynthesis, dry matter and reduction of the filling period (Board *et al*. 1994). The effect of defoliation however depends on the foliar surface eliminated and on the growth stage at which this takes place. Therefore, quantifying yield decreases resulting from defoliation may play an important role in predicting yields, establishing thresholds for pesticide treatments. Hence, an experiment was conducted during 2005–06 and 2006–07 to determine castor yield loss to the level of defoliation at different growth stages and arrive at permissible defoliation for designing effective pest management strategies.

[1,2,3,5]Senior Scientists, [4]Scientist (SS) (E-mail: lakshmiparvathaneni@rediffmail.com, manalakshmi@yahoo.com, lprayaga@rediffmail.com, kalivelu@rediffmail.com, lavanyadey @gmail.com)

MATERIALS AND METHODS

The experiment was conducted at the Narkhoda experimental farm of Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh, using 'DCS 9' castor planted on 28 June during 2006 and 19 June during 2007. Five rows were sown for treatment.

Treatments consisted of 5 defoliation levels (no defoliation/control, 25%, 50%, 75% and 100%) at primary, secondary and tertiary spike initiation stages. In total, the experiment comprised 13 treatments and the experimental design was randomized block with 3 replications. Plants were hand defoliated and for 25% defoliation every 4th leaf, for 50% defoliation every alternate leaf, for 75% defoliation every 2nd, 3rd and 4th leaf from top for every 4 leaves on every branch was removed and for 100% defoliation all leaves on the plant at that particular stage were removed.

Defoliation at primary spike initiation stage was done at 50 and 43 days after sowing at secondary 65 and 63 days after sowing and at tertiary 85 and 84 days after sowing during 2006–07 and 2007–08, respectively.

Removed leaf number, leaf area and dry weight at every stage of defoliation were quantified. Total dry matter at harvest, yield and yield components, viz spike length, number of capsules, capsule weight, seed weight and test weight of different order branches were recorded and total seed yield was computed. As the effect of defoliation during two years showed similar trend, pooled analysis was done and pooled means of 2 years were presented.

RESULTS AND DISCUSSION

Leaf characters and total dry matter

Removed leaf number, area and dry weight were quantified at each stage of defoliation (Table 1). Leaf number removed ranged from 3 to 10, 4 to 19 and 6 to 25 from 25 to 100% defoliation at primary, secondary and tertiary spike initiation stages, respectively during two years. Removed leaf area ranged from 10 to 33, 14 to 63 and 14 to 58 dm^2/plant with 25–100% defoliation at primary, secondary and tertiary spike initiation stages, respectively.

Per cent removed leaf area at 25% defoliation was 23–32, at 50% 50–55, at 75% was 58–71 at different defoliation stages (Table 2). Exact defoliation levels could not be imposed as definite number of whole leaves was removed. On an average 26, 52 and 66% leaf area was removed during 2 years for 25, 50, 75% defoliation, respectively. Removed leaf dry weight also followed same trend as that of removed leaf area.

Table 1 Removed leaf number, area, dry weight and total dry matter at harvest (per plant) (mean of 2 years)

Defoliation stage (%)		Removed leaf number	Removed leaf area (dm^2)	Removed leaf dry wt (g)	TDM at harvest (g)
At primary	25	3	9.69	4.3	256
	50	5	16.72	7.3	244
	75	7	20.82	9.2	244
	100	10	30.25	13.3	227
At secondary	25	4	14.25	7.1	242
	50	8	32.85	16.3	244
	75	11	36.62	18.1	210
	100	19	63.16	30.6	190
At tertiary	25	6	14.17	7.0	262
	50	11	29.14	14.3	260
	75	17	41.41	20.0	247
	100	25	58.20	28.3	199
Control		0	0.00	0.0	302
Mean		10	28.44	13.6	241
SEm ±		0.39	1.89	0.99	5.43
CD (P = 0.05)		1.1	5.4	2.8	15.4
CV (%)		10.1	16.4	18.0	5.5

Table 2 Per cent leaf area removed

Defoliation (%)	Leaf area removed (%)		
	Spike initiation stage		
	Primary	Secondary	Tertiary
25	32	23	24
50	55	52	50
75	69	58	71
100	100	100	100
Average	64	58	61
Control	0	0	0

Total dry matter (TDM) decreased with defoliation at any stage and with increase in per cent defoliation there was significant reduction in total dry matter (Table 1). There was 20% reduction with defoliation at primary or tertiary stages, but defoliation at secondary spike initiation stage showed 27% reduction in total dry matter. Decrease in total dry matter was due to reduced stem, leaf dry weight and seed yield due to defoliation treatments.

Yield components and yield

Data on different yield components, viz. spike length, capsule number, capsule weight, test weight and seed yield of different order branches and total seed yield were recorded with different defoliation treatments. With defoliation at a particular stage, the effective spike length of that order was significantly reduced, ie with defoliation at primary stage, primary spike length was only affected, secondary and tertiary spike lengths were reduced with defoliation at secondary and tertiary spike initiation stage, respectively and the reduction increased with increase in per cent defoliation.

Number of capsules on primary, secondary and tertiary spikes reduced significantly with defoliation at primary, secondary and tertiary spike initiation stages, respectively with 50, 75 and 100% defoliation levels. Total number of capsules decreased with increase in per cent defoliation and the reduction was more significant with defoliation at primary stage (Fig 1). Weight of capsules from primary reduced with

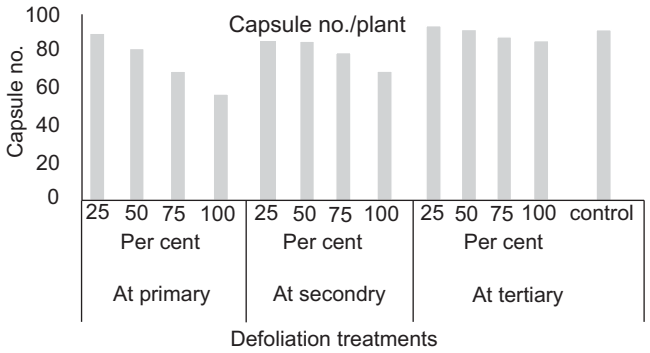

Fig 1 Total capsule number with different defoliation treatments

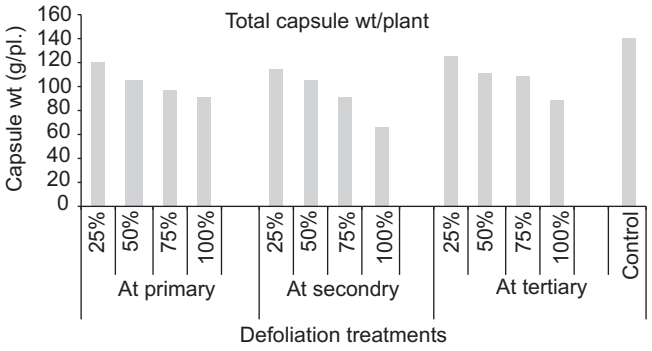

Fig 2 Total capsule weight with different defoliation treatments

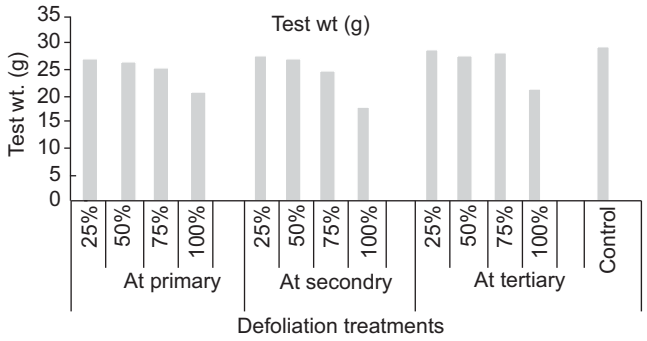

Fig 3 Average test weight (g) of all branches with different defoliation treatments

defoliation at primary and secondary stages. Secondary and tertiary stage defoliation from 50% and above significantly reduced secondary, tertiary and quarternary capsule weight. The weight of the capsules was less (Fig 2) with defoliation at secondary spike initiation ((94.9g/plant) compared to defoliation at primary (104.1 g/plant) and tertiary spike initiation (108.1 g/plant).

Seed yield of different order branches is presented in Table 3. Primary seed yield was reduced significantly at 50% and above defoliation at primary stage due to reduction in spike length and capsule number. Defoliation at primary spike initiation was imposed at 43–50 days after sowing where there was no branching or just initiated, leaves of only primary were removed. So the yield of other order branches was not significantly affected with defoliation at that stage. Whereas, defoliation at secondary significantly reduced secondary, tertiary and other higher orders seed yield. But defoliation at 75 and 100% at this stage reduced even primary seed yield. These treatments imposed at secondary spike initiation stage (65 days after sowing) affected seed filling of primary. As leaves on primary and secondary were removed at this stage, growth of secondary spikes was affected resulting in reduced seed yield of secondary spikes. Defoliation at this stage affected tertiary and quarternary order growth also and reduced seed yield of these orders. Thus, secondary spike initiation stage (60–65 days after sowing) was found to be the crucial stage for castor crop. During this stage primary spike was in seed-filling stage,

Table 3 Effect of defoliation on seed yield of different order branches (mean of 2 years)

Defoliation stage	(%)	Primary	Secondary	Tertiary	Quarternary*
At primary	25	34.4	27.2	24.7	29.2
	50	26.8	26.0	23.8	27.0
	75	17.7	27.4	24.0	28.8
	100	6.6	27.6	30.5	29.7
At secondary	25	34.7	26.0	21.1	21.2
	50	32.7	22.3	23.4	23.0
	75	22.7	19.1	19.6	20.1
	100	11.1	5.0	20.7	19.7
At tertiary	25	36.3	29.6	21.5	23.4
	50	36.6	28.0	14.8	19.0
	75	38.0	23.8	15.9	18.1
	100	38.2	13.8	3.5	14.1
Control		37.1	31.1	30.4	30.1
Mean		28.7	23.8	20.8	23.6
SEm ±		1.88	1.78	1.33	1.42
CD ($P = 0.05$)		5.4	5.1	6.8	4.0
CV (%)		16.1	18.3	15.6	14.7

*includes higher orders also

secondary spike in elongation and capsule formation stage and tertiary branch production was initiated. Defoliation at tertiary was done at 85 days after sowing and leaves on primary, secondary, and tertiary orders were removed. Leaf removal on primary at this stage did not affect its yield as already filling of primary was over. Seed yield from secondaries was significantly reduced with 75% and total defoliation at this stage as the assimilate production on secondary was reduced by removing more leaves (7 and 13 at 75 and 100% defoliation, respectively) and it could not be compensated. Test weight of seeds from secondary spike was significantly reduced with 100% defoliation at tertiary (17.7g in 100% defoliation compared to 23.6 g in control) which clearly indicated the affect of defoliation on seed filling. Seed yield from tertiary and quarternary spikes also reduced with defoliation at tertiary spike initiation stage.

Total seed yield reduced with defoliation at any stage and there was significant yield reduction with defoliation beyond 25%. With increase in per cent defoliation, there was significant reduction in seed yield during both the years. Total seed yield with different defoliation treatments is presented in Table 4. Defoliation at primary reduced seed yield by 10–26%, the reduction ranged from 20 to 55% at secondary and 12 to 45% at tertiary with 25–100% defoliation levels averaged over two years. Total seed yield was reduced significantly even with defoliation at primary spike initiation stage though only primary spike was affected. The yield of all orders was affected with defoliation at secondary spike initiation stage which resulted in reduced total seed yield and the reduction increased with increase in per cent defoliation. Tertiary stage defoliation also reduced total seed yield significantly by reducing tertiary and quarternary order seed yield.

Table 4 Total seed yield (g/plant) and per cent reduction in seed yield

Defoliation stage (%)		Total seed yield (g/plant)			Per cent reduction in seed yield		
		2006–07	2007–08	Pooled mean	2006–07	2007–08	Pooled mean
At primary	25	117	115	116	10	11	10
	50	93	106	99	28	18	23
	75	96	101	99	26	21	24
	100	98	94	96	25	27	26
At secondary	25	107	100	103	18	23	20
	50	101	105	103	22	18	20
	75	76	88	82	41	31	36
	100	65	52	58	50	60	55
At tertiary	25	114	113	114	12	12	12
	50	105	93	99	19	28	23
	75	102	93	97	22	28	25
	100	77	66	72	41	49	45
Control		130	129	129			
Mean		99	98	98			
SEm ±		5.22	4.47	3.28			
CD (P = 0.05)		15.2	13	9.3			
CV (%)		9.0	7.9	8.2			

Defoliation at secondary spike initiation stage was found to be the most sensitive stage which reduced seed yield of all order branches. In general, defoliation at any stage beyond 25% significantly reduced seed yield in castor. Dinesh-Hans and Sundaramoorthy (2002) also reported decrease in plant height, number of branches and spikes, and seed yield of castor with the increase in defoliation rate and frequency. Defoliation up to 67% in maize (*Zea mays* L.) reduced the shoot biomass, plants were taller and thinner than control plants but harvest index increased (Yang and Midmore 2004). In groundnut (*Arachis hypogaea* L.), reduction of pod yield over control increased with higher intensity of defoliation and during advanced stages of the crop (Prasad *et al*. 2008). Complete and partial defoliation treatments reduced both seed weight and head diameter compared with undefoliated check in sunflower (*Helianthus annuus* L.) (Julio Muro *et al.* 2001). In castor removal of leaves proximal to the main spike significantly affected seed yield (Ramesh and Prasad 2001).

On an average, defoliation at primary stage showed 21% yield reduction, the reduction was 33% with secondary stage defoliation. Tertiary stage defoliation showed 26% yield reduction. Defoliation at secondary spike initiation stage was the most sensitive stage and was found to reduce seed yield of all order branches. Defoliation at any stage beyond 25% significantly reduced seed yield in castor.

As there was only primary spike at primary defoliation stage, it affected only primary seed yield. But when defoliated at other two stages, the different branches were in different stages of growth and were affected. The data clearly showed the competition for assimilates from one order to next higher order. The crop could compensate 20–25% defoliation at any stage, but the yield reduction was significant beyond 25%. Accordingly these findings could be applied in the effective management of defoliator pests in castor

REFERENCES

Board J E, Weir A T and Boethel D J. 1994. Soybean yield reduction caused by defoliation during mid to late seed filling. *Agronomy Journal* **86**: 1074–9.

Dinesh-Hans and Sundaramoorthy. 2002. Optimization and defoliation tolerance evaluation of four released castor varieties in semi-arid farming. *Plant-Archives* **2** (2): 285–8.

Julio Muro, Ignacio Irigoyen, Ana F. Militino and Carmen Lamsfus. 2001. Defoliation effects on sunflower yield reduction. *Agronomy Journal* **93**: 634–7.

Lakshminarayana M and Raoof M A. 2005. Insect pests and diseases of castor and their management. *Bulletin*, pp78. Directorate of Oilseeds Research, Hyderabad.

Prasad T V, Nandagopal V, Gedia M V, Makwana K D and Patel H V. 2008. Simulated defoliation during different crop growth stages to assess insect damage and yield losses in Spanish groundnut, *Arachis hypogaea* L. *Journal of Oilseeds Research* **25** (1): 44–7.

Ramesh T and Prasad M M K D. 2001. Effect of source manipulation on yield of castor (*Ricinus communis* L.). *Madras-Agricultural-Journal* **87**: (10/12): 661–3.

Yang By and Midmore D J 2004. Experimental assessment of the impact of defoliation on growth and production of water stressed maize and cotton plants. *Experimental Agriculture* **40**: 189–99.