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SOURCE MANIPULATION INDUCED VARIATION IN DRY MATTER PARTITIONING TO REPRODUCTIVE SINK IN CASTOR

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SUMMARY

An experiment on effect of defoliation at different spike initiation stages on biomass partitioning was conducted for two consecutive years during 2005-07 using DCS-9 variety. Treatments consisted of four defoliation levels (25%, 50%, 75% and 100%) at primary, secondary and tertiary spike initiation stages on entire plant along with control, with 3 replications in RBD. With increase in percent defoliation at any stage there was reduction in stem, leaf, capsule dry weight which resulted in significant reduction in total dry matter. There was compensation in growth only up to 25% defoliation at any stage. Only primary seed yield was affected with defoliation at primary spike initiation stage, but with secondary stage defoliation, yield of all order branches was affected. Secondary, tertiary and quarternary seed yield was affected with defoliation at tertiary stage. Yield of one order decreased with >25% defoliation at that order and >50% defoliation at next lower or higher order spikes.

***Key words*: Castor, defoliation, dry weight, primary, secondary and tertiary spike initiation stages, TDM**

INTRODUCTION

The physiological basis of dry matter production is dependent on source-sink and maximization of source and its proper utilization by the economic sink is important for improvement of yield potential of the crops. Numerous biotic and abiotic factors influence partitioning between vegetative and reproductive plant organs. Heavy foliage loss from leaf-devouring insects like semilooper and spodoptera is very common in castor. Outbreaks of some of these pests cause significant damage and yield reduction to castor (Lakshminarayana and Raoof 2005).

Defoliation decreases yield with reduced leaf area, light interception, photosynthesis, dry matter and reduction of the filling period (Ingram *et al*. 1981, Board *et al*. 1994), the intensity of which depends on the foliar surface eliminated and on the growth stage at which this takes place. Generally, castor crop is capable of recovering from such leaf damage, because of its indeterminate growth habit. 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. Hence an experiment was conducted for two years during 2005-07 with an objective to determine dry matter partitioning to reproductive sink in castor with source manipulation at different crop growth stages.

MATERIALS AND METHODS

The experiment was conducted at the Narkhoda experimental farm of Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh, India using castor cultivar DCS-9 during *kharif* 2005-07. There were fifteen

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treatments including five defoliation levels (control (no defoliation), 25%, 50%, 75% and 100%) at primary, secondary and tertiary spike initiation stages in randomized block design with three replications. Plants were manually 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 is removed and for 100% defoliation all leaves on the plant at that particular stage were removed. As the entire leaves were removed, treatments could not be imposed exactly but on an average, 28, 53 and 65% leaf area was removed during two years for 25, 50 and 75% defoliation, respectively. Growth parameters, stem, leaf, capsule dry weight and total dry matter (TDM) were recorded at each defoliation stage and at harvest. Yield 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 two years were presented.

RESULTS AND DISCUSSION

Growth and leaf characters: Plant height up to primary spike reduced significantly with 100% defoliation at primary (Table 1). Treatmental differences were not significant for secondary branch number but secondary branch length reduced significantly with any amount of defoliation at primary and secondary spike initiation stages. Tertiary branch length decreased significantly with 100% defoliation at secondary and 75,100% at tertiary stage.

Table1. Growth characters, leaf area removed and leaf dry weight with different defoliation treatments.

Treatment	Plant height (cm)	Secondary Branch length (cm)	Tertiary branch number	Tertiary branch length (cm)	Leaf area removed (%)	Leaf dry weight (g/pl) Defoliation at		
						SSIS	TSIS	20 days after all defoliations
PSIS*								
25%	42.9	27.1	3	22.1	32	29.5	39.6	34.6
50%	44.6	27.4	4	24.0	55	19.6	29.7	45.2
75%	39.7	25.9	3	24.6	69	20.4	33.3	32.0
100%	37.3	25.1	4	31.4	100	10.9	27.5	29.6
SSIS**								
25%	40.6	25.9	3	21.4	23	28.8	24.4	27.8
50%	41.1	27.0	3	18.9	52	32.2	25.6	29.5
75%	41.7	24.2	3	19.9	58	28.8	21.0	26.9
100%	44.5	26.6	3	15.5	100	28.8	8.0	27.3
TSIS***								
25%	42.1	33.9	4	19.6	24	28.8	35.8	36.9
50%	42.9	31.6	4	19.1	50	28.8	35.8	25.9
75%	41.5	31.4	5	18.2	71	28.8	35.8	22.9
100%	42.4	33.6	4	15.9	100	28.8	35.8	7.2
control	40.7	31.2	4	22.6	0	28.8	35.8	34.7
mean	41.7	28.8	3	21.0		26.4	28.8	28.7
SEM ±	1.31	1.18	0.29	1.34		6.25	4.96	2.91
CD(0.05)	3.7	3.4	0.8	3.9		NS	14.5	8.50
CV(%)	7.7	10.1	20.8	15.9		41.0	29.8	17.5

*PSIS:Primary spike initiation stage,** SSIS:Secondary spike initiation stage ***TSIS:Tertiary spike initiation stage

Percent removed leaf area with defoliation is presented in Table 1. Removed leaf area ranged from 10-33, 14-63 and 14-58 dm^2/plant with 25-100% defoliation at primary, secondary and tertiary spike initiation stages respectively. Percent removed leaf area at 25% defoliation was 23-32, at 50% was 50-55, at 75% was 58-71 at different defoliation stages. On an average, 26, 52 and 66% leaf area was removed during two years for 25, 50, 75% defoliation respectively.

Dry matter partitioning

Leaf dry weight: In general, there is continuous leaf fall of older leaves due to senescence after primary spike formation which was not accounted for in this experiment. There was 30 and 62% reduction in leaf dry weight at secondary spike initiation stage with 75,100% defoliation at primary (Table 1). With 75, 100% defoliation at secondary spike initiation stage, significant reduction in leaf weight is seen when sampled at tertiary spike initiation stage. Plants recovered 20 days after all defoliations except at 75, 100% defoliation at tertiary which showed significant reduction in leaf dry weight. Differences were not significant at harvest.

Stem dry weight: Plants recorded 4.5 g/plant stem dry weight before imposing defoliation treatments (44 DAS). Data recorded at secondary stage defoliation (64 DAS) shows the effect of defoliation at primary stage on stem dry weight (Table 2). The differences were not significant among treatments as only 4 treatments were imposed but there was 14-15% reduction in stem weight with 50, 75% defoliation and the reduction was 58% with 100% defoliation. At tertiary stage defoliation (84 DAS),

Table 2. Stem dry weight at different defoliation stages and at harvest.

Treatment	Total Stem dry weight (g/pl) Defoliation at				Stem dry weight of different order branches and total at harvest (g/pl)				
	PSIS	SSIS	TSIS	20 days after all defoliations	Primary	Secondary	Tertiary	Quarternary	Total
PSIS*									
25%	4.5	20.0	26.3	52.6	20.9	18.1	14.5	13.8	67.3
50%	4.5	14.3	17.5	48.9	20.4	17.3	14.6	15.4	67.7
75%	4.5	14.5	17.7	35.3	19.4	18.8	13.7	15.1	67.0
100%	4.5	7.0	17.8	28.9	18.5	18.5	13.5	13.0	63.5
SSIS**									
25%	4.5	16.8	22.0	24.6	21.1	18.5	14.7	12.8	67.1
50%	4.5	16.8	20.6	26.2	21.4	19.2	14.6	12.9	68.1
75%	4.5	16.8	19.4	26.6	18.9	16.8	12.9	13.8	62.4
100%	4.5	16.8	15.4	23.2	18.7	14.9	13.6	12.6	59.8
TSIS***		16.8							
25%	4.5	16.8	25.4	45.2	21.3	18.5	15.4	12.9	68.1
50%	4.5	16.8	25.4	35.0	21.0	18.0	15.9	12.7	67.6
75%	4.5	16.8	25.4	27.2	21.1	18.3	15.1	12.9	67.4
100%	4.5	16.8	25.4	23.3	19.4	16.0	9.6	12.4	57.4
control	4.5	16.8	25.4	38.1	23.7	20.9	15.8	15.6	76.0
mean	4.5	16.4	21.4	34.4	20.9	18.1	14.2	12.3	65.4
SEM ±	0.44	4.11	3.98	4.19	1.26	1.69	1.15	1.11	2.66
CD(0.05)	NS	NS	NS	12.2	3.6	NS	3.3	NS	7.6
CV(%)	16.8	9.2	32.3	21.1	14.8	22.8	19.8	22.3	10.0

* PSIS:Primary spike initiation stage ** SSIS:Secondary spike initiation stage ***TSIS:Tertiary spike initiation stage

the treatmental differences were non significant but there was reduction in stem dry weight. The reduction was 13, 19, 24, 29% with 25, 50, 75, 100% respectively with defoliation at secondary spike initiation stage. Even 40 days after defoliation at primary, the reduction in stem dry weight could not be compensated and still there was 30% reduction in stem dry weight with 50-100% defoliation. Stem dry weight compensated with 25% defoliation at this stage.

Twenty days after completing all defoliations (104 DAS), stem weight was on par with control at 25% and beyond 50% still there was reduction in stem weight with defoliation at primary stage. Stem dry weight reduction could not be compensated with secondary stage defoliation and with 100% defoliation at tertiary spike initiation stage, the reduction was significant. Stem dry weight of different order branches was recorded at harvest and total stem dry weight was computed and presented in Table 2. Primary stem weight showed significant reduction with defoliation of 75, 100% at primary and secondary spike initiation stages and with 100% defoliation at tertiary compared to control. The treatmental differences were non significant for secondary and quarternary branches stem weight. Tertiary stem dry weight reduction was significant only with 100% defoliation at tertiary stage. Total stem weight reduced significantly with defoliation at any stage and the reduction was more severe with 100% defoliation.

Capsule dry weight: Capsule weight recorded at secondary spike initiation stage, showed reduction with increase in % defoliation when defoliated at primary stage (Table 3). At tertiary defoliation stage, there was significant reduction in capsule dry weight with 75, 100% defoliation at primary and 100% defoliation at secondary stage. Twenty days after imposition of all defoliation treatments, with 50 to 100% defoliation at primary and tertiary and even with 25% defoliation at secondary, there was significant reduction in capsule dry weight.

Total dry matter: With increase in % defoliation beyond 25% at primary, there was significant reduction in TDM (Table 3). Even at 84 DAS (tertiary defoliation stage) TDM could not be recovered due to 50-100% defoliation at primary stage. The reduction was significant with 100% defoliation at secondary spike initiation stage also. Twenty days after all defoliations, TDM showed significant reduction with 75, 100% defoliation at primary, any amount of defoliation at secondary and 50-100% defoliation at tertiary spike initiation stage. The reduction was significant at harvest with any amount and at any stage of defoliation.

Yield: Data on yield of different spike orders, total seed yield and % reduction in seed yield with different defoliation treatments is presented in Table 4. Primary seed yield reduced significantly with defoliation beyond 25% at primary (28-82%) and 75, 100% at secondary (39, 70%, respectively). Defoliation at secondary spike initiation stage above 25% (28-84%) and above 50% at tertiary spike initiation stage (23-56%) significantly reduced secondary seed yield. Tertiary seed yield reduced with defoliation at secondary (23-32%) and tertiary spike initiation stages (29-88%) of crop growth. Total seed yield reduced significantly with defoliation at any stage and with increase in % defoliation. Defoliation at primary spike initiation stage reduced total seed yield by 10-26%, the reduction ranged from 20-55% at secondary and 12-45% at tertiary with 25-100% defoliation averaged over two years.

The two dominant modes of biomass partitioning are between root and shoot and between vegetative and reproductive structures (Horvitz and Schemske 1988). Partitioning between vegetative and reproductive structures with defoliation is studied here. Plant height reduced with >75% defoliation at primary and length of secondaries was also reduced with primary and secondary stage defoliation and there was reduction in stem, leaf, capsule dry weight and TDM also as there was competition for assimilates for plant growth and spike elongation and when there was source limitation, growth was affected. Plant tried to compensate but only up to 25% defoliation it could compensate. The excess assimilate produced is generally stored in the stem as temporarily stored carbohydrates. Due to defoliation, the demand for assimilates exceed net canopy photosynthesis, so the carbohydrate stored in stem gets remobilized to active sinks which resulted in reduced stem dry weight with increase in percent defoliation. The reduction in translocation of leaf blades was compensated with translocation increases from the stem, translocation of preanthesis assimilates in wheat (Alvaro

Table 3. Capsule dry weight and total dry matter at different defoliation stages and at harvest.

Treatment	Capsule dry weight (g/pl)			Total Dry Matter (g/pl)				
	Defoliation at			Defoliation at				
	SSIS	TSIS	20 days after all defoliations	PSIS	SSIS	TSIS	20 days after all defoliations	at harvest
PSIS*								
25%	7.4	75.5	96.0	12.3	63.0	179.2	226.3	256
50%	5.1	28.1	83.5	12.3	39.0	96.0	220.1	244
75%	2.9	18.6	55.1	12.3	37.9	85.4	141.2	244
100%	1.3	11.3	32.1	12.3	19.3	69.9	116.2	227
SSIS**								
25%	12.4	38.1	64.6	12.3	58.0	125.9	118.5	242
50%	12.4	52.0	67.7	12.3	61.3	134.6	148.4	244
75%	12.4	36.1	52.3	12.3	58.0	113.5	119.1	210
100%	12.4	14.4	30.5	12.3	58.0	60.5	93.9	190
TSIS***								
25%	12.4	53.1	98.1	12.3	58.0	156.4	215.1	262
50%	12.4	53.1	67.2	12.3	58.0	160.5	146.0	260
75%	12.4	53.1	74.9	12.3	58.0	161.0	148.5	247
100%	12.4	53.1	64.9	12.3	58.0	155.2	95.1	199
control	12.4	53.1	79.5	12.3	58.0	155.2	164.9	302
mean	9.9	41.5	33.6	12.3	52.6	127.2	74.5	241
SEM ±	2.96	10.1	2.68	0.65	4.84	16.3	5.4	5.43
CD(0.05)	NS	29.6	7.76	NS	14.1	47.7	15.9	15.4
CV(%)	51.9	42.3	17.6	9.2	15.9	22.3	17.5	5.5

* PSIS:Primary spike initiation stage ** SSIS:Secondary spike initiation stage ***TSIS:Tertiary spike initiation stage

et al. 2008). In general, the castor bean leaf blade takes 20 days for full expansion and its average life span is 60 days. So there is continuous leaf fall from primary spike elongation stage which is actually beneficial to the crop as lower leaves have low photosynthetic efficiency and requires energy for maintenance. Leaf dry weight also reduced with defoliation at any stage. Due to shortage of assimilates from source, capsule dry weight reduced significantly with increase in % defoliation. Dry weights of roots, stems and petioles decreased with reductions in leaf area two and three weeks after defoliation in soybean (Rujito *et al.* 1995).

Only primary spike was affected with >25% defoliation at primary, but when defoliated at secondary stage, the growth of different order branches was affected as the assimilate requirement was high. Primary seed filling, secondary, tertiary and quarternary seed yield was affected. >50% defoliation at tertiary also reduced secondary seed yield by reducing seed filling as seen by reduced test weight. Quarternary and higher orders seed yield was also reduced with secondary and tertiary stage defoliation and reduction was more with tertiary stage defoliation. Yield of one spike order reduced with >25% defoliation at that order and >50% defoliation at next order. The data clearly shows the mobilization of assimilates from one to the other higher or lower order branches depending on the requirement and defoliation at one spike initiation stage affected the growth and yield of other order branches also. 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. Seed yield of castor reduced with removal of leaves proximal to the main spike (Ramesh 2001).

Table 4. Seed yield and percent reduction with defoliation on different spike orders and total seed yield.

Treatment	Seed yield (g/pl)					% reduction in seed yield				
	PSIS	SSIS	TSIS	QSIS	Total	PSIS	SSIS	TSIS	QSIS	Total
PSIS*										
25%	34.4	27.2	24.7	29.2	116	7	13	19	3	10
50%	26.8	26.0	23.8	27.0	99	28	15	22	10	23
75%	17.7	27.4	24.0	28.8	99	52	12	21	4	24
100%	6.6	27.6	30.5	29.7	96	82	11	0	-1	26
SSIS**										
25%	34.7	26.0	21.1	21.2	103	6	17	31	30	20
50%	23.7	22.3	23.4	23.0	103	12	28	23	24	20
75%	22.7	19.1	19.6	20.1	82	39	39	36	33	36
100%	11.1	5.0	20.7	19.7	58	70	84	32	35	55
TSIS***										
25%	36.3	29.6	21.5	23.4	114	2	5	29	22	12
50%	36.6	28.0	14.8	19.0	99	1	10	51	37	23
75%	38.0	23.8	15.9	18.1	97	-2	23	48	40	25
100%	38.2	13.8	3.5	14.1	72	-3	56	88	53	45
control	37.1	31.1	30.4	30.1	129					
mean	28.7	23.7	20.8	23.6	98					
SEM ±	1.88	1.78	1.33	1.42	3.28					
CD(0.05)	5.4	5.1	6.8	4.0	9.3					
CV(%)	16.1	18.3	15.6	14.7	8.2					

* PSIS:Primary spike initiation stage ** SSIS:Secondary spike initiation stage ***TSIS:Tertiary spike initiation stage

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.

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