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RESEARCH ARTICLE :

Effect of drip fertigation on growth and yield of castor + onion intercropping system

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SUMMARY : Field experiments were carried out in the farmer's field at Kokalai village, Namakkal during *Rabi* 2011-12 and 2012 - 13 to study the effect of drip irrigation regimes and fertigation levels on growth yield attributes of castor and onion crops, castor equivalent yield in castor with onion intercropping system. Results revealed that drip irrigation at 80 per cent CPE recorded significantly better growth characters of castor like plant height, leaf area index (LAI), yield attributes *viz*., length of primary spike; number of capsule per primary spikes; total number of spikes per plant; 100 seed weight and castor equivalent yield than 60 per cent and 40 per cent CPE during both the years. Among the different fertilizer levels, application of 100 per cent RDF as water soluble fertilizer (WSF) registered better growth characters *viz*., plant height, LAI, yield attributes and castor equivalent yield during both the years compared to other treatments. The onion growth characters *viz*., plant height, number of leaf sheaths, single bulb yield and number of bulb per plant^{-1} were significantly influenced by drip irrigation at 80 per cent and 100 per cent RDF as water soluble fertilizer during both 2011 -12 and 2012 -13.

KEY WORDS :
Rabi castor,
Drip irrigation,
Fertilizer levels,
Growth character,
Yield attributes, CEY

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BACKGROUND AND OBJECTIVES

Castor (*Ricinus communis* L.) is an important non-edible industrial oilseed crops among nine cultivated oilseeds. It is grown across the world in tropical, sub tropical and warm temperate region and it has great industrial and commercial value (Anjani, 2012). Castor is cultivated on commercial scale in area of 1.52 million hectare in 30 countries with a production of 1.58 million tonnes of seeds. India, China, Brazil, Russia, Ethiopia and Philippines are the major castor growing countries in the world (Damodaram and Hedge, 2011). The major castor growing states in India are Gujarat, Andhra Pradesh, Rajasthan, Tamil Nadu, Karnataka, and Orissa. Keeping in view the potential of crop in terms of industrial uses and ever growing demand for castor oil and derivatives across the globe, there is a need to enhance castor productivity in India.

Irrigation application can be reduced by 50 to 80 per cent with drip irrigation compared to sub surface irrigation and overhead irrigation (Locascio *et al*., 1989). Wali *et al*. (1988) stated that castor grown during *Kharif*

season under irrigated conditions produced significantly higher yield attributing characters *viz*., yield per plant, 100 seed yield and seed yield (2130 kg ha^{-1}) than the rainfed conditions. Under optimum irrigation level, a seed yield of 3780 kg ha^{-1} was obtained with the hybrid GCH 5 (Raj *et al*., 2010). A castor field produced 1774 kg ha^{-1} of seed without irrigation, 2199 kg ha^{-1} with a supplementary irrigation at the end of the growing season and 4252 kg ha^{-1} with supplementary irrigation before and after the rainy season (Souza *et al*., 2007). Drip fertigation of castor with intercrop was not conducted. Hence, considering the above fact, the field experiment was planned to identify suitable drip irrigation regimes with different fertilizer levels on castor with inter cropping system.

RESOURCES AND METHODS

Field experiments were conducted during *Rabi* 2011-12 and 2012 -13 in farmer's field at Kokalai village, Elachipalayam Block, Namakkal district to study the effect of drip irrigation with fertilizer levels on castor under onion intercropping system. The experiment was laid out in split plot design and replicated thrice. The soil of the experimental site was texturally classified under sandy loam with 18.76 per cent field capacity, 7.74 per cent permanent wilting point, bulk density 1.04 (g cc^{-1}) and good drainage capacity. The soil pH was 8.49, organic carbon content 0.23 per cent and EC 0.12 dsm^{-1}. The initial soil nutrient status was 187.5 kg N, 20.3 kg P_2O_5 and 352.5 kg K_2O ha^{-1}.

The treatment comprised of three levels of irrigation regimes {drip irrigation at 40, 60 and 80 per cent cumulative pan evaporation (CPE)} and six levels of fertilizer (F_1: 75 % RDF as conventional fertilizer (CF); F_2: 75 % RDF as water soluble fertilizer (WSF); F_3: 75 % RDF (75 % CF + 25 % WSF); F_4: 100 % RDF as conventional fertilizer (CF); F_5: 100 % RDF as water soluble fertilizer (WSF); F_6: 100 % RDF (75 % CF + 25 % WSF) and surface irrigation with 100 per cent recommended does of fertilizer as control.

The recommended dose of fertilizer was 60:30:30 kg NPK ha^{-1}. N and K were supplied through drip fertigation and full dose of P was supplied as basal in the form of single super phosphate under conventional fertilizer application. In the case of water soluble fertilizer, (poly feed -19:19:19 kg NPK ha^{-1}) was supplied through drip fertigation as nutrient sources for castor + onion intercrop.

For surface irrigation treatment, full dose of phosphorus (30 kg ha^{-1}), 50 per cent of nitrogen (30 kg ha^{-1}) and potassium (15 kg ha^{-1}) were applied as basal in the form of urea, single super phosphate and muriate of potash and remaining 50 per cent N and K (30: 0: 15 kg) were top dressed in two equal split at 30 and 60 day after sowing. Irrigation was supplied IW/ CPE ratio of 0.75 (66.6 mm) for surface irrigation.

Drip system was laid out in such a way that the main pipe was connected with head unit. The main line was divided into three sub line having separate controlling valves for I_1, I_2 and I_3 drip irrigation levels. Lateral lines were connected with sub main at a distance of 150 cm in a normal planting. The drippers were placed at a distance of 60 cm spacing. Castor crop hybrid (YRCH 1) was sown at a spacing of 150 x 120 cm. Onion intercrop (CO_3) was sown at either side of castor with the spacing of 30 x 10 cm. The crop was sown in the second fortnight of October and first week of October during *Rabi*, 2011-12 and 2012-13, respectively. The drip irrigation schedule was started 15 days after sowing upto 150 days. The drip irrigation was given at 3 days intervals based on USWP open pan evaporimeter. Daily pan evaporation was measured with a help of pan evaporimeter and the cumulative of three days were calculated for water requirement under drip system. Water requirement of the crop was worked out by using the formula:

WRc = CPE x Kc x Kp x Wp x A

where, WRc - Computed water requirement (litre $plant^{-1}$), CPE - cumulative pan evaporation for three days (mm), Kp - Pan factor (0.8), Kc - Crop factor {Initial stage (0 - 25 days) - 0.35; Developmental stage (26 - 60 days) - 1.15; Mid stage (61 - 130 days) - 1.15 and final stage (131 - 180 days) - 0.55} Wp - Wetting percentage and A - Area per plant. At 45 DAS, growth character of castor and onion was recorded and yield attributing character was collected at 90 DAS on randomly selected five plants. Castor yield on primary spike was harvested at 90 DAS, and next three picking (30 days interval) were followed within the duration of castor crop (180 days). Onion was harvested at maturity (90 DAS) and marketable onion was recorded for estimating the castor equivalent yield. The castor equivalent yield of intercropping system was computed by converting the yield of intercrops into castor seed equivalent on the basis

prevailing market price.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Growth characters of castor :

During *Rabi*, 2011 - 12 and 2012 - 13, drip irrigation regimes exerted significant influence on plant height, leaf area index (LAI) and days to 50 per cent flowering are presented in Table 1.

Drip irrigation at 80 per cent cumulative pan evaporation CPE (I_3) recorded better growth characters when compared to drip irrigation at 60 per cent CPE (I_2) and 40 per cent CPE (I_1) during both the years. Drip irrigation at 80 per cent CPE recorded maximum plant height, (56.8 and 49.5 cm) at 45 DAS and (93.2 and 99.6 cm) at 90 DAS, higher in leaf area index (0.236 and 0.208) at 45 DAS and (0.606 and0.585) at 90 DAS and more number of days to 50 per cent flowering (52.3 and 48.2 days) during *Rabi* 2011- 12 and *Rabi* 2012-13, respectively. At 40 per cent CPE, obtained lower plant height (43.6 and 43.1 cm) at 45 DAS and (68.8 and 64.6cm) at 90 DAS, lesser LAI (0.144 and 0.126) at 45 DAS and (0.390 and 0.327) at 90 DAS and days to 50 per cent flowering found to be earlier (47.8 days and 46.8 days, respectively) in both the years.

Among the different fertilizer levels, drip fertigation at 80 per cent CPE with 100 per cent RDF as WSF registered taller plants (61.3 and 51.8 cm) at 45 DAS and (103.6 and 92.1 cm) at 90 DAS; maximum LAI (0.294 and 0.260) at 45 DAS and (0.815 and 0.856) at 90 DAS and delayed 50 per cent flowering (53.4 days and 51.6 days) followed by drip fertigated at 100 per cent RDF (75 % CF + 25 % WSF). Drip fertigation at 40 per cent CPE with 75 per cent RDF as CF registered lower plant height, LAI and less number of days to 50 per cent flowering at 45 and 90 DAS in both the years, respectively. During both the years, surface method of irrigation based on IW/ CPE ratio 0.75 with 100 per cent RDF as soil application recorded lower growths *viz.*, plant height (59.7 and 48.9 cm) and (98.7 and 95.8 cm) at 45 and 90 DAS, leaf area index (0.269 and 0.232) and (0.698 and 0.649) at 45 and 90 DAS and less number of days to 50 per cent flowering (53.1 and 49.6 days), respectively.

Yield attributes of castor and castor equivalent yield:

The yield attributes *viz.*, length of primary spike (cm),

Table 1 : Effect of drip fertigation on growth characters of castor

Treatments	Plant height (cm)				Leaf area index 45 DAS				Days to 50 % flowering	
	45 DAS		90 DAS		45 DAS		90 DAS			
	2011 - 12	2012 - 13	2011 -12	2012 - 13	2011 - 12	2012 - 13	2011 - 12	2012 - 13	2011 - 12	2012 -13
Drip irrigation regimes										
I_1 – 40 % CPE	43.6	43.1	68.8	64.6	0.144	0.126	0.390	0.327	47.8	46.8
I_2 – 60 % CPE	53.3	45.3	86.4	83.7	0.219	0.191	0.549	0.519	50.3	47.8
I_3 – 80 % CPE	56.8	49.5	93.2	99.6	0.236	0.208	0.606	0.585	52.3	48.2
S.E.±	1.10	0.37	1.65	1.74	0.006	0.010	0.019	0.021	0.46	0.13
C. D. (P=0.05)	3.07	1.02	4.58	4.84	0.017	0.026	0.054	0.060	1.27	0.37
Fertilizer levels										
F_1 - 75% RDF as CF	47.2	44.1	75.7	79.5	0.168	0.148	0.424	0.388	47.2	45.8
F_2 - 75% RDF as WSF	52.2	46.5	83.6	83.5	0.203	0.180	0.553	0.504	50.7	48.1
F_3 - 75 % RDF (75% CF + 25% WSF)	50.2	45.2	80.8	81.0	0.191	0.168	0.482	0.442	50.5	46.7
F_4 - 100 % RDF as CF	55.3	47.9	91.2	86.5	0.234	0.205	0.601	0.575	52.1	49.7
F_5 - 100 % RDF as WSF	61.3	51.8	103.6	92.1	0.294	0.260	0.815	0.856	53.4	51.6
F_6 - 100 % RDF (75% CF + 25% WSF)	59.3	49.6	97.2	88.7	0.265	0.234	0.671	0.686	52.3	50.6
S.E.±	1.78	1.04	2.54	2.55	0.11	0.011	0.029	0.039	0.43	0.15
C. D. (P=0.05)	3.64	2.11	5.20	5.20	0.023	0.022	0.060	0.079	0.88	0.31
Surface irrigation +100 % RDF as CF	59.7	48.9	98.7	95.8	0.269	0.232	0.698	0.649	53.1	49.6

number of capsule per primary spike (no.), total number of spikes per plant (no.), 100 seed weight (g) and castor equivalent yield (CEY) (kg ha^{-1}) were influenced by irrigation regimes and fertilizer levels are presented in Table 2.

In both the years of experimentation, drip irrigation at 80 per cent CPE at 90 days after sowing (DAS) showed significantly higher in the yield attributes *viz*., length of primary spike (50.9 and 46.9 cm); number of capsule per primary spike (82.1 and 76.3); total number of spikes per plant (19.1 and 17.7); 100 seed weight of (31.6 g and 28.3 g) and CEY (4866 and 4565 kg ha^{-1}); during *Rabi* 2011-12 and 2012-13 followed by drip irrigation at 60 per cent CPE in both years. The lower length of primary spike (38.1 and 37.9 cm); number of capsule per primary spike (52.7 and 51.3); total number of spikes per plant (14.9 and 13.8); minimum 100 seed weight (26.4 and 26.1 g) and CEY (3986 and 3420 kg ha^{-1}) were observed in 40 per cent CPE in both the years.

Among the fertilizer levels, application of 100 per cent RDF as WSF registered maximum yield attributes *viz*., primary spike length (51.2 and 49.1 cm); number of capsule per primary spike (77.1 and 75.3); total number of spikes per plant (21.7 and 19.9); 100 seed weight (31.0 and 28.8 g) and castor equivalent yield (5582 and 5003 kg ha^{-1}) followed by 100 per cent RDF (75 % CF +25 % WSF) and 100 per cent RDF as conventional fertilizer. Application of 100 per cent RDF (75 % CF + 25 % WSF) and 100 per cent RDF as conventional fertilizer found to be on par with each other on yield attributes and CEY on both the years, whereas the primary spike lengths found to be significant in *Rabi* 2011 - 12. The castor equivalent seed yield increase under drip fertigation at 100 per cent RDF as WSF was 17.7 and 12.9 per cent in *Rabi* 2011-12 and 2012 - 13, respectively over 100 per cent RDF as CF over soil application of 100 per cent RDF as conventional fertilizer with surface irrigation.

The lower in yield attributes *viz*., spike length (41.1 and 39.0 cm); number of capsule per primary spike (63.7 and 59.6); total number of spikes per plant (15.1 and 14.6); 100 seed weight (28.3 and 26.3g) and CEY (3938 and 3586 kg ha^{-1}) was registered at 75 per cent RDF as CF in both the year of study. Surface irrigation with 100 per cent RDF recorded minimum spike length (51.3 and 45.6 cm); number of capsule per plant (76.9 and 69.1); total number of spikes per plant (19.4 and 18.2); 100 seed weight (31.6 and 27.8 g) and CEY of 4744 and 4432 kg ha^{-1} compared to 100 per cent RDF as CF in drip fertigation in both the years, (similar report by Raghavaiah and Sudhakarbabu, 2000).

Table 2 : Effect of drip fertigation on yield attributes and castor equivalent yield of castor + onion intercropping system

Treatments	Primary spike length (cm)		No. of capsule per primary spike (No.)		Total number of spikes plant^{-1} (No.)		100 seed weight (g)		Castor equivalent yield (kg ha^{-1})	
	2011 -12	2012 -13	2011 -12	2012 -13	2011 -12	2012 -13	2011 -12	2012 -13	2011 -12	2012 -13
Drip irrigation regimes										
I_1 – 40 % CPE	38.1	37.9	52.7	51.3	14.9	13.8	26.4	26.1	3986	3420
I_2 – 60 % CPE	44.0	42.9	67.8	65.5	17.0	16.0	29.7	27.1	4176	3942
I_3 – 80 % CPE	50.9	46.9	82.1	76.2	19.1	17.7	31.6	28.3	4866	4565
S.E.±	0.98	0.54	1.89	1.53	0.31	0.63	0.20	0.29	71	64
C. D. (P=0.05)	2.71	1.49	5.24	4.23	0.85	1.75	0.55	0.80	198	177
Fertilizer levels										
F_1 - 75% RDF as CF	41.1	39.0	63.7	59.6	15.1	14.6	28.3	26.3	3938	3586
F_2 - 75% RDF as WSF	45.5	42.9	68.0	66.5	17.8	16.4	29.4	27.4	4254	3976
F_3 - 75 % RDF (75% CF + 25% WSF)	43.8	41.2	66.2	63.2	16.3	15.0	29.0	26.8	4128	3845
F_4 - 100 % RDF as CF	47.0	45.4	72.2	67.9	18.8	17.4	30.1	28.2	5049	4495
F_5 - 100 % RDF as WSF	51.2	49.1	77.1	75.3	21.7	19.9	31.0	28.8	5582	5003
F_6 - 100 % RDF (75% CF + 25% WSF)	48.4	46.0	73.7	70.5	19.2	18.2	30.3	28.5	5395	4757
S.E.±	0.50	0.49	0.82	0.94	0.31	0.39	0.21	0.52	49	40
C.D. (P=0.05)	1.02	0.99	1.67	1.92	0.64	0.80	0.43	1.05	100	82
Surface irrigation +100 % RDF as CF	51.3	45.6	76.9	69.1	19.4	18.2	31.6	27.8	4744	4432

Growth and yield attributes of onion :

The effect of drip irrigation and fertilizer influences the growth and yield attributes of onion intercrop are presented in Table 3.

In both the years of experimentation, at 80 per cent CPE (45 DAS and at harvest time) the plant height (37.9, 40.8 and 35.6, 40.2 cm) and yield attributes *viz*., number of leaf sheath (21.3, 25.2 and 17.5, 22.1); single bulb yield were (15.6 and12.7 g) number of bulbs per plant (6.9 and 6.5) were significantly influenced and 100 per cent RDF as WSF plant height (36.5, 45.3 and 38.7, 42.4), number of leaf sheath (22.9, 27.1 and 21.0, 25.9); single bulb yield (15.4 and 13.9 g) and number of bulbs plant^{-1} (7.0 and 6.7) were significantly registered higher values during *Rabi* 2011-12 and 2012 - 13 followed by 60 per cent CPE and 100 per cent RDF (75 % CF + 25 % WSF) in both the years. The lower yield attributes recorded at 40 per cent CPE with 75 per cent RDF as conventional fertilizer.

The growth and yield attributes might have cumulatively influenced higher castor equivalent yield under higher level of nutrient fertilization the results obtained in the present study in accordance with the results reported by Selvaraju *et al.* (2005). Higher value of yield attributes like length of primary spikes, number of capsule per primary spikes, total number of spikes per plant may because of high photosynthesis, which results in high seed filling of castor. All these yield attributes might have cumulatively produced higher castor equivalent yield under higher level of nitrogen. The results obtained in the present study are in accordance with the results reported by Selvaraju *et al*. (2005). Nitrogen application with irrigation enhanced the production of female and male flowers without affecting the sex ratio.

The increase in castor equivalent yield under drip irrigation might be due to maintenance of favourable soil moisture status in the root zone, which in turn helped plants to maintain turgour pressure, thus, utilized moisture as well as nutrients more efficiently from wetted area and ultimately enhanced vegetative as well as reproductive growth of crop. Similar results were also reported by Reddy *et al.* (2006). Irrigation regimes exerted significant seed yield. This might be because of more dry matter production and plants with significantly more number of total racemes per plant following availability of sufficient moisture.

On sufficient supply of nutrient to onion intercrop, the production of IAA might have increased, which consequently had shown simultaneously action in terms of cell elongation resulting gin increased plant height.

Table 3 : Effect of drip fertigation on growth and yield attributes of onion intercrop

Treatments	Plant height (cm)				Number of leaf sheath				Single bulb yield (g)		Number of bulb plant^{-1}	
	45 DAS		At harvest		45 DAS		At harvest					
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Drip Irrigation regimes												
I_1 – 40 % CPE	28.1	29.5	33.5	33.6	15.1	14.1	19.8	17.7	12.6	11.0	5.0	4.9
I_2 - 60 % CPE	34.3	32.3	38.3	36.5	17.6	15.5	22.3	20.2	13.6	11.9	5.8	5.6
I_3 – 80 % CPE	37.9	35.6	40.8	40.2	21.3	17.5	25.2	22.1	15.6	12.7	6.9	6.5
S.E.±	0.65	0.45	1.09	0.46	0.88	0.34	0.66	0.48	0.31	0.10	0.08	0.28
C.D. (P=0.05)	1.80	1.26	3.03	1.29	2.43	0.94	1.84	1.33	0.87	0.26	0.22	0.77
Fertilizer levels												
F_1 - 75% RDF as CF	32.7	29.7	35.2	34.1	16.0	13.6	21.0	17.4	12.9	10.6	5.4	5.2
F_2 - 75% RDF as WSF	33.6	33.5	37.9	37.9	18.9	16.1	22.9	20.6	14.6	12.5	6.1	5.8
F_3 - 75 % RDF (75% CF + 25% WSF)	33.0	31.7	37.2	36.0	17.1	15.0	22.2	19.2	13.7	11.3	5.8	5.6
F_4 - 100 % RDF as CF	34.4	34.9	39.9	38.9	20.1	18.0	23.6	22.8	14.6	13.1	6.3	6.1
F_5 - 100 % RDF as WSF	36.5	38.7	43.3	42.4	22.9	21.0	27.1	25.9	15.4	13.9	7.0	6.7
F_6 - 100 % RDF (75% CF + 25% WSF)	34.8	35.8	40.6	39.7	20.2	18.9	24.2	23.8	14.8	13.4	6.6	6.4
S.E.±	1.00	0.66	1.10	0.78	0.86	0.64	0.98	0.73	0.62	0.14	0.16	0.19
C.D. (P=0.05)	2.04	1.35	2.25	1.59	1.75	1.31	1.99	1.49	1.27	0.28	0.32	0.39
Surface irrigation + 100 % RDF as CF	38.2	33.8	34.9	37.9	19.4	17.4	22.9	21.8	13.8	12.4	5.9	6.8

Significantly higher size and number of bulb per plant might be due to better vegetative growth with the nutrition application which accelerated photosynthesis and translocation of photosynthates (dry matter) into storage organ resulted in increased weight and number of bulb per plant which in turn increase the bulb yield of onion.

Conclusion:

Based on the experimental results conducted during *Rabi* 2011-12 and 2012 -13 it was concluded that potential production and profit from drip irrigated *Rabi* castor, variety YRCH-1 with CO_3 onion intercrop raised in two sides of castor on sandy loam soils of Namakkal district, Tamil Nadu. It can be secured by castor crop irrigation at 80 per cent cumulative pan evaporation based drip irrigation in combination with 100 per cent RDF through water soluble fertilizer which may enhance growth, yield attribute which in turn increase the castor equivalent yield in castor plus onion intercrop and also followed by 80 per cent CPE with 100 per cent RDF as 75 per cent CF and 25 per cent WSF, respectively.

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