

Irrigation and nutrient requirement of safflower (*Carthamus tinctorius*) in black soil

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ABSTRACT

A field experiment was conducted during winter season of 1995–96 to 1997–98 to optimise the irrigation and nutrient requirement of safflower (*Carthamus tinctorius* L.) in a black soil at Bhawanipatna, Orissa. Application of 2 post-sowing irrigations at branching and flowering along with 1 pre-sowing irrigation resulted in the maximum seed yield of 1,822 kg/ha being on par with 1 pre-sowing and a post-sowing irrigation at branching. These 2 irrigation treatments had similar benefit : cost and water-use efficiency (WUE), but consumptive use of water (CU) was more with the former. The seed yield at 80 : 80 : 40 kg of N : P₂O₅ : K₂O/ha was the highest (1,718 kg/ha), followed by 60:60:30 kg/ha (1,696 kg/ha). A declining trend in seed yield at the highest fertility level (80 : 80 : 40 kg/ha) was noticed, particularly when irrigation was withheld at flowering stage. Though CU by safflower increased with increasing level of fertility, both benefit : cost (1.79) and water-use efficiency (4.21 kg/ha-mm) were the maximum at 60 : 60 : 30 kg/ha of N : P₂O₅ : K₂O.

Key words : Safflower, Irrigation, Nutrient, Water-use efficiency

Safflower is grown in an area of 1.39 thousand ha with productivity of 561 kg/ha in Orissa. The crop has high potentiality in the black soil area of the western undulating zone of the state which accounts for 86% of the total area and 88% of the total production. Recently, safflower cultivation is given thrust to elevate the economic condition of the poor peasants of the zone. But, its productivity is very low due to poor management practices. Though safflower is a hardy crop, it has ability to do well on soils of low fertility, nevertheless its growth, yield and oil content can be enhanced by better agronomic manipulations (Rajput *et al.*, 1981; Singh and Yousuf, 1981). Safflower responds well to N and P along with irrigation (Giri, 1995; Singh *et al.*, 1995). Hence the present experiment was undertaken to find out the irrigation and nutrient requirement of safflower to realize maximum yield and net profit.

MATERIALS AND METHODS

A field experiment was conducted during winter seasons of 1995–96 to 1997–98 at the Regional Research Station, Bhawanipatna. The soil was clayey in texture with pH 7.1 and was low in organic carbon (0.42%), available P (7.85 kg/ha) and medium in available K (262 kg/ha). The soil-moisture content was 32.6% at field capacity and 17.5% at permanent wilting point. Five irrigation treatments, viz. one pre-sowing irrigation (I₀), irrigations at

branching, i.e. 30 days after sowing (DAS), and at flowering, i.e. 60 DAS (I_{30,60}), pre-sowing irrigation + irrigation at branching only (I_{0,30}), pre-sowing irrigation + irrigation at flowering only (I_{0,60}) and pre-sowing irrigation + irrigations at both branching and flowering (I_{0,30,60}) were allotted to the main plots and 4 fertility levels, viz. 20 : 20 : 10 (F₁), 40 : 40 : 20 (F₂), 60 : 60 : 30 (F₃), and 80 : 80 : 40 (F₄) kg N : P₂O₅ : K₂O/ha to the sub-plots in split-plot design with 3 replications. Measured quantity of pre-sowing (100 mm) and post-sowing (60 mm) irrigation were applied through a 15 cm Parshall flume.

Full dose of P and half of N and K were applied basal and the rest half of N and K were applied at flowering stage. Safflower 'Bhima' was sown in the second week of November with a spacing of 45 cm × 30 cm. The rainfall received during the cropping seasons was 50.6, 20 and 67.4 mm respectively.

RESULTS AND DISCUSSION

Irrigation

The yield attributes like capitula/plant, seeds/capitulum and seed weight/capitulum were significantly influenced by irrigation schedules (Table 1). Maximum number of capitula/plant and seeds/capitulum were produced by the crop receiving 2 (pre-sowing + branching) and 3 (pre-sowing + branching + flowering) irrigations, respectively,

Table 1. Yield and yield attributes, oil content, economics and consumptive water use of safflower as influenced by irrigation and fertility levels (pooled over 3 years)

Treatment	Capitula/ plant	Seeds/ capitulum	Seed weight/ capitulum (g)	1,000-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index	Oil content (%)	Net return (Rs/ha)	Benefit : cost	Consumpti- ve use of water (mm)	Water-use efficiency (kg/ha-mm)
<i>Irrigation</i>												
Pre-sowing	20.7	28.1	1.12	42.5	1,273	3,352	0.28	30.12	7,004	1.47	355	3.59
Branching + flowering	25.2	34.6	1.22	43.2	1,304	3,536	0.27	30.54	6,908	1.31	363	3.59
Pre-sowing + branching	29.6	32.8	1.21	42.7	1,668	4,487	0.27	30.15	10,250	1.86	408	4.09
Pre-sowing + flowering	25.4	30.7	1.26	43.0	1,556	3,820	0.29	30.86	9,020	1.67	394	3.95
Pre-sowing + branching + flowering	29.2	36.9	1.25	43.2	1,822	4,638	0.28	30.72	11,025	1.81	455	4.00
CD (P=0.05)	4.4	6.8	0.05	NS	212	672	0.01	NS	1,276			
<i>Fertility level</i> (N : P ₂ O ₅ : K ₂ O, kg/ha)												
20 : 20 : 10	21.2	25.5	1.10	40.6	1,172	3,314	0.26	30.16	6,391	1.36	369	3.18
40 : 40 : 20	25.7	29.4	1.23	42.8	1,513	3,826	0.28	30.42	8,881	1.72	388	3.90
60 : 60 : 30	28.6	37.1	1.23	43.7	1,696	4,308	0.28	30.57	10,153	1.79	403	4.21
80 : 80 : 40	27.8	38.5	1.28	43.9	1,718	4,418	0.28	30.76	9,945	1.62	421	4.09
CD (P=0.05)	3.6	5.4	0.04	0.6	168	530	0.01	0.58	1,002			

Table 2. Interaction effect of irrigation and fertility levels on seed yield (kg/ha) of safflower (pooled over 3 years)

Irrigation	Fertility level (N : P ₂ O ₅ : K ₂ O, kg/ha)				Mean
	20 : 20 : 10	40 : 40 : 20	60 : 60 : 30	80 : 80 : 40	
Pre-sowing	1,048	1,316	1,390	1,338	1,273
Branching + flowering	996	1,287	1,454	1,479	1,304
Pre-sowing + branching	1,286	1,665	1,869	1,852	1,668
Pre-sowing + flowering	1,232	1,540	1,704	1,748	1,556
Pre-sowing + branching + flowering	1,297	1,756	2,064	2,171	1,822
Mean	1,172	1,513	1,696	1,718	
	<i>Irrigation</i>	<i>Fertility</i>	<i>Interaction</i>		
CD (P = 0.05)	212	168	308		

whereas the highest seed weight/capitulum was expressed by 2 irrigations (pre-sowing and branching). However, the manifestations of these characters were at par for all the irrigation treatments except the pre-sowing irrigation (I_0). Irrigation at branching resulted in development of sizeable canopy before flowering due to induction of better branching which, in turn, provided potential sites for yield attributes. Zaman and Das (1991) and Chaudhary *et al.* (1997) also opined that pre-sowing irrigation with 1 irrigation at critical phenophase increased the yield attributes of safflower. The maximum seed and stover yields were recorded with 3 irrigations (pre-sowing + branching + flowering), being at par with those at pre-sowing + branching (1,668 and 1,487 kg/ha respectively). However, the harvest index was the highest with 2 irrigations (pre-sowing + flowering), but was at par with 3 irrigations ($I_{0,30,60}$) and pre-sowing irrigation. These results corroborate the findings of Vijay Kumar (1991). The net return was the highest with 3 irrigations ($I_{0,30,60}$) but was on a par with 2 irrigations at pre-sowing and branching. The benefit : cost ratio was the highest for the latter, followed by the former irrigation treatment.

The consumptive water use was the highest with 3 irrigations applied at pre-sowing + branching + flowering ($I_{0,30,60}$) (Table 1). But the water-use efficiency (WUE) was the maximum with 2 irrigations at pre-sowing + branching followed by 3 ($I_{0,30,60}$) and 2 ($I_{0,60}$) irrigations. Katare and Bansal (1995) also found similar results.

Fertility levels

The capitula/plant were the maximum at 60:60:30 kg/ha of N:P₂O₅:K₂O level and was at par with that of 80:80:40 kg/ha and 40:40:20 kg/ha. The seeds/capitulum were, however, the maximum at 80:80:40 kg/ha level, being at par with the lower dose (Table 1). The maximum seed weight/capitulum and 1,000 seed weight were recorded at the highest fertility level (F_4). The seed and stover yields were also the maximum for the same

treatment and were at par with 60:60:30 kg/ha. The harvest index at 40:40:20, 60:60:30 and 80:80:40 kg/ha fertility levels was significantly higher than 20:20:10 kg/ha. The maximum seed oil content was obtained with 80:80:40 kg of N:P₂O₅:K₂O/ha but was at par with 60:60:30 and 40:40:20 kg/ha. The highest net return was realised from 60:60:30 kg/ha, being at par with 80:80:40 kg of N:P₂O₅:K₂O/ha.

The CU was in increasing order with increase in fertility levels, the highest being with 80:80:40 kg of N:P₂O₅:K₂O/ha. However, the WUE was the maximum with the just lower dose (F_3).

Interaction effect

The maximum seed yield was obtained from the crop receiving 3 irrigations ($I_{0,30,60}$) and fertilized with 80:80:40 kg of N:P₂O₅:K₂O/ha, being at par with the 60:60:30 kg/ha either receiving the same irrigation or 2 irrigations at pre-sowing and branching (Table 2). Optimum soil moisture ensured through irrigations might have favourably influenced the availability, uptake and utilization of applied nutrients by the crop. A declining trend in seed yield at the highest fertility level was noticed particularly when the irrigation at flowering stage was withheld. Water stress at reproductive stage might have resulted in insufficient supply of photosynthates for better filling of already created greater sink capacity with the highest fertility level.

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