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Research Paper

Effect of Irrigation and Mulching on Growth, Yield Attributes and Yield of Safflower Under Safflower-Chickpea Intercropping System in Indian Sub-continent

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ABSTRACT

The field experiment was carried out at the Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia (W.B.) to study the effect of irrigation and mulching on yield attributes and yield of safflower chickpea intercropping system during two consecutive winters of 2010-11 and 2011-12. The soil was sandy loam in texture with medium fertility status. The soil *pH* was 6.85, organic carbon (%) and total N (%) were 0.58 and 0.07, and available P_2O_5 and available K_2O were 25.45 and 178.95 kg ha^{-1}, respectively. The experiment was laid out in a split-split plot design, replicated thrice, having 3 irrigation treatments as main plots, viz., I_1 - rainfed, I_2 - Irrigation at 0.5 IW: CPE ratio, I_3 - irrigation at 0.75 IW: CPE ratio and 2 cropping system in sub-plots viz. C_1 - Sole safflower, C_2 - Safflower-chickpea has grown as 3:2 row ratio, respectively, and 2 sub-sub plot treatments, viz., M_0 - No mulching, M_1 - Straw mulching. The results showed that irrigation at 0.75 IW: CPE ratio i.e., I_3 recorded higher values of plant height, final dry matter accumulation (g m^{-2}), leaf area index, and crop growth rate (g m^{-2} day^{-1}) of safflower. Safflower-chickpea grew a 3:2 row ratio, i.e., C_2 gave the highest values of all growth attributes of safflower, and straw mulching gave a better result than no mulching. The highest values of seed yield (1159 kg ha^{-1}), oil content (28.17 %), and oil yield (326.8 kg ha^{-1}) of safflower were obtained under irrigation at IW: CPE of 0.75, i.e., I_3. Among the cropping systems, intercropping safflower gave a better result than sole safflower, and straw mulching gave a better result than no mulching.

HIGHLIGHTS

- IW/CPE ratio.
- Intercropping.
- Mulching.
- Safflower oil content.
- Protein content of chickpea.

Keywords: Intercropping, split-split plot design, cropping system, mulching

Safflower is a vital oilseed crop and is considered humanity's oldest crop cultivated in India. India occupies the premier position in safflower in the world as it was cultivated over an area of 368 thousand hectares (50% of world area) and had a production of 229 thousand tons (27% of world production) during 2015-16 (Anonymous, 2017). The safflower seeds contain 35-50% oil, 15-20% protein, and 35-45% hull fraction (Rahamatalla *et al*. 2001). Standard safflower oil contains about 6-8% palmitic acid, 2-3% stearic acid, 16-20% oleic acid,

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and 71-75% linoleic acid (Nagaraj, 2001). Presently, safflower has become a significant oilseed crop with good oil and fatty acid composition (Yeilaghi *et al.* 2012). The content of linoleic acid ranks first in all kinds of vegetable oils, and it is the best edible oil in the world (Dajue and Mundel, 1996).

India is the largest producer of pulses in the world, yet it is also the largest importer of pulses. About 90% of the global pigeon pea, 75% of chickpea, and 37% of the lentil area fall in India (FAO, 2019). Besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil. Intercropping of oilseed and pulse crops is one of the ways to increase their production because intercropping is more advantageous than sole cropping of either oilseed or pulse (Padhi and Panigrahi, 2006).

Irrigation is one of the most essential aspects of modern agriculture to increase crop production (Zaman *et al*. 2017; Maitra and Pine, 2020). The aim is that little irrigation water should be applied to get the maximum seed yield per unit of water used by the crop (Midya *et al*. 2021). The relationship between crop growth or crop yield and water use has been a primary focus of agricultural research in the arid and semi-arid regions and has been reviewed by many workers (Vaux and Pruit, 1983; Howell, 1990). Covering -row space with straw mulch is well evidenced to increase soil moisture content, decrease harmful activities of soil microbes and soil erosion control, and improve crop productivity.

MATERIALS AND METHODS

The field experiment was undertaken at the instructional farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, during two consecutive winter seasons of 2010-11 and 2011-12 under New Alluvial (Nadia) zone, West Bengal, India. The farm is located south of the tropic of cancer, 22^0 56′ N latitude and 88^0 32′ E longitudes at an elevation of 9.75 m above mean sea level (MSL). The experiment was designed with a split-split plot design with 3 irrigation levels. I_1 – Rainfed, I_2 – Irrigation at 0.50 IW: CPE ratio, and I_3 – Irrigation at 0.75 IW: CPE ratio, respectively considered as main-plot, while 2 cropping systems, viz. C_1 – Sole safflower and C_2 – Safflower-chickpea grown as 3:2 row ratio were considered sub-plot treatment and 2 mulching treatments viz. M_0 – No mulching and M_1 – Straw mulching@ 5t rice straw ha^{-1} were considered sub-sub plot treatments. The soil of the experimental field was delicate in texture and clayey in nature, having a soil pH-6.98, initial organic carbon (0.72%), total N (0.073%), and available phosphorus (92.5 kg ha^{-1}), and available potassium (241.8 kg ha^{-1}), respectively.

The crop variety of safflower and chickpea were MKH 11 and Anuradha, respectively. The recommended dose of fertilizer for safflower was 60: 40: 20 kg ha^{-1} of N: P_2O_5: K_2O, and chickpea - N: P_2O_5: K_2O @ 20:40:20 kg ha^{-1} was considered as the recommended dose of the crops. Full dose of N, P_2O_5, and K_2O was applied as basal. Rest amount of N (40 kg ha^{-1}) was equally split into two, of which 1^{st} was applied at 30 DAS, and 2^{nd} was applied at 45 DAS, respectively, to the safflower crop.

The crop was sown in the 2^{nd} week of November and harvested during the last week of March each year. The crop was harvested from each plot's 4.0 m × 3.0 m net area (gross plot size 5.0 m × 4.0 m), discarding 1 m around to avoid the border effect and threshed. The grain and straw were sun dried thoroughly and weighed separately for each plot. Available N was estimated by extracting the soil with KCL, available phosphorus following Olsen's method, and available potassium was estimated with the help of a flame photometer after extracting the soil with 1(N) ammonium acetate (Jackson, 1967). The data were subjected to statistical analysis using the analysis of variance method (Gomez and Gomez, 1984) and the significance of different sources of variations was tested by error mean square using Fisher and Snedecor's 'F" test at a probability level of 0.05.

RESULTS AND DISCUSSION

Growth attributes

Different irrigation levels significantly influenced the plant height, final dry matter accumulation (g m^{-2}), leaf area index, and crop growth rate (g m^{-2} day^{-1}) of safflower. The maximum values of all the growth parameters were recorded under irrigation at IW: CPE of 0.75, i.e., I_3, which differed significantly from all other irrigation treatments, whereas the lowest values were recorded under rainfed conditions, i.e., I_1. Less response to rainfed

Table 1: Effect of irrigation levels, cropping systems, and mulching on yield attributes, yield and oil content of safflower (Pooled basis)

Treatments	Final plant height (cm)	Final dry matter accumulation (g m^{-2})	Leaf area index at 90 DAS	Crop growth rate (g m^{-2} day^{-1}) 90 DAS-Harvest
(I) Levels of Irrigation				
I_1	76.93	188.93	1.267	1.86
I_2	81.82	220.24	1.352	2.20
I_3	86.35	249.68	1.434	2.51
S. Em (±)	0.417	2.681	0.0029	0.051
C. D. (p = 0.05)	1.362	10.53	0.0116	0.202
(II) Cropping Systems				
C_1	79.51	199.36	1.240	2.13
C_2	82.29	217.88	1.289	2.20
S. Em (±)	0.259	2.206	0.0104	0.041
C. D. (p = 0.05)	0.758	6.44	0.0305	NS
(III) Mulching				
M_0	80.84	212.47	1.315	2.16
M_1	82.55	226.76	1.387	2.22
S. Em (±)	0.206	0.418	0.0031	0.019
C.D. (p = 0.05)	0.590	1.20	0.0090	0.054

I_1 - Rain fed; I_2 - Irrigation at IW/CPE ratio of 0.50; I_3 - Irrigation at IW/CPE ratio of 0.75; C_1- Sole safflower; C_2- Safflower - chickpea grown as 3:2 row ratio; M_0- No mulching; M_1- Straw mulching @ 5t rice straw per ha.

Table 2: Effect of irrigation levels, cropping systems and mulching on yield attributes, yield and oil content of safflower (Pooled basis)

Treatments	Capitulum $plant^{-1}$	Seed $capitulum^{-1}$	Seed $plant^{-1}$	Seed yield (kg ha^{-1})	Stick yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
(I) Levels of Irrigation							
I_1	12.05	13.39	165.67	953.0	1891.0	26.98	258.5
I_2	13.82	14.68	208.15	1086.0	2024.0	27.34	297.0
I_3	15.81	15.41	250.38	1159.0	2097.0	28.17	326.8
S. Em (±)	0.126	0.183	7.025	9.80	0.115	0.093	4.50
C.D. (P = 0.05)	0.412	0.721	27.58	38.50	0.452	0.364	17.90
(II) Cropping Systems							
C_1	12.78	13.01	171.30	1418.0	2356.0	26.75	381.5
C_2	13.39	14.73	201.60	862.0	1801.0	27.45	236.8
S. Em (±)	0.091	0.132	3.748	17.40	18.10	0.192	4.10
C.D. (P = 0.05)	0.267	0.387	10.94	50.70	53.00	0.560	12.22
(III) Mulching							
M_0	13.04	14.05	188.90	1036.0	1974.0	26.98	280.4
M_1	14.76	14.94	227.23	1096.0	2034.0	28.00	307.8
S. Em (±)	0.095	0.099	2.197	5.80	5.40	0.138	1.73
C.D. (P = 0.05)	0.274	0.285	6.301	16.80	15.50	0.397	5.04

I_1 - Rain fed; I_2 - Irrigation at IW/CPE ratio of 0.50; I_3 - Irrigation at IW/CPE ratio of 0.75; C_1- Sole safflower; C_2- Safflower - chickpea grown as 3:2 row ratio; M_0- No mulching; M_1- Straw mulching @ 5t rice straw per ha.

conditions i.e., I_1 may be due to the general response of plants to less water availability. Water deficit and moisture stress may delay plant development, reducing growth (Lu *et al*. 2012).

Among the cropping systems, safflower-chickpea has grown at a 3:2 row ratio i.e., C_2 gave the highest values of all growth attributes of safflower but cropping systems did not show any significant

effect on crop growth rate (g m^{-2} day^{-1}) of safflower between 90 days after sowing (DAS) to harvest.

Among the mulching treatments, straw mulching, i.e., M_1 recorded higher values of all the growth attributes of safflower than no mulching, i.e., M_0.

Yield attributes and yield

Different levels of irrigation significantly influenced the number of capitulum $plant^{-1}$, seeds $capitulum^{-1}$, seed $plant^{-1}$, seed yield (kg ha^{-1}), stick yield (kg ha^{-1}), oil content (%), and oil yield (kg ha^{-1}) of safflower. There were significant differences among the irrigation levels on all the yield attributes of safflower. Among the irrigation levels, Irrigation at IW/CPE ratio of 0.75, i.e., I_3 gave the highest values compared to irrigation at IW/CPE ratio of 0.50, i.e., I_2, and rainfed, i.e., I_1. Water deficit during the vegetative stage severely affects safflower production as compared to full irrigation (Esendal *et al*. 2007). The highest seed yield (1159 kg ha^{-1}) and stick yield (2097 kg ha^{-1}) were obtained by irrigation at IW/CPE ratio of 0.75, i.e., I_3. Higher seed yield in IW/CPE ratio of 0.75, i.e., I_3 might be because the crops developed a better root system by receiving irrigation at the early growth stage and maximum moisture extraction from a large volume of soil (Mandal *et al*. 2018). Safflower oil content was influenced by different irrigation regimes (Ashrafi and Razmjoo 2010). The highest oil content (28.17%) was recorded under irrigation at IW/CPE ratio of 0.75, i.e., I_3. Irrigation at IW/CPE ratio of 0.50, i.e., I_2 recorded 27.34% oil content, which was statistically at par with rain fed i.e., I_1. In contrast, the highest oil yield (326.8 kg ha^{-1}) was obtained under irrigation at IW/CPE ratio of 0.75, i.e., I_3. It may be due to the better plant growth and yield by better utilization of nutrients, moisture, and solar radiation.

Among the cropping systems, safflower-chickpea grown at 3:2 row ratio i.e., C_2 gave the highest values of all yield attributes and oil content (%) of safflower. In contrast, the highest seed yield (1418 kg ha^{-1}), stick yield (2356 kg ha^{-1}), and oil yield (381.5 kg ha^{-1}) were obtained under sole safflower, i.e., C_1, respectively. It might be due to the highest seed yield of safflower obtained under sole safflower, i.e., C_1.

Among the mulching treatments, straw mulching i.e., M_1 recorded the highest values of all the yield attributes, including the yield of safflower. Higher oil content (28 %) and oil yield (307.8 kg ha^{-1}) of safflower were recorded under straw mulching, i.e., M_1. It might be due to better moisture conservation and weed control in straw mulching treatments than no mulching i.e., M_0. The results confirmed the findings of Mandal *et al.* (1990).

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