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Short Communication

Physiological parameters, yield and economics of safflower (*Carthamus tinctorius L.*) cultivars as affected by sowing dates

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Being an oil seed crop, safflower (*Carthamus tinctorius* L.) is known as drought tolerant plant and grown in semiarid climate. Generally, it is known as *kusum or kardi*. Safflower is a member of the family compositae and one of the important edible oilseed crops. It is cultivated in India mainly for oil from the seeds and reddish and yellow dyes for clothing and food preparation from the flowers. It is nutritionally similar to olive oil, with high levels of linoleic acid, but much less costly.

One of the important factors concerning crop management is setting an appropriate planting date for safflower. Sowing date can influence safflower growth and yield in different ways. Since the safflower is a long-day plant and longer days in late planting cause shortening of developmental stages, before the vegetative organs develop fully to create physiological resource. Low temperature may also slow down the growth and development of the crop, resulting in the accumulation of insufficient biomass and shortening of crop duration. Different safflower types and cultivars reflect differently with regard to planting dates. Cultivar selection is also a key management component in any cropping system even more critical in sowing date for crop production. A combination of an early sowing date with an early flowering cultivar would be essential for the production of high seed yield in the lower rainfall area. Sowing date affects most of growth parameters by influencing the light intensity and its penetration into plant. This research aims to investigate the effect of different sowing dates and cultivars on dry matter/plant, physiological parameters (CGR and RGR), yield and economics of safflower.

A field experiment was conducted during *rabi* season of 2013 under All India Coordinated Research Project on Safflower, at College of Agriculture, RVSKVV, Indore, (M.P.). Indore is situated in the "Malwa Plateau" in western parts of Madhya Pradesh at latitude of $22^0$43'N and longitude of $75^0$56'E with an altitude of 555.7 metre above the mean sea level. The rainfall occurs mostly from last week of June to middle of September with an average rainfall of 941 mm. South-west monsoon is responsible for major part of precipitation with occasional showers in winter. The soil of experimental field was a typical medium black soil (vertisol) with uniform topography with soil pH 8.2, EC 0.43 dSm^{-1}, low in organic carbon 3.6 g kg^{-1}, medium in available N (235 kg ha^{-1}) and available P (14.9 kg ha^{-1}) but high in available K (411 kg ha^{-1}). The experiment including three sowing dates (1^{st} November, 15^{th} November, and 30^{th} November) as main-plots and three cultivars (A-1, NARI-6, and NARI-57) as sub-plots was laid out in split-plot design with four replications. The net plot size was 4.50 m x 3.20 m with planting geometry (R×P) 45 x 20 cm. Seed rate was 20 kg ha^{-1} with keeping 4-5 cm depth. Recommended doses of fertilizers were 60 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1}. Full dose of P and K, and half N were applied as basal at the time of sowing, whereas rest of the N was given as top dressing at 45 days after sowing. All other agronomic practices were adopted as per recommended package of practices. Harvesting was done at physiological maturity and yields were recorded. Data were analyzed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1985). The difference between treatments mean were compared with the critical difference (CD) at 5% level of probability (p=0.05).

Dry matter of the plants was taken at 30, 60 and at harvest. The above ground plant parts were kept in an oven on 54^0C at 72 hours for drying. The dry weight of the sample was recorded and averaged for recording dry matter $plant^{-1}$.

CGR is the rate of dry matter production per unit ground area per unit time. It was calculated according to Watson (1952) and expressed in g m^{-2} day^{-1}.

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$$CGR = \frac{w_2 - w_1}{(t_2 - t_1)} * GA$$

Where, W_1 and W_2 = Plant dry weight at time t_1 and t_2; respectively and GA = Ground area

RGR is the rate of increase in the dry weight per unit dry weight already present and was calculated using the formula of Blackman (1919) and expressed as g g^{-1} day^{-1}.

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where, W_1 and W_2 = Dry weight (g) at time t_1 and t_2; respectively and Log_e = Natural Log

The dry matter accumulation in plant is directly related with the growth pattern of the crop, which influences the biological yield linearly. It was observed (Table 1) that the crop sown on 1st November recorded maximum dry matter/plant at 30, 60 DAS and at harvest stages (2.93, 20.75 and 44.82 g; respectively). The cultivar A-1 accumulated higher dry matter/plant at 30 DAS and at harvest stage (2.83 and 45.91 g; respectively) which was significantly superior to rest of the cultivars. At 60 DAS, NARI-57 recorded more dry matter/plant (16.81 g) over A-1 and NARI-6 (16.12 and 15.22 g; respectively).

Table 1: The effect of different sowing dates and safflower cultivars on physiological parameters

Treatments	Dry matter (g $plant^{-1}$)			CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})	
	30 DAS	60 DAS	At harvest	30-60 DAS	60 DAS to At harvest	30-60 DAS	60 DAS to At harvest
Sowing dates (S)							
T November	2.93	20.75	44.82	0.594	0.267	0.028	0.0037
15 November	2.86	0.311	42.34	0.383	0.311	0.023	0.0052
30 November	2.48	0.218	32.66	0.352	0.218	0.024	0.0044
SEm±	0.05	0.24	0.28	0.008	0.004	0.0003	0.00007
CD (P=0.05)	0.16	0.81	0.99	0.027	0.013	0.0011	0.00025
Cultivars (C)							
A-1	2.83	16.12	45.91	0.443	0.331	0.025	0.0052
NARI-6	2.68	15.22	34.50	0.418	0.214	0.025	0.0039
NARI-57	2.76	16.81	39.41	0.468	0.251	0.026	0.0042
SEm±	0.04	0.12	0.24	0.004	0.003	0.0002	0.00004
CD (P=0.05)	0.11	0.36	0.71	0.012	0.008	0.0007	0.00013

Crop growth rate (CGR) is directly related with the growth pattern of the crop. CGR and RGR were significantly influenced by different dates of sowing and cultivars at all crop growth stages. The crop growth rate and relative growth rate increased till 60 DAS thereafter decreased rapidly (Table 1). The significantly maximum CGR and RGR during 30-60 DAS were observed with 1st November sown crop (0.594 g m^{-2} day^{-1} and 0.028 g g^{-1} day^{-1}; respectively) over 15th and 30th November sowing. During 60 DAS to at harvest, the significantly higher CGR and RGR (0.311 g m^{-2} day^{-1} and 0.0052 g g^{-1} day^{-1}; respectively) were observed under 15th November sown crop over rest of the sowing dates. Significantly higher values of CGR and RGR at 30 to 60 DAS were received from NARI-57 (0.468 g m^{-2} day^{-1} and 0.026 g g^{-1} day^{-1}; respectively) over rest of the cultivars while at 60 DAS to at harvest stage, cultivar A-1 gave significantly greater value of CGR and RGR (0.331 g m^{-2} day^{-1} and 0.0052 g g^{-1} day^{-1}; respectively).

Biological yield is the total of crop including economical yield and the straw yield. The biological yield (bundle weight) per net plot was recorded after harvesting. The plot yield was later on converted into kg ha^{-1} by multiplying it by converting factor. Seed yield (kg ha^{-1}) is the most economical character for evaluating the superiority of the treatment over the others. The data (Table 2) indicated that sowing date brought significant variation in seed, straw and biological yield (kg ha^{-1}) and harvest index (%). The significantly higher seed, straw and biological yield (1701, 5683 and 7384 kg ha^{-1}; respectively) and Harvest index (23.06%) were obtained under 1st November sown crop over 15th November (1314, 4787 & 6101 kg ha^{-1} and 21.09%; respectively) and 30th November (1041, 4260 & 5301 kg ha^{-1} and 19.32%; respectively) sowing dates. Mirzakhani (2010) explained seed yield directly related to plant growth duration since in long plant growth duration the rate of radiation absorbed by plant increase and therefore seed yield enhanced. Such close association of seed and straw yield and harvest index (1333, 4767 and 6099 kg ha^{-1} and 21.66%; respectively) and NARI-6 (1022, 4429 and 5451 kg ha^{-1} and 18.27%; respectively). The differential behavior of these cultivars was due to their genetic makeup. The results were in close conformity with the findings of Sheykhlou *et al.* (2012).

Table 2: The effect of different sowing dates and safflower cultivars on yield and economics

Treatments	Yield (kg ha^{-1})			Harvest Index (%)	Gross Return (` ha^{-1})	Net Return (` ha^{-1})	B:C ratio
	Seed	Straw	Biological				
Sowing dates (S)							
1 November	1701	5683	7384	23.06	53887	37623	3.31
15 November	1314	4787	6101	21.09	42415	26151	2.61
30 November	1041	4260	5301	19.32	34533	18269	2.12
SEm±	12	49	43	0.28	248	248	0.02
CD (P=0.05)	40	168	149	0.96	860	860	0.05
Cultivars (C)							
A-1	1700	5535	7235	23.53	53575	37311	3.29
NARI-6	1022	4429	5451	18.27	34408	18144	2.12
NARI-57	1333	4767	6099	21.66	42852	26588	2.63
SEm±	8	35	35	0.16	218	218	0.01
CD (P=0.05)	25	103	105	0.48	648	648	0.04

Recommendation and adoption of any practice by the farmer depend upon economics. Hence it becomes essential to work out the economics of different treatments.Data (Table 2) showed that the higher gross return (`53887 ha$^{-1}$), net return (`37623 ha^{-1}) and B:C ratio (3.31) were obtained under 1st November sown crop, which was significantly superior over 15th November and 30th November sown crop. Among safflower cultivars, A-1 recorded greater gross return (`53575 ha$^{-1}$), net returns (`37311 ha^{-1}) and B:C ratio (3.29) over rest of the cultivars.

From the present study, it can be concluded that the cultivar A-1 sown 1st November proved significantly beneficial in respect of physiological parameters, yield and economics of safflower grown in medium black soils of "Malwa Plateau" in western parts of Madhya Pradesh.

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