International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 291-293

Received: 22-07-2019
Accepted: 24-08-2019

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Production potential and economics of safflower (*Carthamus tinctorius* L.) varieties under different row spacings on vertisol

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Abstract
The field experiment was conducted during *rabi* season of 2015-16 at research farm of All India Coordinated Research Project on Safflower, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra). The soil of experimental field was vertisol. The topography of the experimental site was uniform and leveled. Safflower varieties Annigeri-1 and NARI -38 were tested in F.R.B.D. with three replicated thrice at 30 cm, 45 cm, 60 cm, 75 cm and 90 cm row to row spacing with 20 cm common plant to plant spacing. Data on mean seed yield (kg ha^{-1}) as influenced by different spacing showed that the spacing 45 cm × 20 cm produced highest seed yield of 1149 (kg ha^{-1}) than other treatments. Between two varieties, Annegiri-1 recorded higher seed yield of 1099 (kg ha^{-1}) which was higher over NARI-38.Gross and net monetary returns followed the similar trend. Oil content of safflower was not influenced due to spacing or variety.

Keywords: Production potential, safflower, spacing, safflower variety, vertisol

Introduction
Safflower (*Carthamus tinctorius* L.) is an important *rabi* oilseed crop of Maharashtra. Apart from its superior adaptability to scanty moisture conditions, it produces oil rich in polyunsaturated fatty acids (Linoleic acid, 78%) which play an important role in reducing the blood cholesterol level. For centuries, it has been under cultivation in India for its coloured much valued florets and oil. In India, Maharashtra and Karnataka are the two most important safflower growing states. It is also grown to a limited extent in Gujarat, Andhra Pradesh, Madhya Pradesh, Orissa, Bihar. There is tremendous scope for expansion of area in India and Maharashtra (Anonymous, 2010) [1]. Safflower is normally in rows 50 to 100 cm apart. Narrower rows allow greater suppression of weeds, whilst wider rows may facilitate better air flow for disease control. Wider rows are also more suited to inter row sowing, cultivation for weed control or band spraying. Low sowing rates and very wide rows to 150 cm may be preferable in very dry situations, but row spacing's above 100 cm have resulted in lower yields in more favorable growing conditions (Marchione, 1997 [3] and Oad *et al*., 2002) [4].

Methodology
The field experiment was conducted during *rabi* season of 2015-16 at research farm of All India Coordinated Research Project on Safflower, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra). The soil of experimental field was Vertisol. The topography of the experimental site was uniform and leveled. The soil of experimental field was clayey in texture. It was low in nitrogen, medium in phosphorus and high in potash, while medium in organic carbon and slightly alkaline in nature. Safflower varieties Annigeri-1 and NARI -38 were tested in F.R.B.D. with three replications at 30 cm, 45 cm, 60 cm, 75 cm and 90 cm row to row spacing with 20 cm common plant to plant spacing. Recommended dose of fertilizer (60:40:00 NPK kg/ha) was applied at the time of sowing and top dressing through urea, Diamononium phosphate (DAP), Single super phosphate (SSP) and Murat of potash (MOP). Sowing was done by dibbling 2-3 seeds per hill, on October 13, 2015. One irrigation was given before sowing; 2nd after 35 DAS sowing while 3rd irrigation was given at the time of branching. For protection of crops from the pest and diseases, seed treatment and spraying of pesticide was done. In addition, the crop was protected from bird damage by keeping regular watch. Data on growth characters *viz.*, plant height, number of branches, leaf area, and number

of capitula was recorded from five plants randomly selected in each treatment. Data was collected at 15 days interval starting from 30 days after sowing. While dry matter was recorded from one plant randomly selected from the experimental plots. At the final harvest, data on yield and yield contributing characters *viz.* number of seeds / plant seed yield / plant, in each crop were recorded from the five plants selected earlier for growth characters. All plants from net plots were harvested at maturity and data on seed and straw yield were recorded. At harvest the seeds of safflower were analyzed for oil content by NMR method at AICRP on safflower Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Oil yield (kg / ha) was calculated by using following formula.

$$\text{Oil yield (kg/ha)} = \frac{\text{Oil content (\%)} \times \text{Seed yield (kg ha}^{-1})}{100}$$

Monetary returns per hectare was computed on the basis of prevalent market prices of different items or products. The total income (gross monetary returns) per hectare was divided by the total cost of cultivation per hectare to obtain B: C ratio. The statistical analysis was done by the standards as tested by "f" test to know whether observed treatment effects were real or not. The results were inferred based upon the 5% probability (P=0.05) level of significance. However, the critical difference (CD) was computed only of those effects where the variance ratio was found significant.

Results and discussion

Data on mean seed yield (kg ha^{-1}) as influenced by different spacing are presented in Table 1 which showed that the spacing of 45 cm × 20 cm produced higher safflower seed yield of 1149 (kg ha^{-1}) and it was superior over 30 cm × 20 cm, 60 cm × 20 cm, 75 cm × 20 cm and 90 cm × 20 cm spacing. The similar trend was observed in case of straw yield (kg ha^{-1}) and biological yield (kg ha^{-1}). If the spacing is optimum increase in the seed yield, straw yield and biological yield of safflower was observed by Barik and Sahoo (1989) [2], Patel *et al*. (1994) [5], Ozel *et al*. (2004) [6]. Harvest index was not influenced by different row spacing.

The results of oil content and oil yield (Table 2) revealed that on an average oil content in safflower was 29.00. The mean oil yield was 291.09 kg ha^{-1}. The sowing of safflower in different row spacing was not influenced significantly the oil content of safflower. The oil yield was influenced significantly by row spacing. With increase in seed yield per hectare oil yield is also increased. The similar results were reported by Uke *et al.* (2009) [7].

The performance of safflower varieties in respect of seed yield kg ha^{-1} was very encouraging and followed a similar trend that of yield attributes. The safflower variety Annegiri-1 recorded higher seed yield (1099 kg ha^{-1}) which was higher over NARI-38. Safflower variety Annegiri-1 produced biological yield (4221 kg ha^{-1}) and straw yield (3122 kg ha^{-1}) which was higher over NARI-38. The highest biological yield of Annegiri-1 as compared to NARI-38 might be due to accumulation of more dry matter and higher biomass potential.

The results of oil content and oil yield revealed that on an average oil content in safflower was 29.00. The mean oil yield was 291.09 kg ha^{-1}. The sowing of safflower varieties could not influence significantly the oil content of safflower, however, the oil yield was influenced significantly with the increase in seed yield.

Economics

The sowing of safflower at spacing of 45 cm × 20 cm produced higher gross monetary returns, net monetary returns and B**:**C ratio and it was found to be on par with 60 cm × 20 cm spacing and superior over 60 cm × 20 cm, 75 cm × 20 cm, 90 cm × 20 cm spacing. The similar trend was observed in case of net monetary returns and benefit: cost ratio. Safflower variety Annegiri-1 recorded higher values of gross monetary returns, net monetary returns and B: C ratio as compared to variety NARI-38.

The interaction effects were not influenced significantly in case of yield and economics of safflower.

Table 1: Mean seed, straw, biological yield (kg ha^{-1}) and harvest index (%) under various treatments

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Spacings (S)				
S_1- (30cm×20cm)	1082	3244	4326	26.00
S_2- (45cm×20cm)	1149	3562	4711	24.67
S_3- (60cm×20cm)	950	2660	3610	24.17
S_4- (75cm×20cm)	922	2489	3394	24.33
S_5- (90cm×20cm)	830	2075	2905	22.50
S.E.±	32.19	319.83	309.39	0.93
C.D.at 5%	95.52	950.15	919.16	NS
Varieties (V)				
V_1- (Annegeri-1)	1099	3122	4221	25.00
V_2- (NARI-38)	874	2490	3357	24.67
S.E.±	20.36	202.27	195.68	0.59
C.D.at 5%	60.41	600.93	81.33	NS
Interaction (S×V)				
S.E.±	45.53	452.28	437.55	1.31
C.D.at 5%	NS	NS	NS	NS
General Mean	987	2806	3789	24.33

Table 2: Oil content (%) and oil yield (kg ha^{-1}) as affected by various treatments

Treatments	Oil content (%)	Oil yield (kg ha^{-1})
Spacings (S)		
S_1- (30cm×20cm)	26.73	280.10
S_2- (45cm×20cm)	28.20	334.91
S_3- (60cm×20cm)	28.48	279.81
S_4- (75cm×20cm)	30.22	290.71
S_5- (90cm×20cm)	31.38	269.91
S.E.±	1.30	14.580
C.D.at 5%	NS	43.314
Varieties (V)		
V_1- (Annegeri-1)	30.22	330.32
V_2- (NARI-38)	27.79	251.86
S.E.±	0.82	9.22
C.D.at 5%	NS	27.39
Interaction (S×V)		
S.E.±	1.84	20.61
C.D.at 5%	NS	NS
General Mean	29.00	291.09

Table 3: Monetary returns as influenced by various treatments

Treatment	Gross monetary returns (GMR) (Rs. ha^{-1})	Net monetary returns (NMR) (Rs. ha^{-1})	Benefit: cost ratio (B:C)
Spacings (S)			
S_1- (30cm×20cm)	35690	14390	1.62
S_2- (45cm×20cm)	37917	16917	1.81
S_3- (60cm×20cm)	31350	10650	1.52
S_4- (75cm×20cm)	30426	10026	1.49
S_5- (90cm×20cm)	27390	7290	1.36
S.E.±	1062.50	1062.50	0.05
C.D.at 5%	3152.20	3152.20	0.15
Varieties (V)			
V_1- (Annegeri-1)	36267	15567	1.75
V_2- (NARI-38)	28842	8142	1.40
S.E.±	671.98	671.98	0.03
C.D.at 5%	1993.50	1993.50	0.10
Interaction (S×V)			
S.E.±	1502.6	1502.6	0.07
C.D.at 5%	NS	NS	NS
General Mean	32555	11854	1.57

Conclusion

For maximum productivity and highest net returns, it is essential to undertake sowing of safflower at 45 cm x 20 cm on vertisols. Safflower variety Annigeri- 1 was found to be more productive in respect of seed yield.

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