

Original Research Article

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Effect of Sulphur Levels and FYM on Yield, Oil Content and Nutrient Uptake of Safflower under Dry Land Agriculture

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ABSTRACT

Keywords

Safflower, Sulphur, palmitic acid, linolic acid, oleic acid

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The Field experiments were conducted during the six consecutive years (*kharif*) from 2013-14 to 2019-20 at the Dryland Farming Research Station, Zonal Agriculture Research Station, Solapur to ascertain the effect of sulphur levels and FYM on yield, oil content and nutrient uptake of safflower under dry land agriculture. Application of NPK 50:25:00 kg ha⁻¹ + FYM 1 t ha⁻¹ with sulphur 40 kg ha⁻¹ recorded significantly higher plant height (78.70 cm), number of capsules / plant (22.58), 100 grain weight (6.55gm), moisture use efficiency for grain (6.30 kg ha⁻¹mm⁻¹), grain and straw yield (15.83 and 38.42 q ha⁻¹) oil yield (500.3 kg ha⁻¹), oil content (31.60%) significantly higher uptake of N, P and K (44.76,17.37 and 100.15 kg ha⁻¹) with higher gross monetary returns, net returns and cost benefit ratio (Rs.72249/- ,Rs.47429/- and 2.91).

Introduction

In India, safflower (*Carthamus tinctorius* L.) is the crucial annual oilseed crop grown in *rabi* season and occupies 0.46 lakh ha. with productivity of 537 kg ha⁻¹ while in Maharashtra it grown on 0.25 lakh ha with productivity of 475 kg ha⁻¹ in the year 2018-19. Seed contains 30-40 % oil and 15-20 % protein (Rahamatalla *et al.*, 2001) and mostly

possess fatty acid like stearic acid (2-3%), oleic acid (16-20%), palmitic acid (6-8%) and linolic acid (71-75 %). It is the most suitable crop for the dryland farming due to its important characteristics like drought resistance, deep root system, short duration, cultivable in all types of soil with low inputs and grown on residual soil moisture (Walia *et al.*, 2005). Most of the world oilseed production occurs in the semi arid tropics

suffer from sulphur deficiency resulting in low yield. Sulphur fertilization influences the composition of the oil. Sulphur fertilization with an adequate supply of nitrogen and phosphorous accelerate the metabolic pathway of linolenic acid synthesis as it result in a large decrease in the percentage of stearic acid, oleic and linoleic acid with concurrent increase in the content of linolenic acid (Nagaraj, 1993). The oil is rich in polyunsaturated fatty acid and is beneficial to the patients having cardiac problems. FYM is a store house of several macro and micronutrients which are released during the process of mineralization and stimulated the activity of microorganism that make the plant nutrients readily available to the crop (Rasool *et. al.* 2013).

Sulphur ranks 13th in terms of abundance in the earth's crust and is the fourth major plant nutrient after N, P and K (Kanwar and Mudahar, 1986). Mineralization of organic matter releases sulphur in the available form to the plant and plant absorb sulphur mostly through roots in the form of sulphate (Singh *et. al.* 2001). Sulphur helps in increasing the oil content of oil seed crops and acts as a major nutrient in determining the quality of oil (Roy and Ghosh, 2020). Sulphur helps in the synthesis of cystein, methionine, chlorophyll, vitamins (Biotin and thiamin), metabolism of carbohydrates especially by its effect on the protolytic enzymes (Najar *et al.*, 2011).

In the recent year, a concept of integrated nutrient supply involving the use of organic manures and inorganic fertilizers has been developed to obtain sustained agriculture production (Gaikwad and Puranik, 1996.) Integrated nutrient management (INM) involves the use of manures, biofertilizers and chemical fertilizers to achieve sustained crop production and maintain better soil health. INM is better approach for better utilization of resources and to produce crops with less

expenditure. In view of these, the present investigation was carried out to study the effect of sulphur levels and FYM on yield, oil content and nutrient uptake of safflower under dryland condition.

Materials and Methods

The field experiment was conducted on the Dryland Farming Research Station, Zonal Agriculture Research Station, Solapur for the six consecutive years (*kharif*) from 2013-14 to 2019-20. The experiment was laid out in Randomized Block Design, having seven treatments combinations which were replicated four times and compared with the recommended dose. The treatments are T₁ i.e. Absolute control, T₂ i.e. (R.D.F. N: P₂O₅ : K₂O : 50 :25 : 0 kg ha⁻¹ + FYM 1 t ha⁻¹), T₃ i.e. R.D.F + FYM 1 t ha⁻¹ + sulphur 10 kg ha⁻¹, T₄ i.e. R.D.F + FYM 1 t ha⁻¹ + sulphur 20 kg ha⁻¹, T₅ i.e. R.D.F + FYM 1 t ha⁻¹ + sulphur 30 kg ha⁻¹, T₆ i.e. R.D.F + FYM 1 t ha⁻¹ + sulphur 40 kg ha⁻¹ and T₇ i.e. R.D.F + FYM 1 t ha⁻¹ + sulphur 50 kg ha⁻¹. FYM as per the treatment was incorporated in the soil and the N and P was uniformly applied to each plot as a basal dose during both the years of the experiment. Sulphur was applied through elemental sulphur. The seeds of safflower variety SSF-708 was line sown spaced at 45x20 cm. Five random plants were selected in each treatment excluding the border row for taking the observations of plant height, No. of capsules / plant and 100 grain weight. Soil P^H was measured in 1:2 soil water suspensions where 10 gm of soil was taken and stirred intermittently for 30 minutes with 20 ml of water and measured with P^H meter (McLean, 1982). The electrical conductivity was measured in 1:2 soil water suspensions using conductivity meter (Rhoades, 1982). N.P and K content of crop residues were analyzed by standard procedures outline by Jackson (1973).Organic carbon (Walkley and Black, 1934). Available N (Subbaiah and Asija,

1956), Available P₂O₅ (Olsen *et al.*, 1954) and Available K₂O (Knudsen and Peterson, 1982). Sulphur (Singh *et al.*, 1988). The oil content in the seeds for each treatment was determined by Nuclear Magnetic Resonance analysis (Tiwari *et al.*, 1974). The data obtained in respect of the observations was statistically analyzed by Pance and Sukhatme (1985).

Results and Discussion

Morphological Characters and MUE

The pooled data of effect of sulphur levels and FYM on MUE and morphological characters i.e. plant height, No. of capsules / plant and 100 grain weight was presented in Table 1. The data depicted in the table showed that, the higher moisture use efficiency for grain (6.30 kg ha⁻¹mm⁻¹) was recorded in treatment T₆ i.e. NPK 50:25:00 kg ha⁻¹+ FYM 1 t ha⁻¹ with sulphur 40 kg ha⁻¹ followed by T₇ (5.78 kg ha⁻¹mm⁻¹).

As regards to the morphological characters, Treatment T₆ i.e. NPK 50:25:00 kg ha⁻¹ + FYM 1 t ha⁻¹ with sulphur 40 kg ha⁻¹ recorded significantly higher plant height, number of capsules and 100 grain weight (78.70 cm, 22.58 no of capsules / plant and 6.55gm respectively) over rest of the treatments.

Increased in plant height might be due to increased in metabolic processes in the plant and increased meristematic activities causing more apical growth. Synthesis of proteins due to sulphur may have resulted in proper partitioning of photosynthesis from source to sink resulting in improvement in yield contributing attributes like 100 grain weight. Rasool *et al.*, (2013) reported that, synthesis of

phytin (Isoinositolhexa phosphate) which is a salt of Ca, magnesium (Mg) and P (salt of Ca and Mg are present in cow urine) may have increased the seed weight.

Grain, Straw, oil yield and oil content

The pooled data of effect of sulphur levels and FYM on Grain, Straw, oil yield and oil content of safflower under dryland agriculture as influenced by different treatments were presented in Table 2. From this table, it was revealed that, the treatment T₆ i.e. NPK 50:25:00 kg ha⁻¹+ FYM 1 t ha⁻¹ with sulphur 40 kg ha⁻¹ recorded significantly higher grain, straw, oil yield and oil content (15.83 and 38.42 q ha⁻¹, 500.3 kg ha⁻¹ and 31.60 %) over rest of the treatments. Whereas, treatment T₁ i.e. absolute control recorded lowest grain, straw, oil yield and oil content (7.97 and 17.24 q ha⁻¹, 240.7 kg ha⁻¹ and 30.22 %). Increased in yield to be associated with release of nutrients during microbial decomposition. Organic matter is a source of energy for soil microflora which brings transformation of inorganic nutrients held in soil in a form that readily utilized by growing plants. FYM help in increasing the availability of sufficient amount of nutrients throughout growth period resulting in better uptake, plant vigour and superior yield attributes (Shivakumar and Ahlawat, 2008). Kumar *et al.*, (2009) reported that, use of organic manures along with inorganic fertilizers attribute to higher availability and adsorption of nutrients. Thirumelai and Khalak (1993) reported that, increase in stover yield in soybean might be due to supply of essential mineral nutrients in balanced amount which resulted in better growth and development of plants.

Table.1 Effect of sulphur levels and FYM on growth, yield contributing character and MUE of safflower (pooled mean of 2013-14 to 2019-20)

Treatments	Plant Height (cm)	No. of capsules / plant	100 grain wt. (gm)	MUE (kg ha ⁻¹ mm ⁻¹)
T ₁ . Absolute Control	70.52	12.58	5.85	3.22
T ₂ . RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	72.87	16.77	6.15	4.45
T ₃ . RDF + FYM 1 tha ⁻¹ + Sulphur 10 kgha ⁻¹	72.48	18.68	6.25	4.86
T ₄ . RDF + FYM 1 tha ⁻¹ + Sulphur 20 kgha ⁻¹	74.65	19.53	6.37	4.89
T ₅ . RDF + FYM 1 tha ⁻¹ + Sulphur 30 kgha ⁻¹	75.50	20.85	6.54	5.35
T ₆ . RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	78.70	22.58	6.55	6.30
T ₇ . RDF + FYM 1 tha ⁻¹ + Sulphur 50 kgha ⁻¹	74.48	20.57	6.37	5.78
SE _±	0.99	0.64	0.09	0.34
CD at 5%	2.89	1.86	0.28	0.97

Table.2 Effect of sulphur levels and FYM on yield and quality parameters of safflower (pooled mean of 2013-14 to 2019-20)

Treatments	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)	Oil yield (kg ha ⁻¹)	Oil content (%)
T ₁ . Absolute Control	7.97	17.24	240.7	30.22
T ₂ . RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	10.29	23.11	314.4	30.56
T ₃ . RDF + FYM 1 tha ⁻¹ + Sulphur 10 kgha ⁻¹	11.75	27.50	364.1	31.00
T ₄ . RDF + FYM 1 tha ⁻¹ + Sulphur 20 kgha ⁻¹	12.98	31.15	405.1	31.21
T ₅ . RDF + FYM 1 tha ⁻¹ + Sulphur 30 kgha ⁻¹	13.90	33.08	437.1	31.46
T ₆ . RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	15.83	38.42	500.3	31.60
T ₇ . RDF + FYM 1 tha ⁻¹ + Sulphur 50 kgha ⁻¹	14.31	34.66	449.8	31.43
SE _±	0.31	0.91	9.78	0.07
CD at 5%	0.89	2.63	28.39	0.20

Table.3 Effect of sulphur levels and FYM on Nutrient uptake of safflower (pooled mean of 2013-14 to 2019-20)

Treatments	N uptake (kg ha ⁻¹)	P uptake (kg ha ⁻¹)	K uptake (kg ha ⁻¹)
T ₁ . Absolute Control	24.01	7.50	47.84
T ₂ . RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	29.15	9.47	62.07
T ₃ . RDF + FYM 1 tha ⁻¹ + Sulphur 10 kg ha ⁻¹	33.77	10.70	72.07
T ₄ . RDF + FYM 1 tha ⁻¹ + Sulphur 20 kg ha ⁻¹	35.63	13.29	80.53
T ₅ . RDF + FYM 1 tha ⁻¹ + Sulphur 30 kg ha ⁻¹	37.94	15.15	86.63
T ₆ . RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	44.76	17.37	100.15
T ₇ . RDF + FYM 1 tha ⁻¹ + Sulphur 50 kg ha ⁻¹	39.18	15.43	90.60
SE _±	1.01	0.61	2.48
CD at 5%	2.97	1.79	7.28

Table.4 Effect of sulphur levels and FYM on Soil properties (pooled mean of 2013-14 to 2019-20)

Treatments	pH	EC (dSm ⁻¹)	Organic Carbon (%)	Sulphur content (ppm)
T ₁ . Absolute Control	7.57	0.30	0.40	5.33
T ₂ . RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	7.69	0.31	0.45	5.91
T ₃ . RDF + FYM 1 tha ⁻¹ + Sulphur 10 kg ha ⁻¹	7.62	0.33	0.46	6.60
T ₄ . RDF + FYM 1 tha ⁻¹ + Sulphur 20 kg ha ⁻¹	7.60	0.33	0.48	7.54
T ₅ . RDF + FYM 1 tha ⁻¹ + Sulphur 30 kg ha ⁻¹	7.63	0.31	0.46	8.16
T ₆ . RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	7.55	0.32	0.48	9.40
T ₇ . RDF + FYM 1 tha ⁻¹ + Sulphur 50 kg ha ⁻¹	7.60	0.31	0.50	9.62
SE _±	0.04	0.014	0.02	0.19
CD at 5%	NS	NS	NS	0.55

Table.5 Effect of sulphur levels and FYM on Nutrient availability (pooled mean of 2013-14 to 2019-20)

Treatments	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
T ₁ . Absolute Control	144.8	9.56	552.5
T ₂ . RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	163.2	13.41	590.8
T ₃ . RDF + FYM 1 tha ⁻¹ + Sulphur 10 kg ha ⁻¹	167.8	14.06	594.7
T ₄ . RDF + FYM 1 tha ⁻¹ + Sulphur 20 kg ha ⁻¹	171.8	14.08	611.8
T ₅ . RDF + FYM 1 tha ⁻¹ + Sulphur 30 kg ha ⁻¹	173.2	14.71	611.7
T ₆ . RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	176.0	15.16	624.0
T ₇ . RDF + FYM 1 tha ⁻¹ + Sulphur 50 kg ha ⁻¹	174.2	15.15	614.7
SE _±	5.03	0.39	8.22
CD at 5%	14.59	1.21	23.84

Table.6 Effect of sulphur levels and FYM on economics of safflower under dryland Agriculture (pooled mean of 2013-14 to 2019-20)

Tr. No.	Treatment details	Yield (q ha ⁻¹)		Cost of cultivation (Rs ha ⁻¹)	Gross Monetary returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	B:C ratio
		Grain	Stover				
T ₁	Absolute Control	7.97	17.24	16500	36060	19560	2.19
T ₂	RDF N:P ₂ O ₅ (50:25:0) + FYM 1 t ha ⁻¹	10.29	23.11	23200	46684	23484	2.01
T ₃	RDF + FYM 1 tha ⁻¹ + Sulphur 10 kgha ⁻¹	11.75	27.50	23620	53475	29855	2.26
T ₄	RDF + FYM 1 tha ⁻¹ + Sulphur 20 kgha ⁻¹	12.98	31.15	24020	59188	35168	2.46
T ₅	RDF + FYM 1 tha ⁻¹ + Sulphur 30 kgha ⁻¹	13.90	33.08	24420	63342	38922	2.59
T ₆	RDF + FYM 1 tha ⁻¹ + Sulphur 40kg ha ⁻¹	15.83	38.42	24820	72249	47429	2.91
T ₇	RDF + FYM 1 tha ⁻¹ + Sulphur 50 kgha ⁻¹	14.31	34.66	25220	65301	40081	2.59
	SE _±	0.31	0.91	--	--	--	--
	CD at 5%	0.89	2.63	--	--	--	--

Rates :Grain : Rs 4200/- q⁻¹, Stover : Rs 150/- q⁻¹, Sulphur @ Rs. 40 /- kg⁻¹.

FYM seems to act directly in increasing crop yield either by accelerations of respiratory process by increasing cell permeability by hormone growth action or by combination of all the process *viz.* release of nutrients, increasing the availability of nutrients and improving soil physical, chemical and biological properties (Rasool *et al.*, 2013). Roy and Ghosh (2020) reported that, sulphur play an important role in the formation of glucosides which on hydrolysis produce higher amount of oil and also responsible for sulpho- hydriyl linkage and activation of enzymes which help in biochemical reactions within the plant help in increasing the oil content. Aziz *et al.*, (2018) reported that, application of FYM (10 t ha⁻¹) recorded highest oil content in grain of soybean. This increase may be due to mineralization of organic nutrients of FYM as well as microbial

activity due to available organic carbon. The mineralization of organic nutrients enhanced oil content due to synthesis of fatty acids and their etherification by accelerating biochemical reaction in glycoxalate cycle.

Nutrient uptake

The pooled data regarding nutrient uptake are presented in Table 3. From the pooled data, it was revealed that, the treatment T₆ i.e. NPK 50:25:00 kg ha⁻¹ + FYM 1 tha⁻¹ with sulphur 40 kg ha⁻¹ recorded significantly higher uptake of N, P and K (44.76,17.37 and 100.15 kg ha⁻¹) over rest of the treatments.

Soil analysis at harvest

The treatment wise soil samples were collected after harvest and analyzed for

different parameters and are presented in Table 4. From the pooled data, it was seen that, the soil pH, EC, and the organic carbon content was found non-significant except the sulphur content (ppm) due to different treatments. The treatment T₇ i.e. NPK 50:25:00 kg ha⁻¹ + FYM 1 tha⁻¹ with sulphur 50 kg ha⁻¹ recorded higher sulphur content (9.62 ppm) over rest of the treatments. However, it was on par with the treatment T₆.

Available Nutrients

The pooled data regarding the available nutrients (kg ha⁻¹) was presented in Table 5. From the data it was revealed that, T₆ i.e. NPK 50:25:00 kg ha⁻¹ + FYM 1 tha⁻¹ with sulphur 40 kg ha⁻¹ recorded significantly higher available N, P and K (176.0, 15.16 and 624.0 kg ha⁻¹) followed by the treatment T₇. Kumar *et al.*, (2009) reported that, organic manures along with inorganic fertilizers attribute to higher availability and adsorption of nutrients. FYM is a store house of several macro and micronutrients which are released during the process of mineralization and stimulated the activity of microorganism that make the plant nutrients readily available to the crop (Rasool *et al.*, 2013).

Economics

The pooled data pertaining to economics are reported in Table 6. From this table it was revealed that, the highest pooled grain and stover yield (15.83 and 38.42 q ha⁻¹) with higher gross monetary returns, net returns and cost benefit ratio (Rs.72249/-, Rs.47429/- and 2.91 respectively) was observed in treatment T₆ i.e. NPK 50:25:00 kg ha⁻¹ + FYM 1 tha⁻¹ with sulphur 40 kg ha⁻¹ over rest of the treatments.

Based on the foregoing results, it can be concluded that, significantly higher grain and stover yield and its components as well as

nutrient uptake and available nutrients in the soil were obtained with the plants supplied with recommended dose of NPK 50:25:00 kg ha⁻¹ + FYM 1 tha⁻¹ with sulphur 40 kg ha⁻¹ and required more critical testing of such nutrient studies at multiplications.

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