



Effect of Different Moisture Conservation Methods and Nutrient Management Practices on Growth, Yield and Economics of Safflower (*Carthamus tinctorius* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To determine the effect of moisture conservation methods and nutrient management practices on growth, yield and economics of safflower.

Study Design: Split plot.

Place and Duration of Study: Agricultural Research Station, Tandur, between November 2021 and March 2022.

Methodology: A field experiment was conducted at Agricultural Research Station, Tandur, Vikarabad (District) during *rabi* 2021-22 to assess the effect of different moisture conservation methods and nutrient management practices on growth, yield and economics of safflower (*Carthamus tinctorius*) under rainfed condition. The experiment was assigned in twenty treatments, laid out in split plot design with three replications. Treatments included were 4 treatments of

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moisture conservation methods (i) M_1 = Fallow in *kharif fb* safflower in *rabi* (ii) M_2 = Greengram in *kharif fb* safflower in *rabi* (iii) M_3 = Compartmental bunding in *kharif fb* safflower in *rabi* (iv) M_4 = Barnyard millet in *kharif fb* safflower in *rabi* and 5 fertility levels (i) N_1 = Control (No fertilizer) (ii) N_2 = 50% RDF (iii) N_3 = 75% RDF (iv) N_4 = 100% RDF (v) N_5 = 125% RDF randomly placed in sub plots of the main plot.

Results: Significantly higher grain yield (1402 kg ha⁻¹), stover yield (3130 kg ha⁻¹) was recorded under compartmental bunding in *kharif fb* safflower in *rabi* (M_3). Similarly maximum grain yield (1565 kg ha⁻¹), stover yield (3659 kg ha⁻¹) was observed in 125% RDF (N_5). The lower yield was recorded in M_4 in moisture conservation practices whereas it was N_1 (control) as in case of fertility levels. Exceptionally higher net returns was observed in M_3 (Rs.53401) and N_5 (Rs.61506).

Conclusion: Adoption of moisture conservation methods during *kharif* in semi arid regions impounds the rainwater effectively thereby providing more residual moisture for the upcoming *rabi* crop and enhances the crop yield.

Keywords: *Compartmental bunding; fertility levels; growth parameters and yield attributes.*

1. INTRODUCTION

Safflower locally known as kusum, is an annual oilseed plant belongs to the family asteraceae and botanically it is called *Carthamus tinctorius* L. In India safflower is grown in the winter dry season in mixture with other *rabi* crops, such as wheat and sorghum. Safflower has been grown in India since ancient times not only for orange red dye extracted from florets but also for oil. The dye was largely used for coloring purposes in food and textile industry. Safflower produces oil rich in polyunsaturated fatty acids which play important role in reducing blood cholesterol level and is considered as good healthy cooking medium [1]. Safflower is an important oil seed crop of *rabi* season in India mainly grown in semi-arid regions for vegetable and industrial oil purposes, although elsewhere its seeds are used as bird feed, young plants as a forage plant and florets for preparing textile dyes. Safflower seed contains around 28 to 34 per cent of oil with high levels of linoleic acid, which is known to reduce blood cholesterol content. Now-a-days the rainfall is erratic and undependable, causing excess or deficient moisture conditions during one or the other stage of crop growth. Therefore, the yield of crops is often low and erratic. The variability in yield has mostly been caused by a lack of even distribution of rainfall all through the *kharif* season, as well as a low infiltration rate of the soil. Crop production in rainfed locations has become more problematic in recent years due to uncertainty in rainfall availability, as well as variations in monsoon commencement, continuation, and withdrawal patterns [2]. In these circumstances, effective rainwater management measures provide crop insurance during periods of unusual rainfall. Drought stress is one of the most significant constraints to crop

development and output. Rainwater conservation and effective recycling are vital in achieving a sustainable farming production system in a rainfed zone. Compartmental bunding, ridge and furrow, and broad bed furrow developed systems are among the several moisture conservation strategies that show promise in minimizing surface runoff, reducing soil loss through erosion, and enhancing infiltration.

2. MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2021-22 at Agricultural Research Station, Tandur, Vikarabad (District) with twenty treatments, laid out in split plot design with three replication. The soil of the experimental site was clayey in texture and slightly alkaline in reaction (pH 7.94), low in organic carbon (0.44%) and available nitrogen (220.5 kg ha⁻¹), high in available phosphorus (37.2 kg ha⁻¹) and potassium (381.37 kg ha⁻¹) with electrical conductivity of 0.3 ds m⁻¹. Treatments included were 4 treatments of moisture conservation practices (i) M_1 = Fallow in *kharif fb* safflower in *rabi* (ii) M_2 = Greengram in *kharif fb* safflower in *rabi* (iii) M_3 = Compartmental bunding in *kharif fb* safflower in *rabi* (iv) M_4 = Barnyard millet in *kharif fb* safflower in *rabi* and 5 fertility levels (i) N_1 = Control (No fertilizer) (ii) N_2 = 50% RDF (Recommended Dosage of Fertilizers) (iii) N_3 = 75% RDF (iv) N_4 = 100% RDF (v) N_5 = 125% RDF randomly placed in sub plots of the main plot. Safflower variety 'ISF 764' was sown in the field with a seed rate of 10 kg ha⁻¹, maintaining 45 cm x 20 cm as spacing at a depth of 2-3 cm. The crop was fertilized with 40:20:00 kg (100% RDF) Nitrogen, Phosphorus and Potassium ha⁻¹ in the form of Urea and DAP. Economics (Benefit:Cost ratio) were calculated by dividing

the gross returns with cost of cultivation. Soil moisture content (%) was done by gravimetric method.

$$\text{B:C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

$$\frac{\text{Soil moisture content (\%)}}{\frac{\text{fresh weight of the soil} - \text{oven dry weight of the soil}}{\text{oven dry weight of the soil}}} =$$

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The data presented in (Table 1) shows the moisture conservation practices had not shown any significant difference among growth parameters of safflower. The M₃ treatment recorded higher plant height (77.95 cm), no. of branches (17.2), Leaf area index (3.58) and dry matter production (6311 kg ha⁻¹). The fertility levels recorded significantly higher plant height and other crop growth parameters. The 125% RDF (N₅) had recorded significantly higher plant height (99.77), no. of branches (21.5), leaf area index (3.85) and dry matter production (7351 kg ha⁻¹) followed by 100% RDF. The control treatment recorded the lowest growth attributes due to non availability of nutrients. Instant and adequate availability of N, P and K under N₅ treatment resulted in higher plant height compared to other treatments. The low amount of nutrient availability might be the reason for the slight response in the concerned treatments (N₁, N₂ and N₃). Similar results were reported by Rajput et al. [3], Kannan et al. [4] and Vijayprabhakar et al. [5]. Residual soil moisture in the compartmental bunding treatment found to be beneficial to enhance the plant growth resulting in production of more number of branches per plant. The application of 125% RDF significantly increased the production of more branches due to availability of nutrients, and their absorption and utilization by the crop. Similar views were also expressed by Kubsad et al. [6] and Rajput [7].

3.2 Yield Attributes and Yield

The moisture conservation practices recorded significantly higher seed yield and stalk yield (Table 2). The M₃ treatment showed significantly higher seed yield (1402 kg ha⁻¹) and stalk yield (3130 kg ha⁻¹). The maximum no. of capitula plant⁻¹ (19.2), no. of seeds capitulum⁻¹ (18.3), weight of capitula plant⁻¹ (35.6 g plant⁻¹) was

observed in M₃ followed by M₁. Among fertility levels 125% RDF recorded significantly higher yield attributes and yield (seed and stalk). Significantly higher no. of capitula plant⁻¹(20.0), weight of capitula plant⁻¹(42.5 g plant⁻¹), no. of seeds capitulum⁻¹(21.4), seed yield (1556 kg ha⁻¹) and stalk yield (3659 kg ha⁻¹) were recorded in 125% RDF. Seed yield and stalk yield of 100% RDF (N₄) is on par with 75% RDF (N₃). The interaction effect due to moisture conservation methods and nutrient management practices on yield attributes, seed yield and stalk yield of safflower was non significant. Increased seed yield of safflower was due to increase in yield attributes like number of capitula plant⁻¹, number of seeds capitulum⁻¹, weight of the capitula plant⁻¹ and 100 seed weight as observed in the present investigation. Increased NP availability due to adequacy of instant NO₃ ions from the fertilizers during seedling and vegetative stage might have increased dry matter production and its better partitioning resulted in improvement of yield attributing characters, culminating in higher seed yield and stalk yield which was clearly observed in case of N₅. Similar findings were also reported by Ramesh and Devasenapathy [8], Singh and Singh [9], Kumar et al. [10], Meshram et al. [11].

3.3 Harvest Index

The data presented in (Table 2) visualize that the moisture conservation practices did not have a conspicuous effect on harvest index but the harvest index was influenced significantly by fertility levels. The higher harvest index was noted with M₃ and the lower harvest index with M₁. The significantly higher harvest index was observed in case of 125% RDF (N₅) followed by 100% RDF (N₄) whereas the lowest with control (N₁).

3.4 Economics

Compartmental bunding in *kharif fb* Safflower in *rabi* (M₃) registered higher net returns and B:C ratio (Table 2) among the moisture conservation practices. This was followed by Fallow in *kharif fb* Safflower in *rabi* (M₁). On the flip, least net returns and B:C ratio was observed with M₄. Among sub plots significantly higher net returns, B:C ratio was observed with 125% RDF (N₅) followed by 100% RDF (N₄). The least net returns were observed in N₁ (control) due to lower yields. Safflower under compartmental bunding coupled with 125% RDF recorded

Table 1. Growth parameters of safflower as influenced by moisture conservation methods and nutrient management practices

| Treatments | Plant height (cm) | | | | Number of branches | | | Leaf area index (LAI) | | | | Dry matter production (kg ha ⁻¹) | | | |
|--------------------------------------|-------------------|--------|--------|---------|--------------------|--------|---------|-----------------------|--------|--------|---------|--|--------|--------|---------|
| | 30 DAS | 60 DAS | 90 DAS | Harvest | 60 DAS | 90 DAS | Harvest | 30 DAS | 60 DAS | 90 DAS | Harvest | 30 DAS | 60 DAS | 90 DAS | Harvest |
| Moisture conservation methods | | | | | | | | | | | | | | | |
| M ₁ | 9.79 | 53.55 | 70.53 | 74.20 | 6.5 | 14.8 | 17.0 | 0.37 | 2.93 | 3.88 | 3.57 | 864 | 2837 | 4760 | 5726 |
| M ₂ | 8.61 | 51.73 | 69.95 | 75.18 | 6.4 | 14.5 | 17.0 | 0.36 | 2.92 | 3.87 | 3.49 | 844 | 2742 | 4464 | 5689 |
| M ₃ | 10.09 | 58.00 | 71.01 | 77.95 | 7.0 | 15.7 | 17.2 | 0.37 | 2.95 | 3.96 | 3.58 | 922 | 2937 | 5128 | 6311 |
| M ₄ | 8.45 | 49.33 | 68.94 | 72.48 | 6.1 | 13.7 | 16.0 | 0.31 | 2.74 | 3.84 | 3.14 | 822 | 2666 | 4289 | 5488 |
| SEm± | 0.40 | 2.03 | 1.60 | 3.64 | 0.12 | 0.39 | 0.63 | 0.01 | 0.09 | 0.11 | 0.12 | 35.6 | 123.9 | 140.2 | 182.9 |
| CD (P=0.05) | 1.37 | NS | NS | NS | 0.40 | NS | NS | 0.05 | NS | NS | NS | NS | NS | NS | NS |
| Nutrient management practices | | | | | | | | | | | | | | | |
| N ₁ | 4.59 | 36.16 | 50.51 | 56.87 | 4.2 | 11.7 | 13.5 | 0.27 | 2.22 | 3.59 | 3.11 | 764 | 1846 | 3655 | 4361 |
| N ₂ | 5.58 | 46.89 | 58.42 | 61.02 | 5.1 | 12.5 | 14.5 | 0.32 | 2.64 | 3.62 | 3.36 | 809 | 2149 | 3996 | 4944 |
| N ₃ | 7.05 | 56.74 | 67.02 | 72.36 | 5.9 | 14.3 | 15.7 | 0.34 | 2.77 | 3.85 | 3.40 | 837 | 2388 | 4502 | 5834 |
| N ₄ | 13.01 | 60.24 | 81.76 | 84.75 | 7.8 | 16.2 | 18.8 | 0.39 | 3.16 | 4.03 | 3.51 | 915 | 3112 | 5181 | 6527 |
| N ₅ | 15.95 | 65.73 | 92.84 | 99.77 | 9.7 | 18.7 | 21.5 | 0.44 | 3.63 | 4.35 | 3.85 | 990 | 4476 | 5962 | 7351 |
| SEm± | 0.31 | 1.79 | 2.27 | 2.48 | 0.24 | 0.48 | 0.57 | 0.02 | 0.11 | 0.14 | 0.12 | 32.1 | 91.5 | 158.1 | 185.2 |
| CD (P=0.05) | 0.88 | 5.16 | 6.54 | NS | 0.70 | 1.39 | 1.65 | 0.06 | 0.32 | 0.41 | 0.35 | 92.4 | 263.7 | 455.4 | 533.6 |
| Interaction | | | | | | | | | | | | | | | |
| SEm± | 0.67 | 3.79 | 4.36 | 5.73 | 0.44 | 0.94 | 1.20 | 0.04 | 0.21 | 0.28 | 0.25 | 64.2 | 183.1 | 316.18 | 370.5 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Note: M₁ = Fallow in kharif fb safflower in rabi, M₂ = Greengram in kharif fb safflower in rabi, M₃ = Compartmental bunding in kharif fb safflower in rabi, M₄ = Barnyard millet in kharif fb safflower in rabi, N₁ = Control (No fertilizer), N₂ = 50% RDF, N₃ = 75% RDF, N₄ = 100% RDF, N₅ = 125% RDF, cm- centimeter, DAS-Days after sowing, NS- Non significant

Table 2. Effect of moisture conservation methods and nutrient management practices on yield attributes, yield and economics of safflower

| Treatments | No. of capitula plant ⁻¹ | No. of seeds capitulum ⁻¹ | Weight of capitula plant ⁻¹ (g) | 100 seed weight (g) | Seed yield | Stalk yield | Harvest index (%) | Gross returns | Net returns | B:C ratio |
|--------------------------------------|-------------------------------------|--------------------------------------|--|---------------------|------------|-------------|-------------------|---------------|-------------|-----------|
| Moisture conservation methods | | | | | | | | | | |
| M ₁ | 17.6 | 18.2 | 31.6 | 3.62 | 1251 | 2748 | 31.30 | 68090 | 46799 | 3.18 |
| M ₂ | 17.1 | 18.0 | 31.6 | 3.57 | 1207 | 2728 | 30.47 | 65691 | 43402 | 2.93 |
| M ₃ | 19.2 | 18.3 | 35.6 | 3.88 | 1402 | 3130 | 31.31 | 76292 | 53501 | 3.34 |
| M ₄ | 17.0 | 17.1 | 28.8 | 3.53 | 1116 | 2625 | 29.77 | 60737 | 38446 | 2.70 |
| SEm± | 0.76 | 0.75 | 1.21 | 0.12 | 38.74 | 77.92 | 1.11 | 2107.52 | 2107.66 | 0.09 |
| CD (P=0.05) | NS | NS | 4.19 | NS | 134.0 | 274.9 | NS | 7434.75 | 7435.25 | 0.34 |
| Nutrient management practices | | | | | | | | | | |
| N ₁ | 15.6 | 15.7 | 22.0 | 3.48 | 947 | 2182 | 29.99 | 51538 | 30363 | 2.43 |
| N ₂ | 16.3 | 16.7 | 26.5 | 3.56 | 1070 | 2470 | 30.26 | 58200 | 36317 | 2.66 |
| N ₃ | 17.6 | 17.3 | 31.8 | 3.64 | 1225 | 2786 | 30.67 | 66683 | 44448 | 3.00 |
| N ₄ | 19.0 | 18.3 | 36.8 | 3.69 | 1426 | 2939 | 32.75 | 77588 | 54998 | 3.43 |
| N ₅ | 20.0 | 21.4 | 42.5 | 3.89 | 1565 | 3659 | 29.77 | 84504 | 61560 | 2.68 |
| SEm± | 0.59 | 0.61 | 1.04 | 0.12 | 36.9 | 77.9 | 0.91 | 2011.1 | 2011.1 | 0.09 |
| CD (P=0.05) | 1.71 | 1.74 | 2.99 | NS | 106.4 | 225.4 | NS | 5819.8 | 5819.8 | 0.26 |
| Interaction | | | | | | | | | | |
| SEm± | 1.19 | 1.21 | 2.08 | 0.24 | 86.6 | 174.2 | 2.50 | 4712.5 | 4712.8 | 0.21 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Note: M₁ = Fallow in kharif fb safflower in rabi, M₂ = Greengram in kharif fb safflower in rabi, M₃ = Compartmental bunding in kharif fb safflower in rabi, M₄ = Barnyard millet in kharif fb safflower in rabi, N₁ = Control (No fertilizer), N₂ = 50% RDF, N₃ = 75% RDF, N₄ = 100% RDF, N₅ = 125% RDF, cm- centimeter, NS- Non significant, B:C ratio- Benefit Cost ratio

Table 3. Soil moisture content (%) at initial, critical stages and at harvest of safflower as influenced by moisture conservation practices

| Treatments | Initial | | | rosette | | | branching | | | flowering | | | At harvest | | |
|------------------------|----------------|-----------------|--------------|----------------|-----------------|--------------|------------------|--------------|--------------|------------------|--------------|--------------|-------------------|--------------|--------------|
| Depths | 0-30 | 30-60 cm | 60-90 | 0-30 | 30-60 cm | 60-90 | 0-30 | 30-60 | 60-90 | 0-30 | 30-60 | 60-90 | 0-30 | 30-60 | 60-90 |
| Main treatments | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm | cm |
| M ₁ | 21.84 | 24.44 | 28.50 | 20.73 | 23.74 | 27.61 | 18.56 | 20.98 | 24.78 | 16.74 | 18.88 | 22.91 | 14.01 | 14.95 | 19.57 |
| M ₂ | 21.25 | 23.60 | 28.00 | 20.34 | 22.80 | 26.37 | 17.81 | 20.67 | 24.68 | 16.50 | 18.65 | 22.50 | 13.86 | 14.81 | 19.42 |
| M ₃ | 22.05 | 25.91 | 29.39 | 21.01 | 24.49 | 28.19 | 19.19 | 21.95 | 25.14 | 16.87 | 19.04 | 23.03 | 14.18 | 15.21 | 19.77 |
| M ₄ | 19.07 | 23.28 | 27.34 | 18.21 | 21.56 | 25.94 | 16.39 | 19.12 | 22.10 | 15.45 | 17.89 | 20.88 | 11.91 | 14.54 | 18.36 |
| SEm± | 0.85 | 1.10 | 1.08 | 0.77 | 1.94 | 1.12 | 0.79 | 0.91 | 1.05 | 0.69 | 0.86 | 0.85 | 0.52 | 0.71 | 0.88 |
| CD (P=0.05) | 2.93 | NS | NS | 2.68 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Sub treatments | | | | | | | | | | | | | | | |
| N ₁ | 21.45 | 25.19 | 28.92 | 20.72 | 22.31 | 26.80 | 18.45 | 21.43 | 24.93 | 16.82 | 19.27 | 23.04 | 14.22 | 15.42 | 19.75 |
| N ₂ | 20.97 | 24.90 | 28.23 | 20.18 | 23.45 | 26.12 | 17.93 | 21.02 | 24.60 | 16.46 | 19.04 | 22.68 | 13.75 | 15.22 | 19.60 |
| N ₃ | 20.74 | 24.43 | 27.48 | 19.59 | 22.85 | 26.29 | 17.52 | 20.59 | 24.18 | 16.14 | 18.63 | 22.31 | 13.43 | 14.86 | 19.25 |
| N ₄ | 20.54 | 23.86 | 26.06 | 19.19 | 21.89 | 24.95 | 17.45 | 20.20 | 23.75 | 15.74 | 18.26 | 22.00 | 13.18 | 14.59 | 19.02 |
| N ₅ | 20.07 | 23.29 | 25.73 | 18.84 | 21.79 | 24.27 | 17.34 | 20.16 | 23.43 | 15.54 | 17.89 | 21.62 | 12.87 | 14.30 | 18.79 |
| SEm± | 0.68 | 0.88 | 0.94 | 0.66 | 0.83 | 0.98 | 0.57 | 0.67 | 0.79 | 0.54 | 0.61 | 0.72 | 0.49 | 0.48 | 0.65 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Interaction | | | | | | | | | | | | | | | |
| SEm± | 1.35 | 1.92 | 2.00 | 1.32 | 1.67 | 1.96 | 1.13 | 1.34 | 1.57 | 1.07 | 1.21 | 1.44 | 0.97 | 0.95 | 1.30 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

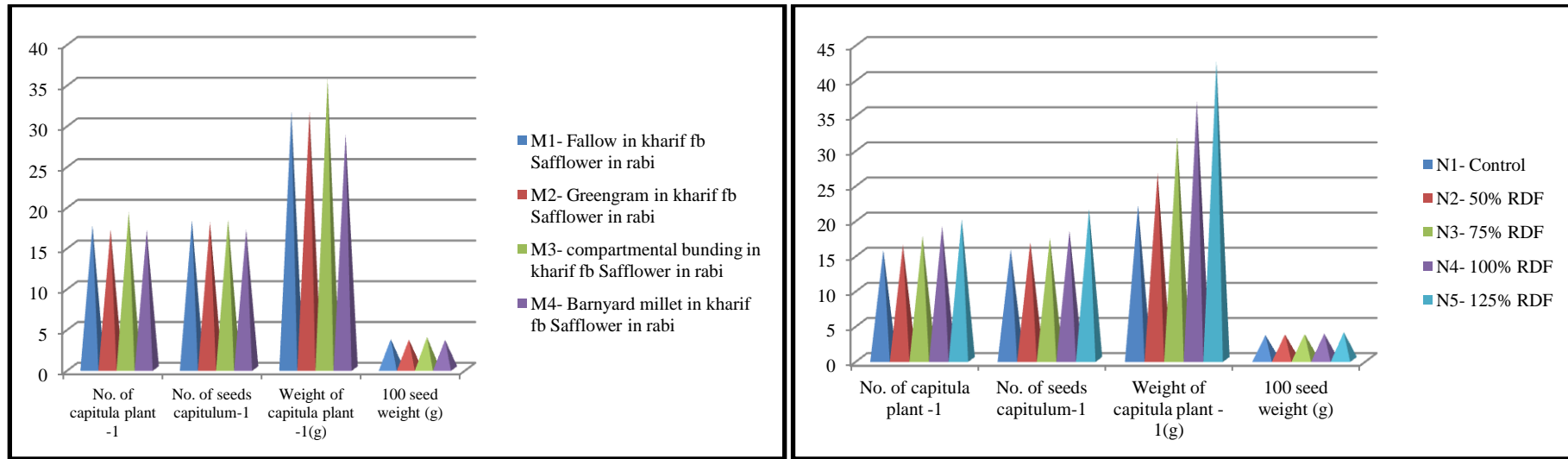


Fig. 1. Yield attributes of safflower as influenced by moisture conservation practices and fertility levels

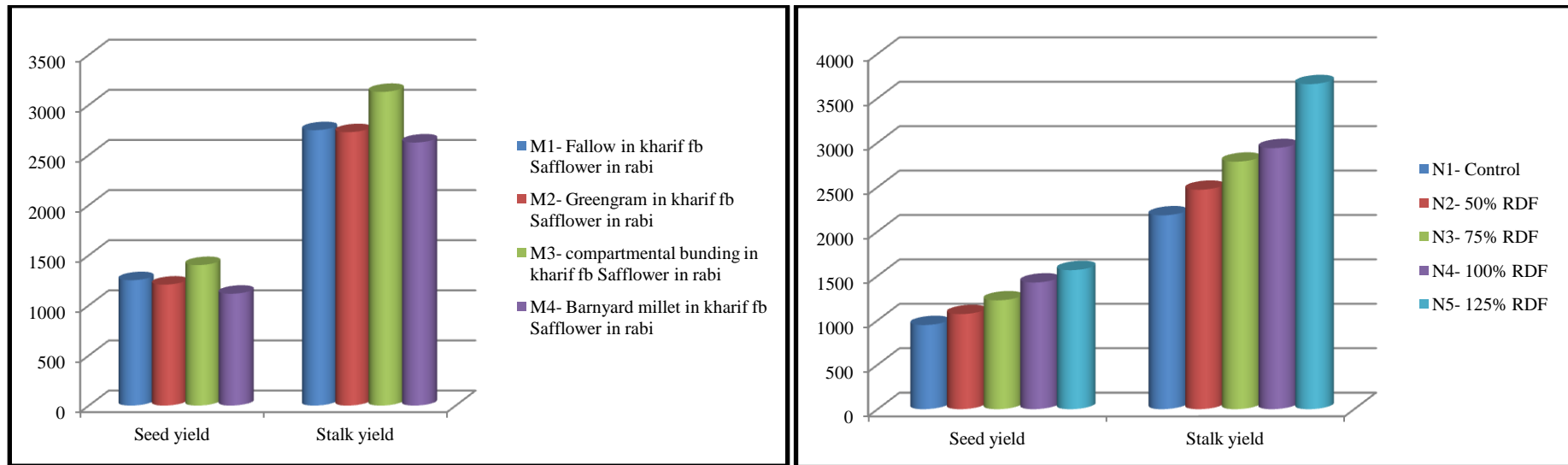


Fig. 2. Seed yield and Stalk yield (kg ha⁻¹) of safflower as influenced by moisture conservation practices and fertility levels

significantly higher gross returns, net returns and BC ratio due to vigorous plant growth, higher nutrient uptake improving translocation of photosynthates for elevated yield components production and higher seed yields resulting in higher monetary returns and BC ratio. These results tend to support the results of Patil et al. [12] and Narayana et al. [13].

3.5 Soil Moisture Content (%)

At initial the Compartmental bunding in *kharif fb* Safflower in *rabi* (M₃) was recorded significantly higher soil moisture content (22.05%) followed by Fallow in *kharif fb* Safflower in *rabi* (M₁) (21.25%), Greengram in *kharif fb* Safflower in *rabi* (M₂) (21.84%) and Barnyard millet in *kharif fb* Safflower in *rabi* (M₄) (17.87%). Similar trend was observed at rosette, flowering, branching and at harvest. The data reveal that with increasing depth the moisture content showed increasing trend, being highest at the depth of 60-90 cm and also with the age of the crop the moisture content showed declining trend, being highest at sowing time and lowest at harvest under different nutrient management and moisture conservation practices during the crop growing period. It is also obvious that with increase in combination of nutrients the moisture content slightly decreased, being highest under control (N₁) and lowest at 125% RDF (N₅) at different stages of crop growth. On the other hand the different moisture conservation practices behaved differently in respect to their effects on moisture content. On the basis of data the different moisture conservation practices may be placed in the sequence given below:

M₃- Compartmental bunding in *kharif fb* Safflower in *rabi* > M₁- Fallow in *kharif fb* Safflower in *rabi*. > M₂- Greengram in *kharif fb* Safflower in *rabi* > M₄- Barnyard millet in *kharif fb* Safflower in *rabi*.

4. CONCLUSION AND RECOMMENDATIONS

Comparing compartmental bunding to other moisture conservation techniques, it can be said that compartmental bunding in the *kharif fb* safflower in *rabi* was more cost-effective in obtaining better seed yields and high net returns. Compartmental bunding during the *kharif* season ensures safflower production in areas where ongoing droughts and frequent crop failure are normal occurrences.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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