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Effect of row proportions and moisture conservation practices on growth yield and economics of sunflower in sunflower and sesame intercropping system

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Abstract

Field experiment was carried out during *rabi* 2024 at Raichur with an objective to determine the impact of row proportions and moisture conservation in sunflower and sesame intercropping. A split-plot design was adopted, replicated thrice. Treatments were soil moisture conservation measure surface mulching @ 5 t ha⁻¹ at 15 days (DAS) and spray of multinutrient @ 8 g L⁻¹ at 30 and 60 DAS in main plots and sunflower + sesame intercropping compared with sole crops in subplots. Moisture conservation measure has improved the productivity of sunflower (1251 kg ha⁻¹) and sesame (542 kg ha⁻¹), and oil yield (460 and 96 kg ha⁻¹). It has also enhanced plant height, leaf area, light interception, and dry matter production of both the crops. In the economic perspective, adoption of moisture conservation practices with crop residue mulching and foliar multinutrient spray @ 8 ml L⁻¹ gave maximum gross returns (Rs.91,524 ha⁻¹), net returns (Rs.50,317 ha⁻¹), and benefit cost ratio (2.18), compared to the control. Among the intercropping systems, paired sunflower + sesame (2:2) proved most remunerative has achieved the higher gross returns (Rs.94,732 ha⁻¹), net returns (Rs.52,314 ha⁻¹) and BC ratio (2.23), followed by sunflower + sesame in paired rows (2:1).

Keywords: Economics, growth parameter, intercropping, mulching, multinutrient spray and seed yield

Introduction

The demand for vegetable oils in both food and industrial sectors has increased sharply, making India one of the largest importers of vegetable oils despite being the fifth largest producer of oilseeds. Oilseeds are the second most important crops in India, covering 15.7% of the gross cultivated area and contributing 11% to the total agricultural output (Meena *et al.*, 2023) [7].

Sunflower (*Helianthus annuus* L.) is a major oilseed crop known for its high-quality edible oil content (35-48%) and adaptability to diverse agro-climatic conditions. Sunflower oil is nutritionally superior, containing 20-27% protein and about 60% polyunsaturated fatty acids, which help in maintaining healthy cholesterol levels. Besides its use in food and feed, sunflower oil has industrial applications in the production of lecithin, tocopherols, and hydrogenated oils. The protein-rich oilcake (40-44%) serves as an excellent livestock feed. Its short duration, photinsensitivity, and drought tolerance make it a suitable crop for sustainable rainfed systems and intercropping. In India, Karnataka ranks first in sunflower cultivation, contributing 29% of the area and 27% of the total production (Anon., 2021) [3].

Sesame (*Sesamum indicum* L.), another important oilseed crop, is widely grown as a sole or intercrop in rainfed regions. Its premium oil (46-52%) and high market value make it an attractive option for smallholder farmers. It contains 18-20% protein and is rich in minerals, vitamin E, and natural antioxidants like sesamin, sesamol, and sesamolol, which enhance oil stability and nutritional quality (Rangkadilok *et al.*, 2010) [12].

Drought remains a major constraint in Indian agriculture, affecting about 68% of the cropped area that depends on monsoon rainfall. It hampers growth, photosynthesis, and nutrient uptake, leading to reduced yields. Agronomic strategies such as mulching, conservation tillage, intercropping, and micro-irrigation help mitigate these effects.

Intercropping enhances resource use efficiency (Ma *et al.*, 2017)^[6], water productivity, and yield stability under rainfed conditions (Singh *et al.*, 2014)^[15]. It also improves soil water retention, reduces evaporation losses, and optimizes light and nutrient utilization (Echarte *et al.*, 2011)^[4].

Considering the complementary traits of sunflower and sesame, their intercropping under Vertisols with suitable moisture conservation practices is a promising yet underexplored strategy. Therefore, the present study entitled “Effect of row proportions and moisture conservation practices on performance of rainfed sunflower and sesame intercropping system” was undertaken to address this research gap.

Material and methods

A field experiment was conducted at the Climate Change Centre, Main Agricultural Research Station, Raichur, Karnataka, during the *rabi* season of 2024-25 to evaluate the performance of rainfed sunflower and sesame intercropping systems. The experimental site is situated at 16°15'N latitude, 77°20'E longitude, and an altitude of 389 m above mean sea level. The soil of the experimental field was clayey in texture with available nutrient status of 260.9 kg ha⁻¹ nitrogen, 27.1 kg ha⁻¹ phosphorus (P₂O₅), and 298.2 kg ha⁻¹ potassium (K₂O), along with 0.54% organic carbon content.

The experiment was laid out in a split-plot design with three replications. The main plot treatments consisted of two moisture conservation practices: crop residue mulching @ 5 t ha⁻¹ combined with foliar application of multinutrient spray @ 8 g L⁻¹ (M₁), and a control without mulch and spray (M₂). The subplot treatments included different intercropping systems, sunflower + sesame at 1:1 and 1:2 row proportions, paired sunflower + sesame at 2:1 and 2:2 row proportions along with sole sunflower and sole sesame for comparison.

Agronomic observations were recorded by randomly selecting five representative plants from each plot. Growth parameters such as leaf area index, stem diameter, aerial dry biomass, SPAD values, NDVI readings (using Green seeker), total chlorophyll content and days to 50% flowering were observed periodically. Yield attributes including seed yield, stalk yield, and harvest index were recorded at harvest to assess the performance of different treatment combinations.

Result and discussion

Crop Growth Parameters: Moisture conservation practices significantly influenced the growth and physiological

performance of sunflower under rainfed conditions (Table 1). The adoption of crop residue mulching @ 5 t ha⁻¹ combined with foliar multinutrient spray at 30 and 60 DAS (M₁) recorded superior growth compared to the control (M₂). Under M₁, sunflower attained a higher leaf area index (2.96), total dry matter production (6345 kg ha⁻¹), stem diameter (4.10 cm), SPAD value (44.85), NDVI (0.535), and total chlorophyll content (5.56 mg g⁻¹), with earlier flowering (53 DAS) than under M₂ (57 DAS).

These improvements are attributed to better soil moisture retention and temperature regulation under mulching, creating a favorable microclimate for root and microbial activity. Crop residue mulch acted as a barrier to evaporation, improved nutrient availability, and maintained favorable soil moisture. The foliar multinutrient spray supplied essential micronutrients, promoting chlorophyll synthesis, photosynthetic efficiency, and assimilate partitioning, leading to higher dry matter accumulation and plant vigor. The combined effect of moisture conservation and nutrient supplementation ensured early flowering and improved crop development, highlighting their synergy in enhancing sunflower performance under dryland conditions.

Intercropping systems also influenced sunflower growth attributes. Sole sunflower (S₁) recorded the highest SPAD (48.05), NDVI (0.547), and chlorophyll content (5.35 mg g⁻¹) due to the absence of interspecific competition. Among intercropped treatments, paired sunflower+ sesame (2:2) (S₆) showed superior LAI (2.70), total dry matter (6168 kg ha⁻¹), stem diameter (4.02 cm), and earlier flowering (55 DAS), followed by paired sunflower + sesame (2:1) (S₅). Normal row intercropping (S₃: 1:1 and S₄: 1:2) recorded lower LAI, SPAD, and delayed flowering due to competition for light, nutrients, and moisture. Paired-row arrangements improved canopy structure, light interception, and resource use efficiency, while sole sesame (S₂) had the highest LAI (3.37) but did not improve sunflower performance. Interaction effects were mostly non-significant, except for chlorophyll content, which improved under M₁ with paired intercropping. Overall, crop residue mulching with foliar multinutrient spray and paired sunflower + sesame (2:2) intercropping proved best for achieving higher growth and physiological efficiency. Similar findings were reported by Vishwanatha (2009), Pavani *et al.* (2012), Reddy *et al.* (2015), Sharma *et al.* (2017), and Priyanka *et al.* (2024)^[9, 10, 13, 14, 17].

Table 1: Growth parameters of sunflower as influenced by moisture conservation practices and row proportions of sunflower and sesame intercropping

Treatment	LAI	TDMP (kg ha ⁻¹)	Stem diameter (cm)	SPAD	NDVI	Total chlorophyll content	Days to 50% flowering
Moisture Conservation (M)							
M ₁ : Crop residue mulching @ 5 t ha ⁻¹ + multi-nutrient spray @ 8 g L ⁻¹ at 30 & 60 DAS	2.96	6345	4.10	44.85	0.535	5.559	53.0
M ₂ : Control	2.32	5385	3.81	42.51	0.531	3.660	57.0
SEm±	0.03	101	0.03	0.12	0.031	0.026	0.2
CD @ 5%	0.18	614	0.18	0.72	0.180	0.158	1.2
Intercropping (S)							
S ₁ : Sole Sunflower	2.74	6187	4.03	48.03	0.547	5.347	54.0
S ₂ : Sole Sesame	3.37	-	-	-	-	-	-
S ₃ : Sunflower + Sesame (1:1)	2.32	5570	3.94	40.10	0.530	4.282	56.0
S ₄ : Sunflower + Sesame (1:2)	2.08	5423	3.86	39.20	0.525	3.983	57.0
S ₅ : Paired Sunflower + Sesame	2.61	5976	3.94	44.15	0.530	4.653	56.0
S ₆ : Paired Sunflower + Sesame	2.70	6168	4.02	45.12	0.532	4.782	55.0
SEm±	0.06	183	0.08	0.90	0.011	0.098	0.2

CD @ 5%	0.17	553	NS	2.71	NS	0.296	0.6
S × M (interaction)							
SEm±	0.02	5	0.01	0.01	0.001	0.058	0.4
CD @ 5%	NS	NS	NS	NS	NS	0.439	NS
M × S (interaction)							
SEm±	0.07	231	0.10	0.10	0.014	0.127	0.3
CD @ 5%	NS	NS	NS	NS	NS	0.401	NS

Note: LAI: Leaf area index, TDMP: Total dry matter production, SPAD: Soil plant analyzer, NDVI: Normalized difference vegetation index, ns: Non-significant

Yield performance

Seed yield and related traits of sunflower were significantly influenced by moisture conservation and intercropping (Table 2). Crop residue mulching @ 5 t ha⁻¹ with foliar multinutrient spray (M₁) produced higher seed yield per plant (43.54 g), per hectare (1251 kg ha⁻¹), and stalk yield (2872 kg ha⁻¹) than the control (M₂), which recorded 40.51 g plant⁻¹, 1087 kg ha⁻¹, and 2522 kg ha⁻¹, respectively. Harvest index remained similar (0.301). The yield advantage of M₁ is attributed to improved soil moisture, moderated soil temperature, and better nutrient uptake, resulting in enhanced photosynthesis, assimilate partitioning, and grain filling.

Among intercropping systems, sole sunflower (S₁) recorded the highest seed yield (50.32 g plant⁻¹; 1382 kg ha⁻¹) and stalk yield (3214 kg ha⁻¹). Among intercropped systems, paired sunflower + sesame (2:2) (S₆) performed better than normal rows, yielding 46.44 g plant⁻¹, 1270 kg ha⁻¹ seed, and 2861 kg ha⁻¹ stalk, followed by paired sunflower + sesame (2:1) (S₅). Normal row systems (S₃, S₄) produced lower yields due to greater interspecific competition. Paired rows enhanced canopy structure, light use, and resource efficiency, maintaining higher biomass and yield without affecting harvest index. Similar trends were reported by Vishwanatha *et al.* (2012), Alikhan and Akmal (2014), Olowe and Adebimpe (2009), and Amrullah (2023) [1, 2, 8, 18].

Production economics: Economic analysis revealed that both moisture conservation and intercropping significantly affected sunflower profitability (Table 3). Crop residue mulching @ 5 t ha⁻¹ with foliar multinutrient spray (M₁) achieved higher gross returns (Rs. 95,079 ha⁻¹), net returns (Rs. 59,382 ha⁻¹), and B:C ratio (1.74) than the control (M₂). The higher profitability of M₁ was due to improved yield through better soil moisture and nutrient management.

Among intercropping systems, paired sunflower + sesame (2:2) (S₆) recorded the highest gross returns (Rs. 1,05,593 ha⁻¹), net returns (Rs. 67,111 ha⁻¹), and B:C ratio (1.74), followed by paired sunflower + sesame (2:1) (S₅) with Rs. 99,014 ha⁻¹ gross, Rs. 60,553 ha⁻¹ net, and a B:C ratio of 1.57. Sole sunflower (S₁) recorded moderate returns (Rs. 86,910 ha⁻¹ gross; Rs. 50,499 ha⁻¹ net; B:C 1.39), whereas normal row intercropping (S₃, S₄) showed lower profitability. The advantage of paired intercropping is due to reduced competition, better canopy structure, and efficient resource utilization. These findings agree with Kumar *et al.* (2019), Sudhir (2019), and Ram (2020) [5, 11, 16].

Overall, the integration of crop residue mulching with foliar multinutrient spray and paired sunflower + sesame (2:2) intercropping proved the most efficient strategy for improving growth, yield, and profitability of sunflower under rainfed conditions.

Table 2: Yield parameters of sunflower as influenced by moisture conservation practices and row proportions of sunflower and sesame intercropping

Treatment	Seed yield (g plant ⁻¹)	Sunflower seed yield (kg ha ⁻¹)	Sunflower stalk yield (kg ha ⁻¹)	Harvest index
Moisture Conservation (M)				
M ₁ : Crop residue mulching @ 5 t ha ⁻¹ + multi-nutrient spray @ 8 g L ⁻¹ at 30 & 60 DAS	43.54	1251	2872	0.301
M ₂ : Control	40.51	1087	2522	0.301
SEm±	0.17	17	38	0.001
CD @ 5%	1.03	103	228	0.006
Intercropping (S)				
S ₁ : Sole Sunflower	50.32	1382	3214	0.302
S ₂ : Sole Sesame	-	-	-	-
S ₃ : Sunflower + Sesame (1:1)	37.70	1051	2365	0.305
S ₄ : Sunflower + Sesame (1:2)	32.68	951	2214	0.300
S ₅ : Paired Sunflower + Sesame (2:1)	42.97	1190	2830	0.303
S ₆ : Paired Sunflower + Sesame (2:2)	46.44	1270	2861	0.305
SEm±	0.82	71	117	0.008
CD @ 5%	2.50	213	352	NS
Interaction (S × M)				
SEm±	0.38	15	86	0.003
CD @ 5%	NS	NS	NS	NS
Interaction (M × S)				
SEm±	1.06	89	152	0.010
CD @ 5%	NS	NS	NS	NS

Note: NS: Non-significant

Table 3: Economic returns of sunflower and sesame intercropping system as influenced by moisture conservation practices and varying row proportions

Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B:C ratio
Moisture Conservation (M)				
M ₁ : Crop residue mulching @ 5 t ha ⁻¹ + multi-nutrient spray @ 8 g L ⁻¹ at 30 & 60 DAS	35,696	95,079	59,382	1.74
M ₂ : Control	34,415	81,820	47,406	1.46
SEm±	-	471	471	0.03
CD @ 5%	-	2,865	2,865	0.18
Intercropping (S)				
S ₁ : Sole Sunflower	36,412	86,910	50,499	1.39
S ₂ : Sole Sesame	-	-	-	-
S ₃ : Sunflower + Sesame (1:1)	38,536	87,156	48,621	1.26
S ₄ : Sunflower + Sesame (1:2)	38,661	82,515	43,854	1.13
S ₅ : Paired Sunflower + Sesame (2:1)	38,461	90,091	51,630	1.34
S ₆ : Paired Sunflower + Sesame (2:2)	38,482	1,05,559	67,111	1.74
SEm±	400	400	400	0.12
CD @ 5%	1260	1260	1260	0.35
S at same level of M				
SEm±	-	1158	1158	0.07
CD @ 5%	-	NS	NS	NS
M at same level of S				
SEm±	5263	5263	5263	0.15
CD @ 5%	NS	NS	NS	NS

Note: NS: Non significant

Conclusion

Crop residue mulching with foliar multinutrient spray and paired sunflower + sesame intercropping (2:2) maximized growth, yield, and profitability under rainfed conditions. M1S6 enhanced LAI, biomass, seed and stalk yield, net returns, and B C ratio by improving soil moisture, microclimate, and resource use efficiency. This integrated practice is recommended for sustainable and productive rainfed sunflower systems.

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