PERFORMANCE OF ZERO TILLAGE SAFFLOWER (*Carthamus tinctorius* L.) UNDER DIFFERENT IRRIGATION SCHEDULES AND NUTRIENT LEVELS IN NORTHERN TELANGANA ZONE (NTZ)

ABSTRACT

An experiment was carried out at Regional Agricultural Research Station, Polasa, Jagtialin Northern Telangana Zone during *rabi*(winter season), 2023-2024where the performance of zero tillage safflower (*Carthamus tinctorius* L.) was tested under different irrigation schedules and nutrient levels.The experiment was executed using a *factorial* randomized block design with 15 treatment combinations, with three replications. The treatments consisted oftwo factors i.e., factor-1 includedirrigation schedules-; I_1: Irrigation at rosette and flower initiation stages, I_2: Irrigation at rosette and seed development stages, I_3: Irrigation at branching and flower initiation stages, I_4: Irrigation at branching and seed development stages and I_5: No irrigation(residual moisture) and factor-2 includednutrient levels, S_1: 75% Recommended dose of fertilizer(RDF), S_2: 100% RDF and S_3: 125% RDF. The results revealed thatirrigation at branching and seed development stages(I_4)reported significantly highest seed(1199kgha^{-1}), stalk yield (4724kg ha^{-1}) and yield attributing traits viz.; number of heads plant^{-1}(22.5), number of seeds head^{-1}(23.4),seed weight plant^{-1}(19.8 g),100-seed weight(7 g), whereas the lowestyieldwere observed withno irrigation (residual moisture) (I_5) treatment. Among different nutrient levels, application of 125% RDF (S_3)resulted in thehighest seed (1105 kg ha^{-1}) and stalk yield(4429kg ha^{-1}) and yield attributing traits viz.; number of heads plant^{-1}(21.4), number of seeds head^{-1}(22.6), seed weight plant^{-1}(19.5 g), 100-seed weight(6.7 g)over 75% RDF (S_1).Among different treatments, irrigation at the branching and seed development stages combined with the application of 125% RDF gave the best results.

Keywords: Safflower, Zero tillage, Irrigation and Nutrient levels.

1. INTRODUCTION

India is one of the largest producers, consumers and importers of edible oilseeds.Globally, ranks as the 4th largest oilseeds producer in the world. Safflower is a major *rabi* season (winter crop) oilseed crop in India, known for its drought resistance and ability to thrive in dry conditions. It is primarily grown in Maharashtra, Karnataka, and parts of Madhya Pradesh, Orissa, Andhra Pradesh, Bihar, and Telangana.India is the largest producer of safflower globally, with Maharashtra and Karnataka contributing over 90% of the total production. Despite its higher area (0.43 Mha), the average productivity remains low at 465 kg ha^{-1} due to factors like reliance on rainfed farming (Times of Agriculture Today, 2022). In Telangana safflower is growing in an area of 3036hawith 2732tonnesof production (Department of Agriculture and Farmers Welfare, 2022). In Telangana it is mostly grown in theSangareddy district.

Irrigation plays a crucial role in influencing plant growth and yield, particularly in arid regions. The proper time of application of irrigation to crop is very important for increasing production and thereby increasing profitability (Parameshnaik*et al.,* 2022). Under irrigated conditions, safflower can nearly double the yield compared to rainfed crops. Higher productivity can be attained by implementing irrigation at critical stages (Suryavanshi *et al*., 2007) and providing irrigation three times for safflower crop has been shownenhanced plant growth and yield parameters resulting in higher seed yields (Chordia and Gaur,1986).Conventional tillage (CT) that involves ploughing followed by cultivation has been practicedforcenturies.However,CTleads tosoilerosionandlossoforganicmatterleadingto unsustainabilityofagriculture.Asaremedy,conservationtillagethatincludesminimumtillage (MT)andzerotillage(ZT)has beenwidelyacceptedbyfarmers inmanydevelopedcountries without losing the yield. Many studies showed that ZT has economic, ecological, environmental and social benefits. These factors encompass erosion control, water conservation, nutrient cycling, time and fossil fuel savings, reduced wear and tear on machinery, and soil carbon sequestration (Lal, 2007). The availability of plant nutrients in soil, whether naturally present or artificially supplied, is a key determinant in the success or failure of a crop production system. Effective soil fertility management is crucial for enhancing crop production. Currently, safflower productivity in India remains low due to insufficient fertilizer applicationand improper management(Vishwanath *et al*., 2006). To enhance safflower production, it's crucial to augment fertilizer application, including micronutrients (Abbas *et* *al*., 1995). Optimal yields and quality of safflower oil can only be achieved when adequate quantities of all three major nutrients N, P, and K are supplied in a balanced manner (Mundal *et al*., 2004). Safflower crop is one of the alternate crop to *rabi* rice in NTZ.This trail was conducted in order to study the proper irrigation schedules and nutrient levels for enhancing the yield in safflower

2. MATERIALS AND METHODS

The field experiment was conducted during *rabi* (winter season) season of 2023-2024 atthe Regional Agricultural Research Station (RARS), Jagtial. The RARS was located at an altitude of 243.4 m above mean sea level (MSL) on 18°84'08" N latitude and 78°94'85" E longitude and it is categorized under Northern Telangana Zone (NTZ). The experiment was laid out with 5x3 Factorial Randomized Block design with threereplications. There are two factors v*iz*., first factor includes five irrigationsschedules (I_1: at rosette and flower initiation stages, I_2:at rosette and seed developmentstages, I_3: at branching and flower initiation stages, I_4:at branching and seed developmentstages, I_5: No Irrigation (residualmoisture) and second factorincludedthree nutrient levels**,** S_1-75% RDF (30:19:0 kg ha^{-1}),S_2-100% RDF (40:25:0 kg ha^{-1}), S_3-125% RDF (50:31:0 kg ha^{-1}).Theexperimental siteconsisted of sandy clay loam soils, with slightly acidicpH (6.14),electrical conductivity(0.35dSm^{-1}),low organic carbon (0.48 %), lowin N (187.7 kg ha^{-1}), P(14.31 kg ha^{-1}) availability, but high in K(315.42 kg ha^{-1}) availability.After harvesting the preceding rice crop,healthy and mature seeds of safflower variety TSF-1 were manually sown, placing 1-2 seeds $hill^{-1}$ at a depth of 5 cm, with a spacing of 45cm x20cm.A total two irrigations were givenat the different stages of crop growth according to the treatment at a depth of 5 cm using water meter at each irrigation.Fertilizer was applied based on nutrient level treatments.Phosphorus and half of the nitrogen were applied as a basal dose at the time of sowing, while the remaining half of the nitrogen was applied at the flowering stage of the safflower crop.The data was analyzed by the method of "Analysis of Variance" as described by Panse and Sukhatme.

3. RESULTS AND DISCUSSION

3.1 Seed yield (kg ha^{-1})

The data presented in the table 1, show that the highest seed yield (1199 kg ha^{-1}) of safflower was achieved with irrigation applied at the branching and seed development stages (I_4), which is statistically on par with the irrigation applied at rosette and seed development stage (1092 kg ha^{-1}). No irrigation (residual moisture) treatment (I_1)resulted in significantly the lowest seed yield (744 kg ha^{-1}).

Irrigation applied at branching stage led to the development of a sizable canopy before flowering due to improved branching, which provided potential sites for yield attributes. The higher seed yield with two irrigations was attributed to the availability of more nutrients for plant growth and enhanced yield attributes such as heads per plant, seeds per head, and 100-seed weight. Water deficiency causes stomata closure, reducing photosynthesis and the translocation of photo assimilates during grain filling. This impacts yield components like the number of seeds $head^{-1}$ and the 100-seed weight, ultimately leading to a reduction in seed yield. These results weresimilar to the findings of Bastia *et al*. (2003) Jabbari *et al*. (2009) and Jhansi *et al*. (2018).

Significantly highest seed yield (1105 kg ha^{-1}) was achieved with application of 125% RDF treatment. This yield was statistically on par with seed yield obtained with 100% RDF application (1039 kg ha^{-1}). In contrast, significantly lowest seed yield (837 kg ha^{-1}) was reported with 75% RDF application.

The increased nitrogen and phospherous supply, owing to the adequacy of instant NO^{-3} ions from the fertilizers during the seedling and vegetative stages, may have boosted dry matter production. This improved partitioning led to better yield attributes, including the number of capitula $plant^{-1}$, seeds capitulum $^{-1}$, and the weight of capitula $plant^{-1}$, ultimately resulting in a higher seed yield. These results are similar with Kumar *et al*. (2017).

The interaction between irrigation scheduling and nutrient levels had no significant impact on seed yield in rice fallow safflower.

3.2 Stover yield (kg ha^{-1})

The data in the table 1 show that among the irrigation schedules, the highest stalk yield (4724 kg ha^{-1}) was achieved with irrigation applied at the branching and seed development stages. This yield is statistically similar to that obtained with irrigation applied at the rosette and seed development stages (4413 kg ha^{-1}). The treatment with no irrigation (residual moisture) resulted in the significantly lowest stalk yield (3000 kg ha^{-1}).The increase in stalk yield of safflower may be attributed due to improved moisture availability and nutrient availability, which enhanced plant height, leaf area, crop growth rate, absolute growth rate, dry matter production and yield attributes, including the number of capitula plant^{-1}, seeds plant^{-1} and 100-seed weight.Similar findings were reported by Dashora and Sharma (2006) and Kumar *et al*. (2017).

Results presented in table 1 show that among different nutrient levels, application of 125% RDF resulted in significantly thehighest stalk yield (4429 kg ha^{-1}). These results are statistically similar (4109 kg ha^{-1})with stalk yield obtained with application of 100% RDF. In contrast, significantly lowest stalk yield (3386 kg ha^{-1}) was observed with 75% RDF application.The increase in seed yield could be due to the improved growth of the plant resulting from readily available moisture and nutrient absorption, which enhanced metabolic activity and dry matter accumulation, ultimately leading to increased yield.These findings are supported by the results of Gitanjali *et al*. (2017).

The interaction between irrigation schedulingand nutrient levels was not significant with stalk yield in rice fallow safflower.

3.3 Number of heads plant^{-1}

The data in table 2 reveals that, irrigation at branching and seed development stageresulted insignificantly thehighest number of heads plant^{-1} (22.5). These resultswere statistically on par with irrigation applied at rosette and seed development stage (21.1). Significantly lowest number of heads plant^{-1}(13.3) was obtained with treatment ofno irrigation (residual moisture).The rise in the number of heads plant^{-1} with irrigation waslikely due to the efficient transfer of photosynthates from the source to the sink. On the other hand, reduced yield attributes under stress conditions may be due to accelerated aging and diminished net photosynthesis.Similar finding were reported by Gitanjali *et al*. (2017) and Parameshnaik*et al*. (2022)

Table 2 shows that significantly thehighest number of heads plant^{-1} (21.4) was achieved with the application of 125% RDF, followed by the application of 100% RDF (19.1). In contrast, the application of 75% RDF resulted in the significantly lowest number of heads plant^{-1}(16.8).The application of fertilizers established better conditions for nutrient absorption, leading to enhanced plant growth. As a result, yield attributes improved. The fertilizers also provided a higher supply of photosynthates, which were directed towards the reproductive parts of the plants.Similar findings were reported by Patil *et al*. (2009) and Yadav *et al*. (2009).

The number of heads plant^{-1} in rice fallow safflower was not significantly influenced by the interaction between irrigation scheduling and nutrient levels.

3.4 Number of seeds head^{-1}

The data (Table 2)showed that irrigation at branching and seed development stage achieved significantly thehighest numberofseedshead^{-1}(23.4), followed by irrigation at rosette and seed development stage (22.2). Whereas significantly thelowest numberofseedshead^{-1}(15.9) were observed with treatment no irrigation (residual moisture).Adequate moisture ensures the efficient transfer of photosynthates from the source to the sink, thereby increasing yield attributes. Conversely, the unavailability of moisture during various phenological stages and increased competition for moisture among plants reduce the number of capsules plant^{-1}, the number of seeds capsule^{-1}, and the 100-seed weight. Similar results were documented by Parameshnaik*et al*. (2022) and Kocaman *et al*. (2016).

The highest numberofseedshead^{-1} (22.6) was observed with the application of 125% RDF, followed by the application of 100% RDF. In contrast lowest numberofseedshead^{-1}(19.0) was observed with application of 75% RDF. The increase in yield attributes may be attributed to vigorous plant growth. This growth facilitated the absorption of a higher amount of nutrients from the soil. As a result, overall yield improved. Comparable results were reported by Gitanjali *et* *al*. (2017) and Naik (2005).

During the study, the number of seedshead^{-1}was not influenced significantly withthecombinedeffectofirrigation scheduling and nutrient levels.

3.5Seedyieldplant^{-1}(g)

The data in Table2, demonstrates that irrigation at branching and seed development stage resultedin significantly thehighest seed yield plant^{-1}(19.8 g). The significantly lowest seed yield plant^{-1} (17.5 g) was reported withthe no irrigation (residual moisture) treatment.The increase in seed yield plant^{-1} may result from greater moisture availability and improved growth and yield attributes.These findings aligned with those of Gitanjali *et al*. (2017).

The data presented in Table2, showed that seed yield plant^{-1} wasaffected significantly with different nutrient levels. Thelowest seed yield plant^{-1} significantly, (17.8 g)was noted with the application of 75% RDF. Significantly thehighest seed yield plant^{-1} (19.5 g) was observed with application of 125% RDF and followed by 100% RDF application (18.6 g). Related findings were presented by Gitanjali *et al*. (2017).

The interaction effect of irrigation scheduling and nutrient levels did not show any significant differencesin seed yield plant^{-1}.

3.6 100-seed weight (g)

Irrigation at branching and seed development stages showed significantly highest 100-seed weight (7.0 g), followed by the irrigation at rosette and seed development stages (6.6 g). Conversely, the no irrigation (residual moisture) treatment yielded significantlythe lowest 100-seed weight of (4.7 g).

The treatment with 125% RDF application recorded a test weight (6.7 g), which is significantly superior to the100-seed weights of the 100% and 75% RDF treatments (6.1 g and 5.6 g, respectively). Related observations were detailed by Gitanjali *et al*. (2017).

Irrigation scheduling and nutrient levels did not show any significant interaction effect on 100-seed weight.

Table1: Seedyield(kgha^{-1}) and stalkyield(kgha^{-1})ofsafflowerasinfluencedbyirrigation schedulingand nutrient levels under zero tillage condition.

Treatments	Seed yield (kgha^{-1})	Stalkyield (kgha^{-1})
Factor-1: Irrigation		
I_1: Rosette andflower initiation Stage	943	3728
I_2: Rosette andseed development stage	1092	4413
I_3: Branching andflower initiation stage	991	4007
I_4: Branching andseed development stage	1199	4724
I_5: No Irrigation (residual moisture)	744	3000

SEm±	68.01	189.31
CD(P=0.05)	198.0	551.2
Factor-2: Nutrient levels		
S1: 75% RDF	837	3386
S2: 100% RDF	1039	4109
S3: 125% RDF	1105	4429
SEm±	52.68	146.64
CD(P=0.05)	154.4	427.0
Interaction (I×S)		
SEm±	117.8	327.9
CD(P=0.05)	NS	NS

Table2: **Yieldattributesofsafflowerasinfluencedbyirrigation schedulingandnutrient levels under zero tillage conditions.**

Treatments	**Yield attributes**			
	No of heads plant-1	**No of seeds head^{-1}**	**Seed yield plant-1 (g)**	**100-seed weight(g)**
Factor-1: Irrigation				
I1: Rosette andflower initiation Stage	17.9	20.5	18.2	6.4
I_2: Rosette andseed development stage	21.1	22.2	19.3	6.6
I_3: Branching andFlower initiation stage	20.6	22.1	18.4	6.0
I_4: Branching andseed development stage	22.5	23.4	19.8	7.0

I_5: No Irrigation (Residual Moisture)	13.3	15.9	17.6	4.7
SEm±	0.64	0.39	0.15	0.23
CD(P=0.05)	1.87	1.16	0.45	0.67
Factor-2: Nutrient levels				
S1: 75% RDF	16.8	19.0	17.8	5.6
S2: 100% RDF	19.1	20.7	18.6	6.1
S3: 125% RDF	21.4	22.6	19.5	6.7
SEm±	0.49	0.39	0.12	0.17
CD(P=0.05)	1.45	1.16	0.39	0.51
Interaction (I×S)				
SEm±	1.11	0.69	0.26	0.39
CD(P=0.05)	NS	NS	NS	NS

CONCLUSION

The results above indicate that providing irrigation at the branching and seed development stages along with applying of 125%RDF, gives significantly higherseed and stalk yield, as well as improved yield attributes such as the number of heads per plant, number of seeds per head, seed weight per plant and test weight.The study concludes that this combination of irrigation at the branching and seed development stages along with125% RDF application performed the best among all treatment combinationsin the variety TSF-1.

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