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Studies on RDF, Phosphorus Biofertilizers and Foliar Spray of Potassium Fertilizers on Growth and Yield of Sunflower (*Helianthus annuus* L.)

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A B S T R A C T

A field experiment was conducted during the *kharif* season 2017 at Main Agricultural Research station, University of Agricultural Sciences, Dharwad, to study the "Effect of levels of RDF, phosphorus biofertilizers and foliar spray of potassium fertilizers on growth and yield of sunflower (*Helianthus annuus* L.)" The soil of the experimental site was clayey in texture, and neutral in reaction. The results revealed that application of 100 per cent RDF along with soil application of VAM and foliar spray of I per cent KNO_3 at 45 DAS recorded significantly higher plant height (197 cm), no. of green leaves (7.7), leaf area (27.94 dm^{-2} $plant^{-1}$), relative chlorophyll content (SPAD value) (31.10), total dry matter production (72.14 g $plant^{-1}$), seed yield (2,019 kg ha^{-1}), stalk yield (3,397 kg ha^{-1}) and harvest index (37%) followed by application of 75 per cent RDF along with seed treatment of PSB at 20g per kg or soil application of 12 kg VAM per hectare and foliar spray of 1 per cent KNO_3 at 45 DAS.

Introduction

Oilseeds play an important role in agricultural economy of India. Oilseeds are important next only to food grains in terms of area, production and value. The production of oilseeds in India is below the target levels. Among oilseed crops, Sunflower (*Helianthus annuus* L.) is an important annual oilseed crop, popularly known as "Surajmukhi" or "Sooryakanthi", belongs to family *Asteraceae*. Sunflower ranks third, next to groundnut and soybean in the total production of oilseeds in the world. Presently in India sunflower is grown over an area of 0.55 million hectares with a production of 0.42 million tonnes and a productivity of 753 kg ha^{-1} (Anon., 2016) which is far below than its potential. Karnataka accounts majority of the sunflower production (0.21 million tonnes) in India with an area of 0.36 million hectares and productivity of 597 kg ha^{-1}. The lower productivity of crop is mainly ascribed to cultivation of sunflower in less fertile marginal lands under low and uncertain rainfall situations with low and imbalanced use of fertilizers (Ramulu *et al.*, 2011). Most Indian soils are deficient phosphorus (P). P is generally a limiting factor in sunflower growth and yield because P deficiencies

reduce the accumulation of crop biomass (Zubillaga *et al.,* 2002). Considering the importance of P nutrition in sunflower and the need for economising P fertilizer use, microbial P-solubilization as well as mobilization would be the only possible way to increase plant-available P (Peix *et al.*, 2001). PSB plays a vital role for making unavailable phosphorus to available phosphorus by mineralisation of organic phosphate or by solubilization of inorganic phosphate by production of acids (Rodriguez and Fraga, 1999). Another important biofertiliser, Vesicular-Arbuscular Mycorrhizae (VAM) fungi provides significant amount of nutrients to the plants such as copper, zinc, phosphorus and sulphur by making their widely extended hyphal network on the upper or lower side of the soil layer. Favourable response of phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizae (VAM) have been noticed by many workers (Tilak and Singh, 1994).

Further, sunflower is deep rooted and heavy feeder of nutrients. Under intensive cultivation, it is essential to replenish the soil with nutrients. In this situation, utilization of soil nutrients may be slow and deficiency symptoms cannot be corrected if applied through soil. However, foliar application addresses the issues associated with excessive use of chemical fertilizers in conventional soil application method. Foliar application is the best option for quick correction of the deficiencies and to increase nutrient use efficiency for sustainable production. Recently, foliar feeding of nutrients has become an established fact in crop production to increase yield and improve quality of crop produce (Roemheld and El-Fouly, 1999) and nutrient use efficiency, besides lowering the pollution by reducing the amount of fertilizers added to soil (Abou-El-Nour, 2002). Foliar feeding of nutrients might have actually promoted root absorption of the same nutrient or other nutrients by improving root growth and increasing nutrient uptake.

Potassium (K^+) is one of the indispensable nutrients for plant growth and imperative for sustaining productivity in agriculture. Potassium improves economic crop produce and its quality. Thus, application of potassium fertilizer results in higher value to product and therefore greater return to the farmer.

Potassium plays an important role in enzyme activation, provides turgidity to plants, involved in translocation of assimilates photosynthates and involved in maintenance of water status of plant especially the turgor pressure of cells, opening and closing of stomata and increase the availability of metabolic energy for the synthesis of sugar, starch and proteins. In addition to this potassium enhances nitrogen and sunlight utilization and resistance against pests, diseases, drought, frost, salinity or sodiciy (Sekhon *et al*., 1992).

Materials and Methods

A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, under rainfed conditions and it was located at 15° 27 N' latitude and 75° 0' E longitude with altitude of 730 m above mean sea level in Northern Transition Zone (Zone-8) of Karnataka, India.

The soil was medium black clayey in texture, medium in organic carbon (0.52%), medium in available nitrogen (265.6 kg N ha^{-1}), medium in available phosphorus (34.35 kg P_2O_5 ha^{-1}) and high in available potassium (405 kg K_2O ha^{-1}) with pH of 7.3. Sunflower hybrid KBSH-53, with duration of 100 days was used in the trial. Fertilizer was applied at the rate of 35:50:35 kg N, P_2O_5 and K_2O ha^{-1}. Half dose of nitrogen and full dose of

potassium and phosphorus were applied as basal dose to all the treatments. Remaining 50% of nitrogen was top dressed at 30 days after sowing. The observation on plant height, no" of green leaves, leaf area, leaf area index, relative chlorophyll content (SPAD value), total dry matter production were recorded at 90 days after sowing seed yield and stalk yield were recorded after harvesting and the observation recorded were statistically analyzed by adopting the procedure of Gomez and Gomez (1984). The experiment consisted of two levels of RDF (L) as first factor (L_1:75 per cent RDF, L_2: 100 per cent RDF), two phosphorus biofertilizer (B) as second factor (B_1: seed treatment with PSB, B_2: Soil application of VAM) and Foliar spray of potassium fertilizers (F) as third factor (F_1: KNO_3 @ 0.5% spray at 45 DAS, F2: KNO_3 @ 1% spray at 45 DAS, F_3: Mop @ 1% spray at 45 DAS) with one control (RDF only) and was laid out in randomized block design (factorial concept) with three replications.

Results and Discussion

The data (Table 1) on growth attributes revealed that treatments receiving 100 per cent RDF recorded significantly higher plant height (L_2:193 cm) over application of 75 per cent RDF (L_1:182 cm). Biofertilizer application had no significant effect on plant height. Foliar application of potassium fertilizers also had significant effect on sunflower plant height spraying of KNO_3 @ 1.0 per cent at 45 DAS recorded significantly higher plant height (F_2:192 cm) was on par with KNO_3 @ 0.5 per cent at 45 DAS (F_1:188 cm) and significantly lower plant height was observed in treatment received MOP @ 1.0 per cent at 45 DAS (F_3:183 cm). Data on number of green leaves per plant indicated significant variation due to different levels of RDF application of 100 per cent RDF recorded significantly higher number of green leaves plant^{-1} (L_2:7.2) over 75 per cent RDF (L_1:6.2). Foliar application of potassium fertilizers also had significant effect on number of green leaves per plant spraying of KNO_3 @ 1.0 per cent at 45 DAS recorded significantly higher number of green leaves plant^{-1} (F_2:7.1) was on par with KNO_3 at 0.5 per cent at 45 DAS (F_l:6.7) and significantly lower number of green leaves per plant were recorded by MOP at 1.0 per cent at 45 DAS (F_3:6.3), leaf area is important growth parameter used for evaluating assimilation and transpiration rates. It plays a major role in solar radiation interception, canopy photosynthesis and finally on yield. In the present investigation, significantly higher leaf area per plant was recorded (5.92% higher and 25.75 dm^2 plant^{-1}) with application of 100 per cent RDF over other 75 per cent RDF (24.31 dm^2 plant^{-1}) which might be due to more number of leaves per plant. Owing to adequate nutrient supply, the expansion of cells and cell division occurred and resulted in increased leaf number, leaf area and reproductive parts of plant (Thakuria *et al.*, 2004). The significant increment in the growth parameters resulted in higher total dry matter production (TDM). The amount of TDM produced is an indication of the overall efficiency of the utilization of resources. Yield of a particular crop is decided by higher total dry matter production coupled with maximum translocation of photosynthates to sink. In this experiment, application of 100 per cent RDF recorded (Table 1) significantly higher total dry matter (6.03% and 70.24 g plant^{-1}) over 75 per cent RDF. The main reasons for increased dry matter production might be attributed to higher assimilatory surface area, which persisted for longer period with higher rate of photosynthesis which accelerated the cell division and elongation. Hence its subsequent accumulation was noticed in sink (Patel *et al.*, 2012) also observed that, adequate nutrients found to influence rapid cell division and elongation and most of the physiological processes in

plants. These results are in conformity with the findings of Yadav *et al.*, (2009).

The yield of sunflower crop differed significantly with levels of RDF. In the present study data revealed that application of 100 per cent (35:50:35 kg $N:P_2O_5:K_2O$ ha^{-1}) was found superior and recorded significantly higher sunflower seed yield (2,019 kg ha^{-1}) over 75 per cent RDF (26.25:37.5:26.25 kg $N:P_2O_5:K_2O$ ha^{-1}) (1,868 kg ha^{-1}). The increase in sunflower seed yield with 100 per cent RDF was to the tune of 8"03 per cent over 75 per cent RDF.

Table.1 Effect of levels of recommended dose of fertilizer (RDF), phosphorus biofertilizers and foliar spray of potassium fertilizers on growth attributes of sunflower

Treatment	Plant height (cm)	No. of green leaves	Leaf area (dm^2)	Total dry matter production (g $plant^{-1}$)
Factor I: Levels of RDF (L)				
L_1: 75% RDF	182	6.2	24.31	66.24
L_2: 100% RDF	193	7.2	25.75	70.24
S.Em±	1.5	0.2	0.45	0.40
C.D. at (P=0.05)	4.3	0.5	1.33	1.18
Factor II: Phosphorus biofertilizers (B)				
B_1: Seed treatment with PSB	185	6.4	24.61	67.70
B_2: Soil application of VAM	189	7.0	25.45	68.78
S.Em±	1.5	0.2	0.45	0.40
C.D. at (P=0.05)	NS	NS	NS	NS
Factor III: Foliar spray of potassium fertilizers (F)				
F_1: KNO_3 @ 0.5% spray at 45 DAS	188	6.7	24.88	68.34
F_2: KNO_3 @ 1% spray at 45 DAS	192	7.1	26.13	69.94
F_3: MOP @ 1% spray at 45 DAS	183	6.3	24.08	66.43
S.Em±	1.80	0.2	0.55	0.49
C.D. at (P=0.05)	5.3	0.7	1.63	1.45
Interaction (LxBxF)				
$L_1B_1F_1$	179	5.9	24.35	66.06
$L_1B_1F_2$	184	6.1	24.86	67.23
$L_1B_1F_3$	176	5.7	22.80	63.44
$L_1B_2F_1$	184	6.5	23.60	66.72
$L_1B_2F_2$	191	7.3	25.75	69.87
$L_1B_2F_3$	177	5.7	24.49	64.12
$L_2B_1F_1$	193	7.1	25.54	70.20
$L_2B_1F_2$	194	7.3	25.95	70.53
$L_2B_1F_3$	186	6.4	24.15	68.74
$L_2B_2F_1$	195	7.3	26.03	70.39
$L_2B_2F_2$	197	7.7	27.94	72.14
$L_2B_2F_3$	191	7.2	24.89	69.41
S.Em±	3.6	0.4	1.11	0.99
C.D. at (P=0.05)	10.6	1.3	3.25	2.89
RDF (Control)	174	5.3	22.45	62.60
S.Em±	3.5	0.4	1.08	0.97
C.D. at (P=0.05)	10.2	1.3	3.14	2.82

Table.2 Effect of levels of recommended dose of fertilizer (RDF), phosphorus biofertilizers and foliar spray of potassium fertilizers on yield of sunflower

Treatment	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (kg ha^{-1})
Factor I: Levels of RDF (L)			
L_1: 75% RDF	1,868	3,454	35
L_2: 100% RDF	2,019	3,632	36
S.Em±	34.04	37.37	0.41
C.D. at (P=0.05)	99.84	109.59	NS
Factor II: Phosphorus biofertilizers (B)			
B_1: Seed treatment with PSB	1,894	3,489	35
B_2: Soil application of VAM	1,993	3,597	36
S.Em±	34.04	37.37	0.41
C.D. at (P=0.05)	NS	NS	NS
Factor III: Foliar spray of potassium fertilizers (F)			
F_1: KNO_3 @ 0.5% spray at 45 DAS	1,954	3,541	36
F_2: KNO_3 @ 1% spray at 45 DAS	2,019	3,633	36
F_3: MOP @ 1% spray at 45 DAS	1,858	3,455	35
S.Em±	41.69	45.76	0.51
C.D. at (P=0.05)	122.27	134.22	NS
Interaction (LxBxF)			
$L_1B_1F_1$	1,873	3,433	35
$L_1B_1F_2$	1,873	3,450	35
$L_1B_1F_3$	1,757	3,367	34
$L_1B_2F_1$	1,917	3,413	36
$L_1B_2F_2$	2,005	3,663	35
$L_1B_2F_3$	1,783	3,396	34
$L_2B_1F_1$	1,953	3,633	35
$L_2B_1F_2$	1,993	3,623	35
$L_2B_1F_3$	1,917	3,426	36
$L_2B_2F_1$	2,071	3,683	36
$L_2B_2F_2$	2,203	3,797	37
$L_2B_2F_3$	1,977	3,630	35
S.Em±	83.38	91.53	1.01
C.D. at (P=0.05)	244.55	268.44	2.97
RDF (Control)	1,682	3,351	33
S.Em±	80.29	88.68	0.97
C.D. at (P=0.05)	234.34	258.84	2.83

Improvement in yield attributing parameters could be attributed to better growth parameters in addition to total dry matter production at different stages of the crop growth and it's partitioning into different parts due to application of higher levels of nitrogen and phosphorus fertilizers (Khakwani *et al.*, 2014, Bakth *et al.*, 2015). These results are in conformity with the findings of Yasin *et al.*, (2013) and Yadav *et al.*, (2009).

The seed yield revealed that sunflower responded significantly to different levels of RDF. Application of 100 per cent RDF

recorded significantly higher seed yield (L_2: 2,019 kg ha^{-1}) over 75 per cent RDF (L_1:1,868 kg ha^{-1}). Biofertilizer application had no significant effect seed yield. However seed yield ranges from 1,894 kg ha^{-1} to 1,993 kg ha^{-1}. Foliar application of potassium fertilizers also had significant effect on seed yield. Spraying of KNO_3 @ 1.0 per cent at 45 DAS recorded significantly higher seed yield (F_2:2,019 kg ha^{-1}) was on par with KNO_3 @ 0.5 per cent at 45 DAS (F_1:1,954 kg ha^{-1}) and significantly lower seed yield was recorded at MOP 1.0 per cent foliar spray at 45 DAS (F_3:1,858 kg ha^{-1}).

The increase in sunflower seed yield with $R_2B_2F_2$ was to the tune of 30.97 per cent over control (RDF only) (1,682 kg ha^{-1}). This was again comparable with application of 75 per cent RDF, soil application of VAM and KNO_3 spray @ 1.0 per cent at 45 DAS ($R_1B_2F_2$) (2,005 kg ha^{-1}). However application of 100 per cent RDF with either of biofertilizer and along foliar spray of KNO_3 @ 1.0 per cent or KNO_3 @ 0.5 per cent at 45 DAS was found on par with superior treatment. These findings are in confirmative with those reported by Keshta *et al.,* (2006), Dhanasekar *et al.,* (2012), Farnia and Moayedi (2014), Khan *et al.,* (2016) and Mirparsa *et al*, (2016). Positive effect of foliar spray of KNO_3 @ 1.0 per cent or KNO_3 0.5 per cent at 45 DAS with either of VAM or PSB was noticed in all the treatment combinations This could be possible increased because of more availability of nutrients and their uptake. Similar findings were also reported by Tiwari and Parihar (1992), Ramesh *et al.,* (1999), Gorttappeh *et al.,* (2000), Saeed *et al.,* (2002), who stated that biofertilizer in combination with synthetic fertilizers significantly increased seed and biological yield against control. Improved uptake of nutrient elements is one of the main foliar spray effects. Also, the environmental destructive effect of chemical fertilizers application in soil is reduced with foliar spray (Malakooti and Tehrani, 1999). Although chemical fertilizers have an important role in increasing crop yield. But, soil fertility management with the use of biofertilizer and foliar nutrient elements instead soil application of chemical fertilizers is an important issue in sustainable agriculture.

The stalk yield revealed that sunflower responded significantly to different levels of RDF. Application of 100 per cent RDF recorded significantly higher stalk yield (L_2:3,632 kg ha^{-1} over 75 per cent RDF (L_1:3,454 kg ha^{-1}). Biofertilizer application had no significant effect stalk yield. However stalk yield ranges from 3,541 kg ha^{-1} to 3,633 kg ha^{-1}. Foliar application of potassium fertilizers also had significant effect on stalk yield. Spraying of KNO_3 @ 1.0 per cent at 45 DAS recorded significantly higher stalk yield (F_2:3,633 kg ha^{-1}). However it was on par with KNO_3 @ 0.5 per cent at 45 DAS (F_1:3,541 kg ha^{-1}) and significantly lower stalk yield was recorded at MOP 1.0 per cent foliar spray at 45 DAS (F_3:3,455 kg ha^{-1}).

The interaction effect on stalk yield due to levels of RDF, phosphorus biofertilizers and foliar spray of potassium fertilizers differ significantly among different treatment combinations. Treatment combination of $L_2B_2F_2$ recorded significantly higher stalk yield (3,791 kg ha^{-1}). However, it was on par with ($L_2B_2F_1$:3,683 kg ha^{-1}, $L_1B_2F_2$:3,663 kg ha^{-1}, $L_2B_1F_2$:3,623 kg ha^{-1} and $L_2B_1F_1$:3,633 kg ha^{-1} and $L_2B_2F_3$:3,630 kg ha^{-1}). Control treatment receiving only RDF alone recorded significantly lower stalk yield (3,351 kg ha^{-1}) over rest of the treatment combinations.

The data on harvest index revealed that levels of RDF, phosphorus biofertilizers and foliar application of potassium had no significant effect on harvest index.

The interaction effect on sunflower harvest index due to levels of RDF, phosphorus biofertilizers and foliar spray of potassium fertilizers differ significantly among different treatment combinations. Treatment combination of $L_2B_2F_2$ recorded significantly higher harvest index (37%). However, it was on par with ($L_2B_2F_1$:36%, $L_2B_1F_3$:36%, $L_1B_2F_2$:36%, $L_2B_1F_2$:35%, $L_2B_2F_3$:35%, $L_2B_1F_1$:35, $L_1B_2F_1$:35% and $L_1B_2F_2$:35%). Control treatment receiving only RDF recorded significantly lower harvest index (33%) over rest of the treatment combinations.

It would be concluded from the above results that, application of 75 per cent RDF along with seed treatment of PSB at 20 g kg^{-1} or soil application of 12 kg VAM per hectare and foliar spray of 1 per cent KNO_3 at 45 DAS found suitable for higher growth and yield of sunflower.

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