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 1 per cent KNO3 at 45 DAS recorded significantly higher plant height (197 cm), no. of green leaves (7.7), leaf area (27.94 dm2 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 KNO3 at 45 DAS.

Keywords
VAM, PSB and KNO3

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 sodicity (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 P₂O₅ ha⁻¹) and high in available potassium (405 kg K₂O 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, P₂O₅ and K₂O 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 (L1:75 per cent RDF, L2: 100 per cent RDF), two phosphorus biofertilizer (B) as second factor (B1: seed treatment with PSB, B2: Soil application of VAM) and Foliar spray of potassium fertilizers (F) as third factor (F1: KNO₃ @ 0.5% spray at 45 DAS, F2: KNO₃ @ 1% spray at 45 DAS, F3: 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 (L₂:193 cm) over application of 75 per cent RDF (L₁:182 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 KNO₃ @ 1.0 per cent at 45 DAS recorded significantly higher plant height (F₂:192 cm) was on par with KNO₃ at 0.5 per cent at 45 DAS (F₁:188 cm) and significantly lower plant height was observed in treatment received MOP @ 1.0 per cent at 45 DAS (F₃:183 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 (L₂:7.2) over 75 per cent RDF (L₁:6.2). Foliar application of potassium fertilizers also had significant effect on number of green leaves per plant spraying of KNO₃ @ 1.0 per cent at 45 DAS recorded significantly higher number of green leaves plant⁻¹ (F₂:7.1) was on par with KNO₃ at 0.5 per cent at 45 DAS (F₁:6.7) and significantly lower number of green leaves per plant were recorded by MOP at 1.0 per cent at 45 DAS (F₃:6.3), 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 dm² plant⁻¹) with application of 100 per cent RDF over other 75 per cent RDF (24.31 dm² 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:P₂O₅:K₂O 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:P₂O₅:K₂O 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 (dm²) | Total dry matter production (g plant⁻¹) |
|--------------------------------|-------------------|---------------------|-----------------|------------------------------------------|
| **Factor I: Levels of RDF (L)** |                   |                     |                 |                                          |
| L₁: 75% RDF                    | 182               | 6.2                 | 24.31           | 66.24                                    |
| L₂: 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)** |                   |                     |                 |                                          |
| B₁: Seed treatment with PSB    | 185               | 6.4                 | 24.61           | 67.70                                    |
| B₂: 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)** |                   |                     |                 |                                          |
| F₁: KNO₃ @ 0.5% spray at 45 DAS| 188               | 6.7                 | 24.88           | 68.34                                    |
| F₂: KNO₃ @ 1% spray at 45 DAS  | 192               | 7.1                 | 26.13           | 69.94                                    |
| F₃: 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)**        |                   |                     |                 |                                          |
| L₁B₁F₁                         | 179               | 5.9                 | 24.35           | 66.06                                    |
| L₁B₁F₂                         | 184               | 6.1                 | 24.86           | 67.23                                    |
| L₁B₁F₃                         | 176               | 5.7                 | 22.80           | 63.44                                    |
| L₁B₂F₁                         | 184               | 6.5                 | 23.60           | 66.72                                    |
| L₁B₂F₂                         | 191               | 7.3                 | 25.75           | 69.87                                    |
| L₁B₂F₃                         | 177               | 5.7                 | 24.49           | 64.12                                    |
| L₂B₁F₁                         | 193               | 7.1                 | 25.54           | 70.20                                    |
| L₂B₁F₂                         | 194               | 7.3                 | 25.95           | 70.53                                    |
| L₂B₁F₃                         | 186               | 6.4                 | 24.15           | 68.74                                    |
| L₂B₂F₁                         | 195               | 7.3                 | 26.03           | 70.39                                    |
| L₂B₂F₂                         | 197               | 7.7                 | 27.94           | 72.14                                    |
| L₂B₂F₃                         | 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\(_1\)B\(_1\)F\(_1\)           | 1.873                       | 3.433                       | 35                            |
| L\(_1\)B\(_1\)F\(_2\)           | 1.873                       | 3.450                       | 35                            |
| L\(_1\)B\(_1\)F\(_3\)           | 1.757                       | 3.367                       | 34                            |
| L\(_1\)B\(_2\)F\(_1\)           | 1.917                       | 3.413                       | 36                            |
| L\(_1\)B\(_2\)F\(_2\)           | 2.005                       | 3.663                       | 35                            |
| L\(_1\)B\(_2\)F\(_3\)           | 1.783                       | 3.396                       | 34                            |
| L\(_2\)B\(_1\)F\(_1\)           | 1.953                       | 3.633                       | 35                            |
| L\(_2\)B\(_1\)F\(_2\)           | 1.993                       | 3.623                       | 35                            |
| L\(_2\)B\(_1\)F\(_3\)           | 1.917                       | 3.426                       | 36                            |
| L\(_2\)B\(_2\)F\(_1\)           | 2.071                       | 3.683                       | 36                            |
| L\(_2\)B\(_2\)F\(_2\)           | 2.203                       | 3.797                       | 37                            |
| L\(_2\)B\(_2\)F\(_3\)           | 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$_2$B$_2$F$_2$ 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$_1$B$_2$F$_2$) (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$_2$B$_2$F$_2$ recorded significantly higher stalk yield (3,791 kg ha$^{-1}$). However, it was on par with (L$_2$B$_2$F$_1$: 3,683 kg ha$^{-1}$, L$_1$B$_2$F$_2$: 3,663 kg ha$^{-1}$, L$_2$B$_1$F$_2$: 3,623 kg ha$^{-1}$ and L$_2$B$_1$F$_1$: 3,633 kg ha$^{-1}$ and L$_2$B$_2$F$_3$: 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 ($L_2B_1F_3$:36%, $L_1B_1F_2$:36%, $L_2B_1F_2$:35%, $L_2B_2F_3$: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.

References

Abou-El-Nour, A. A., 2002, Can supplemented potassium foliar feeding reduce the recommended soil potassium. *Pak. J. Biol. Sci.*, 5 (3): 259-262.

Anonymous, 2016, Status paper on oilseeds. Department of Agriculture and Cooperation, *Ministry of Agriculture*, Govt. of India, Krishi Bhawan, New Delhi, pp. 70-74.

Bakth, J., Mohammad. S. and Mohammad, Y., 2015, Effect of various levels of NPK on orop growth and yield of sunflower hybrids grown under autumn seasons. *Pak. J. Bot.*, 47(6):171-180.

Dhanasekar, R. and Dhandapani, R., 2007, Effect of biofertilizers on the growth of *Helianthus annuus*. *Intl. J. Plant, Animal, Env. Sci.*,2 (4):12-18.

Farnia, A. and Moayedi, M., 2014, Effect of phosphate and nitrogen biofertilizers on yield, yield components, oil and protein in sunflower (*Helianthus annuus L.*). *Bull. Env. Pharmacol. Life Sci.*, 3: 110-117.

Gomez, K. A. and Gomez, A. A., 1984, Statistical Procedure for Agricultural Research. John Wiley and Sons, New Delhi, P. 680.

Gorttappeh, A. H., Ghalavand, A., Ahmady, M. R. and Mirnia, S. K., 2000, Effect of organic, inorganic and integrated fertilizers on quantitative and qualitative traits of different cultivars of sunflower (*Helianthus annuus L.*) in western Azarbajyan. *Iran. J Agril. Sci.*,6 (2):85-104.

Keshtra, M. M., Rizk, T. Y. and Abdou, E. T., 2006, Sunflower response to mineral nitrogen, organic and bio-fertilizers under two different levels of salinity. *Proc. 17th Int. Sunflower Conf.*, Cordoba, Spain.

Khakwani. A. A., S. Noor, M. Sadiq, I. U. Awan, M. Munir, M. S. Baloch, Ghazanfarullah and Bakhsh, I., 2014, Impact of plant densities and NPK fertilization on growth and optimum economic return of sunflower. *Sarhad J. Agric*. 30(2): 157-164.

Khan, M. A., Sharmaand V. and Shukla R. K.,2016, Response of sunflower (*Helianthus annuus L.*) to organic manure and biofertilizer under different levels of mycorrhiza and sulphur in comparison with inorganic fertilizer. *J. Crop Weed*, 12 (1):81-86.

Kumar, V. 1994, Nitrogen economy in Indian mustard through use of *Azotobacter chroococcum*. *Crop Res.*, 8: 449-452.

Malakooti M. J. and Tehrani, M., 1999, Effect of micro elements in increased yield and improved quality of agriculture crops. Tarbiat Modares University. Press. Pp.229. (In Persian).

Miparsa T, Ganjali, H. R. and Dahmardeh, M., 2016, The effect of biofertilizers on
yield and yield components of sunflower oil seed and nut. *Int. J. Agril. Biosci.*, 5 (1):46-49.

Piex, A., Mateos, P. F., Barrueco, C. R., Moilna, E. M. and Velazquez, E., 2001, Growth promotion of common bean (*Phaseolus vulgaris* L.) by a strain of *Burkholderia cepacia* under growth chamber conditions. *Soil Biol. Biochem.*, 33:1927-35.

Ramesh, S., Raghbir, S. and Mohinder, S., 1999, Effect of phosphorus, Iron and FYM on yield and quality of sunflower. *Annals Agri. Biol. Res.*, 4 (2):145-150.

Ramulu, N., Krishna Murthy, H. M., Janardhan and Ramachandra, C., 2011, Influence of different levels of nutrients on growth and yield of sunflower under irrigated condition of Eastern Dry Zone of Karnataka, India. *Plant Archives.*, 11 (2):1025-1028.

Rodriguez, H. and Fraga, R., 1999, Phosphate solubilizing bacteria and their role in plant growth promotion. *Biotech. Adv.*, 17: 319-39.

Roemheld, V. and El-Fouly, M. M., 1999, Foliar nutrient application: Challenge and limits crop production. *Proc. 2nd Intl. Workshop on Foliar Fertilization*, April 4-10 Bangkok, Thailand, pp.1-32.

Saeed, M. A. and Ashraf, M., 2009, Alleviation of adverse effects of salt stress on sunflower (*Helianthus annuus* L.) by exogenous application of potassium nitrate. *J. Appl. Bot. Food Qual.*, 83: 19-27.

Sekhon, G. S., Brar, M. S. and Rao, S., 1992, Potassium in some bench mark soils of India PRRI special publications no. 3 Potash research institute of India, Gurgaon, Haryana, India, pp.25-27.

Tilak, K. V. B. R. and Singh, G., 1994, Biofertilizel research gap and future needs. *Fert. News*, 39:11-17.

Tiwari, R. B. and Parihar, S. S., 1992, Effect of nitrogen and variety on grain yield and net profit of sunflower. *Adv. Plant Sci.*, 5(1): 173-175.

Yadav, R. P., Tripathi, M. L. and Trivedi, S. K., 2009, Effect of irrigation and nutrient levels on productivity and profitability of sunflower (*Helianthus annuus* L.). *Indian J. Agron.*, 54(3): 332-335.

Yasin, M., Mahmood, A., Ali, A., Aziz, M., Javaid, M. M., Iqbal, Z. and Tanveer, A., 2013, Impact of varying planting patterns and fertilizer application strategies on autumn planted sunflower hybrid. *Cercetari agronomice in moldova.*, 154 (2):39-51.

Zubillaga, M. M., Aristi, J. P. and Lavado, R. S., 2002, Effect of phosphorus and nitrogen fertilization on sunflower (*Helianthus annuus* L.) nitrogen uptake and yield. *J. Agron. Crop Sci.*, 188: 267-274.

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**How to cite this article:**

Praveen Kumar, B. B., G. Somanagouda and Channakeshava, R. 2021. Studies on RDF, Phosphorus Biofertilizers and Foliar Spray of Potassium Fertilizers on Growth and Yield of Sunflower (*Helianthus annuus* L.). *Int.J.Curr.Microbiol.App.Sci.* 10(01): 3272-3279. doi: [https://doi.org/10.20546/ijcmas.2021.1001.381](https://doi.org/10.20546/ijcmas.2021.1001.381)