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Improving Growth and Yield of Sunflower with Integrated Use of Compost and PGPR (Variovorax Paradoxus) with Different Levels of N-Chemical Fertilizer

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IMPROVING GROWTH AND YIELD OF SUNFLOWER WITH INTEGRATED USE OF COMPOST AND PGPR (*VARIOVORAX PARADOXUS*) WITH DIFFERENT LEVELS OF N-CHEMICAL FERTILIZER

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ABSTARCT

Plant growth-promoting rhizobacteria (PGPRs) stimulate plant growth through their ability, to increasing the root length and growth, by asymbiotic nitrogen fixation, by producing siderophores, solubilization of mineral phosphates and mineralization of other nutrients. Organic waste material of fruits and vegetables was collected and composted in a locally fabricated composting unit. A pot trial was conducted to study the effectiveness of compost and PGPR (*Variovorax paradoxus*) with recommended rate of PK and with different rates of N fertilizer i.e. 50 %, 75 % and 100 %, on growth and yield of sunflower. Results showed that the integrated use of 75 % N of recommended dose in combination with PGPR inoculation and compost caused a significant increase in grain yield and yield-contributing parameters compared with control. PGPR isolate Variovorax paradoxus in combination with 75 % N of recommended dose and compost gave maximum total achene's yield 73 % more than control where recommended NPK was applied. Similarly, in case of Plant height, root length, head diameter, head weight, 100 – Achene's weight and nitrogen content in straw were also increased by PGPR isolate Variovorax paradoxus in combination with 75 % N of the recommended dose and compost up to 11, 109, 27, 26, 17, and 54.0 % respectively over control.

Keywords: PGPR, Compost, N fertilizer, Sunflower, growth, yield and integrated application.

INTRODUCTION

It is the most unfortunate that Pakistan having an agricultural economy has not been able to produce abundant edible oil for its domestic purpose yet. A substantial amount of valued foreign exchange has been spent on the import of edible oil. According to the Economic Survey of Pakistan the import, spending for the last year was 321.535 billion rupees. It is stated that in the year 2017-18 sunflower seed crop was grown on an area of 203,000 acres with a production of 104,000 tonnes. About 40,000 tons of oil was extracted from the sunflower seeds for edible purposes. The total availability of oil production from cotton seeds, rapeseed/ mustard, sunflower and canola in the year 2017-18 was 503,000 tons. The contribution of sunflower in the total production of oil was 32 percent. (anonymous, 2018). In Pakistan, the per hectare yield is far below the inherent potential of the existing promising cultivars. Among the various determining factors, soil fertility status is of prime importance. Hence, under the prevailing circumstances, restoration and

maintenance of soil fertility is a basic and critical problem. This can be accomplished by adding organic material, biologically active substances and plant growth-promoting rhizobacteria, in addition to other field practices.

Now-a-days composting is becoming an increasingly important element of environmentally sound sustainable agriculture. Bioconversion and recycling of organic waste is one of the major options, which could be effective for reducing huge piles of organic wastes. Moreover, recycled organic waste material can be used as a source of important nutrients for sustainable agriculture. Instead of disposing, organic wastes can be used to improve the structure and fertility status of the soil as the application of organic material, not only ameliorates the micronutrient deficiencies but also improves the productivity of soil (Kumar et al., 2017). In addition, compost along with rhizobacteria and N- fertilizer may also improve growth and yield of crops The rhizosphere, volume of soil surrounding roots and influenced chemically, physically and biologically by the plant root, is a highly favorable habitat for the proliferation of microorganisms and exerts a potential impact on plant health and soil fertility (Brahmaprakash et al., 2017). Soil microorganisms are considered a potential and economical source of auxin production released as secondary metabolites, which may have pronounced effects on plant growth and development (Afzal and Asad, 2019).

Compared to organic materials, chemical fertilizers are a ready source of nutrients. However, suboptimal doses of fertilizers are applied due to high cost and poor economic conditions of the farmers. This results in lower crop yields than the actual yield potential. Composted organic material is considered a rich source of nutrients and can also play an important role to conserve soil fertility and enhancing crop production on a sustainable basis (Solaiman et al., 2019; Demissie, 2017). Integrated plant nutrient management is very much relevant to the crop husbandry in Pakistan, as chemical fertilizers being a critical input, have been increasingly used and their application has steadily increased over time since their introduction while the crop yield has not been proportionately increased (Dimkpa et al., 2020). The prospects, opportunities, current status and beneficial effects of integrated plant nutrition especially the integrated use of mineral and organic fertilizer in crop production under Pakistani conditions have been reported (NFDC, 2020; Shahzad et al., 2019).

The project was designed to evaluate the integrated use of compost and PGPR in combination with chemical nitrogen fertilizer for improving the growth and yield of sunflower, reducing the cost of production, and making it ecologically sounder.

MATERIALS AND METHODS

A pot trial was conducted to assess the integrated use of compost and plant growth promoting rhizobacteria (PGPR) for improving growth and yield of sunflower (*Helianthus annuus L.*). Organic waste material containing fruit and vegetables wastes was collected from various fruit and vegetable markets of Faisalabad. This organic waste material was processed in a locally fabricated composter, consisting of drier, crusher and grinder for preparing the compost. The organic waste material collected was air-dried for 24 hours to remove the excessive moisture. Air-dried organic waste materials were graded properly to sort out all unwanted substances from the organic wastes and oven dried at 65±5°C for 24 hours before crushing. Oven-dried material was crushed into fine particles in a crusher unit of the composter.

The pot experiment was conducted in the wire house to assess the effect of compost on growth and yield of sunflower.

A loam (*Typic Haplocambids*) soil was collected from a research field of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad and air-dried, sieved and analyzed for various physico-chemical characters before filling into pots. The analysis of a composite soil sample revealed a pHs 7.9; ECe 1.45dSm^{-1}; and organic matter 0.65%. Seeds of sunflower (Hysun 33 Hybrid) were sown in each pot containing 12 kg soil. The recommended dose of P and K fertilizers @ 80-40 kg ha^{-1} as DAP (Diammonium Phosphate) and SOP (Sulphate of Potash), respectively was applied in all treatments including control as a basal dose by mixing them in the soil before filling the pots. N fertilizer was applied @ 120 kg ha^{-1} in two split doses i.e. at first irrigation and at grain formation stage according to the treatment plan. Treatments were applied as under.

T1=Control (Recommended N: P: K @120:80:40 kg ha^{-1})

T2= PGPR (Variovorax paradoxus) inoculation

T3= Compost @ 300 kg ha^{-1}

T4= Recommended NPK+ Compost @ 300 kg ha^{-1}

T5= PGPR (Variovorax paradoxus) inoculation + 50 % of recommended N+ Compost @ 300 kg ha^{-1}

T6= PGPR (Variovorax paradoxus) inoculation + 75 % of recommended N + Compost @ 300 kg ha^{-1}

T7= PGPR (Variovorax paradoxus) inoculation + 100 % of recommended N + Compost @ 300 kg ha^{-1}

Growth and yield parameters i.e Plant height (cm), Root length (cm), Head diameter (cm). Head weight (g), 100-Achene's weight (g), and Achene's yield (g) were recorded. N contents in straw and grain were determined according to the procedure described by Jackson (1962). The data were analyzed by using completely randomized design (Steel and Torrie, 1980) and means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Plant Height (Cm)

Results (Table 1) revealed that compost and PGPR in combination with N fertilizer significantly influenced plant height. Maximum increase (11 % greater than control) in plant height was observed with the application of 75 % N of recommended dose along with PGPR and compost and it was followed by the full dose of recommended N fertilizer application along with PGPR and application of compost and PGPR in combination with 50 % dose of the recommended N fertilizer.

Root Length (Cm)

PGPR and compost also significantly affected root length of sunflower either applied alone or in combination with N fertilizer as compared to control (Table 1). However, maximum root length (109 % higher than control) was recorded where 75 % N of the recommended dose in combination with PGPR and compost was applied. It was followed by the full dose of recommended N fertilizer application along with PGPR and compost which was statistically at par with the application of compost and PGPR in combination with 50 % dose of the recommended N fertilizer.

Head Diameter (Cm)

Application of PGPR and compost also significantly affected head diameter of sunflower either applied alone or in combination with N fertilizer as compared to control (Table 1). Maximum head diameter was observed where compost and PGPR along with 75 % dose of the recommended N fertilizer was applied which was statistically at par with treatments T_4, T_5, T_6 and T_7. This maximum increase in head diameter was 27

% higher than control. Application of the full dose of recommended N fertilizer along with PGPR and compost also enhanced head diameter (up to 14 %) over control.

Table-1: Integrated effect of compost and plant growth promoting rhizobacteria along with different nitrogen fertilizer on growth and yield contributing parameters of sunflower.

Treatments	Plant Height (cm)	Root length (cm)	Head Diameter (cm)	Head weight (g)
T_1	123.13 d	14.33 de	9.07 bc	101.33 cd
T_2	116.40 f	17.00 cd	8.53 bc	88.27 e
T_3	120.67 e	13.67 e	7.73 c	96.53 de
T_4	124.07 d	17.67 c	9.87 abc	108.27 bc
T_5	127.67 c	19.33 bc	10.13 abc	111.20 b
T_6	136.27 a	30.00 a	11.53 a	127.20 a
T_7	131.00 b	22.00 b	10.31 ab	120.93 a
LSD	2.45	3.13	2.22	9.17

T_1=Control (Recommended N: P: K @120:80:40 kg ha^{-1}); T_2= PGPR (Variovorax paradoxus) inoculation; T_3= Compost @ 300 kg ha^{-1}; T_4= Recommended NPK+ Compost @ 300 kg ha^{-1}; T_5= PGPR (Variovorax paradoxus) inoculation + 50 % of recommended N+ Compost @ 300 kg ha^{-1}; T_6= PGPR (Variovorax paradoxus) inoculation + 75 % of recommended N + Compost @ 300 kg ha^{-1}; T_7= PGPR (Variovorax paradoxus) inoculation + 100 % of recommended N + Compost @ 300 kg ha^{-1};

Table-2: Integrated effect of compost and plant growth promoting rhizobacteria along with different nitrogen fertilizer on yield and nitrogen content of sunflower.

Treatments	100 Achene's Weight (g)	Total Achene's yield (g)	Nitrogen content in straw (%)	Nitrogen content in grain (%)
T_1	3.70 ab	15.00 c	1.35 d	3.66 d
T_2	3.66 b	12.09 d	0.58 e	3.46 e
T_3	2.66 c	8.24 e	0.58 e	2.45 f
T_4	3.86 ab	15.54 c	1.50 b	3.68 c
T_5	3.88 ab	19.44 b	1.51 c	3.68 c
T_6	4.31a	26.02 a	2.08 a	3.92 b
T_7	4.19ab	21.83 b	2.08 a	4.73 a
LSD	0.57	2.84	0.0018	0.0018

T_1=Control (Recommended N: P: K @120:80:40 kg ha^{-1}); T_2= PGPR (Variovorax paradoxus) inoculation; T_3= Compost @ 300 kg ha^{-1}; T_4= Recommended NPK+ Compost @ 300 kg ha^{-1}; T_5= PGPR (Variovorax paradoxus) inoculation + 50 % of recommended N+ Compost @ 300 kg ha^{-1}; T_6= PGPR (Variovorax paradoxus) inoculation + 75 % of recommended N + Compost @ 300 kg ha^{-1}; T_7= PGPR (Variovorax paradoxus) inoculation + 100 % of recommended N + Compost @ 300 kg ha^{-1};

Head Weight (G)

It is evident from Table 1 that the application of PGPR and compost alone and in combination with different levels of the recommended N and full dose of N had significant influence on head weight of sunflower. Maximum increase (26 % greater than control) in head weight was observed with the application of compost and PGPR in combination with 75 % dose of the recommended N fertilizer. This maximum increase was statistically at par with the increase (19 % higher than control) recorded with the application of the full dose of N fertilizer along with PGPR and compost.

100 Achene's Yield

The data regarding the effect of application of PGPR and compost alone and in combination with different levels of the recommended N fertilizer depicted a significant influence on 100 achene's weight of sunflower (Table 2). Maximum increase (17 % higher than control) in 100 achene's weight was recorded in response to the application of compost and PGPR in combination with 75 % dose of the recommended N fertilizer, although this increase was statistically similar with T_1, T_4, T_5 and T_7.

Achene's Yield

The results revealed that the application of different levels of the recommended N fertilizer in combination with PGPR and compost showed a significant influence on achene's yield of sunflower (Table 2). Maximum increase (73% higher than control) in achene's yield was recorded in response to the application of 75% dose of the recommended N fertilizer in combination with PGPR inoculation and compost. While the application of 100% and 50% recommended N fertilizer in combination with PGPR and compost was the second and third best treatments which showed 46% and 30% increase in achene's yield over control, where only NPK fertilizers were applied.

Nitrogen Concentration in Straw

Chemical analysis (Table 2) revealed that all the treatments except compost and PGPR alone had a significant increasing effect on N concentration of straw over control. Maximum N concentration (54.07 % higher than control) was revealed with the application of compost and PGPR in combination with 75 % and 100 % of the recommended dose of N fertilizer.

Nitrogen Concentration in Grains

Table 2 revealed that except compost and PGPR alone all other treatments significantly increased N concentration in grains. Maximum increase (29.23 % over control) in N concentration in grains was observed with the application of compost and PGPR in combination with 100 % of the recommended dose of N fertilizer. It was followed in descending order by the application of compost and PGPR inoculation in combination with 75 % of the recommended dose of N fertilizer which showed a 7.10 % increase in N concentration in grain over control.

DISCUSSION

This study compared the effects of integrated use compost and plant growth promoting rhizobacteria in combination with different levels of recommended N chemical fertilizer and sole application of recommended NPK, compost and PGPR inoculation. In this study the compost was applied as an organic fertilizer, instead of a source of organic matter, which is usually applied in tons while PGPR was applied as bio-fertilizer.

Results demonstrated the efficiency of compost and PGPR in a combination of N fertilizer for improving the growth and yield of sunflower in a pot experiment. The integrated application of compost and PGPR with different levels of N fertilizer had a significant positive effect on the growth and yield parameter of sunflower. Compost and PGPR along with 75 % of the recommended dose of nitrogen fertilizer significantly improved the plant height, root length, head diameter, head weight, 100 achene's weight and achene's yield. In case of plant height, our findings were in line with Akhtar et al. (2007) and Pangaribuan and Hendarto, (2018) who obtained higher plant height due to the application of enriched compost in combination with 50 % dose of the recommended N fertilizer as urea (wheat). Similar results were also reported in maize plant where the inoculation along with synthetic fertilizers mostly increased the height of shoots and roots (Gamez et al., 2019). Plant growth regulating substance such as IAA, GA3 and cytokines produced by inoculums are known to promote better growth (Parween et al., 2017).

The increase in yield and yield contributing parameters might be due to PGPR (Variovorax paradoxus) activity in rhizosphere and availability of balanced nutrients in the presence of compost which prevented the losses of nutrients through leaching and volitization. The increase in head diameter was mainly due to the higher nutrient availability, which enhanced the size of the head. These results were in accordance with the findings obtained by Naveed et al., (2008) who obtained higher grain yield with the application of the organic fertilizer supplemented with 88 kg ha^{-1} N in maize. Similarly, Sabahi et al., 2008 reported that the combined use of manure and inorganic nitrogen fertilizer improved the sunflower growth and yield. Khaliq et al., 2006 also reported that the use of organic matter, effective microorganisms and half dose of mineral fertilizer gave the best results than other treatments. Nouraein et al., (2002), who stated that organic manure alone or in combination with synthetic fertilizers significantly, increased achene and biological yield against control. Some other related results were obtained in general; the growth and yield attributes exhibited maximum values in treatments of bacterial inoculums and seedling treatments in combination with 75% and 100% nitrogen application (Dal Cortivo et al., 2017). In case nitrogen concentration in straw and grain our results are in accordance with Khaliq et al. (2006) and Bargaz et al. (2018) who reported that the combination of different N sources with effective microorganisms also increased the concentrations of NPK in plants. Similarly, Naveed et al. (2008) and Arif et al. (2018) also reported that organic/bio-fertilizer application also significantly enhanced N, P and K uptakes in oil seed crops.

CONCLUSION

This study clearly indicated that the integrated use of compost and PGPR in combination with N fertilizer could have a positive effect on plant growth and yield by acting as a source of soluble nutrients as well as by improving the physical properties of soil. As the results of this study indicated that use of 75% of recommended N in combination with PGPR and compost have a tremendous effect on growth and yield of sunflower and an economical solution for sustainable crop production. So, this approach may also be cost effective, can improve soil health, reduce dependence on chemical fertilizer and most likely help reduce huge piles of organic waste, thus cleaning our environment.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR'S CONTRIBUTION

Muhammad Imran, Muhammad Javed Akhtar, and Muhammad Zeeshan Gulzar were designed and conducted experiment. Sarmad Frogh Arshad and Muhammad Ashfaq were prepared initial draft. Shahzad Ahmad and Kashif Bashir analyzed data and prepared tables. Zulqarnain Khan, Hasan Riaz and Tanveer-Ul-Haq reviewed and finalize the article.

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