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Original Research Article

Growth, Yield and Economics of Sunflower (*Helianthus annuus* L.) as Influenced by Biofertilizer and Fertilizers Levels

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A B S T R A C T

The field experiment was conducted during *kharif* season of 2016-2017 on vertisol soil at Oilseed Research Station, Latur to study the "Response of biofertilizer on the performance of hybrid sunflower (*Heliathus annuus L.*)" in *kharif* season. The experimental field was leveled and well drained. The soil was clay in texture, low in available nitrogen (188.8 kg ha^{-1}), medium in phosphorus (14.82 kg ha^{-1}) and higher in available potassium (588.72 kg ha^{-1}). The soil was alkaline in reaction having soil pH (8.0). Result revealed that application of 100% N + Azosprillum + Azotobactor (T9) recorded highest seed yield (1848 kg hae-1) with net monetary returns (34313) and B: C ratio (1.96).

Keywords

Sunflower, Biofertilizers, Fertilizers

Introduction

Sunflower (*Helianthus annuus L.*) is one of the fastest growing and important vegetable oilseed crops in the world, native to southern parts of USA and Mexico and ranks fourth next to groundnut, soybean and rapeseed. Sunflower (*Helianthus annuus* L.) is a temperate zone crop but it can perform well under varying climatic and soil conditions. In world it is cultivated on area of 18.12 million hectares with an annual production and productivity of 22.03 million tonnes and 1216 kg per hectare, respectively (Anon.2014-2015). Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops in India, grown in an area of 0.55M ha. With a production of 0.42 M.T. and productivity of 753 kg ha^{-1} respectively (Anon.2014-2015). In India soil fertility is diminishing gradually due to soil erosions, loss of nutrition, accumulation of toxic elements, water logging and unbalanced nutrient compensation. Organic manure and bio fertilizers are the alternate sources to meet the nutrient requirement of crops. Among biofertilizers, benefiting the crops are Azotobacter, Azosprillium, Phosphobacter and Rhizobacter are very important. Biofertilizer referred to living microorganisms, symbiotic and asymbiotic way of supplying nutrients to plants.

The asymbiotic nitrogen fixing bacteria Azotobacter, Azosprillium and Rhizobacter lead to significant improvement in crops yield by 15- 20%while reducing the depletion of soil nutrients. Efficiency of different biofertilizers Azospirillum, Azotobacter and Rhizobium with and without suboptimal levels of nitrogen (0, 15 and 75 kg/ha) and recommended level of N revealed that the application of 75 kg N/ha supplemented by Azospirillum (or) Azotobacter (or) Rhizobium was found to be more efficient in influencing the seed yield. It showed a significant increased in SSH-1 and the increased yield was statistically in KBSH-1 as compared to the application of recommended level of 100 Kg N alone/ha. Sunflower oil contains large amount of vitamins (A, D, E and K) and considerable amount of proteins (20 -40%). Biofertilizer can increase the soil fertility, the seed yield and its oil content (Dhanasekar and Dhandapani, 2012).

Biofertilizers plant resistant to adverse environmental stresses. The beneficial effect of Azotobacter is to fix the atmospheric nitrogen. It increases the seed germination, plant growth and yield. In certain condition they also exhibit antifungal activities and there by fungal disease may be controlled indirectly. Azospirillum also fix the atmospheric nitrogen and stimulates the effect on root development. It has ability to reduce nitrite and denitrify, also increase protein percentage.

Materials and Methods

The field experiment was conducted during 2016-2017 on vertisol at Oilseeds Research Station, Latur to study the **"**Response of biofertilizers on the performance of hybrid sunflower (*Helianthus annuus* L.) in *kharif* season". The topography of experimental field was uniform and leveled. The soil was clayey in texture, low in available nitrogen (118.8 kg ha^{-1}), medium in phosphorus (14.82 kg ha^{-1}) and very high in available potassium (588.72 kg ha^{-1}) and alkaline in nature having soil pH 8.0. The adequate amount of rainfall during period of experiment was sufficient for significant for growth and development of sunflower crop which result in significantly higher yield. Overall the thermo-aero-hydro-dynamic properties during crop season were also favorable for physiological activities of crop and its phenophysic development. The experiment was laid out in a Randomized Block Design with nine treatments replicated thrice.

The treatments included T_1 (Control), T_2 (75% N), T_3 (100% N), T_4 (75% N + Azospirillum seed treatment), T_5 (75% N + Azotobacter seed treatment), T_6 (75% N + Azospirillum + Azotobacter seed treatment), T_7 (100% N + Azospirillum seed treatment), T_8 (100% N + Azotobacter seed treatment) and T_9 (100% N + Azospirillum + Azotobacter seed treatment). The gross and net plot size of each experimental unit was 5.4 x 4.5 m and 4.2 x 3.9 m respectively. Sowing was done on 23rd July, 2016 by dibbling the seeds at spacing 60 x 30 cm. The recommended cultural practices and plant protection measures were taken. As per treatments of bio-fertilizers and dose of nitrogen along with full dose of phosphorus and potassium was applied as a basal dose and remaining 50 per cent dose of nitrogen was applied at 30 days after sowing and crop was harvested at 23rd October, 2016.

Results and Discussion

Growth attributes

Plant height

The effect of different treatments on plant height was found to be significant and the higher plant height was recorded with the integrated application of treatment T9

(100% N + Azospirillum + Azotobacter) was found significantly superior than all other treatments. The significant treatment was found at par with treatment T_6 (75% N + Azospirillum + Azotobacter), T_8 (100% N + Azotobacter), T_7 (100% N + Azospirillum) and T_3 (100% N). The control treatment T_1 has lowest plants. The similar results were given by Mohsen Javahery *et al.*, (2011), Radwan, *et al.*, (2013), Tuba Mirparsa *et al.*, (2016).

Stem girth (cm)

The effect of different treatments on stem girth was found to be significant and the higher stem girth was recorded with the treatment T_9 (100 % N+ *Azospirillum* + *Azotobacter*) was found significantly superior over all other treatments, except treatment T_6 (75 % N + *Azospirillum* + *Azotobacter*) were found at par with the significant treatment. The results are in line with Keshta *et al.*, (2006), Mohsen Javahery *et al.*, (2011) and Amin Farnia *et al.*, (2015).

Head diameter

It is clear from the data on mean head diameter plant^{-1} (cm) recorded periodically from 60 days after sowing till the harvest of crop.

The results revealed that the effect of different treatments on head diameter per plant (cm) of sunflower crop was found significant at all growth stages. The application of (100 % N+ *Azospirillum* + *Azotobacter*) (T_9) recorded higher head diameter plant^{-1} (20.88 cm plant^{-1}) which was found at par with application of T_6 (75%N + Azospirillum + Azotobacter), T_8 (100% N + Azotobacter) and T_7 (100% N + Azospirillum) and was found significantly superior over rest of the treatments.

Dry matter

Total dry matter plant^{-1} (g) was the resultant of photosynthetic activity and its photo morphogenesis. The presented data revealed that the mean total dry matter plant^{-1} was influenced significantly due to different treatments at all crop growth stages, except 15 and 30 DAS.

Application (100 % N+ *Azospirillum* + *Azotobacter*) (T_9) recorded higher dry matter plant^{-1} at harvest (166.23 g) which was found significant due to the availability of readily available of all essential nutrients i.e. (organic and inorganic) for rapid initial growth and cumulative improvement in dry matter plant^{-1}. and found at par with application of T_6 (75% N + Azospirillum + Azotobacter), T_8 (100% N + Azotobacter) and T_7 (100% N + Azospirillum) and significantly superior over rest of treatments. The results are coincides with Nandhagopal *et al.*, (2003), Rubapuntthavathy *et al.*, (2006), Mostafa *et al.*, (2010), Wajid Nasim *et al.*, (2012), El-Sayed *et al.*, (2013), Elham *et al.*, (2013) and Pattanayak *et al.*, (2016).

Leaf area index

The data on leaf area index (LAI) as influenced by various treatments are presented in Table 1. The maximum leaf area index (2.81) was recorded at 60 DAS. For T_9 (100% N+ Azospirillum + Azotobacter). The effect of treatment T_9 recorded higher LAI (2.81) for 60 DAS as compared to other treatments.

Yield attributes

The effect of different treatments was noticed on important yield attributes viz., seed yield (kg ha^{-1}), number of filled seed plant^{-1} (%), stalk yield (kg ha^{-1}), biological yield (kg ha^{-1}) and test weight (g) was influenced dut to application of biofertilizers and different fertilizer levels.

Seed yield (kg ha^{-1})

The data pertaining to seed yield are presented in Table 2. The mean seed yield was 1452.41 kg ha^{-1}. Response of nitrogen levels Azotobacter and Azospirillum treatments on seed yield was significant.

The highest seed yield was for treatment T_9 (100% N + Azospirillum + Azotobacter) 1848 kg ha^{-1} which was significantly superior over treatment T_1 (Control), T_2 (75% N), T_3 (100% N), T_4 (75% N +Azospirillum treatment), T_5 (75% N + Azotobacter) and T_7 (100% N + Azospirillum) and at par with T_6 (75% N + Azospirillum + Azotobacter) and T_8 (100% N + Azotobacter). The lowest seed yield was observed for T_1 (705 kg ha^{-1}) control treatment.

These findings are in confirmative with those reported by Keshta *et al.*, (2006), Madhurendra *et al.*, (2009), Rahim Naseri *et al.*, (2010), Dhanasekar *et al.*, (2012), Amin Farnia *et al.*, (2015), Khan *et al.*, (2016) and Tuba Mirparsa *et al.*, (2016).

Number of filled seeds $plant^{-1}$

The effect of nitrogen levels and Azotobacter and Azospirillum through different treatments on number of filled seeds per plant was significant. The mean numbers of filled seeds per plant were 671. Treatment T_9 (100% N + Azospirillum + Azotobacter) recorded maximum number of filled seed per plant (802) and it found significantly superior over treatments T_1 (Control), T_2 (75% N), T_3 (100%), T_4 (75% N + Azospirillum) and T_5 (75% N + Azotobacter) but it was at par with treatment T_6 (75% N + Azospirillum + Azotobacter), T_8 (100%N + Azotobacter) and T_7 (100% N + Azospirillum) treatment. The lowest number of filled seeds per plant was recorded for treatment T_1 i.e. (Control) followed by T_2 (75% N) seed treatments. The similar results were reported by Shehata *et al.*, (2003), Nandhagopal *et al.*, (2003), Pramanik *et al.*, (2013), Amin Farnia *et al.*, (2014) and Sana Abdaslam *et al.*, (2016).

Stalk yield kg ha^{-1}

The data pertaining to stalk yield kg ha^{-1} are presented in Table 2. The mean stalk yield was 4350.97 kg ha^{-1}. The response of nitrogen levels and Azotobacter and Azospirillum treatment on stalk yield was significant.

The treatment T_9 (100% N + Azospirillum + Azotobacter) found significantly superior over all other treatments. There is large different between the stalk yield of significant treatment (T_7) and all other treatments.

Except the treatments T_6 (75% N + Azospirillum + Azotobacter) and T_8 (100% N + Azotobacter). The lowest stalk yield was observed for the treatment T_1 (Control). This shows that, on stalk yield was the real effect of various treatment applied.

Biological yield kg ha^{-1}

Biological yield was significantly influenced by different treatments. Application of 100% N + Azospirillum + Azotobacter) (T_9) produced highest biological yield (7273.76 kg ha^{-1}) which was at par with treatment T_6 –75% N + Azospirillum + Azotobacter T_7– 100% N + Azospirillum, T_8–100% N + Azotobacter a nd was found significantly superior over the rest of the treatments.

Table.1 Effect of biofertilizer and different fertilizer levels on growth attributes of sunflower

Treatments	Plant height (cm)	Stem girth (cm)	Head diameter (cm)	Dry matter	Leaf area index
T_1 – control	136.86	6.20	12.49	111.14	2.25
T_2 –75% Nitrogen	141.36	6.38	13.23	113.93	2.35
T_3 –100% Nitrogen	153.90	6.84	16.32	139.25	2.60
T_4 –75% N + Azospirillum	146.67	6.52	14.50	125.34	2.45
T_5 –75% N + Azotobacter	150.08	6.73	15.76	131.32	2.54
T_6 –75% N + Azospirillum+Azotobacter	166.92	7.75	19.65	161.15	2.72
T_7 –100% N + Azospirillum	157.94	7.01	17.97	148.50	2.64
T_8 – 100% N + Azotobacter	161.75	7.25	18.35	152.59	2.67
T_9–100%N+Azospirillum +Azotobacter	171.20	7.96	20.88	166.23	2.81
SE±	6.72	0.37	0.98	6.17	2.55
C.D.at 5%	20.16	1.11	2.96	18.50	2.25
General Mean	**154.08**	**6.96**	**16.57**	**138.83**	**2.35**

Table.2 Effect of Biofertilizer and Different fertilizer levels on yield attributes of sunflower

Treatments	Seed yield kg plant^{-1}	No. of filled seeds plant^{-1}	Stalk yield (kg ha-1)	Biological yield (kg ha-1)	Test weight (g)
T_1 – control	705.33	441	2445.00	3150.00	45.47
T_2 –75% Nitrogen	1300.00	605	3950.00	5250.01	46.74
T_3 –100% Nitrogen	1383.87	665	4111.37	5495.04	47.26
T_4 –75% N + Azospirillum	1341.33	644	3994.70	5336.03	46.77
T_5 –75% N + Azotobacter	1343.00	654	3997.06	5340.06	47.05
T_6 –75% N + Azospirillum+Azotobacter	1784.67	774	5265.43	7050.10	49.05
T_7 –100% N + Azospirillum	1667.00	714	4943.40	6610.07	48.16
T_8 – 100% N + Azotobacter	1699.00	742	5026.05	6725.05	48.32
T_9–100%N+Azospirillum + Azotobacter	1848.00	802	5425.76	7273.76	49.72
SE±	60.14	33	20.22	328.48	2.19
C.D.at 5%	180.29	99	603.20	984.70	NS
General Mean	**1452.41**	**671**	**4350.97**	**5803.35**	**47.67**

Table.3 Effect of integrated nutrient management on quality and economics of sunflower

Treatments	**Gross monetary return (`)**	**Net monetary return (`)**	**B: C ratio**	**Oil content (%)**	**Oil yield (kg ha^{-1})**
T_1 – control	26790	7138	1.36	34.80	245.34
T_2 – 75% Nitrogen	49400	14154	1.40	34.97	454.61
T_3 – 100% Nitrogen	52592	16711	1.46	36.38	509.28
T_4 – 75% N + Azospirillum	50958	15697	1.44	35.17	471.74
T_5 – 75% N + Azotobacter	51034	15773	1.45	35.95	482.80
T_6 – 75% N + Azospirillum +Azotobacter	67830	32554	1.92	37.79	674.55
T_7 – 100% N + Azospirillum	63346	27450	1.76	37.10	618.45
T_8 – 100% N + Azotobacter	64562	28666	1.80	37.23	632.53
T_9 –100%N + Azospirillum + Azotobacter	70224	34313	1.96	37.82	698.91
SEm±	2285	2285	_	1.37	29.07
C.D. at 5%	6851	6851	_	NS	87.16
General Mean	**55193**	**21384**	**1.61**	**36.40**	**532.00**

Test weight (1000 seed weight g)

The data on mean Test weight (g) are presented in Table 2. The mean Test weight (g) was 47.67 (g). Effect of different treatments on Test weight (g) was found to be non-significant.

However the highest Test weight (49.72 g) was recorded with the application 100% N + Azospirillum + Azotobacter) (T_9) whereas, the lowest test weight (45.47 g) was recorded in treatment T_1 i.e. control

Economics

The Gross monetary return, net monetary return and benefit cost ratio of different treatments are depicted in Table 3.

Gross monetary returns (`)

Data pertaining to the gross monetary return (GMR) as influenced by various treatments are presented in Table 3. The mean gross monetary return of sunflower was recorded as (Rs.55193 ha^{-1}).

The gross monetary return was differed significantly due to different treatments.

The significantly highest gross monetary return (Rs.70224 ha^{-1}) was obtained with T_9 (100% N + Azospirillum + Azotobacter) over rest of the treatments and found on par with T_6 (75%N + Azospirillum + Azotobacter) and T_8 (100%N + Azotobacter).

The application of T_9 (100% N + Azospirillum + Azotobacter) was next best treatment which was closely followed by T_6 (75% N + Azospirillum + Azotobacter) treatments and equally effective in producing higher gross monetary returns of sunflower.

Net monetary return (`)

Data on net monetary return (Rs. ha^{-1}) as influenced by various treatments are presented in Table 3. The mean net monetary return was recorded as (Rs.21384 ha^{-1}).

The net monetary return (Rs. ha^{-1}) of sunflower was influenced significantly due to different treatments. The treatment T_9 (100% N + Azospirillum + Azotobacter) recorded significantly higher net monetary return (Rs.34313 ha^{-1}). This treatment was found on par with T_6 (75% N + Azospirillum + Azotobacter) and T_8 (100%N + Azotobacter) and significantly superior over rest of all the treatments.

Benefit: Cost ratio

Data in respect of B: C ratios as influenced by various treatments are presented in Table 3. The mean B: C ratio was observed as 1.61. The treatment T_9 (100% N + Azospirillum + Azotobacter) was recorded higher B: C ratio (1.96) which was closely followed by T_6 (75% N + Azospirillum + Azotobacter). The treatment T_1 (Control) was recorded lowest B: C ratio (1.36).

Quality

Oil content (%)

The data on oil content and oil yield are presented in Table 3. The mean oil content of sunflower hybrid, (LSFH-171) produced by various treatments was 36.40 per cent.

The oil content of sunflower was not significantly influenced by various treatments however higher oil content (37.82 %) was recorded by treatment T_9 (100% N + Azospirillum + Azotobacter) and lowest i.e. 34.80 % by T_1 (Control).

Oil yield (kg ha^{-1})

The data pertaining to oil yield are presented in Table 3. The mean oil yield produced by different treatments was (532 kg ha^{-1}). The highest value of oil yield (699 kg ha^{-1}) was recorded by treatment T_9 (100% N + Azospirillum + Azotobacter) which was found at par with T_6 (75%N + Azospirillum + Azotobacter), T_8 (100%N + Azotobacter) and T_7 (100% N + Azospirillum). The lowest value of oil yield (245 kg ha^{-1}) was recorded by treatment T_1 (control).

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