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Effect of Fertility Levels and Cytokinin on Growth and Yield of Sunflower (*Helianthus Annuus* L.)

B. Supriya, G.C.Mishra, S.P.Nanda, Sagar Maitra. D Sarath kumar and M Sairam
M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha India

ABSTRACT

The field experiment was carried out at Campus Farm, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha during summer season, 2019. The soil in field was clay loam in texture, slightly acidic in reaction (pH 6.5), low in organic carbon (0.57 %) and available nitrogen (176 kg ha^{-1}), medium in available phosphorus (38.49 kg ha^{-1}) and sulphur (29.52 kg ha^{-1}) and high in available potassium (340.0 kg ha^{-1}). The field experiment was laid out in factorial randomised complete block design with three replications and twelve treatments combination consisted of two factors including factor A (Nutrient management levels) and factor B (Cytokinin levels). The nutrient management treatments for factor A were 100% recommended dose of fertilizer (RDF) i.e. 80:60:40 kg of N: P2O5: K_2O ha^{-1}, 100% RDF + Azotobacter @ 5 kg ha^{-1}, 100% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1}, 125% RDF i.e. 100:75:50 kg of N: P_2O_5: K_2O ha-1, 125% RDF + Azotobacter @ 5 kg ha^{-1}, 125,% RDF + Azotobacter @ 5 kg ha-1 + S @ 30 kg ha^{-1}. The cytokinin levels included in factor B were cytokinin 50 ppm and no cytokinin. The nutrient management treatments and cytokinin significantly influenced the crop growth parameters in terms of plant height, basal stem girth, number of leaves plant^{-1}, dry weight of plant, leaf area index and seed yield. The interaction effect of nutrient management treatments with cytokinin was found positive with respect to seed yield. The crop growth parameters like plant height (151.70 cm), basal stem girth (9.79 cm), number of leaves plant^{-1} (13.93), leaf area index (1.70) and dry matter production (595.08 g m-2) and seed yield (2.43 t ha^{-1}) were obtained from 125% RDF of NPK + Azotobacter @ 5 kg ha-1 + S @ 30 kg ha^{-1}. The corresponding values with application of cytokinin 50 ppm were 145.91cm, 9.44 cm, 13.52, 1.58 and 587.82 g m-2), respectively and seed yield (2.36 t ha^{-1}). The combination of 125% RDF of NPK + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1} with cytokinin 50 ppm found in increasing the seed yield (2.77 t ha^{-1}) which recommended as suitable production technology for sunflower cultivation under South Odisha condition.

KEY WORDS: NPK LEVELS, AZOTOBACTER, SULPHUR, CROP GROWTH, SEED YIELD AND SUNFLOWER.

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INTRODUCTION

Sunflower plays an important role in meeting the shortage of edible oils in our country (Kalaiyarasan et al., 2019). In India, it is cultivated to an area of 0.48 million ha in which 0.29 million ha in rabi season with the total annual production of 0.34 million tonnes (Agricultural research data book, ICAR 2019). Considering the Indian oil economy in point of view, sunflower ranks fourth next to groundnut, soybean and rapeseed. It is one of the fastest growing and important oilseed crop in the world as a chief source of vegetable oil. Due to the national priority of vegetable oil production in India, sunflower has gained popularity in recent times. It is grown throughout the year as a photo-insensitive crop. Though it is a temperate zone crop but it performs well under varying climatic and soil condition (Ijaz et al., 2017).

The farmers are highly interested to grow sunflower. Nitrogen, phosphorus and potassium are the three important major fertilizers used in balanced or unbalanced manner for increasing production (Kalaiyarasan et al., 2019). Nitrogen, phosphorous and potash in balanced manner are most required in crop production in order to boost the yield. Nitrogen is an important nutrient to improve the vegetative growth, yield and quality of sunflower. Phosphorus nutrition is vital for plant growth and involved in energy transfer, photosynthesis, transformation of sugars, starches and nutrient movement within the plant. Potassium improves the crop growth and productivity as well as promotes the tolerance of crops to pest attack (Jehad et al., 2008). The various combination of NPK had greater role in improving the growth and seed yield of sunflower (Ijaz et al., 2017).

Besides nitrogen, phosphorus and potassium, sulphur plays an important role in enhancing the photosynthesis and seed yield of sunflower. Sulphur is responsible for synthesizing of sulphur containing amino acids, proteins and activity of enzymes thus, increases oil content in oil bearing plants. Sulphur deficient plant produces less protein and oil (Gajbhiye et al., 2013). The sulphur is increasingly deficient in Indian soil due to adoption of multiple cropping systems, growing of hybrid and high yielding varieties, substancial use or no use of organic manures and application of high analysis sulphur free fertilizers. The requirement and use of cheap source of sulphur for higher seed and oil yield of sunflower has been reported by Vala et al. (2014). Application of sulphur in conjunction with NPK fertilizer in enhancing the growth and yield (Vala et al. 2014 and Ravikumar et al., 2016) of sunflower is well documented by several agricultural research scientists.

Biofertilizers are the living microorganism that supply the nutrients to plants in symbiotic and asymbiotic way. The beneficial effect of Azotobacter is to fix the atmospheric nitrogen. It increases the seed germination, plant growth and yield (Khandekar et al. 2018). The positive effect of Azotobacter in conjunction with NPK fertilizer in increasing the growth, yield and quality of sunflower has been observed by Pramanik and Bera (2013) and Khandekar et al.(2018). The use of biofertilizer leads to significant improvement in crops yield by 15- 20% and reduces the depletion of soil nutrients (Khandekar et al., 2018). Biofertilizers in an integrated way serves a viable option to improve crop productivity. The plant growth hormone cytokinin plays a vital role in promotion of cell division and differentiation and influences several developmental and physiological aspects in plants including seed germination, apical dominance, growth, flowering time, flower and fruit development and leaf senescence. The benefit of cytokinin results in delayed leaf senescence, better maintenance of photosynthetic rate, increase in plant biomass, higher nitrate influx, increase in post-harvest life in flowers, drought tolerance and higher seed yield (Surya kant et al., 2015). The application of benzyl adenine in augmenting the number of seeds fruit^{-1}, test weight and yield in oil seed crops has been reported by Gora et al. (2018).

MATERIAL AND METHODS

The field experiment was conducted during summer season of 2019 at M.S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi campus. The experimental plot was clay loam in texture, slightly acidic in reaction and low in organic carbon and available nitrogen, medium in available phosphorus and sulphur and high in potassium with pH of 6.5. The experiment was conducted adopting factorial randomized complete block design comprised of six fertility levels in factor A and two cytokinin levels in factor B which were replicated thrice in the plot size of 4.8 m × 4.2 m. The factor A was comprised of six fertility levels like 100% recommended dose of fertilizer (RDF) i.e. 80:60:40 kg of N: P_2O_5: K_2O ha^{-1} , RDF + Azotobacter @ 5 kg ha^{-1}, RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1}, 125% RDF, 125% RDF + Azotobacter @ 5 kg ha^{-1}, 125% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1}.

In factor B, two cytokinin levels like without cytokinin and with cytokinin @ 50 parts per million (ppm) were tested with factor A. The experimental field was ploughed properly and YSH 475 sunflower hybrid was sown on 5th January, 2019 at the spacing of 60 cm × 30 cm. The sources of fertilizers were urea, diammonium phosphate and muriate of potash in the nutrient management treatments having no sulphur. For the nutrient management treatments containing sulphur, the chosen fertilizers were complex fertilizer grade 20:20:0:13, diammonium phosphate, urea and muriate of potash. The recommended fertilizer dose of 80:60:40 kg N: P205:K20 ha^{-1} was applied to the sunflower crop to the specific treatments. In the treatments of 125% recommended dose of fertilizer, 100 kg N, 75 kg P_2O_5 and 50 kg K_2O were used for the purpose.

In all the nutrient management treatments, full dose of P_2O_5 and half dose of K_2O were applied as basal. As to the treatments specification of 100% RDF + 30 kg S ha^{-1} + Azotobacter and 125 % RDF + 30 kg S ha^{-1}

+ Azotobacter, 30 kg S was applied to the nutrient management treatments containing sulphur. In the treatment of 100% recommended fertilizer dose + 30 kg S ha^{-1} + Azotobacter, 51.57 kg N ha^{-1} was applied through complex fertilizers at the time of sowing as basal. For the treatment of 125% recommended dose of fertilizer + 30 kg sulphur + Azotobacter, 57. 44 kg N was incorporated to soil through complex fertilizers just before sowing as basal in that specific nutrient management treatment. The basal dose of fertilizers was applied in furrows just before sowing. Afterwards, the fertilizers were incorporated by placing the soil detached from both the sides of the furrows. The bio-fertilizer, Azotobacter was collected from bio-fertilizer unit of M.S. Swaminathan School of Agriculture and applied to the specific treatments in furrows at the time of sowing.

The remaining amount of N along with 50% K_2O as per the specifications of the nutrient management treatments were top dressed followed by earthing up at 5th week of crop age. The growth regulator benzyladenine was applied at 45 days after sowing for the treatments with 50 ppm cytokinin. The crop was free from pest load and grown with all recommended package of practices. The crop harvested when it attained full maturity. At 90 days after sowing, five plants were randomly selected in each treatment for recording growth parameters like plant height, stem girth, number of leaves plant^{-1}, leaf area index (LAI), dry weight and yield parameters like grain yield. The grain yield was recorded from each plot after proper drying.

RESULTS AND DISCUSSION

Growth parameters: Data pertaining to growth parameters of sunflower affected by different fertility levels and cytokinin levels was presented in Table 1. The maximum plant height was observed in 125% RDF of NPK + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha^{-1} (151.70 cm) being at par with 125% RDF + Azotobacter @ 5 kg ha^{-1} (147.26 cm). It was followed by 100% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha-1 (144.01 cm) which did not differ significantly from other nutrient managemen treatments. The conjugated use of 125 % recommended dose of NPK with Azotobacter @ 5 kg ha^{-1} and S @ 30 kg ha^{-1} increased the absorption and uptake of N, P, K and S nutrients in more available form thereby facilitated the effective movement of nutrients from source to assimilating organ to promote cell division and enlargement there by increased the internodal length that reflected the plant height.

Table 1. Influence of fertility levels and cytokinin levels on plant height, stem girth and number of leaves plant^{-1} at harvest.

MTreatments	Plant h eight (cm)	Stem girthth (cm)	Number of leaves plant-1	LAI	Dry matter accumulation
100% RDF (80:60:40 kg NPK ha^{-1})	140.72	8.66	12.93	1.42	531.80
100% RDF + Azotobacter @ 5 kg ha^{-1}	142.15	8.77	13.04	1.45	540.12
100% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1}	144.01	9.18	13.22	1.52	566.17
125% RDF	142.45	9.38	13.11	1.48	576.12
125% RDF + Azotobacter @ 5kg ha^{-1}	147.26	9.44	13.19	1.50	577.48
125% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30kg ha^{-1}	151.70	9.79	13.93	1.70	595.08
S.Em. (±)	1.27	0.18	0.20	0.03	13.38
CD (P=0.05)	3.74	0.52	0.59	0.09	39.24
Cytokinin					
50 ppm Cytokinin	145.91	9.44	13.52	1.58	587.82
No Cytokinin	143.52	8.96	12.95	1.44	541.10
S.Em. (±)	0.74	0.10	0.12	0.02	7.72
CD (P=0.05)	2.16	0.30	0.34	0.05	22.65
Interaction					
S. Em. (±)	1.79	0.25	0.28	0.04	18.92
CD (P=0.05)	NS	NS	NS	NS	NS

The favourable effect N + Azotobacter + Azospirillum with common dose of phosphorus and potassium (Khandekar et al., 2018), NPK fertilizer with sulphur (Vala et al., 2014) and (Ravikumar et al., 2016) and sulphur with Azotobacter + phosphorus solubilizing bacteria + vesicular arbuscular mycorrhizha along with common dose of NPK @ 80:100:100 kg ha^{-1} (Patra et al., 2013) in increasing the plant height has been reported by several workers.

Stem girth: The maximum stem girth was observed with 125 % recommended dose of NPK with Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1} (9.79 cm) followed by 125% recommended dose of NPK + Azotobacter @ 5 kg ha^{-1} (9.44 cm) and 125% recommended dose of NPK (9.38 cm) which were on par (Table1). The minimum stem girth was observed in 100 % recommended dose of NPK at all the growth stages of crop. Increase in stem diameter is ascribed to positive influence of nutrient management treatments due to better availability and absorption of nutrients that resulted in more translocation of assimilates from source to sink. It favoured the cell division, differentiation and proliferation to enlarge the stem growth. The use of inorganic fertilizer N with Azospirillum + Azotobacter and common dose of P and K (Khandekar et al. 2018) and recommended dose of fertilizer with suphur (Muhammad et al., 2019) in improving the stem diameter of sunflower was recorded by various research workers.

The stem girth of sunflower was increased with application of cytokinin 50 ppm (9.74 cm) over no cytokinin application (8.96 cm). Cytokinin governs the plant growth by regulating the developmental and physiological processes through cell division, proliferation and differentiation facilitating the promotion of shoot growth and elongation. This has been supported by (Kurkawa et al., 2007) and (Schaller et al., 2014). Thus, the favourable effect of cytokinin application resulted in augmentation of stem girth of sunflower.

Table 2. Interaction effect of fertility levels and cytokinin on seed yield

Treatments	Cytokinin 50 ppm	No cytokinin	Mean
100% NPK	2.00	1.76	1.88
100% NPK + Azotobacter @ 5 kg ha^{-1}	1.88	1.91	1.89
100% NPK + Azotobacter + 30 kg S ha^{-1}	2.68	2.00	2.34
125% NPK	2.40	2.04	2.22
125% NPK + Azotobacter	2.41	2.03	2.22
125% NPK + Azotobacter + 30 kg S ha^{-1}	2.77	2.09	2.43
Mean	2.36	1.97	2.16
Fertility levels	Cytokinin	Interaction	
S. Em (±)	0.05	0.03	0.07
CD (P=0.05)	0.14	0.08	0.20

Number of leaves plant^{-1}: The perusal of data (Table 1) on number of leaves per plant indicated that there was a significant difference due to fertility levels. The maximum number of leaves was noticed with use of 125 % recommended dose of NPK with Azotobacter @ 5 kg ha^{-1} + S @ 30 of ha^{-1} (13.93) and other treatments were not significantly different from each other. The lowest number of leaves $plant^{-1}$ was observed with application of 100% recommended dose of NPK. Leaves are the photosynthetic apparatus of the crop. The enhancement of leaves $plant^{-1}$ contributes to increase in source of photosynthates that is mobilized to sink. The nourishment of N, P and K along with S in conjunction with Azotobacter provided the better crop nutrition leading to rapid cell division and elongation resulting in increase in plant height which ultimately facilitated more formation of functional leaves in the plant. Increase in functional leaves $plant^{-1}$ by use of 100 % recommended N with Azotobacter + Azospirillum with common dose of phosphorus and potassium and NPK fertilizer with S was reported by (Khandekar et al., 2018).

It was clearly indicated from data in Table 2 that the plant height of sunflower was significantly enhanced with 50 ppm cytokinin (145.91 cm) over no application of cytokinin (143.52 cm). The application of cytokinin regulates the physiological and metabolic process in plant at all the crop growing period thereby, promotes plant growth through cell division and differentiation leading to activity of shoot apical meristems to enhance shoot growth and elongation of internodes that reflects the plant height. The beneficial effect of benzyl adenine in improving the plant height of oil seed crops was reported by (Gora et al., 2018).

Significant increase in number of leaves was obtained with application of cytokinin 50 ppm giving the values of 13.52 over no cytokinin spray (12.95). Cytokinin application influences many developmental and physiological processes in plants by regulating the cell division, differentiation and proliferation (Kurakawa et al., 2007).

Leaf area index: It is evident from the data (Table 1) that the maximum leaf area index was recorded with 125 % recommended dose of NPK with Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha^{-1} (1.70) was significantly at par with 100% RDF + Azotobacter @ 5 kg ha^{-1} + S @ 30 kg ha-1 (1.52). The minimum leaf area index was recorded from treatment with application of 100% RDF 80:60:40 kg NPK ha (1.42).

The foliar application of cytokinin 50 ppm positively enhanced the LAI at 90 DAS with the values of 1.58, respectively. The corresponding values with no application of cytokinin was 1.44, respectively. The key role of cytokinin is to regulate cell expansion by influencing the cell division and differentiation as stated by Schaller et al. (2014). The beneficial effect of cytokinin leads to increase in size of leaf associated with increase in chlorophyll content and photosynthetic efficiency including the activity of apical and axillary meristem that promotes shoot growth thus, accommodates a greater number of leaves plant^{-1}. This led to increase the canopy development that ultimately enhanced the LAI.

Dry matter accumulation: It is observed from the data that the nutrient management treatments exerted the significant influence on dry matter accumulation (Table 1). The dry matter production was recorded the highest in 125% RDF + Azotobacter @ 5 kg ha-1 + S @ 30 kg ha^{-1} (595.08 g m-2) followed by 125% RDF + Azotobacter @ 5 kg ha^{-1} (577.48 g m-2). The minimum dry matter production was noticed in 100% recommended dose of NPK (531.8 g m-2). The increase in crop growth parameters enhanced the vegetative growth which consequently reflected dry matter production. Increase in vegetative growth with application of 100% recommended dose of N + Azospirillum + Azotobacter with common dose of phosphorus and potassium (Khandekar et al., 2018) and dry matter accumulation with bio fertilizer consortia of Azotobacter + phosphorus solubilizing bacteria + vesicular arbuscular mycorrhiza along with uniform dose of 80:100:100 kg NPK ha^{-1} (Pramanik and Bera, 2013) were observed by various workers.

The foliar application of cytokinin 50 ppm positively increased the dry matter with the value of 587.82 g m-2. (Table 1). The corresponding value for no application of cytokinin was 541.10 g m-2, respectively. Ctokinin application influences many developmental and physiological processes in plants by regulating the cell division, differentiation and proliferation (Kurakawa et al., 2007). Thus it favoured its positive influence on enhancing dry matter peoduction.

Seed yield: The perusal of data pointed out that nutrient management treatments had exerted significant influence on seed yield of sunflower (Table 2). Among the nutrient management treatments, application of 125% recommended dose of NPK + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha^{-1} recorded the highest seed yield (2.43 t ha^{-1}) which remained at par with 100% RDF + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha-1 (2.34 t ha^{-1}). The lowest seed yield was noticed under 100% recommended dose of NPK (1.88 t ha^{-1}). Application of 125% recommended dose of NPK + Azotobacter + 30 kg S ha^{-1} was proved to be ideal nutrient management option resulted in increasing the seed yield. Many research workers reported the conducive effect of higher level of nitrogen when used with uniform dose of P and K (Khandekar et al. 2018), biofertilizer consortia (Azotobacter + phosphorus solubilizing bacteria + vesicular arbuscular mycorrhizha) with common dose of NPK (Pramanik and Bera 2013), NPK with S (Shubangi and Patil 2008) in enhancing the seed yield of sunflower.

The data on seed yield represented in table 2 showed that significantly the higher seed yield was noticed with 50 ppm cytokinin (2.36 t ha^{-1}) than that of no application of cytokinin (1.97 t ha^{-1}). It was attributed to benevolent role of cytokinin in increasing the seed yield. Gora et al. (2018) opined the marked effect of foliar application of benzyl adenine in improving the seed yield.

Interaction effect of nutrient management treatments and cytokinin exhibited positive effect on seed yield of sunflower (Table 2). The maximum seed yield was noticed when crop was fertilized with 125% RDF + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha^{-1} along with 50 ppm cytokinin (2.77 t ha^{-1}) followed by 100% RDF of NPK + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha^{-1} with 50 ppm cytokinin (2.68 t ha^{-1}) which were at par. The minimum seed yield was recorded with application of 100% RDF of NPK without application of cytokinin (1.76 t ha^{-1}).

CONCLUSION

Application of 125% recommended dose of NPK + Azotobacter @ 5 kg ha^{-1} + 30 kg S ha^{-1} along with 50 ppm cytokinin exhibited better growth and maximum seed yield compared to other treatments in sunflower which is preferred for South Odisha ecosystem.

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