FACTORIAL ANALYSIS ON THE EFFECT OF NPK FERTILIZER, MICRONUTRIENTS AND N-PLACEMENT ON THE GROWTH AND YIELD OF SUNFLOWER

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ABSTRACT

This research is to evaluate the effect of NPK, micronutrients and N-placement on the growth and yield of sunflower. The sunflower was studied under 7 different NPK levels and placement methods and 7 varying zinc and boron doses.Factorial designs was adopted in carrying out the data analysis having three replications ,data recorded individually for each parameter were subjected to the ANOVA technique by using MSTATC computer software and the significant means were separated by using Fisher's Protected LSD test. Various statistical test carried out on the data shows that both macronutrient and micronutrient combinations showed significant differences and enhanced plant parameters. The values of all crop parameters increased as the dose of fertilizers increased. The tallest plant height, maximum stem girth, largest head diameter, most seeds head^{-1}, heaviest seed weight head^{-1}, largest seed index and best seed yield (1738.0 kg ha^{-1}) were recorded under application of 90-45-45 NPK with 15-1.5 Zn-B kg ha^{-1} (N applied as fertigation). Beyond these level of macro- and micronutrients responses were not significant. The traditional fertility application, broadcast N at 120-60-60 NPK with 15-1.5 Zn-B kg ha^{-1} was no more effective in achieving higher values of crop parameters than comparable N-fertigated plots. Also,the study proved the incorporation of 90-45-45 kg ha^{-1} (N as

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fertigation) with 15-1.5 Zn-B kg ha^{-1} to be the optimum fertilizer dose for sunflower growth and yield. This could save growers on costs for NPK.

Keywords: Sunflower, Nitrogen, Phosphorus, Potassium, Micronutrients, Fertigation, Placement, Growth, Yield

INTRODUCTION

Sunflower is the fourth oil grain crop grown worldwide by area (Fagundes*et al.*, 2007). Fertilizer management is an important part of crop production. This is due in part to increasing costs for fertilizer materials, particularly nitrogen (N) fertilizer. Producers need to know how different production inputs affect crop yields so that they can choose technically efficient input combinations. They also need to know how input usage affects the profitability of their operations with varying input and crop prices. Fertilizer is an input that can easily be reduced, thus lowering input costs. However, fertilizer is a crop input that has a high return on investment if applied at appropriate level. Prediction of optimum fertilizer rates is important because of increasing economic and environmental concerns. The economic optimum N rate was approximately 110 kg ha^{-1} for sunflower grown under irrigated conditions of Anatolia, Turkey (Peker and Ozer, 2005).

Numerous studies have shown that NO_3–N leaching is a common and sometimes serious problem when inorganic N and organic wastes are used (Roth and Fox, 1990; Weil *et al.* 1990; Schepers*et al.*, 1991; Spalding and Exner, 1993; Bacon, 1995; Moreno *et al.*, 1996). A survey ofgroundwater quality in China indicates that the nitrate level of groundwater is higher in intensively cropped agricultural regions where the primary crops are vegetables and where high rates of water and nitrogen are applied, than in regions where grains are the primary crops (Ju and Zhang, 2003). Leaching of NO_3-N is economically and environmentally undesirable (Ryden*et al.*, 1984; Katyal*et al.*, 1985; Poss and Saragoni, 1992; Jones and Schwab, 1993; Theocharopoulos*et al.*, 1993). The US Environmental Protection Agency (EPA, 1990) has set 10 mg L^{-1} N as the NO_3-N drinking water standard as a safeguard against methemoglobinemia from developing in infants (Fletcher, 1991). Additionally, groundwater with high nitrate levels that discharge into sensitive surface waters can contribute to the long-term eutrophication of these water bodies. Combined application of irrigation and nitrogen through fertigation is now becoming a common practice in modern agriculture because of its advantages over broadcast N application. Some of these advantages [(Gascho*et al.* 1984; Threadgill, 1985; Criado, 1996; Hagin and Lowengart, 1996)] are more timely nitrogen application, more uniform nitrogen application, and reduced environmental contamination, faster movement of applied N into the rooting zone and lessened soil compaction and crop damage related to mechanical side dressing. Concerns about best management practice are increasing because mismanagement of nitrogenous fertilizers can lead to contamination of ground and surface water sources as well as soil degradation. In this regard fertigation had a consistent effect on total nitrogen use efficiency (Hou*et al.*, 2007) and a more uniform initial NO_3-N distribution produced a more uniform NO_3-N distribution through fertigation (Jiusheng*et al.*, 2005). Similar observations of increased uptake as a result of fertigation were reported earlier by Vasane*et al.* (1996). Alva and Mozzafari (1995) also reported that fertigation treatments maintained high concentration of NO_3-N at shallower depth than did broadcast treatments. Further, it was also reported that reduced loss of nutrients could be through fertigation compared to soil application of fertilizer (Hebbar*et al.*, 2004).

There are positive effects of micronutrient application on the growth of sunflower, in terms of plant height, number of leaves and dry matter production per plant. These effects can be contributed to enhanced metabolic function of micronutrients in the plant (Amberger, 1980). Under Egyptian conditions, positive effects of micronutrients on crops were reported in several studies by El-Fouly*et al.* (1990) and Abdalla and Mobarak (1992) found that increases in plant growth in terms of plant height, dry weight and uptake due to continuous addition of Fe, Mn and Zn through irrigation water. Sunflower is also one of the most sensitive crops to low boron supply and deficiency. Among the micronutrients, zinc deficiency is most widespread on a wide range of soils (Graham *et al.*, 1992; Cakmak*et al.*, 1996; Grewal *et al.*, 1997). Incorporation of Zn with other fertilizers into the normal cultivation zone of the soil (top 10 cm) is a common practice to overcome the Zn deficiency problem. Because Zn is readily fixed in soil, little of this Zn moves down the profile below the cultivation zone (Brennan and McGrath, 1988). The role of Zn in subsoil nutrition is of particular interest because of its importance in maintaining membrane integrity of root cells (Cakmak and Marschner, 1988; Welch, 1995) and the possible role of zinc in reducing the toxic effects of excessive B (Graham *et al.*, 1987; Singh *et al.*, 1990); excessive B in subsoil is a problem. Sunflower roots are also sensitive to B deficiencyas they stop their growth in <6 h after the removalof B from the growth medium (Dugger, 1983). The recent observations demonstrate that the concentration of B in soils and plants not only varies with soil type, plant species and environmental conditions, but also its excess or deficiency may affect the plant growth and production, because there is small concentration range between deficiency and toxicity in soilplant system (Tariq and Mott, 2007). Thus, application of adequate micronutrient fertility increased crop yields, improved the nutrient element concentrations in plant tissue, and enhanced soil macro and micronutrient status (Adediran*et al.*, 2004) and can give 67% more yield over control (Taiwo*et al.* 2001). Looking at the above considerations, the study was conducted to explore appropriate rates and placement methods of macro- and micronutrient for sunflower production.

MATERIALS AND METHODS

The experiment was set in a randomized complete block design (factorial) having three replications. The soil was clay loam in texture, non-saline (EC 0.96 dS m^{-1}), alkaline in reaction (pH 8.4), calcareous ($CaCO_3$ 9.8%), low in organic matter (0.57%), available phosphorus (3.06 mg kg^{-1}) and total nitrogen content was 0.05%.

Treatments

Factor A

The NPK treatments studied were:

(0-0-0 NPK kg ha^{-1}, 60-30-30 NPK kg ha^{-1} (N as broadcast), 60-30-30 NPK kg ha^{-1} (N as fertigation), 90-45-45 NPK kg ha^{-1} (N as broadcast), 90-45-45 NPK kg ha^{-1} (N as fertigation), 120-60-60 NPK kg ha^{-1} (N as broadcast) and 120-60-60 NPK kg ha^{-1} (N as fertigation).

Factor B

The micronutrient treatments studied were:

Different zinc and boron doses (0-0, 10.0-1.5, 10.0-2.0, 15.0-1.5, 15.0-2.0, 20.0-1.5 and 20.0-2.0 Zn-B kg ha^{-1}, respectively).

The sunflower variety HO-1 was sown in rows 75 cm apart. Plants were thinned to a spacing of 25 cm w/c rows. The crop was cleared from weeds by one hoeing with Spade before the 1st irrigation. All other cultural practices were adopted uniformly in all the plots to maintain the experimental area.

Fertilizer Placement Methodology

Broadcast

This is practice generally used by farmers. In this method, N fertilizer was incorporated as urea on the surface of soil under three split applications i.e., at the same time as the first, second and third irrigations. However, all the P from triple super phosphate (TSP) and K from muriate of potash (MOP) were applied as indicated above for all treatments during seed bed preparation.

Fertigation

In this method urea was applied in three splits during first, second and third irrigations as fertigation (application of fertilizer with irrigation water). The appropriate urea rate was mixed with water in a tank. The tank was then placed on the head of channel which released droplets in the running water pertaining to the appropriate plots.

Statistical Analysis

Data recorded individually for each parameter were subjected to the ANOVA technique by using MSTATC computer software and the significant means were separated by using Fisher's Protected LSD test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The experimental results revealed that all macro- and micronutrient treatments significantly enhanced plant height, stem girth, head diameter, seeds head^{-1}, seed weight head^{-1}, seed index, and seed yield of sunflower crop. Further, as NPK doses increased from low (60-30-30 NPK kg ha^{-1}) to high (120-60-60 NPK kg ha^{-1}), significant differences in growth parameters were noted. This was also true for micronutrients (Zn and B), where values of all crop parameters increased as the dose of micronutrients increased. Taller plants (202.20 cm), greater stem girth

(12.26 cm), larger head diameter (23.04 cm), more seeds head^{-1} (696.46), heavier seed weight head^{-1} (49.06 g), greater seed index (71.28 g), satisfactory seed yield (2743.07 kg ha^{-1}) and higher dry matter (11666.70 kg ha^{-1}) were recorded under application of 90-45-45 NPK kg ha^{-1} with 15 kg ha^{-1} Zn and 1.5 kg ha^{-1} B (N applied as fertigation). Statistically, beyond this level, non-significant increases in plant parameters studied were exhibited (Table I-VII). The traditional broadcast N application at higher doses (120-60-60 NPK with 15 kg ha^{-1} Zn and 1.5 kg ha^{-1} B) did not result in recording higher values of crop parameters as compared to N-fertigated plots. The seed yield of sunflower showed increasing response to traditional application of higher fertilizer rates up to 120-60-60 NPK kg ha^{-1} but the values were low as compared to 90-45-45 NPK kg ha^{-1} where N applied as fertigation. This may be the reason that N-fertigated plots received equal amounts of N in whole the plot where N might have distributed uniformly in the field as compared to broadcast method. Recently, the farmers are using 120-60-60 NPK kg ha^{-1} as broadcast, but with N-fertigation, the reduced application of 90-45-45 kg ha^{-1} was found to result in equivalent yield with lower fertilizer costs. The present results deviate from the previous study conducted by Ali *et al.* (2004) which showed broadcast application of 150 kg N ha^{-1} increased plant height, head diameter, number of filled seeds per head, 1000-seed weight, biological and seed yields and seed oil content. Malik *et al.* (2004) also observed that increasing levels of N, P and K increased yield and yield components of sunflower (plant height, head diameter, number of achenes head^{-1}, 1000-achene weight) but decreased the seed oil content. Their seed yield (1231.47 kg ha^{-}

IT was recorded with broadcast application of 130-90-90 NPK kg ha . Nawaz *et al.* (2003) found the optimum fertilizer requirement as broadcast of 120-90-60 NPK kg ha^{-1} for sunflower crop. The higher nitrogen broadcast dose of 160 kg N ha^{-1} was exhibited by Ali *et al.* (2000) for maximum seed yield per head by sunflower plants. Other researchers from Pakistan also suggested higher fertilizer doses as broadcast for sunflower crop. Farid*et al.* (2000) recommended 180-120 kg NP ha^{-1}; Hussain *et al.* (1998) observed 125 kg N ha^{-1}; Bakht*et al.* (1989) suggested 120 kg N ha^{-1}. Further, Ali *et al.* (1997) also stated that plant height, stover yield and number of seeds per floral disc increased with N application, with 100 kg N ha^{-1} the optimum rate. Their yield and yield components were not significantly different between P application methods (50 kg P_2O_5 ha^{-1} applied by broadcasting or fertigation).

Hussain *et al.* (1998) reported that yield increased with up to 125 kg N ha^{-1}. Meo*et al.* (1999) found that dry weights of leaves, stems, roots and seeds decreased with decreasing N rate and increasing water stress. Farid*et al.* (2000) also recommended higher doses for sunflower production and reported that application of 180 kg N and 120 kg P_2O_5 ha^{-1} gave the highest yield of 1249.2 kg ha^{-1} of sunflower seed while control plots only yielded 384.3 kg ha^{-1}.

In this study, among the N-placement methods, the N-fertigation was found efficient for growth and yield of sunflower. Cadahia (1993) reported that the advantages of fertigation showed a slow-release fertilizer and lower loss of N and therefore a lower degree of ground water contamination which not only increased the N uptake by the plant as well as the leaf and root weight, but also produced higher yields . This technique can reduce fertilizer application costs by eliminating an operation and improving nutrient efficiency. Also, it could conceivably reduce leaching or denitrification (gaseous) losses of nitrogen and lower the luxury uptake of nutrients by plants. Fertigation enables users to put the fertilizers in the plant root zone or on the canopy at the desired frequency, amount and concentration at appropriate time(Kumar *et al.*, 2000).

In this study, the incorporation of Zn and B as micronutrients also enhanced growth and seed yield of sunflower and 15 kg ha^{-1} Zn and 1.5 kg ha^{-1} B was recorded as optimum dose with N-fertigated plots (Table I-VII). The response of Zn and B in sunflower might be due to the reason that the site was deficient in both these micronutrients, and previous reports also supports that soils of Asia have shortfall in the availability of micronutrients (Asia Feb., 1998). Gitte *et al.* (2005) was in the view that combined application of Zn (5.25 kg ha^{-1}) and B (6.3 kg ha^{-1}) was more effective than Zn (5.25 kg ha^{-1}) alone or B (2.1 kg ha^{-1}) alone. The combined application of Zn and B exhibited increases over the control in straw yield, harvest index, translocation efficiency, 100-seed weight and seed yield. Meanwhile, Marchetti*et al.* (2001) found borax at 1.0 mg/dm^3 to exhibit the highest yield. Castro *et al.* (2002) suggested that boron could also be used with herbicides and application of B with herbicides is a good strategy for avoiding B deficiency while controlling weeds in sunflower. Likewise, Vyakaranahal*et al.* (2001) reported that B at 0.1% spray at ray floret stage increased the processed seed yield by 49.0 and 43.1% in kharif and summer sunflowers, respectively. The foliar sprays also increased the capitulum diameter, number of filled seeds per capitulum, seed set percentage, seed yield per plant, 100 seed weight, volume weight of seed, oil content in seed, germination percentage, seedling dry weight and seedling vigor index. Reddy and Shaik (2000) conducted experiments on various fertilizers and reported that 100% recommended fertilizer dose +500 kg gypsum ha^{-1} + 0.2% borax gave the highest net returns and cost:benefit ratio as a result of increased yield due to boron application. Further, Renukadevi*et al*. (2003) reported that boron nutrition increased the head diameter, number of filled seeds and 100-seed weight (5.8 g).

Table I. ***Plant height (cm) of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 Nfertigation	120-60-60 N-fertigation
0-0	69.79 m	89.73 l	114.65 ij	140.59 f	111.83 j	142.57 ef	145.21 def
10-1.5	70.76 m	100.63 k	127.61 gh	155.55 cd	122.62 hi	158.53 c	161.16 c
10-2.0	72.90 m	110.67 j	139.58 f	185.45 b	137.25 fg	181.43 b	189.06 b
15-1.5	74.82 m	124.63 h	152.05 cde	206.73 a	150.88 cde	207.20 a	209.48 a
15-2.0	74.14 m	125.12 h	152.53 cde	207.39 a	151.39 cde	207.45 a	209.81 a
20-1.5	74.54 m	126.61 h	154.53 cd	208.30 a	153.54 cd	207.70 a	210.07 a
20-2.0	75.60 m	128.11 gh	155.53 cd	209.71 a	155.40 cd	208.29 a	210.57 a

SE= 2.485, LSD(5%) = 6.931, LSD(1%)= 9.143

Table II. ***Stem girth (cm) of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation

0-0	5.08 m	7.17 l	8.75 ghij	9.60 defg	8.51 hijk	9.37 defgh	9.85 def
10-1.5	5.17 m	7.63 kl	9.03 fghi	10.34 d	9.06 fghi	10.21 de	10.36 d
10-2.0	5.23 m	7.92 jkl	9.29 efgh	11.40 bc	9.07 fghi	11.29 c	11.44 bc
15-1.5	5.35 m	8.11 ijk	10.06 de	12.30 ab	9.63 defg	12.26 ab	12.410 a
15-2.0	5.39 m	8.17 ijk	10.07 de	12.42 a	9.74 def	12.32 ab	12.537 a
20-1.5	5.39 m	8.18 ijk	10.24 de	12.52 a	9.84 def	12.42 a	12.588 a
20-2.0	5.39 m	8.19 ijk	10.08 de	12.63 a	9.94 def	12.52 a	12.708 a

SE = 0.2309, LSD(5%)= 0.6441, LSD(1%) = 0.8496

Table III. ***Head diameter (cm) of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation
0-0	7.00 l	8.78 l	12.49 k	14.99 ghi	11.43 k	15.34 fgh	15.44 fgh
10-1.5	7.57 l	11.17 k	15.69 fgh	19.91 bc	13.10 ijk	19.11 bcd	19.29 bc
10-2.0	7.46 l	11.59 k	17.15 def	20.61 b	14.66 hij	20.82 b	20.90 b
15-1.5	7.56 l	12.94 jk	18.38 cde	22.72 a	16.73 efg	23.04 a	23.15 a
15-2.0	7.57 l	12.96 jk	18.40 cde	23.26 a	16.76 efg	23.10 a	23.22 a
20-1.5	7.43 l	12.98 jk	18.42 cde	23.31 a	16.78 efg	23.14 a	23.27 a
20-2.0	7.94 l	13.00 jk	18.43 cde	23.37 a	16.80 efg	23.19 a	23.31 a

SE= 0.4948, LSD(5%)= 1. 380, LSD(1%)= 1.820

Table IV. ***Seeds head^{-1} of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	6 0-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation
0-0	378.71 k	543.81 j	553.77 ij	591.22 efg	554.56 ij	590.94 efg	608.19 bcdef
10-1.5	389.39 k	554.22 ij	576.71 ghi	599.27 defg	566.43 hij	598.51 defg	599.78 defg
10-2.0	388.52 k	562.40 ij	590.37 fg	613.20 bcdef	589.36 fgh	602.80 cdef	614.05 bcdef
15-1.5	395.71 k	617.21 bcd	630.18 b	696.57 a	629.73 b	696.46 a	696.74 a
15-2.0	397.99 k	616.32 bcde	629.05 b	695.36 a	628.17 bc	695.24 a	696.39 a
20-1.5	400.10 k	616.44 bcde	629.18 b	695.47 a	628.30 bc	695.67 a	696.56 a
20-2.0	401.18 k	616.63 bcde	629.27 b	695.58 a	628.38 bc	695.43 a	715.57 a

SE=5.985, LSD(5%)= 16.69, LSD(1%)= 22.02

Table V. ***Seeds weight head^{-1} (g) of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation
0-0	14.71 i	27.92 h	31.50 g	35.83 ef	31.52 g	35.75 ef	36.90 cde
10-1.5	15.14 i	32.52 g	34.06 fg	37.94 bcde	33.99 fg	37.88 bcde	38.03 bcde
10-2.0	15.11 i	34.05 fg	36.24 def	39.79 bc	35.58 ef	39.04 bcd	39.89 b
15-1.5	15.43 i	39.00 bcd	40.54 b	49.62 a	40.55 b	49.06 a	49.64 a
15-2.0	15.53 i	38.96 bcd	40.58 b	49.60 a	40.47 b	49.56 a	49.73 a
20-1.5	15.63 i	38.97 bcd	40.60 b	49.59 a	40.48 b	49.60 a	49.75 a
20-2.0	15.67 i	38.98 bcd	40.60 b	49.59 a	40.48 b	49.59 a	51.30 a

SE = 0.685, LSD(5%)= 1.913, LSD(1%)= 2.424

Table VI. ***Seed Index (g) of sunflower as affected by NPK, Zn, B and placement methods (Mean of two years)***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation
0-0	38.84 g	55.76 f	56.78 ef	60.62 cd	56.86 ef	60.59 cd	60.65 cd
10-1.5	38.88 g	58.69 de	59.00 de	63.31 bc	60.01 d	63.30 bc	63.41 bc
10-2.0	38.90 g	59.66 de	60.53 cd	64.88 b	60.43 cd	64.76 b	64.96 b
15-1.5	39.03 g	63.20 bc	64.48 b	71.29 a	64.40 b	71.28 a	71.34 a
15-2.0	39.04 g	63.19 bc	64.50 b	71.30 a	64.41 b	71.29 a	71.41 a
20-1.5	39.08 g	63.21 bc	64.51 b	71.31 a	64.42 b	71.30 a	71.43 a
20-2.0	39.08 g	63.23 bc	64.52 b	71.32 a	64.43 b	71.31 a	71.67 a

SE = 0.7404, LSD(5%)= 2.065, LSD(1%)= 2.724

Table VII. ***Seed yield (kg ha^{-1}) of sunflower as affected by NPK, Zn, B and placement methods***

Zinc + Boron (kg ha^{-1})	NPK (kg ha^{-1}) 0-0-0	60-30-30 broadcast	90-45-45 broadcast	120-60-60 broadcast	60-30-30 N-fertigation	90-45-45 N-fertigation	120-60-60 N-fertigation
0-0	815.70 i	1548.56 h	1746.85 g	1987.31 cdef	1914.62 efg	1985.39 cdef	1996.94 cdef
10-1.5	839.90 i	1803.71 g	1888.77 fg	2086.09 bcde	1885.17 fg	2101.37 bcd	2114.70 bcd
10-2.0	838.04 i	1888.66 fg	1981.98 def	2262.13 b	2001.01 cdef	2164.74 bc	2267.50 b
15-1.5	855.79 i	2163.0 bcd	2247.45 b	2746.26 a	2248.81 b	2743.07 a	2752.77 a
15-2.0	861.61 i	2159.9 bcd	2250.72 b	2750.36 a	2247.03 b	2749.45 a	2757.65 a
20-1.5	866.90 i	2161.1 bcd	2251.67 b	2752.86 a	2248.78 b	2751.97 a	2759.09 a
20-2.0	869.06 i	2162.03bcd	2251.34 b	2755.66 a	2249.09 b	2754.60 a	2789.34 a

SE= 42.10, LSD(5%)= 117.40, LSD(1%)= 154.90

CONCLUSION

The application of NPK macronutrient and Zn and B micronutrient fertility significantly enhanced yield and yield contributing parameters of sunflower. The values of all crop parameters increased as the dose of fertilizers increased and maximum response was exhibited under 90-45-45 NPK with 15 kg ha^{-1} Zn and 1.5 kg ha^{-1} B (with N applied as fertigation). Beyond this fertility level, non-significant responses were noted. Hence, it may be concluded that application of this treatment seems to be most beneficial for sunflower production.

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