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Growth indices of sunflower (*Helianthus annuus* L.) as influenced by different methods of micronutrients application in combination with bio-fertilizers and pesticide

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Abstract: The study was undertaken to study the influence of micronutrients (Zn and B), bio-fertilizers (*Azotobacter* and *PSB*) and pesticide (Imidacloprid) in sunflower. The experiment consists of fifteen treatments laid out in Randomised Complete Block Design with three replications. Treatments include application of micronutrients through different methods like seed treatment, soil application and foliar application in combination with bio-fertilizers and pesticide as individual applications and in combinations along with RDF (90:90:60 kg NPK ha^{-1}). The experimental results revealed that, seed treatment with micronutrients, bio-fertilizers and pesticide interacted positively in combined application compared to individual application. Different growth indices like LAD, AGR, CGR, RGR and NAR are significantly influenced by these methods at varied rate. Seed treatment with $ZnSO_4$, borax and bio-fertilizers triggered the early plant growth. Hence recorded higher seed yield (2186 kg ha^{-1}) compared to RDF alone (1895 kg ha^{-1}). Seed treatment acts as feasible alternate tool for farmers to improve the early growth of sunflower (KBSH-53) crop and seed yield.

Key words: Micronutrients, Bio-fertilizers, Pesticide, Seed treatment, Growth indices, Sunflower

Introduction

India occupies a prominent place in global oilseeds scenario with 12-15 % of area, 6-7 % of vegetable oil production, 9-10 % of the total edible oil consumption and 13.6 % of vegetable oil imports. Oilseeds account for nearly 3 % of the gross domestic product and 5.98 % of value of all agricultural products (Paroda, 2013). Despite having the largest area under oilseeds in the world (26.77 m ha), India currently imports about 50 % of total vegetable oil requirement at a huge cost of Rs. 56,000 crores. Sunflower ranks third, next to groundnut and soyabean in the total production of oilseeds in the world. In India, sunflower is cultivated on an area of about 0.69 million hectares with an annual production of 0.55 million tonnes and productivity of 791 kg ha^{-1} (Anon., 2013-14). A continued increase in oilseed crops production is essential in order to sustain an increasing population demand. Sunflower (*Helianthus annuus* L.) is quite responsive to micronutrients, among the micronutrients, Zn and B deficiency is most widespread on a wide range of soils, discusssed by Graham *et al*. (1992), Cakmak *et al*. (1996) and Grewal *et al*. (1997). Sunflower is becoming popular because of its wider adaptability to different agro climatic zones and soil types, easy crop management, optimum seed rate, photo insensitivity, short duration, high seed multiplication ratio (1:50) and ability to withstand drought compared to other rainfed crops particularly under delayed sowing conditions (Seshasailasree *et al*. (2004) and Tavoljansky *et al*. (2004). Sunflower is also one of the most sensitive crops to low boron supply and deficiency symptoms appear on the younger leaves, which develop a bronze color and become hardened, malformed and necrotic, the stem becomes corky, the capitulum deformed and poor seed set results (Blamey *et al*. (1987). Hence, emphasis on integrated use of micronutrients, bio-fertilizers and pesticides in sunflower should, therefore, be our high priority. Of late, the production costs in agriculture have increased tremendously but the returns have declined due to indiscriminate use of various resources. Increasing labour costs and unavailability of labours for agricultural operations has led to the use of different application methods. In the context of above facts, combined use of micronutrients, bio-fertilizers and pesticides to provide good initial growth thereby increasing the seed yield. Hence, field research was warranted on the use of these combinations as well as method of application in elucidating the benefits for better growth and yield of sunflower.

Materials and Methods

A field experiment on "Seed treatment with micronutrients, bio-fertilizers and pesticide in Sunflower (*Helianthus annuus* L.)" was conducted during *kharif*-2013 at all India co-ordinated research project on sunflower, Zonal Agricultural Research Station, Gandhi Krishi Vigyana Kendra, University of Agricultural Sciences Bengaluru, Karnataka. The soil of the experimental site was red sandy loam, slightly acidic in reaction (pH 5.80), medium in available nitrogen (283.4 kg ha^{-1}), high in available phosphrous (75 kg P_2O_5 ha^{-1}) and medium in available potassium (150 kg ha^{-1}) with lower organic carbon content (0.38 %), soil is deficit with respect to zinc (1.09 ppm) and boron (0.42 ppm). Micronutrients (Zn and B) were applied through different methods like seed treatment, soil application and foliar application in combination with bio-fertilizers (*Azotobacter* and *PSB*) and pesticide (Imidacloprid) as individual application and in combinations along with recommended dose of fertilizer (RDF) (90:90:60 kg NPK ha^{-1}). The experiment laid out in Randomised Complete Block Design with three replications and consists of fifteen treatments *viz.,* T_1 : RDF (90:90:60 kg NPK ha^{-1} FYM 7.5 t ha^{-1}), T_2 : T_1 + Imidacloprid seed treatment @ 5 g kg^{-1} seed, T_3 : T_2 + $ZnSO_4$ @ 10 kg ha^{-1} as basal soil application, T_4 : T_2 + Borax @ 11 kg ha^{-1} as basal soil application, T_5 : T_2 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 11 kg ha^{-1} as basal soil application, T_6 : T_2 + $ZnSO_4$ spray @ 0.2% at star bud stage, T_7: T_2 + Borax spray @ 0.2 % at ray floret initiation stage, T_8 : T_2 + $ZnSO_4$ spray @ 0.2% at star bud stage + Borax spray @ 0.2% at ray floret initiation stage, T_9 : T_2 + seed treatment of $ZnSO_4$ @ 5 g kg^{-1} kg seed, T_{10} : T_2 + seed treatment of Borax @ 2 g kg^{-1} seed, T_{11} : T_2 + *Azotobacter* and *PSB* as seed treatment @ 150 g kg^{-1} seed, T_{12} : T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + *Azotobacter* and *PSB* @ 150 g kg^{-1} seed as seed treatment, T_{13} : T_2 + Borax @ 2 g kg^{-1} seed + *Azotobacter* and PSB @ 150 g kg^{-1} seed as seed treatment, T_{14} : T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + Borax @ 2 g kg^{-1} seed as seed treatment and T_{15} : T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + Borax @ 2 g kg^{-1} seed + *Azotobacter* and *PSB* @150 g kg^{-1} seed as seed treatment. Seeds were treated by using seed treating machine with the help of polycoat @ 5 ml kg^{-1} seed in recommended sequence *viz*., Micronutrients followed by pesticide and bio-fertilizers. Different growth indices like LAI, LAD, AGR, CGR, RGR, NAR and days for 50 % flowering and physiological maturity were observed and computed with the help of standard formulae given by different authors as mentioned below.

Determinations

Leaf area index –LAI: Given by Watson (1952)

LAI = Leaf area (cm^2 per plant) / Spacing (cm^2 per plant)

Leaf area duration-LAD (days): Given by Power *et al*. (1967)

$LAD = [Li+(Li+1)/2] \times t_2 - t_1$

Absolute growth rate: AGR (g $plant^{-1}$ day^{-1}): Given by Watson (1952)

$AGR = (W_2-W_1) / (t_2-t_1)$

Crop growth rate: CGR (g ^{1} m^{-2} day^{-}): Given by Watson (1952)

$CGR = (W_2-W_1) / [(t_2-t_1) \times spacing]$

Net assimilation rate: NAR (g day^{-1} dm^{-2}): Given by Gregory (1926)

$NAR = [(W_2-W) \times (Log_e L_2 - log_e L_1)] / [(t_2 - t_1) \times (L_2-L_1)]$

Relative Growth rate: RGR (g g^{-1} day^{-1}): Given by Radford (1967).

$RGR = [Log_e W_2 - Log_e W_1] / t_2 - t_1$

Where, L_i = LAI at i^{th} stage, L_{i+1} = LAI at $(i+1)^{th}$ stage, $t_2 - t_1$ = time interval between L_{i+1} and L_i stage, W_2 and W_1 are the plant dry weight (g) at the time t_2 and t_1 (days), respectively and Log_e: Logarithm to the base.

Results and Discussion

Laboratory study observed that different treatments affected the seed germination significantly. The seed treatment with 6 g of borax kg^{-1} of seed and 15 g zinc sulphate kg^{-1} seed brought down the germination to 66.7 to 53.3 per cent compared to 73.3 per cent in control. Seed treatment with borax @ 2 g kg^{-1} seeds and zinc sulphate @ 5 g kg^{-1} seeds recorded higher germination of 86.7 per cent. At 15 days after sowing (DAS), maximum root and shoot length was recorded in the treatment with borax at 2 g kg^{-1} seed (10.52 and 11.01 cm per plant respectively), which was on par with zinc sulphate at 5 g kg^{-1} seed (10.61 and 11.93 cm per plant respectively). Preliminary results showed that the seed treatment with borax and zinc sulphate showed an increase in root and shoot length compared to untreated control plants (Table-1).

Field study revealed that, different methods of micronutrient application significantly influenced the different growth indices of sunflower at varied rate. Higher leaf area duration (days) was recorded with bio-fertilizers treated plots namely, T_{11}- T_2 + *Azotobacter* and *PSB* as seed treatment @ 150 g kg^{-1} seed (46.17 & 67.15), T_{13} -T_2 + Borax @ 2 g kg^{-1} seed + *Azotobacter* and PSB @ 150 g kg^{-1} seed as seed treatment (46.34 & 63.13), T_{14}-T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + Borax @ 2 g kg^{-1} seed as seed treatment

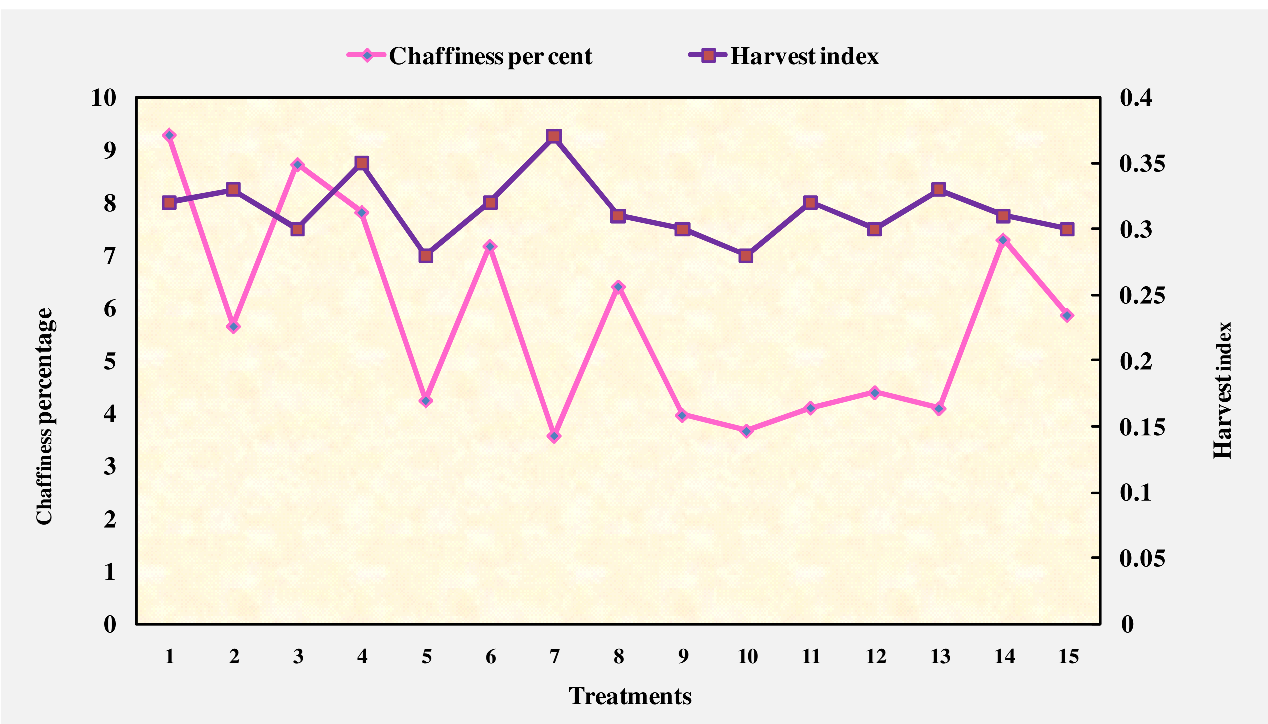

Fig.-1: Chaffiness percentage and harvest index of sunflower as influenced by different methods of micronutrients (Zn and B) application in combination with bio-fertilizers and pesticide

Table-1: Effect of seed treatment of $ZnSO_4$ and borax on the germination, root length and shoot length of sunflower seedling (8 and 15 DAS, lab studies)

Treat-ments	8 DAS			15 DAS	
	Germin-ation (%)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
T_1: control @ 0 g/kg seed	73.3	3.93	3.33	7.34	9.79
T_2: borax @ 2 g/kg seed	86.7	5.14	3.46	10.52	11.01
T_3: borax @ 4 g/ka seed	83.3	7.66	6.06	8.88	10.03
T_4: borax @ 6 g/kg seed	66.7	4.77	3.67	7.67	10.08
T_5: zinc sulphate @ 5 g/kg seed	86.7	5.89	5.70	10.61	11.93
T_6: zinc sulphate @ 10 g/kg Seed	76.7	7.24	5.82	9.42	10.10
T_7: zinc sulphate @ 15 g/kg Seed	53.3	2.74	2.79	6.80	7.00
SEm±	3.56	0.22	0.17	0.47	0.45
CD (P=05)	10.98	0.67	0.53	1.45	1.38

(Average of 3 replications)

Table-2: Growth indices of sunflower as influenced by different methods of micronutrients (Zn and B) application in combination with bio-fertilizers and pesticide

Treat-ments	LAD (DAS)		AGR (DAS)		CGR (DAS)		RGR (DAS)		NAR (DAS)	
	30&60	60&90	30&60	60&90	30&60	60&90	30&60	60&90	30&60	60&90
T_1	41.72	60.77	2.10	0.43	8.51	0.97	1.82	1.86	0.40	0.05
T_2	42.58	60.14	2.18	0.62	8.55	1.79	1.83	1.90	0.41	0.07
T_3	42.44	61.73	2.35	0.45	9.47	1.15	1.86	1.90	0.45	0.05
T_4	41.55	61.05	2.23	0.52	9.39	1.33	1.84	1.89	0.43	0.06
T_5	40.04	60.07	2.13	0.49	8.83	1.30	1.83	1.88	0.42	0.05
T_6	40.46	60.36	2.13	0.43	8.51	1.11	1.82	1.86	0.43	0.05
T_7	43.35	63.86	2.44	0.47	9.71	1.20	1.88	1.91	0.46	0.05
T_8	41.50	62.55	2.27	0.47	9.12	1.18	1.85	1.89	0.44	0.05
T_9	39.25	55.42	2.39	0.47	9.52	1.19	1.87	1.91	0.48	0.06
T_{10}	39.42	58.16	2.37	0.44	9.47	1.03	1.87	1.90	0.48	0.05
T_{11}	46.17	67.15	2.74	0.49	10.79	1.33	1.93	1.96	0.47	0.05
T_{12}	44.82	67.50	2.66	0.54	10.44	1.61	1.92	1.96	0.48	0.05
T_{13}	46.34	63.13	2.27	0.55	8.87	1.58	1.85	1.91	0.37	0.05
T_{14}	46.16	67.49	2.31	0.50	9.25	1.31	1.86	1.90	0.40	0.06
T_{15}	47.51	70.08	2.34	0.45	9.40	1.17	1.86	1.90	0.40	0.05
SEm±	0.733	1.93	0.04	0.03	0.38	0.208	.008	0.005	0.012	0.04
CD(P=05)	2.11	5.58	0.11	NS	1.10	NS	0.023	0.14	0.034	NS

Table-3: Growth and yield factors of sunflower as influenced by different methods of micronutrients (Zn and B) application in combination with bio-fertilizers and pesticide

Treat-ments	Leaf area (cm^2 $plant^{-1}$) 60 DAS	SPAD value at 60 DAS	Days for 50 % flowering	Days for physiological maturity	Seed yield (kg ha^{-1})	Oil content (%)	Crude protein (%)
T_1	4168	33.88	69.67	89.67	1895	39.78	10.31
T_2	4310	34.66	70.33	91.33	1820	39.16	10.81
T_3	4322	34.06	70.67	91.00	1794	39.45	11.41
T_4	4235	35.78	70.33	91.33	2119	40.75	10.84
T_5	4030	34.17	71.00	92.67	1816	39.99	11.78
T_6	4129	35.54	70.00	91.00	2043	39.53	10.69
T_7	4450	35.02	70.00	90.33	2383	40.23	10.59
T_8	4230	36.32	70.67	91.67	1978	39.47	10.84
T_9	3943	36.35	71.00	91.67	1766	39.18	10.78
T_{10}	3980	34.62	72.33	90.67	1820	40.50	10.88
T_{11}	4647	35.20	70.67	91.33	1986	39.60	10.59
T_{12}	4576	35.36	72.00	91.00	2005	39.46	10.91
T_{13}	4474	36.49	73.33	94.67	2186	41.00	11.57
T_{14}	4667	37.56	73.00	94.00	1936	40.17	10.72
T_{15}	4823	36.14	72.33	92.33	1954	40.96	10.72
SEm±	82.79	0.497	0.864	1.076	78.19	1.11	0.43
CD(P=05)	240.0	1.43	NS	NS	226.8	NS	NS

(46.16 & 67.49) and T_{15} - T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + Borax @ 2 g kg^{-1} seed + *Azotobacter* and *PSB* @150 g kg^{-1} seed as seed treatment (47.51 & 70.08) compared to RDF alone (41.72 & 60.77) and other treatments at 60 and 90 DAS respectively, similar was discussed by Muzzammil Hussain *et al*. (2009). The relative growth rate (g day^{-1} dm^{-2}) significantly influenced, higher relative growth rate noticed in treatments receiving combined application of micronutrients, bio-fertilizers and pesticide as seed treatment *i.e.*, T_{11}- T_2 + *Azotobacter* and *PSB* as seed treatment @ 150 g kg^{-1} seed (1.93 & 1.96) and T_{12}- T_2 + $ZnSO_4$ @ 5 g kg^{-1} seed + *Azotobacter* and *PSB* @ 150 g kg^{-1} seed as seed treatment (1.92 & 1.96) compared to RDF alone (1.82 & 1.86) and other treatments at both 60 and 90 DAS respectively. Absolute growth rate (g $plant^{-1}$ day^{-1}), Crop growth rate (g m^{-2} day^{-1}) and net assimilation rate (g day^{-1} dm^{-2}) also responded to different methods of micronutrient application in combination with bio-fertilizers and pesticide significantly at initial stage (Table-2). This might be due to improved growth and development of sunflower crop through combined seed treatment with micronutrients, bio-fertilizers and pesticide along with RDF which helped in improving the crop establishment, early vigour and nutrient availability compared to sole soil and foliar application wherever is affected, these results are in conformity with the study of Muzzammil Hussain *et al*. (2009).

Leaf area indicates that different nutrient application methods in combination with bio-fertilizers and pesticide significantly influenced at 60 DAS. Higher leaf area per plant (4823 cm^2) was recorded in T_{15} - T_2 + $ZnSO_4$, borax and bio-fertilizers seed treatment, which was on par with T_{14} - T_2 + $ZnSO_4$ and borax seed treatment (4667 cm^2) and T_{11} - T_2 + bio-fertilizers seed treatment (4647 cm^2) compared to RDF alone (4168 cm^2). Different methods of nutrient application influenced the SPAD (chlorophyll) meter reading significantly at 60 days after sowing. Higher SAPD meter reading (37.56) was recorded in T_{14} - T_2 + $ZnSO_4$ and borax seed treatment, which was on par with T_{13} - T_2 + borax and bio-fertilizers seed treatment (36.49), T_8 - T_2 + $ZnSO_4$ spray at star bud stage and borax spray at ray floret initiation stage (36.32), T_9 - T_2 + $ZnSO_4$ seed treatment (36.35) and T_{15} - T_2 + $ZnSO_4$, borax and bio-fertilizers seed treatment (36.14) compared to

RDF alone (33.88), this might be due to role of zinc in improving photosynthesis, protein, auxin and carotenoid synthesis, which resulted in prolonged photosynthesis, hence leaves remain more active compared to other treatments and RDF alone. This result is similar to the findings of Saad *et al*. (2011). Even though days for 50 per cent flowering and days for physiological maturity did not affected by these treatments but borax and bio-fertilizer seed treatment in combination with RDF delays the days for 50 per cent flowering and days for physiological maturity (73.33 and 94.67 respectively) compared to RDF alone (69.67 and 89.67 respectively). This might be due to prolonged supply of nutrients, soil moisture and growth stimulating substances excreted by microbes extended the vegetative phase of crop compared to non-microbial inoculation treatments (Gupta and Seema Sahu 2012).

Among different methods of micro nutrient application tried in combination with bio-fertilizers and pesticide, T_7 - T_2 + borax spray at ray floret stage recorded higher seed yield (2383 kg ha^{-1}), which was on par with T_{13} - T_2 + borax and bio-fertilizers seed treatment (2186 kg ha^{-1}) compared to RDF alone (1895 kg ha^{-1}) (Table-3). Foliar spraying helped to meet the crop nutrient requirement quickly compared to other methods of application. Hence foliar spray is not affected by soil and rhizosphere factors. Biofertilizers also contributed to higher yield by improving the nutrient use efficiency through N fixation, P solubilisation and improving the microbial status of soil. Oil content of the seed and crude protein did not respond to any of these methods. Higher seed yield was recorded due to proper seed filling might be resulted from boron role in translocation of sugars from source to sink which resulted in higher pollen viability and lower chaffiness percentage (3.58 %) in T_7 and (4.10 %) in T_{13}, (3.67 %) in T_{10} - T_2 + seed treatment of Borax @ 2 g kg^{-1} seed, (3.97 %) in T_9 - T_2 + seed treatment of $ZnSO_4$ @ 5 g kg^{-1} kg seed and (9.29 %) in RDF alone (Fig 1). The similar result was reported by Al-Amery *et al*. (2011) and Muhammad *et al*. (2013). Hence harvest index was more (0.37) in T_7 -T_2 + borax spray at ray floret stage, which was on par with T_{13}- T_2 + borax and bio-fertilizers seed treatment (0.33), T_{11}- T_2 + *Azotobacter* and *PSB* as seed treatment @ 150 g kg^{-1} seed (0.32), T_2- T_1 + Imidacloprid seed treatment @ 5 g kg^{-1} seed (0.33), T_4- T_2 + Borax @ 11 kg ha^{-1} as basal soil application (0.35) compared to RDF alone (0.32) and other treatments. The oil content did not influenced by these treatments.

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