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EFFECT OF FOLIAR APPLICATION OF PLANT MINERAL NUTRIENTS ON THE GROWTH AND YIELD ATTRIBUTES OF CHICKPEA (*CICER ARIETINUM* L.) UNDER NUTRIENT DEFICIENT SOIL CONDITIONS

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Abstract

A field experiment was conducted to investigate the foliar application of plant mineral nutrients on the growth and yield attributes of chickpea. Commercially available plant mineral nutrients labeled as 'Planto-fuel' (T_1) containing (N+ micronutrients), DAP (T_2) in the solid form, (N+ DAP) labeled as 'Fozan' (T_3) and K-sol (T_4). The experimental results showed that 'Planto-fuel' (T_1) increased significantly ($p < 0.01$) the number of pods /plant, number of seeds /plant and seeds weight/plant. The same treatment also produced the maximum seed yield (2.25 t/ha) and harvest index (47.90%). The highest 100 seed weight (32.63 g) was obtained when DAP (T_2) was used.

Introduction

Chickpea (*Cicer arietinum* L., 2n = 2x = 16) is an earliest leguminous self-pollinated crop, cultivated in various parts of the world since 7000BC (Tekeoglu *et al.* 2000). Globally, Pakistan ranks second in area and third in production of chickpea (FAO 2006). It contributes 4.7% to national economy (GOP 2009). Worldwide, availability of chickpea per capita is 3.4 g/day whereas 16.23 g/day in Pakistan. It fixes atmospheric nitrogen (N)in the soil and helps in soil fertility in the dry land areas (Sharma and Jodha 1984). Chickpea is also a good source of proteins and carbohydrates, both constitute 80% of its dry seed total weight. While, the remaining 20% consists of 2.1 - 11.7% fibers, 0.2% Ca, 0.3% P and 0.8- 6.4% fats (Huisman and Van der Poe 1994). In Pakistan chickpea is one of the most important pulse crops due to its several uses in the traditional farming system (Saxena and Singh 1987).

Primary macronutrients are used in large quantity and complemented as fertilizers[Nitrogen (N), Phosphorus (P) and Potassium (K)] while secondary macronutrients [Calcium (Ca), Magnesium (Mg) and Sulphur (S)] are also utilized in large quantities but sufficiently supplied and are normally readily available. It is determined that during crop growth supplementary foliar fertilization increases plants mineral status and improves crop yield (Rahman *et al.*2014a).

Over the last few years there has been a steady trend to reduce the use of mineral fertilizers, especially soil applied nutrients such as - N, P and K and their use has decreased seven times (Kerin and Berova 2003). These facts create preconditions to increase the importance of foliar fertilization as an alternative to meet plant nutrient demands during the growing season. Interest on foliar fertilization has risen as a result of many advantages associated with methods of foliar nutrients application, such as rapid and effective response to plant needs, regardless of soil conditions (Kerin and Berova 2003). Moreover, foliar application during the growth and development of crops can improve their nutrient balance, which may in turn lead to an increase in yield, quality or both (Kolota and Osinska 2001). Foliar applications may sometimes facilitate the rapid absorption of mineral elements, avoiding the occurrence of soil interactions that may limit root uptake due to nutrient immobilization in the soil.

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Additionally, foliar fertilization may also stimulate the capability of the root system to absorb nutrients from soil solution (Taiz and Zeiger 1998, Lovatt 1999, Kuepper 2003,Fernández and Eichert 2009, Kannan 2010). Alexander and Schroeder (1987) indicated the great potential of foliar fertilization as a means of reducing soil and ground water pollution.

The present study was carried out in the experimental field, Department of Botany, Hazara University to investigate appropriate dosage and effects of mineral nutrients application on growth and yield of chickpea.

Materials and Methods

Field experiment was carried out at the experimental field, Department of Botany, Hazara University, Mansehra, Pakistan in RCBD with four treatments replicated three times during winter season of 2012/2013 to study the response of chickpea growth and yield to foliar macro and micronutrients application.

Soil samples were taken randomly from the experimental area before sowing and after harvesting from each treated plot from 0 to 15 cm and 15 to 30 cm depth for physiochemical analysis *viz.,* soil pH (McLean 1982), Nitrogen through Macro-Kjeldahl method (Paul and Berry 1921), Phosphorus and Potassium were analyzed through ammonium bicarbonate-diethylentriaminpenta acetic acid (AB-DTPA) method (Soltanpour and Woekman 1979).

Chickpea seeds (CM-2000 var.) were soaked for 12 hrs and then sown at10.16 cm plant to plant and 30.48 cm row to row distance and area of each plot was 2.7 × 3.04m^2. All foliar applications were repeated after 14 days of interval till maturity while basal placement of DAP was done one time. The experiment comprised of the following treatments (Table 1).

Table1. Treatments used in the present experiment.

Treatments	Material(s) used
T_0	Control (No fertilizer)
T_1	Planto-fuel (N 200 g/land micronutrients Zn 50, Fe 1000, Mg 100, Cu 10, B 100 and Mn 100 mg/l) [6177ml + 1235.4 L H_2O/ha]
T_2	DAP (Solid form) [123.5 kg/ha]
T_3	Fozan (DAP and 2% N) [DAP= 12.35 L + 617.7 l H_2O/ha and N= 12.35 l + 617.7 l H_2O/ha]
T_4	K-sol (N20%:P20%:K20%) [6177.4g + 1235.4 L H_2O/ha]

Ten chickpea plants were collected from each plot at flowering and harvesting stage at random and yield attributes observed.

Quantitative traits of chickpea included plant height (PH), number of branches/plant (NoBPP), number of leaves /plant (NoLPP), shoot fresh weight (SFW), shoot dry weight (SDW), number of flowers/plant (NoFPP), number of pods/plant (NoPPP), seeds weight/plant (SWPP), 100 seed weight (HSW), seed yield (SY), biological yield (BY) and harvest Index (%) (HI).

The data was statistically analyzed using computer programs SPSS 16.0 and Statistix 8.1, differences among means were calculated using LSD test ($p \leq 0.05$).

Results and Discussion

The soil analysis results showed the pH, EC and Nitrogen, Phosphorus and Potassium values. In soil samples, the N, P and K values were found deficient in the soil samples of experimental field and given asTables2and 3. Soil nutrients standard values are given as Table 4 (Soltanpour 1985).

Table 2. Chemical analysis of soil samples(pre-sowing of chickpea) in experimental field showing pH and the amount of NPK in mg/kg of soil.

Sl.No.	Sample Id	pH	NO_3-N	P	K	EC (dS/m)
1.	(0-15 cm)	6.9	1.93	0.87	120	0.14
2.	(15-30 ")	7.23	1.54	0.66	120	0.32

Table 3. Chemical analysis of soil samples(after harvesting of chickpea) in experimental field showing pH and the amount of NPK in mg/kg of soil.

Treatment	Sample Id	pH	NO_3-N	P	K	EC (dS/m)
T_1	0-15 cm	6.76	3.46	0.84	114	0.28
	15-30 "	7.14	2.03	0.67	133	0.41
T_2	0-15 "	7.12	2.49	0.88	117	0.35
	15-30 "	6.68	1.73	0.62	141	0.27
T_3	0-15 "	6.71	1.74	0.78	96	0.21
	15-30 "	6.94	2.09	0.35	108	0.37
T_4	0-15 "	6.8	1.97	0.81	102	0.19
	15-30 "	7.06	1.35	0.42	126	0.31

Table 4. Standard values of different nutrients in soil (mg/kg).

Sl. No.	Elements	Low	Medium	High
1	N	≤10.00	11 - 20	21 - 30
2	P	≤03.00	04 - 07	08 - 11
3	K	≤60.00	61 - 120	121 - 181

The comparative performance investigation of 16 quantitative attributes of chickpea was recorded and mean squares values of all quantitative attributes are given in Table 5.

Chickpea plant height was highly significantly increased in T_1 application (Table 6). While minimum plant height (43.9 cm) was observed in T_0 application (Fig. 1). It might be due to the effective absorption of nutrients (N+ micronutrients mixture) through foliar spray. Kaya *et al.* (2002) stated that Zinc increased plant height via increasing intermodal distances. Johansen *et al*. (2007) also observed that the growth of chickpea would be improved by micronutrient application. Similar findings have been reported by other researchers e.g. in common bean (Rahman *et al.*

2014b, c) and in cauliflower (Rahman *et al.* 2014d).The root length showed highly significant increase in T_1 (19.00 cm) application, followed by T_2 (17.26 cm). Minimum root length (10.53 cm) was observed in T_0 application.

Table5.Basic statistics for quantitative attributes of chickpea evaluated during 2013.

Sl. No.	Traits	Mean ± S.E*	Minimum	Maximum	Sd**	Variance
1	PH	54.28 ± 1.69	42.40	62.80	6.55	43.01
2	RL	14.45 ± 0.85	10.20	19.60	3.31	10.99
3	NoBPP	4.00 ± 0.33	2.00	6.00	1.30	1.71
4	NoLPP	43.86 ± 2.83	27.00	62.00	10.98	120.6
5	SFW	13.83 ± 1.45	6.70	22.20	5.65	31.93
6	SDW	5.84 ± 0.57	3.00	9.10	2.24	5.03
7	RW	2.84 ±0.63	0.70	6.30	2.44	5.97
8	SD	4.48 ±0.19	3.10	5.70	0.74	0.58
9	NoFPP	19.93 ±1.27	12.00	27.00	4.93	24.35
10	NoPPP	17.40 ±1.18	9.00	25.00	4.59	21.11
11	NoSPP	24.46 ±2.08	13.00	37.00	8.07	65.26
12	SWPP	7.24 ±0.61	3.20	11.20	2.36	5.60
13	HSW	29.25 ±0.99	24.80	38.20	3.84	14.80
14	SY	1.70 ±11.56	93.20	236.60	44.77	2.00
15	BY	3.74 ±20.39	237.50	471.40	78.97	6.23
16	HI	44.90 ±0.78	39.20	50.10	3.04	9.25

*SE: Standard error. **Sd: Standard deviation.

Fig. 1.Shows the response of chickpea plant growth before maturity to different nutrients application.

Table 6showed that highest number of branches/plant was recorded in T_1(5.66) application, followed by T_2 (5.00) while T_3 and T_4 applications showed similar results (3.33) and minimum number of branches/plant (2.66) was observed in T_0 application. These findings agree with previous results (Rahman *et al.* 2014d) that maximum number of branches was noted through foliar spray of B, Mo and Zn. The analysis of variance results for number of leaves/plant attribute revealed that T_1 application resulted in highly significant ($p \leq 0.01$) differences and had the highest number of leaves/plant (57.60), followed by T_2(52.60). Whereas, minimum number of leaves/plant (29.60) was observed in T_0 application (Table 6).Khosa *et al.* (2011) found inline results, and the authors opined that foliar spray of macronutrients 2g (25ml+975ml H_2O) produces maximum number of leaves/plant. The results in Table 6 revealed that fresh and dry weight of shoot showed highly significant ($p \leq 0.01$) differences inT_1applications at harvest with maximum shoot fresh weight (21.1g) and shoot dry weight (8.66 g).Minimum recorded data for shoot fresh weight (7.10g) and shoot dry weight (3.23 g) was scored by T_0 application. The present findings are in full agreement with those of Valenciano *et al.*(2010) where Zinc, Boron and Molybdenum in combination greatly affected the mature plants as a result maximum dry matter production. Similar results were also reported by Torun *et al.*(2001), the authors reported that foliar micronutrients had a great involvement in various biochemical and physiological processes resulting in maximum production of dry matter.

Table 6. Response of chickpea to nutrients application on PH, RL, NoBPP, NoLPP, SFW and SDW.

Treatments	PH (cm)	RL (cm)	NoBPP	NoLPP	SFW (g)	SDW (g)
T_0	43.93 ^{c}	10.53 ^{d}	2.66 ^{b}	29.60 ^{c}	7.10 ^{d}	3.23 ^{c}
T_1	61.46 ^{a}	19.00 ^{a}	5.66 ^{a}	57.60 ^{a}	21.16 ^{a}	8.66 ^{a}
T_2	60.00 ^{a}	17.26 ^{b}	5.00 ^{a}	52.60 $_{a}$	19.20 ^{b}	8.06 ^{a}
T_3	53.46 ^{b}	12.80 ^{c}	3.33 ^{b}	40.30 ^{b}	11.03 ^{c}	4.70 ^{b}
T_4	52.53 ^{b}	12.66 ^{c}	3.33 ^{b}	39.00 ^{b}	10.66 ^{c}	4.53 ^{b}
LSD $_{(0.05)}$	0.90	0.48	0.39	2.70	0.72	0.37

Within each column, treatments carrying same superscript letter are not significantly different at 5% level.

It was revealed from Table 7 that maximum root weight was found in T_1 application (6.13 g), followed by T_2 (5.26 g). T_0 application showed minimum root weight (0.83 g). Stem diameter of chickpea plant was highest in T_2 (5.23 mm) application (Table 7), followed by T_1 (4.76 mm). T_3 and T_4 applications showed similar results (4.20 mm) and minimum stem diameter (3.56 mm) was recorded in T_0 application.

Highest number of flowers/plant (25.67) and number of pods/plant (22.00) was found in T_1 application (Table 7). Minimum recorded data was observed in T_0 application for number of flowers/plant (13.67) and pods/plant (10.66).Analysis of variance (Table 7) for the number of seeds/plant and seeds weight/plant of chickpea at harvest showed highly significant ($p \leq 0.01$) differences in T_1 application with highest number of seeds/plant (35.00) and seeds weight/plant (10.16 g), while minimum number of seeds/plant (14.66) and seeds weight /plant (3.76 g) was observed in T_0 application. Zeidan *et al.* (2006) reported that yield components in lentil are enhanced by foliar application of micronutrients. Due to the enzymatic activity enhancement, microelements effectively increased photosynthesis and translocation of assimilates to the seed.

Table 8 showed that maximum 100 seed weight (32.63 g) was noted in T_2 application, followed by T_1 (31.00 g) and T_3 (29.93 g). In T_0 application, minimum 100 seed weight (25.30 g) was noticed. The results are in agreement with Soylu *et al.* (2005) and Grotz and Guerinot (2006) where significant increase in 100 grains weight with foliar application of micronutrients was reported. The analysis of variance for seed yield showed highly significant ($p \leq 0.01$) differences in T_1 application (Table 8). Mean squares data of seed yield of treated applications revealed that T_1

had the highest seed yield (2213.30 kg/ha), followed by T_2 (2095.00 kg/ha), whereas T_3 and T_4 applications showed seed yield (1601.70 and 1568.70 kg/ha, respectively) and the lowest recorded seed yield (1024.00 kg/ha) was scored for T_0. Rahman *et al.* (2015a) reported that foliar application of macro or micronutrients plays a crucial role in the production of good crop with higher yield. Similar findings were reported by Rahman *et al.* (2015b) for onion. Maximum biological yield (4619.70 kg/ha) was recorded in T_1 application, followed by T_2 (4397.00 kg/ha). While, T_3 and T_4 applications had an average biological yield (3643.00 and 3585.70 kg/ha respectively). Minimum biological yield (2469.70 kg/ha) was recorded for T_0 application (Table 8). Kaya *et al.* (2002) and Cakmak (2008) also noticed that Zinc plays an important role in biomass production. The analysis of variance showed highly significant ($p \leq 0.01$) differences for harvest index in T_1 application (47.90%), followed by T_2 (47.60%) and T_0 showed minimum harvest index (41.40%) value (Table 8). Similar results were found by Bameri *et al.* (2012) in pea.

Table 7. Response of chickpea to nutrients application on RW, SD, NoFPP, NoPPP, NoSPP and SWPP.

Treatments	RW(g)	SD(mm)	NoFPP	NoPPP	NoSPP	SWPP(g)
T_0	0.83 ^{c}	3.56^{c}	13.667 ^{c}	10.66 ^{c}	14.66 ^{c}	3.76 ^{d}
T_1	6.13 ^{a}	4.76 ^{ab}	25.667 ^{a}	22.00 ^{a}	35.00 ^{a}	10.16 ^{a}
T_2	5.26 ^{b}	5.23 ^{a}	24.333 ^{a}	21.66 ^{a}	31.33 ^{a}	8.73 ^{ab}
T_3	1.00 ^{c}	4.20 ^{bc}	18.333 ^{b}	16.33 ^{b}	20.33 ^{b}	7.03 ^{bc}
T_4	1.00 ^{c}	4.20 ^{bc}	17.667 ^{b}	16.33 ^{b}	21.00 ^{b}	6.50 ^{c}
LSD $_{(0.05)}$	0.22	0.41	1.39	1.28	1.70	0.75

Within each column, treatments carrying same superscript letter are not significantly different at 5% level.

Table 8. Response of chickpea to nutrients application on HSW, SY, BY and HI.

Treatments	HSW (g)	SY (kg/ha)	BY (kg/ha)	HI (%)
T_0	25.30 ^{b}	1024.00 ^{c}	2469.70 ^{d}	41.40 ^{b}
T_1	29.93 ^{ab}	2213.30 ^{a}	4619.70 ^{a}	47.90 ^{a}
T_2	32.63 ^{a}	2095.00 ^{a}	4397.00 ^{b}	47.60 ^{a}
T_3	31.00 ^{a}	1601.70 ^{b}	3643.00 ^{c}	43.90 ^{b}
T_4	27.40 ^{ab}	1568.70 ^{b}	3585.70 ^{c}	43.70 ^{b}
LSD $_{(0.05)}$	2.41	62.10	82.62	1.53

With in each column, treatments carrying same superscript letter are not significantly different at 5% level.

From the present findings it is concluded that commercially available plant mineral nutrients labeled as ‘Planto-fuel’ (T_1) containing (N+ Zn, Fe, Mg, Cu, B and Mn mixture) when applied as foliar spray, improved the chickpea plant growth and yield characters significantly. Further, the important yield components were number of pods/plant number of seeds/plant and seeds weight/plant. The same application also produced maximum seed yield and harvest Index and DAP (T_2) has resulted in maximum 100 seed weight.

From the present investigation it may be concluded that foliar application of micronutrients mixture (Zn, Fe, Mg, Cu, B and Mn) in combination with Nitrogen is likely to be the most suitable application to improve the growth and yield attributes of chickpea.

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