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Divya Sahare
Department of Agronomy, Indira Gandhi Krishi Vishwa Vidyalaya, Krishak Nagar, Labhandi, N.H.-6, Raipur, Chhattisgarh, India

GK Shrivastava
Department of Agronomy, Indira Gandhi Krishi Vishwa Vidyalaya, Krishak Nagar, Labhandi, N.H.-6, Raipur, Chhattisgarh, India

Sanjay K Dwivedi
Department of Agronomy, Indira Gandhi Krishi Vishwa Vidyalaya, Krishak Nagar, Labhandi, N.H.-6, Raipur, Chhattisgarh, India

Corresponding Author:
Divya Sahare
Department of Agronomy, Indira Gandhi Krishi Vishwa Vidyalaya, Krishak Nagar, Labhandi, N.H.-6, Raipur, Chhattisgarh, India

Growth and yield maximization of chickpea (*Cicer arietinum*) through basal and foliar application of major and micro nutrients

Divya Sahare, GK Shrivastava and Sanjay K Dwivedi

Abstract
A field experiment to study the effect of basal and foliar application of major and micro nutrients on chickpea was conducted during *rabi* 2013-14 and 2014-15 at the Instructional Cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Results indicated that treatment T_9 (T_3+ Mo+ B+ DAP) registered significantly higher growth parameters viz. plant height (48.83, 49.20 and 49.02cm), number of primary branches plant^{-1} (5.57, 6.07 and 5.82), number of secondary branches plant^{-1} (28.67, 28.96 and 28.82) and dry matter accumulation (19.35, 19.42 and 19.38g); yield attributes like number of pods plant^{-1} (53.86, 58.64 and 56.25), number of seeds pod^{-1} (2.20, 2.31 and 2.26), seed weight (9.93, 10.26 and 10.09 g plant^{-1}) and seed yield (1546, 2088 and 1817 kg ha^{-1}) and stover yield (2058, 2421 and 2240 kg ha^{-1}) as compared to others treatments during 2013-14, 2014-15 and on mean basis, respectively. However, it was at par with treatments T_7 (T_3+ DAP), T_8 (T_3 + B+ DAP), T_{15} (T_4+ B+ DAP) and T_{16} (T_4+ Mo+ B+ DAP) during 2013-14, 2014-15 and on mean basis.

Keywords: Foliar application, DAP, boron, molybdenum, nitrogen, phosphorus, potassium

Introduction
Pulses are considered as an important part of food crop occupying a unique position in agriculture and also an important component of food grain crops because of their high nutritive value. India stands first in area and production of chickpea followed by Pakistan and Turkey. In India chickpea, is cultivated over an area of 8.96 m ha and with a production of 7.66 mt and an average productivity level of 1066 kg ha^{-1} (Anonymous, 2012) [2]. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are the major chickpea producing states sharing over 95 per cent area. In Chhattisgarh, chickpea is grown in an area of 3.9 lakh ha with an annual production of 2.4 lakh t with an average productivity of 1100 kg ha^{-1} (Anonymous, 2015) [3]. Chickpea is mainly cultivated as a rainfed crop and water stress often affects both the productivity and the yield stability of the chickpea. Rainfed soils are generally degraded with poor native fertility (Valenciano *et al.*, 2010) [21]. Nutrient imbalance is one of the major abiotic constraints limiting productivity of chickpea (Thiyagarajan *et al.*, 2003) [19]. Balanced fertilization with major and micronutrients can enhance the chickpea production to a considerable extent. Micronutrients play an important role in increasing the yield of pulse and oilseed legumes through their effects on plant itself and on the nitrogen fixing symbiotic process. (Rahman *et al*, 2014) [15]. It has been well established that most of the plant nutrients are absorbed through the leaves and absorption would be remarkably rapid and nearly complete. The present study was therefore, undertaken to know the effect of basal and foliar application of major and micro nutrient on growth and yield of chickpea.

Materials and methods
A field experiment was conducted at *rabi* season of 2013-14 and 2014-15 in Instructional Cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). The soil of experimental field was unbunded Clayey (Vertisols) deep black soil in texture locally known as *bharri* "*Kanhar"*. The soil was neutral in reaction, low in organic carbon, nitrogen and phosphorus and high in potash contents. The experiment was laid out in randomized block design and consisted of eighteen treatments *viz;* T_1 - Control, T_2 - 20:40:20 kg N: P_2O_5: K_2O ha$^{-1,}$ T_3 - 20:40:20:20 kg N: P_2O_5: K_2O and S ha^{-1}, T4 - 20:20:20:20 kg N P_2O_5, K_2O and S ha^{-1},

T_5 - T_3 + Mo seed treatment@ 1g kg^{-1} seed (T_3 + Mo), T_6 - T_3 + 0.2% Boron spray at flowering and 15 days after flowering (T_3 +B), T_7 - T_3 + 2% DAP spray twice 15 days interval at flowering (T_3+ DAP), T_8 - T_3 + 0.2% Boron spray at flowering and 15 days after flowering + 2% DAP spray twice 15 days interval at flowering (T_3 +B+ DAP), T_9 - T_3 + Mo seed treatment@ 1g kg^{-1} seed + 0.2% Boron Spray at flowering and 15 days after flowering + 2% DAP spray twice 15 days interval at flowering (T_3+Mo+B+DAP), T_{10} - T_3 + Mo seed treatment@ 1g kg^{-1} seed + 0.2% Boron spray at flowering and 15 days after flowering (T_3+Mo+B), T_{11} - T_3 + Mo seed treatment@ 1g kg^{-1} seed + 2% DAP spray twice 15 days interval at flowering (T_3+Mo+DAP), T_{12} - T_4 + Mo seed treatment @ 1g kg^{-1} seed (T_4+Mo), T_{13} - T_4 + 0.2% Boron spray at flowering and 15 days after flowering (T_4+B), T_{14} - T_4 + 2% DAP spray twice 15 days interval at flowering (T_4+DAP), T_{15} - T_4 + 0.2% Boron spray at flowering and 15 days after flowering + 2% DAP Spray twice 15 days interval at flowering (T_4+B+DAP), T_{16} - T_4 + Mo seed treatment@ 1g kg^{-1} seed + 0.2% Boron spray at flowering and 15 days after flowering + 2% DAP spray twice 15days interval at flowering (T_4+Mo+B+DAP), T_{17} - T_4 + Mo seed treatment@ 1g kg^{-1} seed + 0.2% Boron spray at flowering and 15 days after flowering (T_4+Mo+B), and T_{18} - T_4 + Mo seed treatment@ 1g kg^{-1} seed + 2% DAP Spray twice 15 days interval at flowering (T_4+Mo+DAP). Chickpea "JG-130" cultivar was taken as test crop. Seeds were treated first with fungicide i.e. with Bavistin @ 2.5g kg^{-1} of seeds, then with rhizobium @ 10g kg^{-1} of seed and PSB @ 10g kg^{-1} of seed. The seeds in which molybdenum seed treatment required, it treated separately with molybdenum @ 1g kg^{-1} seed after treating them with fungicide, rhizobium and PSB. Source of Molybdenum was ammonium molybdate and source of Boron was Borax (11%). The crop was harvested treatment wise at maturity and seed yield per hectare was computed.

Results and discussion

Growth parameters

Growth parameters like plant height, number of primary branches, secondary branches and dry matter accumulation were significantly influenced by basal and foliar application of major and micro nutrients. The plant height (48.83, 49.20 and 49.02 cm), number of primary branches $plant^{-1}$ (5.57, 6.07 and 5.82), number of secondary branches $plant^{-1}$ (28.67, 28.96 and 28.82) and dry matter accumulation $plant^{-1}$ (19.35, 19.42 and 19.38 g) were significantly highest with treatment T_9 (T_3+ Mo+ B+ DAP) as compared to others during 2013-14, 2014-15 and on mean basis, respectively. However, it was at par with treatments T_7 (T_3 + DAP), T_8 (T_3 + B+ DAP), T_{15} (T_4+B + DAP) and T_{16} (T_4+Mo+B+DAP) during 2013-14, 2014-15 and on mean basis (Table 1). The increase in the growth parameters of chickpea is due to the increase in vegetative growth of the crop. It might be due to application of Nitrogen, phosphorus, potassium and sulphur as it increases photosynthetic activity of plant and helps to develop a more extensive root system and thus enables the plant to extract more water and nutrient from soil depth, resulting in better development of plant growth. The results are in the conformity of findings Nawange *et al.* (2011) [14] and Tomar *et al.* (2013) [20] and Kokani *et al.* (2015) [12]. Kassab (2005) [11] observed a significant effect of micronutrients in growth parameters including yield in mung bean plants by foliar application of zinc, manganese and iron under water stress. Such enhancement effect of foliar application might be attributed to the favorable influence of these nutrients on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzymes activity which in turn encourage vegetative growth of plants (Michail *et al.*, 2004) [13]. Foliar mineral spray significantly affect biomass production of plants irrespective to their growth. The obtained results are in agreement with the findings of Asad *et al*. (2003) [4], Basole *et al.* (2003) [6], Kassab (2005) [11] and Thalooth *et al*. (2006) [18].

Yield attributes and yield

The yield attributes and yield of chickpea were significantly influenced by basal and foliar application of major and micro nutrients. The application of treatment T_9 (T_3+ Mo+ B+ DAP) registered significantly higher number of pods $plant^{-1}$ (53.86, 58.64 and 56.25), number of seeds pod^{-1} (2.20, 2.31 and 2.26), seed weight (9.93, 10.26 and 10.09 g $plant^{-1}$), seed yield (1546, 2088 and 1817 kg ha^{-1}) and stover yield (2058, 2421 and 2240 kg ha^{-1}) as compared to other treatments during 2013-14, 2014-15 and on mean basis, respectively (Table 2 and 3). However, it was at par to T_7 (T_3+ DAP) with seed yield of 1352, 1886 and 1619 kg ha^{-1} and stover yield of 1885, 2154 and 2020 kg ha^{-1}; T_8 (T_3 + B+ DAP) with seed yield of 1468, 1981 and 1725 kg ha^{-1} and stover yield of 1946, 2348 and 2147 kg ha^{-1}; T_{15} (T_4+ B+ DAP) with seed yield of 1313, 1805 and 1559 kg ha^{-1} and T_{16} (T_4+ Mo+ B+ DAP) with seed yield of 1391, 1943 and 1667 kg ha^{-1} and stover yield of 1902, 2276 and 2089 kg ha^{-1} during 2013-14, 2014-15 and on mean basis, respectively. As regards to 100 - seed weight and harvest index, it remained unaffected due to different treatments during both the years and on mean basis. It might be due to the combined application of nutrients through basal and foliar application. Nitrogen, phosphorus and potassium application influenced plant growth and yield attributes of chickpea, which were higher with higher dose of nutrients. Macronutrient nutrition is known to improve yield in chickpea (Devi and Singh, 2005) [8]. Mineral nitrogen increase water use efficiency in chickpea (Bahavar *et al.*, 2009) [5] and therefore, apart from supplying nutrition it could benefit the crop indirectly also. Sulphur besides improving vegetative growth it activates certain photolytic enzymes and co-enzymes (Bixby and Beaton, 1970) [7]. Thus, these bio-activities of sulphur might have played important role in improving yield attributing characters and total yield of chickpea. Chickpea responded significantly due to application of boron and seed treatment with molybdenum in both the years. Increase in grain yield of chickpea with the application of various nutrients could be due to improvement in plant growth and yield attributes such as pods $plant^{-1}$, seeds pod^{-1} and seed $plant^{-1}$. Foliar application of boron enhances flowering which in turn increases number of pods and its deficiency causes flower drop and subsequently, poor podding of chickpeas which results in poor yield of the crop results are in the findings of Srivastava *et al*. (1997) [17] and (Ganie *et al* 2014) [9]. Similarly in Mo-deficient chickpea, the flowers produced are less in number, smaller in size and many of them fail to open or to mature, consequently this leads to lower seed yield (Ahlawat *et al.*, 2007) [1]. Micronutrient application through seed treatments improves the stand establishment, advances phenological events, and increases yield and micronutrient grain contents in most cases. Also, it is an easy and cost effective method of micronutrient application (Farooq *et al.*, 2012) [10]. Therefore in Mo-deficient chickpea, the flowers produced are less in number, smaller in size and many of them fail to open or to mature, consequently this leads to lower seed yield (Ahlawat *et al.*,

2007) [1]. These minerals increased photosynthetic and enzymatic activities and an effective translocation of assimilate to reproductive parts resulting in higher yield (Sarkar and Malik, 2001) [16].

Table 1: Growth parameters of chickpea at harvest as influenced by basal and foliar application of major and micro nutrients

Treatment	Plant height (cm)			Primary branches (No. plant^{-1})			Secondary branches (No. plant^{-1})			Dry matter accumulation (g plant^{-1})		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
T_1- Control	38.33	37.53	37.93	4.21	4.27	4.24	19.13	20.97	20.05	13.93	14.27	14.10
T_2-20:40:20	39.37	40.87	40.12	4.29	4.40	4.35	19.77	21.61	20.69	15.06	16.10	15.58
T_3- 20:40:20:20	44.03	44.19	44.11	4.68	5.23	4.96	20.83	24.02	22.43	16.02	17.23	16.62
T_4- 20:20:20:20	40.40	41.37	40.88	4.31	4.63	4.47	20.00	22.16	21.08	15.18	16.21	15.70
T_5- T_3 + Mo	43.07	42.30	42.68	4.50	5.10	4.80	20.31	22.85	21.58	15.58	16.81	16.19
T_6- T_3 + B	44.83	45.33	45.08	4.81	5.30	5.05	22.43	25.80	24.12	16.86	17.88	17.37
T_7- T_3 + DAP	46.67	47.67	47.17	5.00	5.57	5.29	26.73	27.95	27.34	18.19	18.43	18.31
T_8- T_3 + B + DAP	48.03	48.90	48.47	5.40	5.67	5.54	27.83	28.64	28.24	18.92	19.05	18.98
T_9- T_3 + Mo + B + DAP	48.83	49.20	49.02	5.57	6.07	5.82	28.67	28.96	28.62	19.35	19.42	19.38
T_{10}- T_3 + Mo + B	46.00	47.00	46.50	4.82	5.33	5.08	23.97	25.93	24.95	17.11	18.08	17.59
T_{11}- T_3 + Mo + DAP	46.17	46.27	46.22	4.85	5.43	5.14	24.80	26.61	25.71	17.45	18.13	17.79
T_{12}- T_4 + Mo	40.90	42.14	41.52	4.38	4.77	4.57	20.13	22.31	21.22	15.21	16.31	15.76
T_{13}- T_4 + B	42.03	43.20	42.62	4.39	5.03	4.71	20.20	22.50	21.35	15.34	16.79	16.06
T_{14}- T_4 + DAP	44.03	45.13	44.58	4.73	5.13	4.93	21.07	26.09	23.58	16.24	17.71	16.98
T_{15}- T_4 + B + DAP	46.67	47.07	46.87	4.89	5.53	5.21	25.67	27.53	26.60	17.96	18.26	18.03
T_{16}- T_4 + Mo + B + DAP	46.83	47.77	47.30	5.24	5.60	5.42	26.73	27.96	27.35	18.49	18.53	18.51
T_{17}- T_4 + Mo + B	43.10	43.43	43.27	4.65	5.13	4.89	20.30	22.99	21.65	15.70	17.08	16.39
T_{18}- T_4 + Mo + DAP	43.93	44.13	44.03	4.66	5.17	4.91	20.37	23.49	21.93	15.78	17.21	16.50
SEm±	2.01	2.35	1.46	0.27	0.25	0.26	1.44	1.30	1.29	0.95	0.85	0.87
CD (P=0.05)	5.78	6.77	4.21	0.78	0.73	0.75	4.15	3.73	3.70	2.74	2.44	2.50

Table 2: Yield attributes of chickpea as influenced by basal and foliar application of major and micro nutrients

Treatment	No. of Pods plant $^{-1}$			No. of Seeds No. pod $^{-1}$			Seed weight (g plant^{-1})			100 -seed weight (g)		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
T_1- Control	28.75	32.04	30.40	1.07	1.17	1.12	4.15	5.11	4.63	11.95	12.07	12.01
T_2-20:40:20	30.04	32.07	31.06	1.26	1.26	1.26	5.18	5.32	5.25	13.08	13.13	13.10
T_3- 20:40:20:20	38.05	39.15	38.60	1.77	1.94	1.85	6.33	7.47	6.90	13.64	14.05	13.84
T_4- 20:20:20:20	30.91	34.34	32.62	1.35	1.40	1.38	5.19	5.40	5.30	13.18	13.16	13.17
T_5- T_3 + Mo	33.22	35.49	34.35	1.67	1.63	1.65	5.72	6.41	6.06	13.37	13.48	13.43
T_6- T_3 + B	41.21	42.59	41.90	1.79	2.01	1.90	8.05	8.39	8.22	13.79	14.13	13.96
T_7- T_3 + DAP	50.50	51.63	51.06	1.95	2.24	2.10	8.35	9.75	9.05	14.31	14.30	14.31
T_8- T_3 + B + DAP	52.84	55.13	53.98	2.12	2.26	2.19	8.87	9.97	9.42	14.42	14.93	14.68
T_9- T_3 + Mo + B + DAP	53.86	58.64	56.25	2.20	2.31	2.26	9.93	10.26	10.09	14.45	15.07	14.76
T_{10}- T_3 + Mo + B	43.46	45.12	44.29	1.83	2.01	1.92	8.21	9.12	8.66	13.88	14.19	14.04
T_{11}- T_3 + Mo + DAP	47.39	49.08	48.23	1.85	2.02	1.93	8.24	9.20	8.72	13.93	14.24	14.08
T_{12}- T_4 + Mo	31.71	34.86	33.28	1.39	1.48	1.43	5.25	5.51	5.38	13.29	13.47	13.38
T_{13}- T_4 + B	32.16	34.87	33.51	1.50	1.50	1.50	5.26	5.53	5.39	13.30	13.14	13.22
T_{14}- T_4 + DAP	40.04	41.51	40.78	1.78	2.01	1.89	7.69	8.10	7.90	13.59	14.06	13.83
T_{15}- T_4 + B + DAP	48.67	50.25	49.46	1.90	2.23	2.06	8.26	9.68	8.97	14.11	14.24	14.18
T_{16}- T_4 + Mo + B + DAP	52.25	54.90	53.58	1.95	2.26	2.10	8.46	9.79	9.13	14.36	14.52	14.44
T_{17}- T_4 + Mo + B	33.57	35.99	34.78	1.73	1.74	1.73	6.00	6.48	6.24	13.43	13.62	13.52
T_{18}- T_4 + Mo + DAP	34.84	36.79	35.81	1.74	1.77	1.76	6.75	7.06	6.91	13.42	13.80	13.61
SEm±	1.98	2.62	2.40	0.09	0.09	0.06	0.51	0.48	0.43	0.60	0.70	0.52
CD (P=0.05)	5.69	7.54	6.90	0.26	0.26	0.17	1.47	1.39	1.24	NS	NS	NS

Table 3: Seed and stover yield (kg ha^{-1}) and harvest index (%) at harvest of Chickpea at influenced by basal and foliar application of major and micro nutrients

Treatment	Seed yield (kgha^{-1})			Stover yield (kgha^{-1})				Harvest index (%)	
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
T_1- Control	780	901	840	1193	1136	1164	39.80	44.24	42.02
T_2-20:40:20	1171	1498	1335	1371	1647	1509	46.23	47.57	46.90
T_3- 20:40:20:20	1221	1699	1460	1555	1866	1710	44.11	47.85	45.98
T_4- 20:20:20:20	1145	1593	1369	1378	1745	1562	45.44	47.59	46.51
T_5- T_3 + Mo	1203	1658	1430	1456	1814	1635	45.12	47.70	46.41
T_6- T_3 + B	1265	1737	1501	1698	1950	1824	42.85	47.77	45.31
T_7- T_3 + DAP	1352	1886	1619	1885	2154	2020	41.45	46.68	44.06
T_8- T_3 + B + DAP	1468	1981	1725	1946	2348	2147	42.94	45.61	44.28
T_9- T_3 + Mo + B + DAP	1546	2088	1817	2058	2421	2240	43.26	46.26	44.76
T_{10}- T_3 + Mo + B	1292	1753	1523	1725	2045	1885	43.07	46.12	44.60
T_{11}- T_3 + Mo + DAP	1284	1764	1524	1718	2064	1891	42.85	46.08	44.46

T_{12}- T_4 + Mo	1167	1629	1398	1401	1771	1586	45.57	47.74	46.66
T_{13}- T_4 + B	1181	1635	1408	1428	1790	1609	45.29	47.81	46.55
T_{14}- T_4 + DAP	1262	1700	1481	1562	1927	1745	44.69	46.75	45.72
T_{15}- T_4 + B + DAP	1313	1805	1559	1746	2071	1909	42.97	46.50	44.74
T_{16}- T_4 + Mo + B + DAP	1391	1943	1667	1902	2276	2089	42.18	46.11	44.14
T_{17}- T_4 + Mo + B	1211	1660	1436	1479	1826	1653	45.02	47.54	46.28
T_{18}- T_4 + Mo + DAP	1233	1668	1451	1500	1858	1679	45.25	47.34	46.29
SEm±	81.11	100.81	93.65	102.02	112.57	81.89	2.09	1.97	1.53
CD (P=0.05)	233.27	289.93	269.34	293.42	323.77	235.53	NS	NS	NS

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