Int.J.Curr.Microbiol.App.Sci (2017) *6*(8): 3074-3080

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 8 (2017) pp. 3074-3080**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.608.368

Effect of Foliar and Soil Application of Micro Nutrients and Use of PSB on Productivity and Water Use Efficiency of Chickpea under Rainfed Condition

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Keywords

Chickpea, Foliar application, Water use efficiency, B: C ratio, Basal application.

Article Info

Accepted:
23 June 2017
Available Online:
10 August 2017

A B S T R A C T

A field experiment was conducted during winter (rabi) season of 2012-13 and 2013-14 at Agronomy Research Farm of NDUAT, Faizabad in randomized block design with twelve treatment combination replicated three times. Application of 100 kg DAP ha^{-1} as basal + 2 spraying of 2 % $ZnSO_4$ ha^{-1} at 25 & 45 DAS (T_6) showed marked improvement in different growth and yield of chickpea. Increasing basal application of 100 kg DAP ha^{-1} and two foliar spraying of 2 % Zinc Sulphate ha^{-1} in splits 25 and 45 DAS ha^{-1} (T_6) resulted in highest seed yield (22.72 q ha^{-1}) and straw yield (34.14 q ha^{-1}), consumptive use (124.05 mm) and water use efficiency (25.87 kg/ha mm^{-1}) and net profit (₹ 72461 ha^{-1}) and B: C ratio (3.45).

Introduction

Pulses are the important source of dietary protein and have unique properties of maintaining and restoring soil fertility through biological nitrogen fixation as well as conserving and improving the soil physical properties by virtue of their deep root system and leaf fall. Pulses are grown on nearly 22.99 million hectares of the area with production of 17.58 million tonnes in India (Anonymous 2013). India is the largest producer of chickpea contributing about 65 per cent of world chickpea production. The important chickpea growing states in India are Madhya Pradesh, Rajasthan, Uttar Pradesh, Maharashtra, Karnataka and Haryana. It is mostly cultivated in *rabi* season as its growth is promoted by cool climate and morning dew. In India, chickpea occupies an area of 7.92 million hectares with a production of 7.06 million tonnes (Anonymous, 2013), contributing 34.7 percent to the total area and 48.4 per cent to the total production of pulses in the country. The average productivity of chickpea in India is about 885 kg ha^{-1}. In Uttar Pradesh, chickpea occupies an area of 0.55 million hectares with a production of 0.56 million tonnes, with an average productivity of 1010 kg ha^{-1}. The crop growth and yield performance of chickpea is influenced by a number of factor like soil, climate, manure and fertilizers under intensive system of cultivation is identical as the single most important factor controlling the yield optimization. Since farmyard manure or compost alone cannot supply the entire nutrient requirement of the crop to adequate growth performance throughout the life cycle, the plants often suffer from hidden hunger due to deficiency of major and minor plant nutrients like nitrogen (N), phosphorus (P) and potash (K). Among all the major plant nutrients P plays an important role under rainfed condition, moisture stress, upland condition. Since legume is heavy feeder of phosphorus, therefore, application of phosphatic fertilizer to chickpea promotes the growth, nodulation and the yield. Phosphorus also imparts hardiness to shoot, improves the quality and regulates the photosynthesis and covers other physico- biochemical process. Most of the phosphorus present in the soil is unavailable to plants which are made available through the activities of efficient micro-organism like bacteria, fungi and even cyanobacteria with production of organic acid and increasing phosphatase enzyme activity. Methods of fertilization application are a non-monetary input which influences growth and consequently crop yields. Foliar nutrient is recognized as an important method of fertilizer application, since foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients by the crop (Laha and Nadanassababady, 2003). Therefore keeping these in view an investigation was carried out to study effect of foliar and soil application of micro nutrients and use of PSB on productivity and water use efficiency of chickpea under rainfed condition.

Materials and Methods

The field experiment was conducted at Agronomy research Farm of NDUA&T, Faizabad Uttar Pradesh during the winter (rabi) season of 2012-13 and 2013-14. The soil was silt loam with 8.5 pH 0.32 organic carbon, 0.53 EC, 175.40 kg available N, 15.25 kg available P_2O_5 and 238.0 kg available K_2O ha^{-1} in upper 30 cm soil depth. Twelve treatments combinations comprising Control (T_1), 100 kg DAP as basal (T_2), T_1 + 3 water sprays @ 800 lit. ha^{-1} at 25, 45 and 65 DAS (T_3), 50 kg DAP ha^{-1} as basal + 50 kg DAP as foliar in two splits at 25 & 45 DAS (T_4), 100 kg DAP ha^{-1} as basal + 20 kg $ZnSO_4$ ha^{-1} as basal (T_5), 100 kg DAP ha^{-1} as basal + 2 spraying of 2 % $ZnSO_4$ ha^{-1} at 25 & 45 DAS (T_6), 100 kg DAP ha^{-1} as basal + 40 kg sulphur ha^{-1} as basal (T_7), 100 kg DAP ha^{-1} as basal + 2 spraying of 2 % sulphur as foliar at 25 & 45 DAS (T_8), 100 kg DAP ha^{-1} as basal + 5 kg borax ha^{-1} as basal (T_9), 100 kg DAP ha^{-1} as basal + 2 spraying of 0.5 % Borax ha^{-1} as foliar at 25 & 45 DAS (T_{10}), 50 kg DAP ha^{-1} + PSB (T_{11}), 75 kg DAP ha^{-1} + PSB (T_{12}) were tested in randomized block design (RBD) with three replications. The seeds of chickpea var.PG-186 were sown in plots of 4.5×5.0 m size at a spacing of 45×10 cm in last fortnight of October during both the seasons. The sources of nitrogen, phosphorus, potassium, sulphur and boron were urea, diammonium phosphate, muriate of potash, elemental sulphur and borax, zinc sulphate respectively. All nutrients applied at time of sowing. All recommended cultural practices were adopted to raise the crop. Observation on various growth and yield related attributes were recorded, using standard procedures. The data recorded in respect to different observations were analyzed as per standard statistical procedure. The data thus collected was subjected to analysis of variance using the method proposed by Panse and Sukhatme (1978). The consumptive use of crop was calculated with standard methodology by estimating (cu = Kc × PET). PET was estimated by using Modified Penman method, Doorenbos and Pruitt (1975). The Water Use efficiency was calculated by dividing the grain yield (kg/ha) to cumulative rainfall (mm) from sowing to harvest. WUE (kg/ha mm^{-1}) indicates yield attained by a treatment per millimetre of rain water received during the cropping period.

Results and Discussion

Growth and yield attributes

The various growth and yield attributing characters of chickpea were significantly influenced by treatments. The treatment, T_7 was found superior to other treatments i.e. control, sprayed and unsprayed treatments

(Table1). two spraying of 2% $ZnSO_4$ ha^{-1} at 25 and 45 DAS along with 100 kg DAP ha^{-1} as basal (T_6) appreciably improved growth and yield attributing parameters like plant height, number of pods plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1}, 100 seed weight, seed yield and yield straw. However, harvest index did not show significant variation. Spraying of $ZnSO_4$ at 25 and 45 DAS stage influenced the vigour of the plant through effective absorption of nutrients at critical stages, resulting in enhanced physiological activity and increased dry matter production. Increase in growth and yield attributing characters due to foliar application of $ZnSO_4$ at critical stage could be ascribed to the overall improvement in plant growth, vigour and production of photosynthates owing to increased availability, absorption and translocation of nutrient in plants. Sarkar *et al.*, (1999) and Amanullah *et al.*, (2010) also reported that in growth and yield attributing characters were associated with enhancement of zinc sulphate level in plant due to foliar application of $ZnSO_4$.

Grain and straw yields as influenced by various treatments

The grain and straw yields were significantly influenced by different treatments in both of the years and also when pooled (Table 1). The highest grain yield was recorded by T_6 during individual years 2012-13, 2013-14 and pooled (22.42, 23.01 and 22.72 q ha^{-1}, respectively) which was statistically at par with T_3 and T_4 and significantly superior over the rest of treatments T_1 (control) produced lowest seed yield of chickpea. The straw yield was also significantly influenced by various treatments during 2012-13, 2013-14, similar findings were recorded by Sethi *et al.*, (2016) and in pooled and showed the similar trends as grain yields, similar findings were recorded by Kumar *et al.*, (2015). However, treatment T_6 showed better performance in terms of grain yield, straw yield, WUE and B: C ratio as compared to other. Further monthly rainfall distribution pattern during both the crop season (2012-13 and 2013-14) showed that comparatively higher rainfall was received during January at the time vegetative growth stage, however very limited rainfall was received during sowing and branching stage.

This indicates that higher values of grain yield, straw yield, WUE and B: C ratio in T_6 is due to foliar application of $ZnSO_4$ which contributed significantly in increasing the grain yield and other yield related parameters of the crop under moisture stress condition during critical growth stages (Figure 1) under normal range of temperature for the growth of chickpea (Figure 2). Foliar application Zinc Sulphate produced variation in biomass and grain yield. Zinc Sulphate (2%) when sprayed during 25 and 45 DAS along with 100 kg DAP as basal (T_6) also gave significantly higher number of pods than control treatments in both the years and also in pooled data (Table1). This treatment produced 77.97 numbers of pod plant^{-1} over the rest of treatments. It appears that nutrient supplied through foliar application of $ZnSO_4$ at critical and vegetative stages are effective absorbed by the plants, assimilated and translocated more efficiently to the developing pods for proper filling which reflected in higher values of yield attributes and resulted in higher seed yield.

Table.1 Effect of various treatments on yield and yield attributes of chickpea

Treatments	Number of pod plant^{-1}	Number of seed pod^{-1}	Seed weight plant^{-1} (g)	Test weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Consumptive use (mm)	Water use efficiency (kg/ha mm^{-1})
T_1	63.43	1.35	13.07	12.79	16.29	25.28	39.20	91.18	18.30
T_2	67.60	1.61	16.64	15.27	19.45	30.23	39.15	108.86	22.15
T_3	73.16	1.75	21.09	16.53	21.05	32.05	39.93	117.77	23.97
T_4	76.86	1.86	25.41	17.59	22.40	33.16	40.32	125.35	25.52
T_5	72.47	1.73	20.50	16.36	20.85	31.37	39.84	116.66	23.75
T_6	77.97	1.88	26.52	17.84	22.72	34.14	39.78	127.14	25.88
T_7	71.43	1.71	19.62	16.14	20.55	31.05	39.35	115.00	23.41
T_8	70.56	1.68	18.91	15.94	20.30	30.78	39.74	113.59	23.12
T_9	67.78	1.62	16.76	15.31	19.50	30.15	39.28	109.08	22.21
T_{10}	72.13	1.72	20.20	16.39	20.75	31.19	39.20	116.11	23.63
T_{11}	65.11	1.52	13.86	14.37	18.30	29.11	39.15	102.40	20.84
T_{12}	67.95	1.62	16.89	15.35	19.55	30.13	39.93	109.37	22.27
SEm±	2.58	0.06	0.92	0.53	0.59	0.95	1.40	4.69	0.98
CD at 5%	7.55	0.17	2.70	1.57	1.74	2.78	NS	13.76	2.89

Table.2 Cost of cultivation, gross return, net return and benefit-cost ratio of chickpea

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit : cost ratio
T_1	17866	72273	47904	2.69
T_2	20669	86191	59237	2.87
T_3	21131	93159	65291	3.10
T_4	20900	99066	71124	3.41
T_5	21824	92288	63770	2.93
T_6	21016	100567	72461	3.45
T_7	22769	91037	61607	2.71
T_8	21005	89868	62355	2.97
T_9	20997	86397	59062	2.82
T_{10}	20933	91871	64302	3.08
T_{11}	19724	81175	55477	2.82
T_{12}	20369	86608	59876	2.94

Fig.1 Monthly rainfall during crop season (Oct-Mar) of 2012-13 & 2013-14

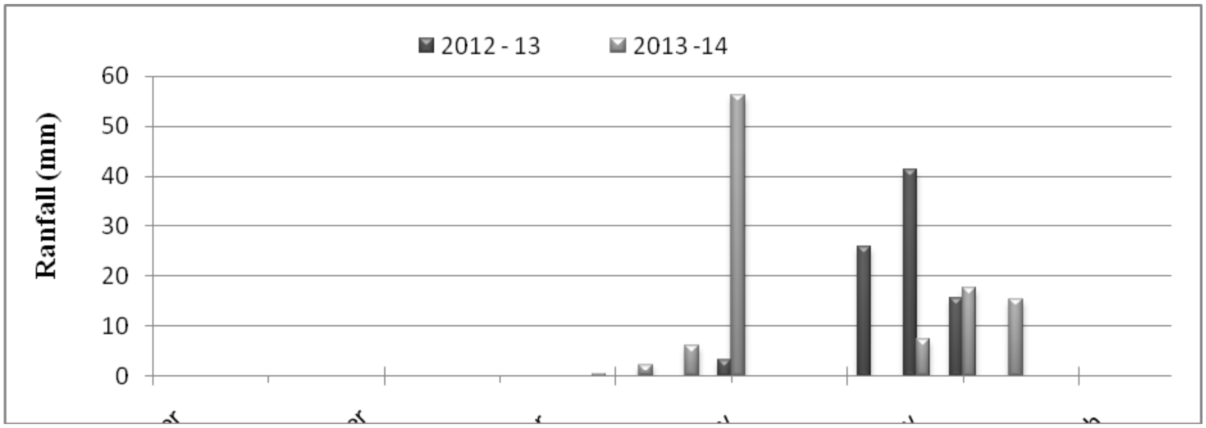
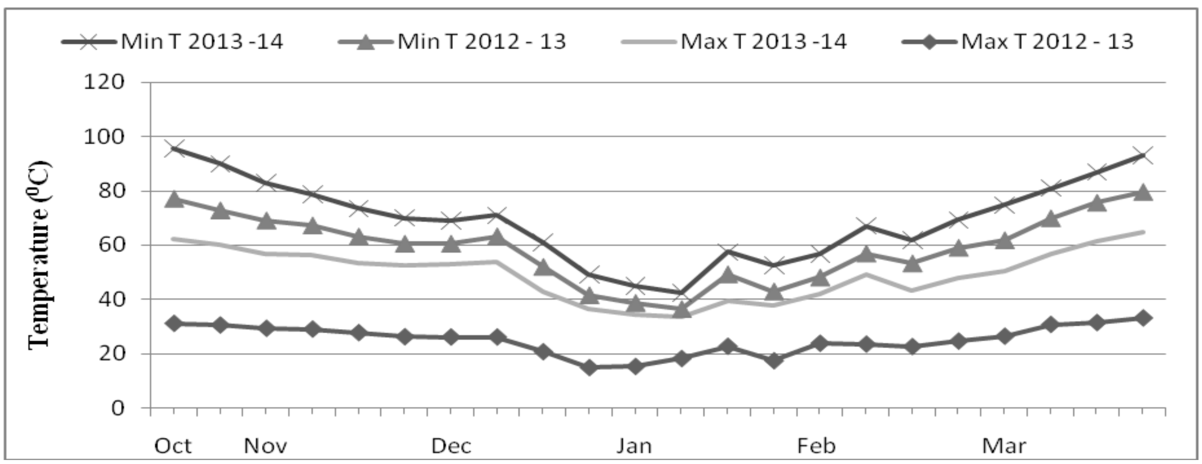


Fig.2 Monthly maximum and minimum temperature (^{0}C) during the crop season (Oct-Mar) 2012-13 & 2013-13



Foliar application $ZnSO_4$ during 25 and 45 DAS also enhances photosynthetic activity in effective leaves and turn supplied the developing pods with current photosynthates and resulted higher yield. Highest straw yield of 34.14 q/ha was also recorded by the treatment T_6. Namvar *et al.*, (2011) reported that P application increase in yield attributes and ultimately seed yield of chickpea. Supplementation of adequate N for crops can increase their growth and development. The increase in seed yield with phosphorus and $ZnSO_4$ application was due to (i) increase in source capacity like plant height, number of branches plant^{-1} and number of leaves plant^{-1} as well as sink capacity like, number of pods plant^{-1}, number of seeds pod^{-1} and test weight (ii) better utilization of photosynthates towards sink due to increase in translocation from source to sink. The result is in conformity with the finding of Singh *et al.*, (2014), Ganga *et al.*, (2014), Pathak *et al.*, (2012), Singh and anubhuti (2011), Kuttimani and Velayutham, (2011) and Singh *et al.*, (2009).

Consumptive use and water use efficiency

It is clear from the data given in Table 1 consumptive use of water was significant affected by various treatments. T_6 treatments (100 kg DAP ha^{-1} as basal + 2 spraying of 2

% $ZnSO_4$ ha^{-1} at 25 & 45 DAS) being at par with T_3, T_4, T_5, T_7 and T_{10} registered significantly higher consumptive use of water over remaining treatments.

The water use efficiency of chickpea was significantly affected by various treatments. T_6 treatments (100 kg DAP ha^{-1} as basal + 2 spraying of 2 % $ZnSO_4$ ha^{-1} at 25 & 45 DAS) being at par with T_3, T_4, T_5, T_7 and T_{10} proved to be significantly superior over remaining treatments. Similar finding were also reported by Upanal *et al.,* (2011).

Economics

Table 2 revealed the position of output and input in term of economics of production. The treatment wise cost of cultivation and their return revealed that the highest net return of ` 73212 was observed in $T_6$ treatment (100 kg DAP $ha^{-1}$ as basal + 2 spraying of 2 % $ZnSO_4$ $ha^{-1}$ at 25 & 45 DAS) gave highest B:C ratio 3.45. However, lowest net return of ` 47904 was obtained in T_1 with returns $`^{-1}$ invested of 2.69 similar trend has also been reported by various workers Kuttimani and Velayutham (2011) and Kumawat *et al.,* (2013).

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How to cite this article:

Pradeep Kumar, Rajeev Kumar, Brij Mohan, Sandeep Kumar Yadav, Shailendra Singh and Bhagwan Singh. 2017. Effect of Foliar and Soil Application of Micro Nutrients and Use of PSB on Productivity and Water Use Efficiency of Chickpea under Rainfed Condition. *Int.J.Curr.Microbiol.App.Sci.* 6(8): 3074-3080. doi: https://doi.org/10.20546/ijcmas.2017.608.368