Effect of Vermicompost and Foliar Spray of Zinc on Soil Properties and Nutrients Uptake by Groundnut (*Arachis hypogaea* L.)

Authors contributions

Author SKD performed study and managed the analysis. Author GKY wrote the protocol and first draft of manuscript.

Abstract

A field experiment was conducted during 2018-19 and 2019-20 to study the effect of vermicompost and foliar spray of zinc on soil properties and nutrients uptake (*Arachis hypogaea* L.) The experiment comprising of 10 treatments *viz*., T_1 (NPK, 15:60:30), T_2 (NPK +VC), T_3 (NPK +VC+ Soil Zn 100%), T_4 (NPK + VC+ Soil Zn 75%), T_5 (NPK + foliar spray of 0.25% $ZnSO_4$), T_6 (NPK + foliar spray of 0.50% ZnSO4), T_7 (NPK + foliar spray of 0.75% $ZnSO_4$), T_8 (NPK + VC + foliar spray of 0.25% $ZnSO_4$), T_9 (NPK + VC + foliar spray of 0.50% $ZnSO_4$) and T_{10} (NPK + VC + foliar spray of 0.75% $ZnSO_4$) were replicated thrice under randomized block design (RBD). The experimental soil was loamy sand in texture, low in available N, high in available P and medium in available K. Groundnut variety, RG 559-3 was tested. The results of the experiment revealed that significantly higher values of soil properties *viz*., Organic carbon (0.56 %), available N (156.59 kg/ha), P_2O_5 (50.39 kg/ha), K_2O (183.14 kg/ha), Zn (0.65 mg/kg) and lower values of pH (7.34), EC (0.22 dSm^{-1}) and nutrient uptake were recorded under the treatment receiving NPK (15:60:30) +VC (5 t ha^{-1}) + Soil Zn 100% (T_3) over control (T_1) while at par with the application of NPK + VC+ Soil Zn 75% (T_4), NPK + VC + foliar spray of 0.25% $ZnSO_4$ (T_8), NPK + VC + foliar spray of 0.50% $ZnSO_4$ (T_9) and NPK + VC + foliar spray of 0.75% $ZnSO_4$ (T_{10}).

Introduction

Groundnut (*Arachis hypogaea* L.) is an annual legume crop and it's native to South America. The groundnut crop is unique among the leguminous crops and it's designated as "Wonder legume". It also has various names such as earthnuts, peanuts, goober peas, pindas, jacknuts, pindars, manilanuts and monkeynuts [1]. Groundnut is also known as poor man's almond.

Groundnut has a useful role in offspring deficiencies as it's a rich source of edible oil and protein, which holds an important position in the Indian diet. Hence, groundnut is known as the king of oilseed crops [2] and an important food legume of tropical as well as subtropical part of the world. Groundnut is one of the most popular and universal crops cultivated in more than 120 countries. The uses of groundnut are diverse; all parts of the plant can be used. Its seed contains high quality of 45-50 percent edible oil, 25-30 percent digestible protein, 20 percent carbohydrates and 5 percent fiber and ash, which make a sustainable contribution to human nutrition [3, 4]. The oil is primarily used for cooking, manufacture of margarine, shortening and soaps. Seeds are consumed directly either raw or roasted, chopped in confectioners or grounded into peanut butter. The young pod may be consumed as vegetables.

The main factors responsible for low yield in groundnut are inadequate and imbalance use of nutrients as well as nutrient deficiencies. Groundnut crop suffers from deficiency of nutrients, especially immobile elements in soil viz; phosphorus and zinc, which are essential for plant growth and pod formation besides N-fixation activity [5].

The use of organic sources is helpful for improving soil aggregation, structure and fertility improving the moisture holding capacity and increasing crop yield [6]. Application of organic manures produced / prepared from various organic wastes can save our environment as a whole [7,8]. The application of organic manures helps in mitigating multiple nutrient deficiencies and at the same time, provides a better environment for growth and development by improving physical, chemical and biological properties of soil [9]. In this context, the use of organic manures such as farmyard manure (FYM), vermicompost (VC), press mud cake (PMC) may supply a sufficient number of micronutrients in available form to crops and improve the quality of the agricultural produces [10]. Due to prohibitive cost of chemical fertilizers, farmers do not apply the recommended doses of nutrients to this energyrich legume crops. Indigenously available organic sources of nutrients have enhanced the efficiency and reduced the requirements of chemical fertilizers [11]. Hence, it is necessary to integrate different sources of nutrients to meet the crop requirement. Sustainable yields in groundnut can be achieved through the conjunctive use of organic and inorganic fertilizers [12]. The efficiency of native micronutrients is further improved when these are used in conjunction with organic manures especially when the soils are belonging to arid and semi-arid areas having light texture, low in organic carbon, low moisture retention and microbial activity. Improvement in available nutrient status of the soil with the incorporation of vermicompost alone or integration with chemical fertilizer could be attributed to the slow decomposition of organic manure and enhancing soil biological activity. These, in turn, provides congenial physical condition, conserves soil nitrogen and increases the availability of other nutrients. Organic manures improve the soil physical, chemical and biological properties and also increase the efficiency of the applied nutrients, especially in light soils [13]. The increasing use of chemical fertilizer, day-by-day is a serious matter of concern and their frequent application is deteriorating bio-physicochemical properties of soil [14]. As a result, soil fertility is being diminished gradually. This in turn is leading to a reduction in crop yield per unit area.

The micronutrients recognized as essential for plants. It is a micronutrient most commonly limiting crop yields in Indian soils. Zinc is transported to plant root surface through diffusion. It aids in the synthesis of plant growth substances and enzyme systems and is essential for promoting certain metabolic reactions. It is necessary for production of chlorophyll and carbohydrates. Iron plays an important role in the synthesis of chlorophyll and also helps in the absorption of other nutrients. As a constituent of chlorophyll, it regulates respiration, photosynthesis, reduction of nitrates and sulphates [3,4]. Thus, the use of organic manure (vermicompost) and supplementation of soil fertility through mineral nutrients is essential not only to harvest higher yields of crops but to maintain the physical, chemical and biological properties of the soil. Therefore, the present study was carried to study the effect of vermicompost and foliar spray of zinc on soil properties and nutrient uptake by groundnut.

Materials and Methods

The experiment was conducted at the research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur (Raj.) during *kharif*, 2018-19 and 2019-20. Geographically, the research farm is located at 75^{0} 47‟ East longitude, at 26^{0} 51‟ North latitude and at altitude of 390 m above mean sea level in Jaipur district of Rajasthan. This region falls under the Agro-climatic zone IIIA (Semi-arid Eastern plain zone) of Rajasthan. The climate of Durgapura is semi-arid characterized by extremes of temperature both in summer and winter, with low rainfall and moderate relative humidity. The average annual rainfall is approximately 500 mm which is mostly received during July to early September; sporadic showers in winters are also not uncommon. The maximum temperature ranges from 28 to 45ºC during May and June, while in December and January, it falls below 5ºC. The evaporation ranges from 1.3-17.5 mm/day. The experiment comprising ten treatments *viz.*,T_1 (NPK, 15:60:30), T_2 (NPK +VC), T_3 (NPK +VC+ Soil Zn 100%), T_4 (NPK + VC+ Soil Zn 75%), T_5 (NPK + foliar spray of 0.25% $ZnSO_4$), T_6 (NPK + foliar spray of 0.50% ZnSO4), T_7 (NPK + foliar spray of 0.75% $ZnSO_4$), T_8 (NPK + VC + foliar spray of 0.25% $ZnSO_4$), T_9 (NPK + VC + foliar spray of 0.50% $ZnSO_4$) and T_{10} (NPK + VC + foliar spray of 0.75% $ZnSO_4$) were evaluated in randomized block design with three replications. The soil of the experimental plot was Loamy sand in texture and slightly alkaline in reaction with pH 7.78, EC 0.22 dSm^{-1} and organic carbon 0.13%. The soil was low in available nitrogen (134.2 kg ha^{-1}), high in available phosphorus (41.0 kg ha^{-1}), medium in potash (169.1 kg ha^{-1}). Groundnut cv. RG 559-3was sown at 30 cm x 10 cm spacing with 100 kg seed ha^{-1}. After crop harvest the soil samples were analyzed for pH and electrical conductivity [15], organic carbon [16], available nitrogen [17], phosphorus [18], potassium [19] and zinc [20]. The N, P, K and Zn contents in plant were estimated as per the procedures [21]. The uptakes of these nutrients were calculated by multiplication of concentrations with the respective yield data.

Results and Discussion

Soil Properties

The data in Table (1) showed that the pH and electrical conductivity of the soil decreased significantly with increasing vermicompost and zinc application in soil. The lowest pH (7.42) and EC (0.16 dSm^{-1}) were recorded with the application of treatment T_3 (NPK +VC+ Soil Zn 100%), whereas minimum under control (T_1). The decrease in pH and EC of soil with the application of vermicompost is due to the fact that the production of organic acid through the decomposition of organic matter and improvement in soil aggregation might have resulted into lowering of soil pH and EC [22, 23]. The maximum organic carban (0.56 %), available nitrogen (156.6 kg ha^{-1}), phosphorus (50.39 kg ha^{-1}), potassium (183.14 kg ha^{-1}) and Zn (0.65 mg kg^{-1}) were observed under treatment T_3 (NPK +VC+ Soil Zn 100%) over the control. It may be ascribed to the beneficial role of vermicompost in mineralization of native as well as its own nutrient content by creating favorable conditions for microbial as well as chemical activities which enhanced the available nutrient pool of the soil. As a matter of fact, all the available nutrients are not taken up by the plant and the rest remains in the soil which improves the available nutrient status of soil after harvest of crop [22, 24].

Uptake of Nutrients

The data presented in Table (2) show that the uptake of N, P, K and Zn in plants, the highest uptake of nitrogen (103.65 kg ha^{-1}), phosphorus (79.6 kg ha^{-1}), potassium (321.1 kg ha^{-1}) and Zn (0.143 mg kg^{-1}) in plant were observed under treatment T_3 (NPK +VC+ Soil Zn 100%), whereas minimum under control (T_1). The positive influence of vermicompost was due to an adequate supply of nutrients in the root zone and plant system. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have synthesized more nutrients and their accumulation in various plant parts. Thus, crop supplied with higher dose of vermicompost had utilized more nutrients as compared to lower doses resulting in increased nitrogen, phosphorus, potassium and sulphur content in plant. The increased uptake of these nutrients seems to be due to the fact that uptake of nutrients is a product of biomass and nutrients content [23, 24]. The increase in content of Zn with the application of vermicompost and zinc might be due to increased availability of native micronutrients cations. This is due to the transformation of their solid phase form to soluble metalo-complexes and the application of micronutrients increased their contents [25].

Conclusion

Based on two-year field experimentation, it can be concluded that treatment T_3 [NPK (15:60:30) +VC (5 t ha^{-1}) + Soil Zn 100%] increased soil organic carbon, available N, P_2O_5, K_2O, Zn and nutrients uptake (N, P, K and Zn) by plants and decreased the values of pH and EC, over the control (T_1). It can be inferred from above study that the application of vermicompost along with NPK and Zn is helpful on improving macro and micro nutrients uptake in groundnut and improves availability of nutrients in the soil.

Table 1. Effect of vermicompost and foliar spray of zinc on soil properties (two years pooled data)

	Soil properties						
Treatments	**pH**	**EC (dSm^{-1})**	**OC (%)**	**N (kg/ha)**	**P (kg/ha)**	**K (kg/ha)**	**Zn (mg/kg)**
T_1-Control (N:P:K, 15:60:30)	7.78	0.98	0.14	134.20	41.00	169.10	0.33
T_2-NPK +VC	7.65	0.66	0.36	142.20	44.30	176.12	0.47

T_3-NPK +VC+ Soil Zn 100%	7.34	0.22	0.56	156.59	50.39	183.14	0.65
T_4-NPK + VC+ Soil Zn 75%	7.55	0.23	0.51	148.40	46.98	180.54	0.61
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	7.60	0.90	0.20	135.40	42.78	170.30	0.37
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	7.69	0.82	0.28	136.80	43.15	169.42	0.40
T_7-NPK + foliar spray of 0.75% $ZnSO_4$	7.71	0.32	0.32	139.60	43.49	170.96	0.43
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	7.36	0.25	0.46	149.80	47.93	174.46	0.63
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	7.42	0.24	0.49	149.20	48.02	179.11	0.62
T_{10}-NPK + VC + foliar spray of 0.75% $ZnSO_4$	7.40	0.26	0.52	152.40	49.98	180.92	0.64
SEm±	0.18	0.014	0.009	2.86	1.30	4.78	0.01
CD (P = 0.05)	0.23	0.04	0.12	8.48	3.85	11.22	0.03
CV	4.10	4.41	4.17	3.44	4.98	4.68	4.66

Table 2. Effect of vermicompost and foliar spray of zinc on nutrients uptake (two years pooled data)

	Nutrients uptake			
Treatments	**N (kg/ha)**	**P (kg/ha)**	**K (kg/ha)**	**Zn (ppm)**
T_1-Control (N:P:K, 15:60:30)	59.69	59.69	234.43	0.07
T_2-NPK +VC	78.95	65.32	274.75	0.10
T_3-NPK +VC+ Soil Zn 100%	103.65	79.60	321.10	0.14

T_4-NPK + VC+ Soil Zn 75%	96.45	76.41	296.15	0.13
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	68.50	61.19	261.35	0.08
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	72.68	63.24	269.35	0.08
T_7-NPK + foliar spray of 0.75% $ZnSO_4$	76.20	64.15	271.21	0.09
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	95.09	73.34	287.68	0.12
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	96.35	74.38	292.16	0.12
T_{10}-NPK + VC + foliar spray of 0.75% $ZnSO_4$	100.25	77.20	294.86	0.13
SEm$\pm$	3.44	2.79	11.74	0.01
CD (P = 0.05)	10.23	8.28	34.88	0.02
CV	7.14	7.06	7.30	7.03

References

1. Annadurai K, Palaniappan SP. Effect of potassium on yield, oil content and nutrient uptake of sunflower. Madras Agricultural Journal. 2009;81(10):568-569.
2. Sathya Priya R, Chinnusamy C, Manickasundaram P, Babu C. A review on weed management in groundnut (*Arachis hypogaea* L.). International Journal of Agricultural Science. 2013;3(1):163-172.
3. Fageria NK, Baligar VC, Jones C. Growth and mineral nutrition of field crop. Second Edition Marcel Dekker Incorporated, New York 1001 K. 1997;494.
4. Joshi SS, Thorve PV, Nagre KT. Effect of rhizobium and nitrogen on the yield and quality of groundnut and soybean. PKV Research Journal. 1989;13(2):152-155.
5. Vishwakarma AK, Pathak KA, Ramakrishna Y. Effect of different sources of nutrient application on productivity, nutrient uptake and economics of groundnut (*Arachis hypogaea* L.) in Kolasib district of Mizoram. Indian Journal of Soil Conservation. 2012;40(2):152-157.

6. Marinari S, Masciandaro G, Ceccanti B, Grego S. Influence of organic and mineral fertilisers on soil biological and physical properties. Bioresource Technology. 2000;72(1):9-17.
7. Doran JW, Zeiss MR. Soil health and sustainability: Managing the biotic component of soil quality. Applied Soil Ecology. 2000;15(1):3-11.
8. Doran JW. Soil health and global sustainability: Translating science into practice. Agriculture, Ecosystems & Environment. 2002;88(2):119-127.
9. Avitoli K, Singh AK, Kanaujia SP, Singh VB. Quality production of kharif onion (*Allium cepa*) in response to biofertilizers inoculated organic manures. Indian Journal of Agricultural Sciences. 2012;82(3):236- 240.
10. Maynard AA. Evaluating the suitability of MSW compost as a soil amendment in field-grown tomatoes. Compost Science & Utilization. 1993;1(2):34-36.
11. Bhat MA, Singh R, Kohli A. Effect of integrated use of farmyard manure and fertilizer nitrogen with and without sulphur on yield and quality of Indian mustard (*Brassica juncea* L.). Journal of the Indian Society of Soil Science. 2007;55(2):224-226.
12. Singh RP, Das SK, Rao VMB, Reddy MN. Towards sustainable dryland agricultural practices. Central Research Institute for Dry Land Agriculture, Hyderabad (A.P.) India. 1990;106.
13. Pandey N, Verma AK, Gopalaswamy A. Effect of organic and inorganic nitrogen combination on rice yield and N uptake. Journal of the Indian Society of Soil Science. 2000;48(2):398-400.
14. Mahajan AN, Bhagat RM, Gupta RD. Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. SAARC Journal of Agriculture. 2008;6(2):29-32.
15. Jackson ML. Soil Chemical Analysis Prentice Hall of India Private Ltd, New Delhi. 1973.
16. Walkley A, Black IA. Rapid titration method of organic carbon of soils. Soil Science. 1934; 37:29-33.
17. Subbiah BV, Asija GL. A rapid procedure for the estimation of available N in soils. Current Science. 1956; 25:259-260.

18. Olsen SR, Cole RV, Watanabe FS, Lean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circular. 1954;939.
19. Metson AJ. Methods of chemical analysis of soil survey samples. Bull. No. 2, Department of Scientific and Industrial Research. 1956;12.
20. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Proceeding. 1978; 42:421-428.
21. Prasad R, Shivay YS, Kumar D, Sharma SN. Learning by doing exercises in soil fertility–A practical manual for soil fertility. Division of Agronomy, IARI, New Delhi. 2006; 68.
22. Sharma P, Majumdar SP, Sharma SR. Impact of vermicompost, potassium and iron on physico-chemical properties of *Typic* Ustipsamment. Environment and Ecology. 2013; 31:1980-1983.
23. Kansotia BC, Sharma Y, Meena RS. Effect of vermicompost and inorganic fertilizers on soil properties and yield of Indian mustard (*Brassica juncea* L.). Journal of Oilseed Brassica. 2015; 6(1): 198-201.
24. Jat G, Sharma KK, Jat NK. Effect of FYM and mineral nutrients on physiochemical properties of soil under mustard in western arid zone of India. Annals of Plant and Soil Research. 2012; 14(2):167-170.
25. Samant TK. Effect of mulching and nutrient management practices on growth, yield, nutrient uptake of Indian mustard (*Brassica juncea* L.) and soil moisture content, International Journal of Current Research Limited, New Delhi. 2015.