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Effect of Vermicompost and Foliar Spray of Zinc on Growth, Quality and Productivity of Groundnut (*Arachis hypogaea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SKD and AS designed the study. Author SKD performed the statistical analysis and managed the analysis of the study. Author GKY wrote the protocol and wrote the first draft of the manuscript. Author CK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2018-19 and 2019-20 to study the effect of vermicompost and foliar spray of zinc on growth, quality and productivity of groundnut (*Arachis hypogaea* L.) The experiment comprising of ten treatments *viz*., T_1 (NPK), 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% $ZnSO_4$), 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 and evaluated in the randomized block design (RBD). The experimental soil was loamy sand in texture, low in N, high in available P and medium in K. Groundnut variety, RG 559-3 was tested. The results of the experiment revealed that significantly higher values of growth parameters viz., plant height and number of root nodules plant^{-1}; yield viz.,

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pod yield (44.3, 47.2 q ha^{-1}) and haulm yield (54.03, 58.8 q ha^{-1}); quality parameters viz., oil content and protein content 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}).

Keywords: Groundnut; vermicompost (VC); zinc.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume crop and it's native from South America. The groundnut crop is unique among the leguminous crops and it's designated as "Wonder legume". This is also known as 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 Indian diet. Hence, groundnut is known as the king of oilseed crops [2] and 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 per cent 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]. 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 plant nutrients which play more important role in the nutrition of groundnut crop are nitrogen, phosphorus and potassium. The amount of N fixed by root nodules and N content of soil determines rate of nitrogen to be supplied through different sources. As groundnut is a legume crop it has ability to fix the free atmospheric nitrogen in root nodules of *Rhizobium* spp. Inoculants have a favorable effect on legume like groundnut [4]. Phosphorus plays important role in flowering, pod formation stages, shelling percentage, oil content and root nodulation. Groundnut removes fairly large quantities of nutrients from the soil. The average nutrient removal by groundnut crop per tonne yield under field conditions are 58.1 kg N, 19.6 kg P_2O_5 and 30.1 kg K_2O. A balanced application of N:P: K fertilizers in the ratio 1:1.5:1 is observed to be better than single nutrients application. 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 is 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, use of organic manures such as farm yard 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 energy-rich 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 soils of arid region are characterized with low organic matter content and deficient in zinc. Zinc functions in plants are largely associated with activity. It plays as an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which produces more plant cells and more dry matter which in turn will increase seed yield. Several studies have demonstrated that application of vermicompost and foliar spray of zinc showed good behavior in increasing their growth and yield. Therefore, an experiment on effect of vermicompost and foliar spray of zinc on growth, quality and productivity of groundnut (*Arachis hypogaea* l.) has been undertaken.

2. MATERIALS AND METHODS

The experiment was conducted at research farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (Raj.) during *kharif*, 2018-19 and 2019-20. Geographically, this place is situated 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, 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% $ZnSO_4$), T_7 (NPK + foliar spray of 0.75% $ZnSO_4$), T_8 (NPK + VC + foliar spray of 0.25% $ZnSO_4$), T_9 (T9-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 potash (169.1 kg ha^{-1}). Groundnut cv. RG 559-3was sown at 30cm x10 cm spacing with 100 kg seed ha^{-1}. For determination of oil content (%) in the kernel, determined by using a Soxhlet apparatus [15] and protein content in the kernel was analyzed by indirect method. First, the percent nitrogen content of the sample was estimated by the microkjeldahl method [16]. Then the nitrogen value was multiplied by a factor 6.25 to get the protein content of the sample and expressed in percentage [17]. Regularly biometric observations were recorded at specific time intervals by selecting randomly five plants in each treatment. Finally, the crop was harvested and produce was dried, threshed, cleaned and weighed. The yield data were subjected to statistical analysis.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Growth parameters of groundnut viz., plant height at harvest and the number of root nodules/plant at harvest was significantly influenced by different treatments. The data presented in Table 1 reveals that vermicompost and zinc application increased the plant height and number of root nodules/plant during the year 2018-19 and 2019-20. Maximum plant height 23.53, 24.60 cm and number of root nodules/plant 81.50, 82.96 were recorded with the application of treatment T_3 (NPK +VC+ Soil Zn 100%) during 2018-19 and 2019-20, respectively. The effect of the treatments, T_4 (NPK + VC+ Soil Zn 75%), 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% $ZnSO_4$) on plant height and number of nodules/plants were found at par with each other. The application of vermicompost and zinc showed the highest plant height and number of root nodules/plant, it might have accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amounts of plant nutrients and ultimately increased the plant height. Similar results were also found by Thirunavukkarasu and Vinoth [18]. Similarly, Arancon et al. [19] also reported that the enhancement of growth might be attributed to the role of vermicompost in greater the nutrient availability and increase in beneficial enzymatic activities, increased population of beneficial microorganisms or the presence of biologically active plant growth influencing substances such as plant growth regulators or plant hormones in the vermicompost and humic acids. The findings are close to findings of Patil et al. [20], Rahevar et al. [21] and Sengupta et al. [22].

3.2 Quality Attributes

The data presented in Table 2 reveal that vermicompost and zinc application affected the oil content and protein content during the year 2018-19 and 2019-20. The treatment T_3 (NPK +VC+ Soil Zn 100%) resulted in production of maximum oil content, 51.92 and 52.28 percent and protein content 24.06 and 24.36 percent during 2018-19 and 2019-20, respectively. The effect of the treatments, T_4 (NPK + VC+ Soil Zn 75%), 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% $ZnSO_4$) on oil content and protein content were found at par with each other. The increased oil and protein content might be ascribed to the role of nitrogen and sulphur as these two are integral parts of protein and phosphorus is the structural element of certain co-enzymes involved in biosynthesis of oil and storage organs, which are proteinaceous in nature. These findings are in close conformity with those reported by Ola et al. [23] and Madhu Bala and Kedar Nath [24].

3.3 Yield and Economics

The data presented in Table 3 reveal that vermicompost and zinc application affected the pod yield and haulm yield during the year 2018-19 and 2019-20. The treatment T_3 (NPK +VC+ Soil Zn 100%) showed a maximum pod yield 44.3 and 47.2 q ha^{-1} and haulm yield 54.3 and 58.8 q ha^{-1} in 2018-19 and 2019-20, respectively. The effect of the treatments, T_4 (NPK + VC+ Soil Zn 75%), 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% $ZnSO_4$) on pod yield and haulm yield were found at par with each other.Increased values in these yield attributes might have been on account of the overall improvement in vegetative growth and nodulation which favorably influenced the flowering and fruiting and ultimately resulted into increased number of matured pods and pod weight per plant. These findings are in agreement with the results obtained by Chaudhary et al [25], Madhu Bala and Kedar Nath [24] and Rahevar et al. [21]. The data presented in Table 4 reveal that the highest net returns from groundnut (Rs.145027.3 ha^{-1}) was obtained in T_3 (NPK +VC+ Soil Zn 100%). However, the higher B:C ratio (2.97) of groundnut was recorded in T_1 (NPK).

Table 1. Effect of vermicompost and foliar spray of zinc on plant height and number of root nodules/plant of groundnut

Treatment	Plant height (cm)		Number of root nodules/plant	
	2018-19	2019-20	2018-19	2019-20
T_1-NPK (15:60:30)	15.18	15.25	69.55	70.10
T_2-NPK +VC	17.13	17.30	72.33	72.80
T_3-NPK +VC+ Soil Zn 100%	23.53	24.60	81.50	82.96
T_4-NPK + VC+ Soil Zn 75%	21.90	22.00	80.90	81.13
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	16.07	16.25	71.10	71.67
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	17.56	17.60	73.20	73.46
T_7-NPK + foliar spray of 0.75% ZnSO4	18.20	18.35	73.69	74.35
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	21.48	21.68	78.90	79.29
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	21.85	22.16	80.77	80.94
T_{10}-NPK + VC + foliar spray of 0.75% ZnSO4	22.10	22.25	80.69	81.14
S. Em$\pm$	0.74	0.79	2.65	2.68
CD(P=0.05)	2.18	2.46	7.78	7.84
CV (%)	6.40	6.57	5.84	5.87

Table 2. Effect of vermicompost and foliar spray of zinc on quality of oil content and protein content of groundnut

Treatment	Oil content (%)		Protein content (%)	
	2018-19	2019-20	2018-19	2019-20
T_1-NPK (15:60:30)	46.33	46.79	**20.13**	20.29
T_2-NPK +VC	47.26	47.78	20.06	20.13
T_3-NPK +VC+ Soil Zn 100%	51.92	52.28	24.06	24.36
T_4-NPK + VC+ Soil Zn 75%	50.82	50.96	23.47	23.89
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	46.57	46.69	20.39	20.78
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	46.76	46.93	20.59	20.93
T_7-NPK + foliar spray of 0.75% $ZnSO_4$	46.88	48.01	20.78	20.97
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	48.13	48.39	22.40	22.77
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	48.96	49.24	22.89	23.07
T_{10}-NPK + VC + foliar spray of 0.75% $ZnSO_4$	49.46	49.83	23.18	23.39
S. Em±	0.96	1.08	0.93	0.96
CD(P=0.05)	3.81	4.17	3.13	3.24
CV (%)	3.18	3.25	6.97	7.11

Table 3. Effect of vermicompost and foliar spray of zinc on pod yield and haulm yield of groundnut

Treatment	Pod yield (q ha^{-1})		Haulm yield(q ha^{-1})	
	2018-19	2019-20	2018-19	2019-20
T_1-NPK (15:60:30)	37.0	38.5	44.6	46.8
T_2-NPK +VC	39.6	41.3	47.2	50.0
T_3-NPK +VC+ Soil Zn 100%	44.3	47.2	54.3	58.8
T_4-NPK + VC+ Soil Zn 75%	41.3	44.1	49.4	52.9
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	38.1	39.8	45.3	48.0
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	38.7	40.3	46.4	49.2
T_7-NPK + foliar spray of 0.75% $ZnSO_4$	39.2	40.8	47.1	49.9
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	42.1	43.9	48.7	52.3
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	42.5	44.8	49.7	53.7
T_{10}-NPK + VC + foliar spray of 0.75% $ZnSO_4$	43.8	46.1	52.2	55.9
S. Em±	1.48	1.90	1.90	2.23
CD(P=0.05)	4.35	5.60	5.57	6.56
CV (%)	6.32	7.74	6.79	7.49

Table 4. Effect of vermicompost and foliar spray of zinc on economics of groundnut

Treatments	Economics (Rs/ha)			
	Cost of cultivation	Gross Return	Net Return	BCR
T_1-NPK (15:60:30)	42782	169738.2	126956.2	2.97
T_2-NPK +VC	58782	182034.1	123252.1	2.10
T_3-NPK +VC+ Soil Zn 100%	60832	205859.3	145027.3	2.38
T_4-NPK + VC+ Soil Zn 75%	60545	192213.8	131668.8	2.17
T_5-NPK + foliar spray of 0.25% $ZnSO_4$	45335	175239.9	129904.9	2.87
T_6-NPK + foliar spray of 0.50% $ZnSO_4$	45389	177649.6	132260.6	2.91
T_7-NPK + foliar spray of 0.75% $ZnSO_4$	45440	180068.6	134628.6	2.96
T_8-NPK + VC + foliar spray of 0.25% $ZnSO_4$	60335	193634.9	133299.9	2.21
T_9-NPK + VC + foliar spray of 0.50% $ZnSO_4$	60389	196400.6	136011.6	2.25
T_{10}-NPK + VC + foliar spray of 0.75% $ZnSO_4$	60440	202310.6	141870.6	2.35

4. CONCLUSION

Based on two-year field experimentation, it can be concluded that significantly higher growth, yield, quality and economics of groundnut can be obtained by the application of 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}). The highest net returns (Rs.145027.3 ha^{-1}) was obtained in T_3 (NPK +VC+ Soil Zn 100%). However, the higher B:C ratio (2.97) of was recorded in T_1 (NPK).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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