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Research Article

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Integrated Effect of Organic Amendments and Chemical Fertilizers on yield of Groundnut and Soil Health Under Rainfed Condition

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Abstract

Although inorganic fertilizers increase the growth of crops, but their toxicity is the main concern due to their over utilization. To tackle this problem, the integrated application of organic amendment especially vermicompost, with NPK fertilizers would be a good choice. For this, the integrated effect of organic amendments including vermicompost (VC) and phosphorus solubilizing bacteria (PSB), and chemical fertilizers (NPK) on yield of groundnut and soil health, a field trial was done at the research area of Barani Agricultural Research Institute (BARI), Chakwal. The experiment was done with eight treatments in randomized complete block factorial design replicated thrice. The experimental data revealed that the treatment T_8: Recommended dose of fertilizers (RDF) (NPK 20:80:60 Kg ha^{-1}) + VC @ 4t ha^{-1} + PSB had superior effect on plant height (54.76.23%), number of plants per m^2 (22.25%), number of pods per plant (61.90%), pod yield (83.25%) and haulem yield (86.02%) as compared to control. Similarly, a higher benefit cost ratio (BCR) was observed in T8 than rest of the treatments and control. Soil fertility indicators (OM, NO_3-N, P and K) were improved, indicating the improvement in soil health with the combine application of VC, PSB and RDF. A combination of organic amendment, bio fertilizer, and inorganic fertilizer is necessary to optimize groundnut growth and yield attributes, as well as soil health.

Keywords: Economic analysis, Groundnut yield, NPK, Soil fertility, Vermicompost

Introduction

Groundnut (Arachis hypogaea L.) is the 3rd major oil seed crop and is grown in around 37 million acres worldwide (Mahantesh, Babu, Ghanti, & Raddy, 2018). It is a good source of macromolecules and helps to meet protein requirements, particularly in developing countries (Eapen, 2003). Groundnut seeds are rcih fat (40-50%), protein (20-50%), and carbohydrate (10-20%), as well as a few important minerals and vitamins (Okello, Biruma, & Deom, 2010). Peanuts grow best in semi-arid habitats with little rainfall (Hamidou, Halilou, & Vadez, 2013); sandy and sandy loam soils with low fertility and water retention capacity (Mohsen & Abdel-Fattah, 2015); low soil organic matter (Samuel, 2013), and thus low fertilizer efficiency. Nutrient management is an important step for the long-term sustainable production of the crops. Utilizing nutrients for agricultural production is crucial to increase crop production (Zhang *et al.*, 2020) but frequent use of inorganic fertilizers harms the soil and pollution of the environment (Krasilnikov, Taboada, & Amanullah, 2022). Inorganic fertilizers are utilized excessively to raise crop yields, cause environmental problems for instance soil salinity, greenhouse effect, water eutrophication, and accumulation of heavy metals and nitrate (Savci, 2012). These problems can be avoided with the use of organic fertilizers (biofertilizers, vermicompost and green manure), which ensures nourishment of the soil as well as environment, hence can be regarded as sustainable method for the production of crops (Bisht & Chauhan, 2020). Organic fertilizer application can also improve

soil nutrients availability, improve the fertilizers efficacy (Swarup, 2010), encourage the proliferation of different groups of soil microbes, and play a vital role in soil conservation (Chaudhary, Singh, & Jha, 2011). The use of earthworms in the composting process is known as vermicomposting. Vermicompost application caused a substantial increase in yield of legumes and other plants (Daniel, Dhar, & Desai, 2005). Vermicomposting is a new eco-friendly and cost-effective process that influences soil pH, microbial population, and enzyme activity. Earthworms not only boost soil fertility but also enhnces crop yield through excreting beneficial soil microbes and releasing polysaccharides, and other nitrogenous substances into the soil (Rekha, Valivittan, & Kaleena, 2013). Vermicompost and chemical fertilizers are used together to preserve yield stability. This increases the efficacy of associated nutrients, corrects minor nutrient shortages, and ensures favorable conditions for soil (Gill & Walia, 2014). The application of organic manures in conjunction with bio-fertilizers is widely advocated for increasing biological, physico-chemical properties of soil and attaining high agricultural production (Mahrous, Safina, Abo Taleb, & El-Behlak, 2015). Although many studies are available on individual application of inorganic and organic fertilizer for groundnut production, however little research is available on the combine application of vermicompost with inorganic fertilizer for groundnut production in rainfed conditions. Therefore, this study attempted to evaluate vermicompost (enriched with microbial consortia) and RDF by investigating its effect on the growth and production of kharif groundnut under sandy loam soil conditions in rainfed conditions. In addition, to assess their impact on soil health and economics.

Materials and Methods

In 2021, a field study was done at experimental area of Barani Agricultural Research Institute, Chakwal (32º55'33"N, 72 º43'30"E) to evaluate the combined impact of vermicompost and chemical fertilization on groundnut (BARI-16) growth and yield. There were 3×8= 24 treatment combinations. The treatments were laid out in randomized complete block design (RCBD) in a factorial arrangement with three replications and their details were as T_1: Control where fertilizer, vermicompost (VC) and PSB were applied, T_2: Recommended dose of fertilizers (RDF) of NPK (urea, single super phosphate, potassium sulphate) (20:80:60) in kg ha^{-1} was applied (Barani Agricultural Research Institute, Chakwal), T_3: Vermicompost (VC) @ 4t ha^1, T_4: Phosphorus Solubilizing Bacteria (PSB) @ 500g/40 kg seed, T_5: RDF + VC @ 4t ha^{-1}, T_6: RDF + PSB, T_7: VC @ 4t ha^{-1} + PSB and T_8: RDF + VC @ 4t ha^{-1} + PSB. During 2021, mean minimum and maximum rainfall was 15 mm and 201 mm, and temperature was 19 ºC and 38 ºC (Fig. 1). Soil sampling was done before sowing at the depths of 0-15 cm and 15-30 cm by means of soil sampler and analyzed according to standard procedures (Table 1). The mineral content of well-prepared vermicompost obtained from the vermiculture unit at BARI, Chakwal is shown in Table 2. To assess the effectiveness in the rainfed conditions of Chakwal, PSB inoculants were obtained from the Land Resources Research Institute, NARC Islamabad. The land was prepared by ploughed, followed by three cultivations and sowing. Groundnut (GN) seed rate was 175 Kg pods ha^{-1} and it was inoculated with PSB prior to sowing. RDF of NPK and vermicompost were applied at the time of sowing (5th April 2021). Monitoring of crop was done regularly and cultural practices such as hoeing and weeding pest control were ensured when needed. The single drill method was used for crop sowing by keeping row to row distance as 22.8cm with plot size of 3m x10m. Harvesting was done on 25th September 2021 and agronomic data on number of plants per m^2, average pod yield (Kg ha^{-1}), plant height (cm) with meter rod, number of pods per plant, 100 kernal weight (g), haulem (Kg ha^{-1}), thousand grain weight (g), and final yield (Kg ha^{-1}) with weighing balance was measured and subjected to statistical analysis of variance (Statistixs 8.1 software) to establish the significant means of values following Steel et al. (1997). The BCR was also calculated for every treatment using the formula given below.

$$B:C = \frac{Total\ Income\ (Rs.)}{Cost\ of\ Production\ (Rs)}$$

Table 1: Soil analysis before sowing

Parameters	Values	References
pH	7.6	(Salinity)
EC	0.78 dSm^{-1}	(Salinity)
Organic matter	0.31%	(Walkley, 1947)
Available N	3 mg kg^{-1}	(Bremner *et al.*, 1965)
Available P	2.5 mg kg^{-1}	(Olsen *et al.*, 1954)
Available K	110 mg kg^{-1}	(Salinity)
Soil texture	Sandy loam	(Salinity)
Moisture contents	3% and 7.2% in 0-6 inch and 6-12 inch	(US Salinity lab staff, 1954)

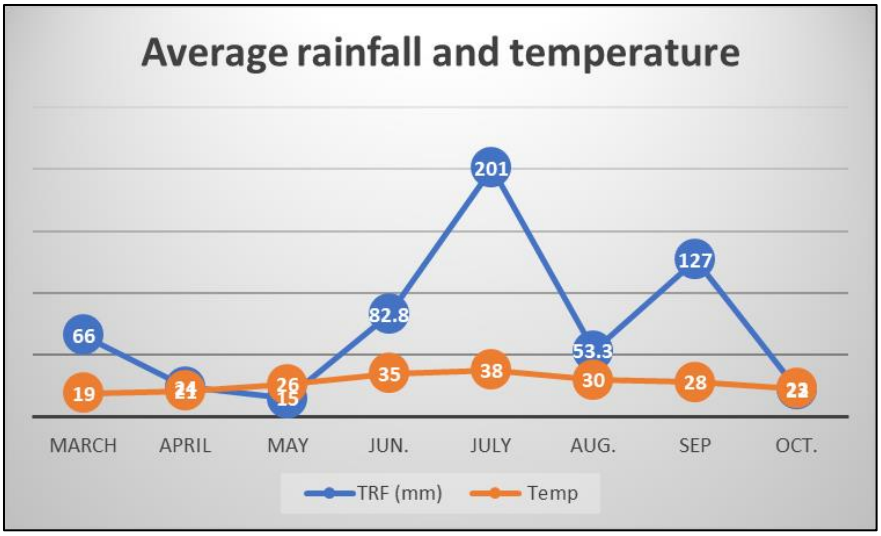

Fig. 1: Rainfall and temperature in BARI, Chakwal

Table 2: Vermicompost chemical composition

Parameters	Units	Quantity
Organic carbon	%	18
Organic matter	%	23
Nitrogen	%	0.7
Phosphorus	%	0.3
Potassium	%	1.8
Calcium	%	0.2
Magnesium	mg kg^{-1}	480
Zinc	mg kg^{-1}	150
Copper	mg kg^{-1}	45
Iron	mg kg^{-1}	2300
CN ratio		26
pH		6.8
Moisture	%	27

Results and discussion

Treatments effect on growth and yield attributes of GN: Growth: The combined use of RDF, VC, and BF had a considerable influence on plant height. As indicated in Table 4, the treatment T8 (RDF+VC+BF) witnessed the tallest plant height (42 cm). The other treatments (T2, T3, T4, T5, T6 and T7) also showed greater impact on plant height as compared to control (T1) with plant height 23 cm. The tallest plant height in T8 could be attributed to the collective effects of integrated application of inorganic fertilizers and VC on plant height (Bekele, Dechassa, Tana, & Sharma, 2019). The treatment T8 likewise had the highest number of plants per m^2 (12). It was followed by T6 and T5 (11.33 and 10.76, respectively). However, minimum number of plants per m^2 were observed in the control. Similarly, T8 (RDF+VC+BF) produced the most pods per plant (84) than the other treatments and control, which could be because of the beneficial effect of vermicompost which ensured availability of nutrient throughout the growing season (Murugan, Kumaravel, & Akila, 2020). A higher pod yield of mung bean due to collective effect of organic and inorganic fertilizers was also witnessed by Armin *et al.* (2016). RDF, VC, and BF treatments enhanced groundnut 100 kernel weight. The maximum 100 kernal weight (100 g) was obtained with application of T8 (RDF+VC+BF). It was followed by T6 and T5 with100 kernal weight as 56 and 55 g. The minimum kernel weight of 100 was recorded in control (Table 4). The best performance of treatment T8 (RDF+VC+BF) in terms of groundnut growth parameters could be to constant accessibility of nutrients and growth promoting effect of vermicompost, which ultimately results in increased photosynthetic activities, metabolic process and improvement of soil structure (Murugan *et al.*, 2020). The findings match with those of Chaudhary *et al.* (2011) and Yagoub, Ahmed, and Mariod (2012), who reported improved growth of groundnut, green gram, and soyabean, respectively, due to mixing of organic and inorganic fertilizers.

Yield: The highest pod yield (1630 kg ha^{-1}) was observed in treatment which received RDF+VC+BF (T8). It was followed by T6, where pod yield 1282 kg ha^{-1} was recorded. The control treatment showed the least pod

yield (273 kg ha^{-1}), which indicates that for sustainability of yields, integrated use of organic and inorganic fertilizers are essential (Parvathi *et al.,* 2013). Sowmya and Ganapathy (2021) reported that organic fertilizer in combination with NPK improved the soil environment, encouraging a proliferous root structure, causing enhanced absorption of nutrients and water from lower soil layers and higher pod output. Similarly, treatment T8 (RDF+VC+BF) had the highest haulem (kg ha^{-1}) of the treatments. The maximum haulem was 2933 kg ha^{-1} in T8 (RDF+VC+BF), whereas the minimum was 410 kg ha^{-1} in control. The findings are consistent with Tiwari, Dwivedi, and Dikshit (2002), who found that using organic fertilizer increased groundnut output much more than using only inorganic fertilizer. According to Akbari et al. (2011), the usage of biofertilizers and organic fertilizers increased groundnut output.

Table 4. Effect of treatments on growth and yield attributes of GN

Treatments	Plant height (cm)	No. of Plants per m^2	No. of pods per plant	100 kernal weight (g)	Pod yield (kg ha^{-1})	Haulem (kg ha^{-1})
T1	23 d	9.33 d	32 f	40 e	273 f	410 f
T2	37 abc	10.33 c	65 cd	53 bcd	1071 c	1927 c
T3	32 c	10 cd	50 e	50 d	548 e	987 e
T4	33 bc	10.33 c	58 de	53 bcd	631 de	1132 de
T5	36 abc	10.67 bc	69 bc	55 abc	1194 bc	2150 bc
T6	38 ab	11.33 ab	77 ab	56 ab	1282 b	2307 b
T7	33 bc	9.33 d	61 cd	51 cd	753 d	1356 d
T8	42 a	12 a	84 a	58 a	1630 a	2933 a
CV	10.31	5.08	8.08	4.55	10.51	11
SE	2.87	0.432	4	1.89	79	142

Effect of organic amendments and inorganic fertilizers on soil properties: Soil fertility improved when organic source fertilizers were administered, according to post-harvest soil analysis (Table 5). The application of VC at 4t ha^{-1} and microbial inoculant in conjunction with RF considerably enhanced OM, accessible N, P, and K in soil compared to the control. Except for the control treatment, all treatments that used organic amendments and inorganic fertilizers improved the soil fertility. The positive response to combine application of organic manures might be attributed to the better nutrient availability and its favorable effect on soil physical and biological properties resulting in increased yield attributes and finally higher yields (Patra, Sinha, & Mahesh, 2011). Choudhary, Jat, Sharma, and Singh (2011) reported that use of vermicpmost helps in maintaining soil fertility and practices of precious eco-friendly environment of the soil. Previous investigations of Arsaln *et al.* (2020) and Pandey, Dwivedi, and Pandey (2009) showed an improvement in soil fertility when organic amendments were administered alongside chemical fertilizers in wheat

Table 5: Effect of treatments on soil fertility

Treatments	OM %	NO_3-N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})
T1	0.21	3	3	95
T2	0.30	8.3	5.7	115
T3	0.5	12	8.3	118
T4	0.27	7	5.8	102
T5	0.52	13	8.7	115
T6	0.42	7	7.9	110
T7	0.54	8	9.9	122
T8	0.65	15	10	124

Economics of treatments: Economic study is the only tool that makes farmers to choose crops for cultivation (Khan, Awan, & Zafar, 2009). Consequently, economic exploration of agroecosystems is essential for good management. T8 yielded the highest BCR, as seen in Table 6. This was related to the treatment T8's greater groundnut pod and haulm production. However, the control had the lowest BCR, which could be attributed to the decreased pod and haulm production of groundnut in this treatment. According to data, integrated applications of RDF and organic amendments create higher revenue, making them an excellent fit for rainfed areas. In a study by Arsaln *et al.* (2020), a greater BCR was reported with the combine application of vermicompost with NPK for wheat crop

Table 6: Economic analysis of treatments

	Input Cost (Rs/ha)					Output Cost (Rs/ha)				
Treatments	Cost of Seed	Fertilizer /VC/BF	Cost of Chemical	Harvest /Thresh cost	Total Input Cost	Value of Straw	Value of Pod Yield	Total output value	Net Return	BCR
T1	45000	0	8000	30000	83000	5130	82000	87130	4130	0.05
T2	45000	30000	8000	33750	116750	10710	171400	182110	65360	0.56
T3	45000	15000	8000	30000	98000	5180	115200	120380	22380	0.23
T4	45000	7000	8000	30000	90000	7400	123400	130800	40800	0.45
T5	45000	45000	8000	33750	131750	10640	177400	188040	56290	0.43
T6	45000	37000	8000	33750	123750	9590	225600	235190	111440	0.90
T7	45000	22000	8000	33750	108750	9230	147600	156830	48080	0.44
T8	45000	52000	8000	33750	138750	17060	299400	280000	141250	1.02

Recommendations/conclusion: The present study witnessed a substantial impact of the combined application of vermicompost and inorganic fertilizers on groundnut in rainfed conditions. The T8 treatment (RDF + VC @ 4t ha^{-1} + PSB) showed enhanced groundnut growth, yield and BCR than control and other treatments. The soil health of post-harvest soil was modestly improved by combining vermicompost with inorganic fertilizers. From results it is can be inferred that the integrated application of organic amendments with RDF would cause reduction in the use of inorganic fertilizer and improve plant growth and soil fertility. Hence it can be recommended that organic amendments with RDF is a superior choice for enhancing groundnut production in Pakistan's barani area.

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