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RESEARCH ARTICLE

VERMICOMPOST WITH CHEMICAL FERTILIZERS IMPACT ON GROUNDNUT YIELD AND SOIL FERTILITY IN CHARLAND

M Yasmin*[a], M.S Rahman[b], M.A Rahman[a], F.S Shikha[a]

[a] Soil Science Division, Bangladesh Agricultural Research Institute, Jamalpur-2000, Bangladesh.
[b] Tuber Crop Research Centre, Bangladesh Agricultural Research Institute, Jamalpur-2000, Bangladesh.
**Corresponding Author Email: monirayasmin86@yahoo.com*

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ABSTRACT

A field experiment was conducted on the growth of groundnuts in a farmers' field in Nouvanger Char, Jamalpur, Bangladesh by combining vermicompost with chemical fertilizer during the rabi season of 2020-2021 and 2021-2022. The goals were to increase groundnut yield, to boost soil fertility and to improve the stock of organic carbon in soil. A randomized complete block design (RCBD) with three replications was employed to set up the experiment and the test crop was BARI Chinabadam-9.There were seven different treatments: T_1 was100 % RDCF (control), T_2 was 100 % RDCF + vermicompost @ 1 t ha^{-1}, T_3 was 100 % RDCF + vermicompost @ 3 t ha^{-1}, T_4 was 85% RDCF + vermicompost @ 1 t ha^{-1}, T_5 was 85% RDCF + vermicompost @ 3 t ha^{-1}, T_6 was 70% RDCF + vermicompost @ 1 t ha^{-1} and T_7 was 70% RDCF + vermicompost @ 3 t ha^{-1}. According to two years' worth of average data, the combined use of vermicompost and chemical fertilizer boosted groundnut output and BCR compared to the solitary application of chemical fertilizers. T_5 treatment (85% RDCF + VC @ 3 t ha^{-1}) provided the highest average groundnut yield (2.16 t ha^{-1}) out of all the treatments, which was 19.33% greater than 100% RDCF dose. On the other side, groundnut yield gradually dropped as chemical fertilizers were reduced. The T_6 treatment (70% RD + vermicompost @ 1 t ha^{-1}) had the lowest average ground nut yield which was 1.55 t ha^{-1}. Integrated treatment outperformed sole chemical treatment in terms of soil organic matter and N, P, and K contents of post-harvest soils. The amount of organic carbon in the soil as well as its stock and buildup increased as a result of integrated treatment. Given the overall results, farmers can be encouraged to grow groundnuts in charland using 85% chemical fertilizer with vermicompost @ 3 t ha^{-1} application. With this combination, farmers would be able to boost groundnut productivity, improving their income and way of life.

KEYWORDS

Chemical Fertilizer, Vermicompost, Groundnut, Soil Fertility, Carbon Accumulation and Yield.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a very significant oil seed generating crop in Bangladesh. On a dry seed basis, groundnut seeds have an oil content of 44–56%, a protein content of 22–30% and a rich source of minerals (phosphorus, calcium, magnesium and potassium) and vitamins (E, K and B group). In the food industry, it is used as edible oil to produce cake, biscuits, and bakery goods. It is typically consumed as fried "badam." Despite its significance as an oil crop and its numerous uses in daily life, there is a shortage of knowledge regarding its production performance. In sandy soils and riverbeds, it is mostly grown. N, P, Ca, S, and B are less readily available in char land soils than other problematic soils, and the organic matter is also insufficient. A significant amount of macro and micronutrients are removed from the soil by groundnuts because they are such intensive crops.

With the development and perfection of the market economy, there is an increase in the indiscriminate use of chemical fertilizers, which lowers soil fertility and crop nutrient quality. This condition is brought about by the loss of soil organic matter, one of the fundamental components of sustainable agricultural systems. (Liu et al., 2009). It was discovered that using inorganic fertilizer to continue cropping increased production for just a short period of time, but over the long term, it proved ineffective and caused soil degradation (Satyanarayana et al., 2002). When organic elements are applied with inorganic fertilizers, the system is more productive and the soil's health is maintained for a longer period of time (Gawai and Pawar, 2006).

Vermicomposting is a novel eco-friendly and cost effective technology which affects soil PH, microbial population and soil enzyme activities. By excreting beneficial soil organisms and secreting polysaccharides, proteins, and various nitrogenous compounds into the soil, earthworms improve soil fertility and increase crop output (Rekha et al., 2013). In order to maintain yield stability, vermicompost and chemical fertilizers are used in conjunction. This improves the effectiveness of linked supplements, corrects minor nutrient deficiencies, and creates beneficial soil conditions (Gill and Walia, 2014). However, there is a dearth of information in Bangladesh on the usage of vermicompost in conjunction with inorganic fertilizers for the production of groundnuts. Therefore, an effort will be made to research how groundnuts react to the application of vermicompost in charland. The ultimate objective is to optimize fertilizer management to increase yields and quality while minimizing the usage of inorganic fertilizer and preserving high-quality soil.

2. MATERIALS AND METHODS

In Bangladesh's Jamalpur district during the rabi seasons of 2020–2021

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and 2021–2022, a two-year field study on the impact of vermicompost on groundnut yield and soil fertility was done. The address of the site is Sonalata series beneath AEZ-9 (Old Brahmaputra Floodplain Soil). The experimental site's soil had a sandy clay loam texture. Before the experiment began, soil samples were taken from a depth of 0 to 15 cm and examined using conventional techniques. Initial value of some chemical and physical properties of experimental soil is presented in Table 1and Table 2, respectively.

Table 1: Initial Chemical Properties of Experimental Soil at Nouvanger Char in Jamalpur

Location	pH	OC (%)	Ca	Mg	K	Total N%	P	S	B	Cu	Fe	Mn	Zn
			meq / 100ml				ppm						
Nouvanger char, Jamalpur	7.78	0.72	2.63	1.18	0.22	0.093	13	4.2	0.40	2.12	50.5	4.59	0.83
Critical level	-	-	2.0	0.5	0.12	-	10	10	0.20	0.2	4	1	0.6

Table 2: Initial Physical Properties of Experimental Soil at Nouvanger Char in Jamalpur

Depth (cm)	Textural Class	Particle Size Distribution			Bulk Density (gcc^{-1})
		Sand	Silt	Clay	
0-15 cm	Sandy clay loam	38%	36%	26%	1.48 gcc^{-1}

The chemical composition (such as organic carbon, N, P, K, S, B, Cu, Fe, Mn, Zn, Mg, Ca and pH) of vermicompost was presented in Table 3.

Table 3: Chemical Composition of Vermicompost Used for the Experiment

Properties	pH	OC %	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Zn
			meq $100g^{-1}$				µg g^{-1}					
Vermicompost	6.2	14.9	1.45	0.83	0.76	0.92	0.57	0.39	0.008	0.001	0.50	0.014

The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. The unit plot size was 3m x 2m and the variety was BARI Chinabadam-9. Groundnut seeds were sown on 01 November, 2021 in a spacing of 30 cm x 15 cm. Recommended doses of chemical fertilizer for groundnut were calculated on the basis of soil test values.

T_1 = 100 % RDCF (control)

T_2 = 100 % RDCF + vermicompost @ 1 t ha^{-1}

T_3 = 100 % RDCF + vermicompost @ 3 t ha^{-1}

T_4 = 85% RDCF + vermicompost @ 1 t ha^{-1}

T_5 = 85% RDCF + vermicompost @ 3 t ha^{-1}

T_6 = 70% RDCF + vermicompost @ 1 t ha^{-1}

T_7 = 70% RDCF + vermicompost @ 3 t ha^{-1}

Blanket dose: $N_{42}\ P_{33}\ K_{38}\ S_{30}\ Zn_2\ B_1$ Kg ha^{-1} (FRG-2018)

Other intercultural operations were done as per requirement.The crop was harvested in April, 2022. Data on yield and yield contributing characters were recorded from ten plants selected randomly for each plot and analyzed statistically using statistical software STAR which was developed by IRRI. Least significant differences (LSD) were used for means separation at 5% probability level. Carbon stock and Carbon accumulation were calculated using following formula.

Carbon stock (t ha^{-1}) = Carbon concentration (%) x bulk density (gcc^{-1}) x depth (cm)

Carbon accumulation (t ha^{-1}) = Final carbon stock (t ha^{-1}) - Initial carbon stock (t ha^{-1})

Table 4: Treatments Combinations for Groundnut Crop

Treatments	Treatment Combination						
	Chemical Fertilizer (kg ha^{-1})						Organic Manure (t ha^{-1})
	N	P	K	S	Zn	B	vermicompost
T_1	42	33	38	30	2	1	0
T_2	33	27	30	30	2	1	1
T_3	14	16	15	30	2	1	3
T_4	27	22	24	30	2	1	1
T_5	8	11	9	30	2	1	3
T_6	21	17	19	30	2	1	1
T_7	2	6	4	30	2	1	3

Note: T_1 = 100 % RDCF, T_2 = 100 % RDCF + VC @ 1 t ha^{-1}, T_3 = 100 % RDCF + VC @ 3 t ha^{-1}, T_4 = 85% RDCF + VC @ 1 t ha^{-1}, T_5 = 85% RDCF + VC @ 3 t ha^{-1}, T_6 = 70% RDCF + VC @ 1 t ha^{-1} and T_7 = 70% RDCF + VC @ 3 t ha^{-1}

3. Results and Discussion

3.1 Effects of Chemical Fertilizer and Vermicompost on Plant Growth and Yield of Groundnut

The development and output of groundnut plants were considerably impacted by the amounts of chemical fertilizer (CF) and vermicompost (VC) used (Table 5). Significantly higher plant height of 48.09 cm was recorded in the treatment T_3 (100% RDCF + VC @ 3 t ha^{-1}). The number of branches $plant^{-1}$ was varied significantly due to the different combined applications of CF and VC. The highest number of branches $plant^{-1}$ (9.42) was observed in the plant treated 85 % RDCF with VC @ 3t ha^{-1} combination whereas the lowest number of branches $plant^{-1}$ was observed in the T_6 (70% RDCF + VC @ 1 t ha^{-1}) treatment.

T_5 treatment (85 % RDCF + VC @ 3 t ha^{-1}) exhibited maximum nut per plant (28.33), kernel per plant (43.68) which was statistically higher than the rest of the treatments. This treatment also gave the highest 100 kernel weight (44.52 g) than that of sole chemical fertilizer (T_1) treatment. This might be as a result of using vermicompost, a good natural source that allows for excellent air circulation of environmental factors and soil moisture. It also had a high concentration of humic acids, which increase plant height, leaf area index, and growth rate (Atarzadeh et al., 2013). Shelling percentage varies from 66.03 % to 71.69 % in different treatment.

The single or combined applications of chemical fertilizer and vermicompost had a substantial impact on the nut yield of BARI Chinabadam-9. In 2021-2022, the highest nut yield of 2.16 t ha^{-1} was obtained in the treatment T_5 (85 % RDCF + vermicompost @ 3 t ha^{-1}). It was also observed that, among all the treatments, T_5 (85% RDCF + VC @ 3 t ha^{-1}) exhibited the maximum increase in nut yield which was 22.03 % higher over 100 % RDCF.This result corroborated with the findings of Bachman and Metzger and they discovered an observable improvement in the plant growth properties after adding vermicompost to the growing media (Bachman and Metzger, 2008). Earthworms may speed up the metabolism and activity of microorganisms, which may have an impact on their populations. In turn, the soil receives an increase in the amount of readily available nutrients and microbial metabolites (Tomati et al., 1998).

As opposed to this, the T_1 treatment (100% RDCF) resulted in a nut yield of 1.77 t ha^{-1} which was lower than T_2, T_3, T_4 and T_5, indicated that inorganic fertilizer applications could not provide plants with necessary nutrients. It is revealed from the result that combination of organic and inorganic fertilizers increased the nut yield than sole use of inorganic fertilizer. This may be due to the fact that organic fertilizers are known to include plant nutrients, growth-promoting agents, and beneficial microorganisms, which when combined with inorganic fertilizers create favorable soil conditions and increase nutrient usage efficiency. Similar results were reported by A.S. Channaveerswami in groundnut (Channaveerswami, 2005). As inorganic fertilizers were reduced, nut yield gradually declined. The T_6 treatment (70% RDCF + VC @ 1 t ha^{-1}) had the lowest nut yield, measuring 1.54 t ha^{-1}.

3.2 Changes in soil chemical properties from different treatment combination

Table 6 displays the nutrient composition of the groundnut experiment field's post-harvest soil. Comparing the solitary chemical fertilizer (control) treatment to the integrated application of vermicompost with chemical fertilizer, an improvement in soil nutrient status was noted. The treatment with the highest pH value was in T_5 (85% RDCF + VC @ 3 t ha^{-1}), while the treatment with the lowest pH values was in chemical fertilizer (control). In the same treatment, 3 t ha^{-1} of vermicompost and 85% RDCF were applied, and the largest amount of soil organic carbon was found. Comparing the available N content of the soil under T_5 (85% RDCF + VC @ 3 t ha^{-1}) treatment to the control, a 12.04% increase was seen. In the T_5, P and K both had notable increases relative to the control, of roughly 32.84% and 17.39%, respectively. This outcome was consistent with Le Bayon and Binet's observation that soil phosphorus levels could be raised by the direct action of worm gut enzymes and the stimulation of microorganisms (Le Bayon and Binet's, 2006). Similar to this, noted a rise in K content as sewage sludge was composted using vermicomposting (Delgado et al., 1995).

Table 5: Effect of Chemical Fertilizer and Vermicompost on Yield and Yield Components of Groundnut

Treatment	Plant Height (cm)	Nut Plant^{-1}	Kernel Plant^{-1}	100 Kernel Wt. (g)	Shelling (%)	Nut Yield (t ha^{-1})		% Increase over RD
						2020-21	2021-22	
T_1	45.43 b	18.33 c	30.45 d	38.05 d	67.67 c	1.86 c	1.77 d	-
T_2	46.47 b	24.33 b	35.57 c	42.32 b	70.33 ab	2.01 b	2.02 b	14.12
T_3	48.09 a	25.67 b	36.34 c	42.40 b	70.35 ab	2.03 b	2.04 b	15.25
T_4	45.44 b	24.00 b	42.50 b	40.56 c	70.01 b	2.00 b	1.89 c	6.77
T_5	43.36 c	28.33 a	43.68 a	44.52 a	71.69 a	2.17 a	2.16 a	22.03
T_6	40.89 d	14.67 d	23.04 f	35.37 e	66.03 d	1.56 e	1.54 e	-
T_7	41.21 d	16.00 d	24.32 e	36.37 e	67.02 cd	1.72 d	1.63 e	-
CV%	3.49	6.58	6.23	8.56	4.87	9.39	11.45	-
LSD (0.05)	1.60	1.78	1.06	1.58	1.34	0.13	0.10	-

Means in a column followed by same letter(s) do not differ significantly at 5% level by LSD

Note: T_1 = 100 % RDCF, T_2 = 100 % RDCF + VC @ 1 t ha^{-1}, T_3 = 100 % RDCF + VC @ 3 t ha^{-1}, T_4 = 85% RDCF + VC @ 1 t ha^{-1}, T_5 = 85% RDCF + VC @ 3 t ha^{-1}, T_6 = 70% RDCF + VC @ 1 t ha^{-1} and T_7 = 70% RDCF + VC @ 3 t ha^{-1}

Table 6: Changes in Soil Chemical Properties as Influenced by Integrated Use of Vermicompost With Chemical Fertilizer in Groundnut Field

Treatments	pH	SOC (%)	Total N (%)	K meq 100g^{-1}	P	S	B	Zn
					µg g^{-1}			
T_1	7.29	0.70	0.083	0.23	13.7	6.3	0.41	1.0
T_2	7.47	0.76	0.085	0.24	15.9	10.4	0.41	1.11
T_3	7.57	0.77	0.091	0.25	17.1	13.1	0.42	1.13
T_4	7.53	0.76	0.087	0.25	17.5	12.8	0.41	1.11
T_5	7.58	0.78	0.093	0.27	18.2	13.3	0.43	1.22
T_6	7.48	0.73	0.083	0.25	15.2	10.1	0.40	0.87
T_7	7.49	0.73	0.086	0.26	15.6	11.2	0.41	0.89
Initial soil	7.28	0.72	0.083	0.22	13.5	6.2	0.40	0.83

Note: T_1 = 100 % RDCF, T_2 = 100 % RDCF + VC @ 1 t ha^{-1}, T_3 = 100 % RDCF + VC @ 3 t ha^{-1}, T_4 = 85% RDCF + VC @ 1 t ha^{-1}, T_5 = 85% RDCF + VC @ 3 t ha^{-1}, T_6 = 70% RDCF + VC @ 1 t ha^{-1} and T_7 = 70% RDCF + VC @ 3 t ha^{-1}

Table 7: Carbon Accumulation in Soil as Influenced by Different Treatment Combination

Treatments	Initial Soil			Post Harvest Soil			Carbon Accumulation (t ha^{-1})
	SOC (%)	BD (gcc^{-1})	C Stock (t ha^{-1})	SOC (%)	BD (gcc^{-1})	C Stock (t ha^{-1})	
T_1	0.72	1.48	15.98	0.70	1.47	15.43	-0.54
T_2	0.72	1.48	15.98	0.76	1.45	16.53	0.55
T_3	0.72	1.48	15.98	0.77	1.44	16.63	0.65
T_4	0.72	1.48	15.98	0.76	1.44	16.41	0.43
T_5	0.72	1.48	15.98	0.78	1.44	16.84	0.86
T_6	0.72	1.48	15.98	0.73	1.46	15.98	00
T_7	0.72	1.48	15.98	0.73	1.45	15.87	-0.11

Note: T_1 = 100 % RDCF, T_2 = 100 % RDCF + VC @ 1 t ha^{-1}, T_3 = 100 % RDCF + VC @ 3 t ha^{-1}, T_4 = 85% RDCF + VC @ 1 t ha^{-1}, T_5 = 85% RDCF + VC @ 3 t ha^{-1}, T_6 = 70% RDCF + VC @ 1 t ha^{-1} and T_7 = 70% RDCF + VC @ 3 t ha^{-1}

Table 8: Cost and Return of Groundnut Production as Influenced by Different Treatment Combination

Treatments	Average Groundnut Yield (t ha^{-1})	Gross Return	Total Variable Cost	Gross Margin	BCR
		(TK ha^{-1})			
T_1	1.81	181000	97500	83500	1.85
T_2	2.01	201000	107000	94000	1.87
T_3	2.03	203000	119000	84000	1.70
T_4	1.94	194000	98000	96000	1.97
T_5	2.16	216000	106000	110000	2.03
T_6	1.55	155000	85000	70000	1.82
T_7	1.67	167000	101000	66000	1.65

Note: T_1 = 100 % RDCF, T_2 = 100 % RDCF + VC @ 1 t ha^{-1}, T_3 = 100 % RDCF + VC @ 3 t ha^{-1}, T_4 = 85% RDCF + VC @ 1 t ha^{-1}, T_5 = 85% RDCF + VC @ 3 t ha^{-1}, T_6 = 70% RDCF + VC @ 1 t ha^{-1} and T_7 = 70% RDCF + VC @ 3 t ha^{-1}

Input: Unit price **(**Tk.Kg^{-1}**):** Urea=16, TSP= 22, MoP = 15, Gypsum = 12, Zinc sulphate = 200, Boric acid = 250, vermicompost = 10 Output: Price of groundnut: 100 Tk Kg^{-1}

3.3 Carbon Accumulation in Soil from Different Treatment Combination

The information on the soil fertility characteristics in the field of groundnut experimentation is shown in Table 7. Following a two-year trial, the condition of soil carbon was examined, and it was discovered that applying vermicompost had a favorable impact on soil carbon stocks and accumulation. Initially, soil had an organic carbon content of 0.72%, a bulk density of 1.48 g cc^{-1}, and a carbon stock of 15.98 t ha^{-1}. The bulk density after two years ranged between 1.44 and 1.47 g cc^{-1}. After harvest, SOC concentration was found to be high (0.78%) in the T_5 (85% RDCF + VC @ 3 t ha^{-1}) treatment, which was almost 11.42% higher than the concentration (0.70%) from a chemical treatment alone. Comparing post-harvest soil to initial soil, chemical treatment results in a drop in carbon stock, whereas organic amendment treatments, with the exception of T_6 and T_7, result in a gain. The application of more vermicompost decreased the bulk density of the soil and boosted carbon accretion, according to the data. The soil supplemented with 3 t ha^{-1} vermicompost had the maximum carbon accumulation (0.86 t ha^{-1}) regardless of treatments. Soil carbon sequestration potential is thus maximum in this case.

3.4 Cost and Return Analysis

Table 8 displays the cost and return of producing groundnuts as modified by various treatment combinations. Among the treatments, the T_5 treatment (85% RDCF + VC @ 3 t ha^{-1}) achieved the highest gross return (Tk 216000 ha^{-1}), gross margin (Tk 110000 ha^{-1}) and BCR (2.03) while the T_7 treatment (70% RDCF + VC @ 3 t ha^{-1}) recorded the lowest gross margin (Tk 66000 ha^{-1}) and BCR (1.65).

4. Conclusion

The results showed that applying 85% chemical fertilizer along with 3 t ha^{-1} of vermicompost worked well in terms of groundnut production and BCR. The consumption of at least 15% chemical fertilizer can be decreased by combining inorganic and organic fertilizer. By combining vermicompost with chemical fertilizer, the nutritional level of post-harvest soil was marginally improved. This combination (85% RDCF + VC @ 3 t ha^{-1}) may therefore be recommended as a better option for increasing groundnut production at char area of the Jamalpur region (AEZ-9) in Bangladesh.

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