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Performance of Finger Millet [*Eleusine coracana* (L.) *Gaertn*.] Influenced by Integrated Effect of Vermicompost and Inorganic Fertilizer Rates in Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Finger millet is extensively cultivated in the tropical and sub-tropical regions of Africa and is known to save the lives of small income farmers from starvation at times of extreme drought. Therefore, this field experiment was carried out to study the integrated effect of vermicompost and inorganic fertilizer blended NPSB with urea on yield and yield components of finger millet. Treatments of the experiment consisted of four levels of vermicompost (25, 50, 75, and 100%) and three levels of recommended NPSB and urea (25, 50 and 75%) rates, control, recommended vermicompost alone (4.64 t ha^{-1}), and inorganic fertilizer alone (100 kg NPSB ha^{-1} and 90 kg urea ha^{-1}). Experiment was arranged in the field in Randomized Complete Block Design in fifteen treatments replicating thrice. The maximum (10730.4 kg ha^{-1}) dry biomass weight and straw yield (88235 kg ha^{-1}) was obtained with the application of 100: 25% vermicompost and recommended NPSB with urea. Utmost harvest index (33.8 7%) and grain yield (2202 kg ha^{-1}) of finger millet were obtained with the application of 25:50% vermicompost and blended NPSB with urea. The highest net benefit of ETB 56475.9 ha^{-1} with a marginal rate of return of 93.63% was recorded from application of 25:50% vermicompost (1.16 tons ha^{-1}) and blended NPSB with urea, (50 kg NPSB ha^{-1} and 45 kg urea ha^{-1}), fertilizer.

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Hence, it is recommended to apply 25:50% vermicompost (1.16 tons ha^{-1}), and blended NPSB with urea, (50 kg NPSB ha^{-1} and 45 kg urea ha^{-1}), fertilizer to increase finger millet productition in the study area.

Keywords: Finger millet; NPSB; urea; vermicompost.

1. INTRODUCTION

"Finger millet is the sixth important cereal crop after tef, wheat, maize, sorghum and barley" [1]. "The production and yield of finger millet in Ethiopia decreased from year to year as a result of increased drought and soil fertility degradation, thus the area allocated for this crop has significantly increased" [2]. "This crop comprises about five percent of the total land devoted to cereals between 2001 and 2017, finger millet area in Ethiopia increased from 346,780 to 463, 992 ha^{-1} with an increase of 33.8%, and the total production in the same duration increased from 316,166 to 1,077,616 tones which is more than a threefold increment" [1]. The problems of low soil fertility resulting from continuous chemical fertilizer application, crop removal and inaccurate fertilizer application are key challenges to producing surplus food for the ever-increasing population of Ethiopia [3].

2. MATERIALS AND METHODS

The field experiment was conducted at Bako Agriculture Research centre which is located in Gobu-Sayo District, east Wollega Zone, and Oromia National Regional State. Bako Agriculture Research centre is situated in the western part of Ethiopia between 37^o 1' 00" E to 37^o 3' 40" E and 9^o 4' 20'' N to 9^o 7' 20" N with an altitude of 1650 m.a.s.l., covering a total land area of 1440 hectares. It is characterized by hot and humid weather. The area has annual mean minimum temperature of 13.3°C and the mean maximum temperature of 28°C.

Bako 09, an improved variety of finger millet was used as a test variety. The variety was released by Bako Agricultural Research Centre in the year 2017 for its high grain yield potential and moderately resistant against *Magnapor* the *oryzea* disease. The average grain yield under the research and farmer fields were 2.99 and 2.426 t ha^{-1}, respectively. The variety is adapted to an altitude of 1400 to 2200 (m.a.s.l) and a rainfall ranging 1200-1300 mm [4]. Blended NPSB fertilizer containing 18.9% N, 37.7% P_2O_5, 6.9% S, and 0.1% B and Urea (46% N) were used for the study. Vermicompost prepared from soybean straw and cattle manure was used for the study. The vermicompost had a composition of 8.2 pH, 32.22% OC, 1.98% total N, 1.39% total P, 3.94% total K, 7.91% total Ca, 8.7% total Mg and it had a C: N ratio of 16.27 [5].

Experimental treatments consisted of a combination of vermicompost and inorganic fertilizer such as NPSB and urea. Treatments were four levels of vermicompost (25, 50, 75, and 100%) and three levels of recommended NPSB and urea (25, 50 and 75%) rates, control (untreated), vermicompost alone (4.64 tons ha^{-1}) as recommended by Kifle et al. [5], as well as inorganic fertilizer alone (90 kg urea ha^{-1} and 100 kg NPSB ha^{-1}). The experiment was laid out in a Randomized Complete Block Design in fifteen treatments with three replications.

Plot area was 9.6 m^2 (3.2 m x 3 m) and the spacing between the blocks and plots was 1.5 m and 0.5 m respectively. The two outer rows (one row from both sides of the plot), were left as border rows. Thus, the central six rows (7.2 m^2) were used for data collection and as net plot size. Soil bunds were constructed around each plot and around the entire experimental field to minimize nutrient and water movement from plot to plot. Sowing of seeds was done on June 23, 2021 by hand drilling at a seed rate of 15 kg ha^{-1} in rows spaced 40 cm apart. Nitrogen was applied in two equal splits, the first 50% of urea was applied as basal dose at planting and the remaining half was side-dressed at 5-10 cm depth at the maximum tillering stage (40 days after emergence). Unlike N, the total dose of NPSB fertilizer was applied during sowing based on treatments.

2.1 Data Collected and Measurements

Days to 50% emergence: It was recorded as a number of days from the date of sowing to the time when 50% of the seedlings emerged in each plot from the ground.

Days to 50% flowering: Number of days from sowing to the date on which 50% of plants on the net plot produce at their first flower was recorded.

Plant height: It was measured starting from the base of the ground to the tip of the plant using measuring tape for ten randomly selected plants for each plot at maturity.

Green leaf number: It was counted from ten randomly selected plants for all plots at the stage flag-leaf appear.

Green leaf area: A green leaf area (GLA) was calculated using the formula below, correction factor which became 0.79, based on the formula below green leaf area (GLA) was calculated can be as described by Assefa (2013), GLA = (C*L *W). Leaf length (L) and Leaf width (W) were measured by Area meter, Am100 Bio Scientific Ltd, UK.

Days to 90% physiological maturity: The number of days from sowing to the stage when 90% of the plants in a plot have reached physiological maturity was determined based on visual observation. i.e. the stage at which the leaf loses their pigmentation and begins to dry.

Total tillers per plant: It was recorded from ten randomly selected pre-tagged plants of each plot at physiological maturity.

Number of Productive tillers per plant: The numbers of tillers with fertile heads from ten randomly selected pre-tagged individual plants were recorded for each treatment, excluding the mother plant.

Panicle number per head: It was counted from ten randomly selected pre-tagged plants from each treatment.

Panicle Length: It was measured from the base of the panicle to the tip of the panicle from randomly selected pre-tagged ten plants for each treatment.

Biomass Yield: It was cut off and weighed using sensitive balance at harvest and average weight was computed and used for further analysis after sun drying until attain constant weight.

Straw yield: It was calculated by subtracting the grain yield from the total above-ground biomass output after threshing and measuring the grain yield.

Grain yield: It was measured using electronic balance and then adjusted to 12.5% moisture and convert to hectare basis.

Thousand seed weight: It was determined from 1000 randomly taken from each plot and weighed using electronic grain counter and then adjusted to 12.5% moisture level.

Harvest Index: It was estimated from the proportion of grain yield to the above-ground biomass yield per plot.

All collected parameters were subjected to analysis of variance using SAS version 9.3. Whenever a treatment effect is significant, the means was separated using the least significant difference (LSD) procedures test at 5% level of significance.

Partial budget analysis was performed to investigate the economic feasibility of the treatments. To compare the economic feasibility of the treatments used, the economic analyses were carried out using the procedures described by CIMMYT [6]. The average yield was downwarded by 10% to get what farmers would get. Costs that vary were considered to perform a partial budget analysis. The finger millet grain yield and straw yield were valued at an average open market price of ETB 3200.00 and ETB 30.00, $100kg^{-1}$ respectively. The cost of blended NPSB, urea, vermicompost fertilizer and cost of vermicompost transportation and cost of inorganic fertilizers transportation were 2017.68 ETB, 2946.89ETB, 800 ETB, 20 ETB and 60 ETB) per 100kg respectively, were used for economic analysis. Cost of land preparation, seed, field management, harvest and storage was not included in the analysis, as they were not variable.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The plant height of finger millet was significantly ($P < 0.05$) affected by integrated vermicompost and blended NPSB with urea fertilizer (Table 1). The highest (70.8cm) at plant height of finger millet was recorded from application of inorganic fertilizer alone, which is statistically at par with all treatments except control which the shortest (55.4cm) plant height of finger millet (Table 1). The reason for better growth and development under inorganic fertilizer alone might be the increased availability of nutrients from the inorganic fertilizers. The result was in harmony with Aparna et al. [7] observed that plant height of finger millet was significantly affected by the application of 75% recommended dose of nutrients + 25% N through cotton stubbles vermi compost + 2% rock phosphate significantly increased plant height (107.1 cm).

3.2 Number of Leaf per Plant and Leaf Area

The integrated use of vermicompost and inorganic fertilizers did not significantly (P<0.05) affected the Number of Leaf per plant and leaf area of finger millet crop (Table 1). However, numerical difference observed between control and the rest of the treatments in the case of Number of Leaf per plant. This could be due to the ability of plants to switch from using most of its energy from vegetative development to reproductive organs development. The result was in agreement with Wafula et al. [8] who reported that inorganic fertilizer rates did not influence the number of leaves per plant of finger millet.

3.3 Number of Total Tillers per Plant

The number of total tillers per plant significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 2). The highest (6.4) number of Total tillers per plant of finger millet was recorded on recommended vermicompost with 75% blended NPSB with urea treatment, which was statistically at par with all treatments except 75: 50% vermicompost and blended NPSB with urea treatment (Table 2). While the lowest (3.27) number of total tillers per plant was recorded from application of 75 : 50% vermicompost and blended NPSB with urea , which was statistically similar with the rest of the treatments, except recommended vermicompost with 75% blended NPSB with urea. This might be due to the availability of nutrients from integrated of organics and inorganics fertilizers produced under favourable condition in terms of nutrients uptake by the crop. The result was in agreement with Aparna et al. [7], who reported high number of tillers under 75% recommended dose of nutrients + 25% N through cotton stubbles vermi compost + 2% phosphate over other treatments.

3.4 Number of Productive Tillers per Plant

The number of productive tillers per plant was significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 2). The highest (3.96) productive tiller was recorded from application of 100: 75% recommended vermicompost and blended NPSB with urea, which was statistically at par with all integrated treatments except at 25: 50 and 75% vermicompost integrated with 75: 75 and 50% blended NPSB with urea, respectively (Table 2).While the smallest (2.03) productive tiller was recorded from application of 50: 75% vermicompost and NPSB with urea fertilizer treatments, which was statistically par with the rest of the treatments except 100% vermicompost with 50 and 75% blended NPSB with urea and control. The reason for high productive tillers at full dose of vermicompost with 75% inorganic fertilizer could be due to the readily availability nutrients from inorganic source of fertilizer and the enhancement of high vermicompost mineralization which provides better nutrition for the crop and better soil environment. Likewise, Maitra et al. [9] reported that 75% recommended dose of fertilizer + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1} gave maximum number of productive tillers on finger millet.

3.5 Number of Fingers per Head

The mean number of fingers per head did not significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 3). However, numerical difference observed between the control and the rest of the treatments in the case of finger number per head. This numerical difference might be due to nutrient management practices through vermicompost alone with inorganic fertilizer, compared to all other treatment combinations and control. The result was in agreement with Tounkara et al. [10] the number of panicles m^{-2} averaged 5.36 in 2016 and was not affected by either the organic fertilizers or by the inorganic fertilizer application.

3.6 Finger Length

Finger length was non-significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 3). However, numerical difference was observed between the control and the rest of the treatments in the case of finger length. The numerical increase in the finger length is probably to the enhanced metabolic processes due to availability of nutrients, and lack of reduced metabolic activity. However, the insignificant response to applied integrated organic and inorganic fertilizers might be due to the optimal availability of N and supplement of Urea during study period which led to the luxurious vegetative growth. Similarly, Maitra et al. [9] reported that application of integrate effect of nutrient management of fertilizer did not significantly affect the test weight and length of finger of the finger millet, these two characters did not vary significantly among the different treatments. The results clearly indicated that finger length was a very stable character and much variation by different nutrient management practices was not observed.

3.7 Finger Width

The mean finger width of finger millet was significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer. The highest (1.18 cm) width of finger millet was recorded from application of 50:75% vermicompost with blended NPSB with urea, (Table 3). While the lowest (0.97 cm and 0.99 cm) finger width of finger millet was recorded on treatment absolute control and 100: 75% vermicompost and NPSB with urea respectively, this was statistically similar with the rest of the treatments. The increase in the fingers width was due to the synthesis of amino acid and chlorophyll and better carbohydrates transformation which resulted in better growth and a higher width of panicles which ultimately produced more number of grains per spikelet [8]. Similarly, Khadadiya et al. [11] application of vermicompost @ 10 tons ha-^{1} with 100 per cent recommended dose of fertilizer improved growth attributes and finger ear head girth.

Table 1. Integrated effects of vermicompost and inorganic fertilizers on plant height, number of leaf and leaf area of finger millet

Treatment combination	Plant height(cm)	Number of leaf per plant	Leaf area (cm^2)
Control (non-treated)	55.40^{b}	8.90	33.56
vermicompost alone	62.06^{ab}	8.93	29.13
Inorganic Fertilizers alone	70.80^{a}	9.66	34.69
25:25% VC and NPSB, urea	63.23^{ab}	9.63	29.76
25:50% VC and NPSB, urea	64.76^{ab}	9.33	30.64
25:75% VC and NPSB, urea	69.13^{a}	9.63	32.62
50: 25% VC and NPSB, urea	62.33^{ab}	9.20	31.84
50:50% VC and NPSB, urea	65.27^{a}	9.60	28.05
50:75% VC and NPSB, urea	68.07^{a}	9.73	32.69
75: 25% VC and NPSB, urea	67.00^{a}	9.33	27.55
75: 50% VC and NPSB, urea	63.23^{ab}	9.40	30.96
75: 75% VC and NPSB, urea	61.90^{ab}	9.33	33.63
100 : 25% VC and NPSB,urea	66.36^{a}	9.80	30.49
100 : 50% VC and NPSB,urea	62.86^{ab}	9.40	33.89
100: 75% VC and NPSB,urea	67.16^{a}	9.23	32.49
LSD (5%)	9.85	NS	NS
CV (%)	9.11	8.68	14.35

Means followed by the same letter within a column are not significantly different at P<0.05. NS= non-significant

Table 2. Integrated effects of vermicompost and inorganic fertilizers rates on number of total tillers per plant and number of productive tillers per plant of finger millet

Treatment combination	Number of total tillers per plant	Number of productive tillers per plant
Control (non-treated)	5.97^{ab}	3.46^{ab}
Vermicompost alone	5.00^{ab}	2.90^{abc}
Inorganic Fertilizers alone	4.17^{ab}	2.90^{abc}
25:25% VC and NPSB, urea	5.03^{ab}	2.96^{abc}
25:50% VC and NPSB, urea	5.17^{ab}	3.00^{abc}
25: 75% VC and NPSB, urea	3.93^{ab}	2.46^{bc}
50: 25% VC and NPSB, urea	5.83^{ab}	3.10^{abc}
50:50% VC and NPSB, urea	4.20^{ab}	2.76^{abc}
50 :75% VC and NPSB, urea	3.93^{ab}	2.03^{c}
75 :25% VC and NPSB, urea	3.90^{ab}	2.70^{abc}
75: 50% VC and NPSB, urea	3.27^{b}	2.30^{bc}
75: 75% VC and NPSB, urea	5.77^{ab}	2.96^{abc}
100: 25% VC and NPSB, urea	4.17^{ab}	2.70^{abc}
100 : 50% VC and NPSB, urea	6.03^{ab}	3.50^{ab}
100: 75% VC and NPSB, urea	6.40^{a}	3.96^{a}
LSD (5%)	3.03	1.2032
CV (%)	16.42	22.38

Means followed by the same letter within a column are not significant (P < 0.05) probability level

Table 3. Integrated effects of vermicompost and inorganic fertilizers on finger number, finger length and finger width of finger millet

Treatments	Finger number/head	Finger length(cm)	Finger Width (cm)
Control (non-treated)	6.66	6.04	0.97^{c}
Vermicompost alone	6.56	6.21	1.07^{abc}
Inorganic Fertilizers alone	6.86	6.24	1.09^{abc}
25:25% VC and NPSB, urea	6.30	5.92	1.05^{bc}
25:50% VC and NPSB, urea	6.26	6.10	1.09^{ab}
25: 75% VC and NPSB, urea	6.46	6.10	1.04^{bc}
50: 25% VC and NPSB, urea	7.10	6.07	1.04^{bc}
50:50% VC and NPSB, urea	6.03	6.25	1.07^{abc}
50 :75% VC and NPSB, urea	6.40	6.46	1.18^{a}
75: 25% VC and NPSB, urea	5.96	6.16	1.03^{bc}
75: 50% VC and NPSB, urea	6.26	6.43	1.11^{ab}
75:75% VC and NPSB, urea	6.73	6.73	1.03^{bc}
100:25% VC and NPSB, urea	5.87	7.06	1.10^{ab}
100:50% VC and NPSB, urea	7.03	6.07	1.03^{bc}
100:75% VC and NPSB, urea	6.50	5.85	0.99^{bc}
LSD (5%)	NS	NS	0.129
CV (%)	11.58	8.56	7.31

Means followed by the same letter within a column are not significant (P < 0.05) probability level, NS= non-significant

3.8 Biomass Yield

The biomass yield of finger millet was significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 4). The highest (10730 kg ha^{-1}) biomass yield was recorded from application of 100:25% vermicompost with NPSB with urea. While the lowest (5632 kg ha^{-1}) biomass yields finger millet was recorded from absolute control (Table 4). The possible reason for the increase in biomass yield compared to the control treatment might be due to readily availability of nitrogen to the crop from inorganic source of fertilizer and the mineralization of vermicompost which provides better nutrition and soil environment for the finger millet crop. It's also possible that because of sufficient amounts and balanced proportions of plant nutrients in vermicompost were given to the crop as needed during the growth phase, resulting in a beneficial enhancement in yield contributing characteristics. The result was similar with Dass et al. [12] who observed that biomass weight was significantly affected by integrated nutrient management on finger millet. Similarly, Tekulu et al. [13] reported that as biomass yield was considerably increased under balanced fertilization with vermicompost and blended NPS fertilizer.

3.9 Grain Yield

The mean grain yield of finger millet was significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 4). The highest (2201.6, 2030.2 and 1948.4 kg ha^{-1}) grain yields of finger millet were recorded from application of 25: 50 and 50: 75% vermicompost and NPSB with urea, and inorganic fertilizer alone; which were statistically at par with 100: 25% vermicompost and NPSB with urea , and 100: 75% vermicompost with NPSB with urea (Table 4). While the lowest (1058 kg ha^{-1}) grain yields finger millet were recorded on absolute control treatment.

The significant relationship between the increasing integrated vermicompost and inorganic fertilizer on the yield and growth components could also be attributed to the optimum photosynthetic activities in addition to the availability of the nutrients and the presence of adequate moisture in the soil. Also, Selim [14] suggested that finger millet responds well to integrated vermicompost and inorganic fertilizer treatment. These indicated that optimal blended NPSB levels of vermicompost and inorganic fertilizer have a good effect on the yield components of finger millet in the study area. Pallavi et al. [15] found comparable results in a study on the performance of finger millet as influenced by nutrient sources as well as integrating organic vermicompost and inorganic fertilizer.

3.10 Straw Yield

The mean straw yield of finger millet was significantly (P<0.05) affected by the use of integrated vermicompost and inorganic fertilizer rate (Table 4). The highest (8823 and 8399 kg ha^{-1}), straw yield of finger millet were recorded from application of 100: 25 and 25:75% vermicompost and blended NPSB with urea, respectively (Table 4), while the lowest (4574 kg ha^{-1}), straw yield was recorded on absolute control treatments.

The higher straw yield could be due to high photosynthesis which is more owing to adequate supply of nitrogen, vermicompost along with inorganic fertilizer increase the photosynthetic activity and production of biomass, which ultimately resulted in high straw yield. Similarly, Ejigu et al. [16] found that using organic vermicompost fertilizers in conjunction with inorganic NPSB with urea fertilizers greatly boosted straw yield. Maitra et al. [9] also discovered that the use of 100 percent NPK in combination with 10 tons of FYM per hectare resulted in significantly improved grain and straw yields, as well as an increase in soil organic matter.

3.11 Thousand Seed Weight

The mean thousand seed weight of finger millet did not significantly (P<0.05) affected by the use of integrated vermicompost and blended NPSB with urea fertilizer (Table 5). The highest (5.23 g) thousand seed weight obtained with and lowest (4.33 g) seed weight obtained from 25:50% vermicompost and blended NPSB with urea and absolute control, respectively (Table 5). This numerical difference might be due to the improvement of seed quality and size as a result of balanced integrated nutrients application. Similarly, Wafula et al. [8] found that the inorganic fertilizer did not have significant influence on the weight of 1000-grains in two locations for two seasons of finger millet. Pallavi et al. (2016) also noted that thousand grain weight was not affected by the integrated nutrient management but the maximum value of harvest index (23.7) was recorded with (100% recommended dose of fertilizer) which was followed by (75% recommended dose of fertilizer + 2 t FYM + Azospirillum @ 5 kg ha^{-1}) and the least value was noted with control treatment of finger millet.

3.12 Harvest Index

The mean harvest index of finger millet was significantly (P<0.05) affected by integrated vermicompost and blended NPSB with urea fertilizer (Table 5). The highest (33.877 and 32.7%) harvest index, was recorded from application of 50: 75% vermicompost and blended NPSB with urea, and 25: 50% vermicompost and blended NPSB with urea (Table 5). While the lowest (16.03) harvest index was recorded on integrated 100: 50% vermicompost and NPSB with urea.

Table 4. Integrated effects of vermicompost and inorganic fertilizers on biomass weight, grain and straw yields of finger millet

Treatments	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Control (non-treated)	5631.7^{i}	1057.7^{gf}	4574^{ef}
Vermicompost alone	7962.7^{f}	1457.0^{ef}	6505.7^{abcd}
Inorganic Fertilizers alone	10026.7^{b}	1948.4^{a}	8078.3^{ab}
25:25% VC and NPSB, urea	6867.2^{gh}	1447.5^{ef}	5419.7^{bcde}
25:50% VC and NPSB, urea	7983.6^{ef}	2201.6^{a}	6082^{abcd}
25: 75% VC and NPSB, urea	9996.2^{b}	1597.1^{bcde}	8399.1^{a}
50: 25% VC and NPSB, urea	8009.3^{ef}	1374.0^{ef}	6635.3^{abcd}
50:50% VC and NPSB, urea	7344.5^{g}	1467.1^{de}	5877.4^{bcde}
50 :75% VC and NPSB, urea	8497.8^{de}	2030.2^{a}	6467.6^{abcd}
75: 25% VC and NPSB, urea	9106.8^{c}	1486.7^{de}	7620.1^{abc}
75: 50% VC and NPSB, urea	7989.0^{ef}	1408.2^{ef}	6580.8^{abcd}
75 :75% VC and NPSB, urea	7371.9^{g}	1505.6^{cde}	5866.3^{bcde}
100 :25% VC and NPSB, urea	10730.4^{a}	1907.9^{abc}	8822.5^{a}
100:50% VC and NPSB, urea	6867.2^{gh}	1457.1^{ef}	5410.1^{bcde}
100:75% VC and NPSB, urea	8698.0^{dc}	1642.4^{abcde}	7055.6^{abc}
LSD (5%)	3006.4	416.95	1601.1
CV (%)	3.81	16.34	11.75

Means followed by the same letter within a column are not significant (P < 0.05) probability level

Table 5. Integrated effects of vermicompost and inorganic fertilizers (blended NPSB with urea) on thousand seed weight and harvest index of finger millet

Treatments	**Thousand seed weight (g)**	**Harvest index (%)**
Control (non-treated)	4.33	20.810^{ef}
Vermicompost alone	5.20	23.680^{cde}
Inorganic Fertilizers alone	4.83	29.523^{abcd}
25:25% VC and NPSB, urea	5.03	30.533^{abc}
25:50% VC and NPSB, urea	5.23	32.720^{a}
25 : 75% VC and NPSB, urea	4.70	24.700^{cde}
50 : 25% VC and NPSB, urea	5.00	22.230^{ef}
50:50% VC and NPSB, urea	4.67	24.600^{cde}
50:75% VC and NPSB, urea	5.067	33.877^{a}
75 : 25% VC and NPSB, urea	4.43	21.253^{ef}
75: 50% VC and NPSB, urea	5.13	22.710^{edf}
75:75% VC and NPSB, urea	4.57	30.533^{abc}
100:25% VC and NPSB, urea	4.90	19.250^{ef}
100 :50% VC and NPSB, urea	4.87	16.030^{ef}
100:75% VC and NPSB, urea	4.70	22.557^{def}
LSD (5%)	NS	7.14
CV (%)	12.71	16.84

Means followed by the same letter within a column are not significant (P < 0.05) probability level, NS= non-significant

Table 6. Correlation between phenological, growth, yield and yield components of finger millet in Gobu-Sayo district

ED	FD	PH	LN	GLA	NT	NPDT	FN	FL	FW	MaD	BMW	TW	HI	TH	GY
ED	0.47**	-0.53	-0.22	-0.23	0.1ns	0.08ns	-0.04	-0.19	-0.25	0.18ns	-0.32	-0.23	-0.18	0.12ns	-0.3
FD		-0.69	-0.32	-0.2	0.41**	0.45**	-0.003	-0.27	-0.45	0.34*	-0.41	-0.44	-0.45	0.05ns	-0.67
PH			0.44**	0.41**	-0.22	-0.21	0.25**	0.20*	0.26**	-0.13	0.72***	0.64***	0.11ns	-0.18	0.74**
LN				0.35**	0.24**	-0.24	0.47**	0.21**	-0.03	-0.09	0.41*	0.32*	0.12ns	0.15ns	0.39**
GLA					0.12ns	0.06ns	0.60***	0.27**	0.01ns	0.10ns	0.30*	0.28	0.04ns	-0.04	0.26*
NT						0.87***	0.16ns	-0.24	-0.31	0.32*	-0.03	0.02ms	-0.21	-0.019	-0.12
NPDT							0.08ns	-0.38	-0.44	0.21*	-0.08	-0.04	-0.29	-0.08	-0.21
FN								0.19ns	-0.17	0.23*	0.49**	0.36*	-0.19	0.16ns	0.28**
FL									0.09	0.13ns	0.30*	0.06ns	-0.19	-0.11	0.35**
FW										-0.22	0.01ns	0.12ns	0.16	0.25*	0.13ns
MaD											0.14	0.16ns	-0.13	-0.041	-0.01
BMW												0.79***	-0.21	-0.09	0.79**
STW													-0.12	-0.11	0.69**
HI														0.012	0.38**
THS GY															-0.04

*Whereas: - ***, ** and * correlation is significant at the 0.001, 0.01 and 0.05 significance level respectively. ED: number of days to emergence, FD: number of days 50% flowering, PH: plant height, LN: leaf number, GLA: green leaf area, NT: number of tiller, NPDT: number of productive tiller, FN: finger number, FL: finger length, FW: finger width, MaD: number of 90 % Maturity days, BMW: biomass weight, STW: straw weight, HI: harvest index, THS: Thousands seed weight, GY: grain yield*

Table 7. Economic analysis of integrated vermicompost and blended NPSB with urea fertilizer rate on finger millet production in Gobu-Sayo district

Treatments	Grain yield (kg ha^{-1})	Adjusted grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Adjusted straw yield (kg ha^{-1})	Gross grain yield field benefit (ETB ha^{-1})	Gross straw benefit (ETB ha^{-1})	Total field benefit (ETB ha^{-1})	Total variable cost (ETB ha^{-1})	Net benefit (ETB ha^{-1})	Value to cost ratio	Marginal rate return (%)
Control (non-treated)	1057.7	951.9	4574	4116.6	30461.8	1235.0	31696.7	0.0	31696.7	_	_
Inorganic Fertilizers alone	1948.4	1753.6	8078.3	7270.47	56113.9	2181.1	58295.1	5084.6	53210.5	10.5	423.12
25:25 % VC & NPSB, urea	1447.5	1302.8	5419.7	4877.73	41688.0	1463.3	43151.3	7301.1	35850.2D	5.0	
25:50 % VC & NPSB, urea	2201.6	1981.4	6082	5473.8	63406.1	1642.1	65048.2	8572.3	56475.9	6.6	93.63
25:75 % VC & NPSB,urea	1597.1	1437.4	8399.1	7559.19	45996.5	2267.8	48264.2	9843.4	38420.8D	3.9	
50:25 % VC & NPSB, urea	1374	1236.6	6635.3	5971.77	39571.2	1791.5	41362.7	13331.1	28031.6D	2.1	
50:50 % VC & NPSB, urea	1257.1	1131.4	5877.4	5289.66	36204.5	1586.9	37791.4	14602.3	23189.1D	1.6	
50 :75 % VC & NPSB,urea	2030.2	1827.2	6467.6	5820.84	58469.8	1746.3	60216.0	15873.4	44342.6D	2.9	
75: 25 % VC & NPSB,urea	1486.7	1338.0	7620.1	6858.09	42817.0	2057.4	44874.4	19391.1	25483.2D	1.3	
75:50 % VC & NPSB, urea	1408.2	1267.4	6580.8	5922.72	40556.2	1776.8	42333.0	20662.3	21670.7D	1.1	
75:75 % VC & NPSB, urea	1505.6	1355.0	5866.3	5279.67	43361.3	1583.9	44945.2	21933.4	23011.8D	1.1	
Vermicompost alone	1457	1311.3	6505.7	5855.13	41961.6	1756.5	43718.1	24120.0	19598.1D	0.8	
100 :25 % VC & NPSB,urea	1907.9	1717.1	8822.5	7940.25	54947.5	2382.1	57329.6	25391.1	31938.5D	1.3	
100:50 % VC & NPSB,urea	973.7	875.1	5410.1	4869.09	28002.1	1460.7	29462.9	26692.3	2770.6D	0.1	
100 :75 % VC & NPSB,urea	1642.4	1478.2	7055.6	6350.04	47301.1	1905.0	49206.1	27963.4	21242.7D	0.8	

Where: - grain yield cost 100 kg^{-1}= ETB 3200, Cost of straw 100kg^{-1} = ETB 30, Cost of NPSB 100 kg^{-1} =ETB 2017.68, Cost of Urea =ETB 2946.89, Cost of transportation of vermicompost 100kg= ETB 20, cost of transportation NPSB with urea fertilizers 100kg= ETB 60vermicompost cost 100kg-^{1} = ETB 800= D = dominate

The possible reason for significance in harvest index might be due to availability of sufficient quantity of nutrients through integrated of inorganic with organics vermicompost fertilizer enhanced the productive efficiency through concurrent photosynthesis and effective translocation of assimilates from source to sink during the grain filling period. Similarly, Pallav et al. (2016) significantly higher harvest index of finger millet was gained through the application of 25% N through vermicompost + *Azosprillum* + 50% N through fertilizer.

3.13 Correlation between Phenological, Growth, Yield and Yield Components of Finger Millet

Finger millet growth, grain yield and yield components demonstrated a positive correlation (Table 6). Grain yield was found to be significantly and positively correlated with plant height (0.739), leaf number (0.395), Greenleaf area (0.260), finger number (0.280), finger length (0.348), biomass yield (0.796), and straw yield (0.692) and harvest index (0.375). These positive correlations between grain yield and these features suggested that increasing grain yield by employing an optimum integrated vermicompost level and an integrated NPSB with urea fertilizer enhanced finger millet through improving the aforementioned parameters. This result agreed with Chavan et al. [17] who reported that harvest index, number of finger heads per plant, biomass production per plant, and plant height were all found to be significantly related to finger millet grain yield. Similarly Kumar et al. [18] discovered a substantial and positive relationship between grain yield and millet harvest index.

3.14 Economic Feasibility of Integrated Vermicompost and Inorganic Fertilizer Application in Finger Millet Production

The optimum application rate of integrated vermicompost and blended NPSB with urea fertilizer treatments resulted in higher net benefits than the control, which consisted of 25: 50% vermicompost and NPSB with urea, and inorganic fertilizer alone (Table 7). The highest net benefit ETB 56,475.9 ha^{-1} was obtained from the application of integrated 25:50% vermicompost and blended NPSB with urea per ha^{-1} of fertilizer, with a marginal rate of return of 93.63%, while the lowest net benefit ETB 2770.58 ha^{-1} was obtained from the application of 100:50% vermicompost and blended NPSB with urea fertilizer. As a result, 25:50% vermicompost (1.16 tons ha^{-1}) and blended NPSB with urea, (50 kg NPSB ha^{-1} and 45 kg urea ha^{-1}) was found economically feasible for finger millet production.

4. CONCLUSION

The current research on the effects of integrated vermicompost and blended NPSB fertilizer with urea rates was critical for developing long-term finger millet cultivation. The pre-sowing soil analysis indicated that the study region has strongly acidic soil with poor soil fertility, which requires an amendment to boost crop output in the study area. The post-harvest soil analysis also revealed that the application of integrated vermicompost along with blended NPSB with urea fertilizers had a positive effect on crop growth and yield of finger millet, and maintained good soil health. However, inconsistent soil nutrient change was observed on the treated experimental plots.

The highest number of days to 50% flowering and number of days to 90% physiological maturity (99.6 days and 149.33 days respectively) of finger millet were obtained with the application of 50:75% vermicompost and recommended NPSB with urea. The tallest (70 cm) plant height was obtained with the application of inorganic fertilizer alone. Moreover, the highest (6.4 and 3.96) number of tillers per plant and number of productive tillers per plant were obtained with the application of 100:75% vermicompost and recommended NPSB with urea; and the maximum (10730 and 8823 kg ha^{-1}) dry biomass and straw yield were obtained with the application of 100:25% vermicompost and recommended NPSB with urea. Similarly, the highest (33.8 7% and 2202 kg ha^{-1}) harvest index, and grain yield of finger millet were obtained with the application of 25:50% vermicompost and recommended NPSB with urea. The highest net benefit of ETB 56475.9 ha^{-1} with a marginal rate of return of 93.63% was recorded from the treatment that received 25:50% vermicompost and inorganic NPSB with urea application in the study area.

Based on some of the soil lab analysis result, the soil of the study area is medium in fertility, but strongly acidic in reaction. Therefore, integrated soil fertility management practices such as liming and the addition of organic and inorganic fertilizers are recommended to improve yields of finger millet, and soil fertility in the study area. Application of integrated 25:50% vermicompost and blended NPSB with urea resulted in better grain yield (2202 kg ha^{-1}) with a net benefit of ETB 56475.9 ha^{-1} and a marginal rate of return 93.63%. Hence, farmers in the study area and similar agro ecologies can be advised to use integrated**,** 25:50% vermicompost (1.16 tons ha^{-1}) and blended NPSB with urea, (50 kg NPSB ha^{-1} and 45 kg urea ha^{-1}) to boost finger millet production and productivity. However, experiment was conducted in one location and season; hence it should be repeated in different locations and seasons to provide a credible suggestion for long-term finger millet production and productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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