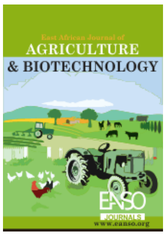

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Original Article

Farmyard Manure Integrated with Triple Superphosphate for Improved Soil Conditions and Yield of Bio-Fortified Common Beans

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ABSTRACT

Increasing prices of fertilizers and low nutrient concentration in organic manure are highly contributing to poor soil conditions and increased yield gap of bio-fortified common beans. A field study was carried out to assess the effect of farmyard manure integrated with triple superphosphate on soil conditions and yield of bio-fortified common bean Genotypes in central Uganda. The experiments were set in a Randomized Complete Block Design (RCBD) conducted at Mukono Zonal Agricultural Research Institute (MUZARDI) in two rainfall seasons. Treatments included; Cattle manure + TSP, Swine manure + TSP, Chicken manure + TSP, TSP alone and control replicated five times. Bio-fortified common bean genotypes studied were: Naro bean 1, Naro bean 3 and NABE16 a local check. Data was collected on; organic matter, soil pH, nitrogen, potassium and phosphorus content, harvest index, number of pods, pod length, number of seeds per pod, weight of 100 seeds, and grain yield of bio-fortified common beans. Data was subjected to statistical test and analysis of variance using GenStat statistical package (15th edition). Results showed that amending field plots with Swine manure + TSP significantly increased Organic matter by; 1.51% and potassium 1.22% than Chicken manure + TSP, Cattle + TSP, TSP alone and a control respectively. Chicken manure + TSP increased soil pH and Nitrogen by 1.80 and 2.20% while, TSP alone improved Phosphorus by 5.2 PPM than other treatments. Yield parameters were not significantly ($P>0.05$) affected by treatments except weight of 100 seeds. However, bean genotypes grown in Swine manure + TSP recorded maximum yield of 14 pods, 4 seeds per pod, 32.93 g weight of 100seeds, grain yield was (1843 kgha-1) and lowest (1253 to 650 kg/ha) in TSP+ cattle manure and control. It was therefore, concluded that swine manure + TSP significantly improved soil conditions and yield of bio-fortified common beans. Therefore, basing on these findings, farmers should adopt amendment of swine manure with TSP for improved soil conditions and yields of Naro bean 1.

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INTRODUCTION

Low soil fertility has significantly increased malnutrition in developing continents like South America, Africa, and Asia (Smith, 2016). In sub-Saharan Africa, Uganda is under threat as 660 kg N ha^{-1}, 75 kg P ha^{-1} and 450 kg K ha^{-1} on average have been depleted from most cultivated fields in the last 30 years (Bumb & Gregory, 2006). This has provoked farmers to use other alternatives measures like integrated nutrient strategies to boost yield without compromising soils as production units. However, the best combination especially on farmyard manure and fertilizers particularly limited nutrient for that plant, has not yet been identified (Kimetu et al., 2006). Yet, 39% poor Ugandan households staying in urban and villages severely hungry and deficient in Iron, Zinc, proteins, and fats (FAO, 2008; Sidhu, 2020. Crop breeders in the region have bred bean genotypes that are highly yielding and bio-fortified by Iron and Zinc. As a multidisciplinary approach to combat hunger and hidden hunger (micro nutritional deficiencies) (Pierrot *et al*., 2014). However, production of these beans genotypes has been limited by low soil fertility especially P, a key requirement (20-30% or 10-15 mg/ kg is needed by individual bean plant) in energy metabolism during nodulation and protein synthesis (Broadley, 2009). Yet, Africa is old with its soil nutrients pool exhausted in some parts like Uganda. Due to high levels of poverty among households, forcing them to cultivate land season after season (FAO, 2008). Thus, poor soil health leading to low bean yield accounting to 217.5- 600 $kg^{-}ha$ produced in all regions of Uganda for other varieties (Catherine et al., 2016; CIAT, 2015) compared to 1750-3750 $kgha^{-1}$ achievable yield (MAAIF, 2017). When, beans are a reliable feeder to all Ugandans, as its per capita consumption has increased from 19 kg to 21 kg as a result of human population increase (Karfakis et al., 2011). High consumption than production, is compromising the achievement of the second sustainable development goals: No hunger by 2030 (WFP, 2019).

Consequently, to achieve no hunger by 2030, poor soil amendment techniques like, application of only fertilizers or organic manure as recommended by other studies, should be abolished, or not depended on and integrated approach be adopted. Because, fertilizer prices are increasing every year, suppresses symbiotic association of legumes and Rhizobium bacteria species especially the R. *etli* species which is the major nodulating bacterium species. Hence growth and yield are compromised (Dogra & Dudeja, 1993). On another hand, Organic matter is cheap and supplies all the required micro and macronutrient, unfortunately its nutrients exist in low concentration (Teppei *et al*., 2008). Hence these strategies are not adequately capable of adjusting soil fertility to sustain soil and crop productivity (Kimetu et al., 2006).

So, to contribute to the strategy ''Zero hunger and improved wellbeing of Ugandans by 2030''. Dereje *et al* (2018) recommendations of every crop having a limiting nutrient for example; cereals and vegetables are limited to nitrogen,

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bananas to potassium, tubers, and beans to phosphorus, for their potential growth and yield or catering for their explicit essential nutritional needs, should be followed by integrating farmyard with a crop's limiting nutrient. However, there is limited information on effect of farmyard manure integrated Triple supersphate on soil conditions, yield of biofortified common bean genotypes in Uganda.

MATERIALS AND METHODS

A field experiment was conducted at Mukono Zonal Agricultural Research and Development Institute (MUZARDI), located in Ntawo Division, Mukono District in Central Uganda. The institute is situated at 1200 m above sea level and gently sloping to the western direction, along latitude 1.029^0 South and 40.29^0 North and longitude 32.77^0 East. The site has a minimum temperature range of 15 ^{0}C to 18 ^{0}C and maximum temperature range of 25 ^{0}C to 28 ^{0}C, with a bimodal rainfall regime of 1100 mm-1600 mm (Mungyereza, 2014). Its soils are mainly ferrosols which are shallow, well weathered with low to moderate inherent fertility (Opio & Tomma, 2018).

Soil characterization was carried out to ascertain physical and chemical properties. Twelve Soil samples were collected by transverse method from 0-25 cm (Akinola et al., 2018). Samples were mixed together thoroughly in the bucket to obtain a homogeneous composite sample, that was air dried for five days at room temperature and sieved through 2 mm sieve (Uchida, 2000).

Physical composition of sandy, clay, silt and texture was determined by Bouyoucos hydrometer method, soil pH was determined by glass electrode pH meter and Potassium, calcium and magnesium were determined by flame photometer (Tekalign et al., 1991). The available phosphorus was determined by Bray1 extraction method (Olsen et al., 1954) while Nitrogen and organic matter were further determined through a rapid titration (Walkley, 1934). Soil analysis were carried out from Makerere University and Kawanda soil science laboratories and results are presented in *Table 1*.

Table 1: Soil physical and chemical properties at MUZARDI for first and second season (2018-2019)

Sample Details	pH	OM	N	P	K	Na	Ca	Mg	Sand	Clay	Silt
	%								PPM		
First Season	6.1	2.65	0.2	2.6	1.2	0.1	6.7	0.1	50	44	6.0
Second Season	6.2	2.32	0.1	2.1	1.4	0.1	5.2	0.2	48	46	6.0

Management and Chemical Analysis of Farmyard Manure

Farmyard manure samples were collected from layers under cage system, cow dung from dairy cattle and pig dung from piggery unit at Kyambogo University farm. Three samples from chicken, swine and cattle dung were picked at random, wrapped separately in aluminium foil papers to enclose escape of bad smell, nitrogen, and contamination by dust particles during transportation to the laboratory for carbon (C): nitrogen (N) ratio determination (Walkley and Black, 1934). Results showed that, all manure samples were of poor quality as they had a low C: N ratio (chicken dung 10.2: 2, cattle dung 11.2: 1 and swine dung 13: 1.49). This means, when such manure is composted, more ammonia and carbon dioxide will be produced and so, microorganisms will lack or have less to eat and multiply. Hence manure produced will be of poor quality (Charles et al., 2006). According to Wabusa et al. (2021) to improve quality of manure, chopped dry maize straw with carbon content 30:0.4 was further quantified by calculating using equation presented by (Wortmann, 2006).

$$\text{QA} = 2000\text{ibs x } N_m x(\text{C: N}_t - \text{C: N}_m) x\, DM_m \div N_A x(C{:}\ N_A - C{:}\ N_T) x\, DM_A \quad (1)$$

i.e. QA- quantity of maize straw required to improve quality of manure, 2000ibs- quantity of manure used, N_m - % N_2 in manure, C: N_T - normal carbon in manure, C: N_m- carbon in manure after

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analysis, D mm % dry matter of manure, N_A - % N_2 in maize straw or material with high carbon, C: N_A -normal carbon in maize straw, C: N_T- carbon in maize straw after analysis and DM_A – dry matter in material with high carbon.

After calculation, 296 kgs of maize straw was blended into 600 kgs of chicken dung, 260 kgs maize straw was mixed in 600 kgs cow dung and 216 kgs straw with 600 kgs pig or swine dung. Thereafter, manure was organized in row piles, composted under a protected roof using wind row method for 8 weeks. In the first two weeks, manure was turned trice per week accompanied by watering whenever temperatures could rise above 60 ^{0}C. This was followed by weekly turning since temperatures were dropping until when manure was fully composted. On the 9th week, three different sample from each manure pile where pick for analysis and findings were presented in *Table 2*. The rest of the manure was packed in sacks and transported to the experimental site for application. Same activities and procedures were followed for second season and results are presented in table 3 below. However, Triple Super Phosphate (TSP) was bought and phosphorus content in it was 35%. TSP was blended with manure at ratio of 10 t/ha manure: 30 kg/ha TSP at the time of planting following calibrations recommended by Nazir (2016) and Kayuki *et al* (2011).

Table 2: Chemical properties of manure for first season at Kyambogo university farm

Samples	pH	OM	N	Mg	K	Na	Ca	P	Zn	Fe
	%							PPM		
Cattle manure	7.49	3.22	1.46	1.04	0.05	0.01	0.01	2.53	157.67	7391.33
Swine manure	6.68	4.04	4.92	1.91	0.13	0.02	0.07	3.12	196.67	9424.17
Chicken manure	8.36	3.67	5.98	1.21	0.18	0.03	0.03	2.56	182.34	9644.00

Table 3: Chemical properties of manure for second season at Kyambogo university farm

Samples	pH	OM	N	Mg	K	Na	Ca	P	Zn	Fe
	%							PPM		
Cattle manure	8.21	3.11	1.28	0.48	0.04	0.01	0.01	2.34	151.24	28810.33
Swine manure	6.88	3.49	3.98	1.53	0.14	0.01	0.06	3.81	187.87	9810.91
Chicken manure	8.48	3.47	4.37	1.30	0.09	0.02	0.03	2.49	169.01	9791.48

Experimental Design

The experiment was laid in a Randomized Complete Block Design (RCBD), replicated five times. Treatments composed of three sources of farmyard manure: Chicken, Swine, and Cattle manure. During integration Chicken manure was combined with TSP (POLM), Swine manure combined with TSP (SWM), cattle manure combined with TSP (CATM). Farmyard manure was integrated with TSP at a rate of 9 kgs: 27 g TSP, followed by application of 27 g of TSP alone as a positive control and control (no amendments) forming five treatments. The field was marked into 5 blocks (replicates) and 75 plots, each measuring 9 m^2 separated by 1.5 m width between blocks, and 1 m width between plots to enable easy movement

Agronomic practices. Included: primary, secondary cultivation to obtain a fine tilth, planting, spacing, Weeding, Watering and Pests and diseases control (Wabusa et al., 2021)

Data Collection on Effect of Farmyard Manure Integrated with TSP

Soils were sampled twice i.e., before and after planting. Before planting, random soil sampling technique was employed to ascertain the baseline information before planting (*Table 1*). Soil samples were collected at the depth 0-25 cm using a soil auger by transverse method (Akinola et al., 2018). After planting or harvesting, zone sampling technique was employed at the middle of every experimental unit. Samples from experimental units were collected and combined together in a block to obtain five representative

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samples for each block per treatments and labelled as swine + TSP block1-5, cattle + TSP block1-5, TSP block1-5, chicken + TSP block1-5 and control block1-5. The samples collected were, air dried for five days under room temperature and thereafter sieved through 2 mm sieve (Burton, 1990). Followed by analysis of organic matter, soil pH and Nitrogen, phosphorus, potassium availability. Data obtained were analysed by a **t**-test to generate means that determined improvement in soil conditions created by treatment from means of baseline or not (Hentz, *et al*., 2016).

Organic Matter Content

During analysis of organic matter steps described by Okalabo et al. (2002, as cited in, Wabusa et al. 2021) was followed.

$$O_c = Tx0.3x0.2 \div S_w \qquad (2)$$

Where Oc-organic carbon, T-reagent blanks, and Sw-sample weight. Same procedures were followed to other samples.

Soil pH

Soil pH was determined using glass electrode pH meter using Okalabo et al. (2002) procedures.

Nitrogen Content

In the process of analysing nitrogen present in the soil, steps presented by Okalebo et al. (2002) was followed.

$$\%N_2 = (a - b)\; x\; 0.1\; x\; V\; x\; 100\; \div 100\; x\; W\; x\; al \qquad (3)$$

Where a- volume of 1 titre HCl for blanks, b-volume of 1 titre HCl for samples, V- final volume of digestion, W- weight of the samples taken and al- aliquot of the solution taken for analysis

Phosphorus Content

In the process of phosphorus extraction, 2 g of soil sample was weighed out accurately into 150 ml polythene shaking bottle. Followed by addition of 50 ml of Olsen's or Bray1extracting solution (depending on the soil pH of the samples) to each bottle. Analysis was carried out following procedures of Okalabo et al. (2002, as cited in, Wabusa et al. 2021).

$$P(ppm) = (a - b)x\; V\; x\; f\; x\; 1000\; \div 1000\; x\; W \qquad (4)$$

Where a- concentration of P in extract solution, b-concentration of p in blank sample, v-extract volume, w -weight of soil, f- additional dilution factor.

Potassium Content

Extraction procedures; air dried soil sample of 5 g was put into a clean plastic bottle with stopper, 100 ml of ammonium acetate solution NH_4OAc (pH 7) was added and shaken for 30 minutes. Thereafter the solution was filtered through No. 42 Whatman paper and analysis was carried out following the procedures (Tekalign et al., 1991). Reported by (Wabusa et al., 2021).

$$\%K = (a - b)\; x\; V\; x\; f\; x\; 1000\; \div 1000\; x\; W \qquad (5)$$

Where a- concentration of K in digest sample, b-concentration of K in blank digest, w- volume of the sample, v- volume of digest solution and f-dilution factor.

Effect of Farmyard Manure Integrated with TSP on Growth and Yield Parameters

Ten plants were tagged on the middle lines of plots, leaving out plants on the opposite lines and data was collected on harvest index, number of pods, number of seeds in the pod, pod length was determined when the plants had achieved their physiological maturity on the 58th day after planting for Naro bean 3 and 70th day after planting for Naro bean 1 and Nabe 16. On the other hand, grain yield and weight of 100 seeds data were collected after threshing and drying (14% moisture content) all plants from individual plots per treatment.

Harvest Index

Ten sampled plants were uprooted as per treatments, roots were cut off and abandoned. Pods were cut off from the shoot weighed and record as fresh weight, there after they were

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wrapped in newspapers labelled using its field tag number. The same process was done on the shoot and finally samples were oven dried at 80 ^{0}C, for 48 hours. Samples were removed and weighed again using electronic sensitive scale as dry weight, values obtained here were subtracted from fresh weight and recorded. The same procedures were followed on the shoot, so as to obtain harvest index (%Hi) economic yield (EY) was divided by the total biological mass (BM) of the plant and then multiplied by 100% according to (Mohanty, 2017).

$$\%H_i = EY \div BM \; x \; 100 \qquad (6)$$

Number of Pods

All pods on each tagged plants were counted and recorded there after an average number was obtained per plot (Barcchiya, 2014).

Number of Seeds Per Pod

Number of seeds was determined using (Beebe, 2008) method as reported by (Wabusa et al., 2021)

Length of the Pod

This was worked out by observation and measuring the length of each pod produced per plant using a thread and meter ruler, average length of pods on the plant was obtained and recorded (Kyebogola, 2013).

Weight of 100 Seeds

All plants in experimental plots were uprooted and threshed by hand and seeds or grains were dried to a required moisture content of 14%. Thereafter 100 seeds were picked ten times as representative samples randomly from all bean genotypes in plots as per their treatments, weighed separately using a digital electronic scale and an average weight of each plot was obtained and recorded (Mohanty, 2017).

Grain Yield

Weight of grains from each plot was determined as per the treatment and weighed using a digital electronic balance results obtained were extrapolated to yield per hectare (Kumar, 2018) and (Mohanty, 2017).

Data Analysis

During data analysis first and second season data was statistically tested for Normality using Shapiro-Wilk test (Ghasemi & Zahediasl, 2012), Number of pods, pod length and grain yield skewed positively. So, this data, was transformed to log base ten and further tested for homogeneity by Barlett test (Barlett, 1937). Data was then imported into GenStat 2015 version. Parameters on soil conditions were analysed by a **t-** test after passing a normality and a homogeneity test and Analysis of variance was run for yield parameters of bio-fortified bean genotypes and the difference between treatments were declared at LSD 5% to separate the means. However, interactions between bean genotypes and treatments were established graphically in Microsoft Excel 2013; with standard error represented by bars over the mean.

RESULTS

Integrating Triple Superphosphate with Farmyard Manure on Soil Conditions

In this section, the effect of farmyard manure integrated with TSP on soil conditions was achieved by getting a difference between means of statistical test due to the effect of treatments and the baseline values in *Table 4*.

Findings revealed that application of swine + TSP and chicken + TSP significantly ($P<0.05$) improved organic matter by 1.51% and 0.99%, respectively. By contrast on one hand, cattle + TSP, and TSP did not significantly ($P>0.05$) increase organic matter. Similarly, though, not significant ($P>0.05$), there was a decline in organic matter by -0.66% in plots that did not receive treatments (*Table 4*).

Results here indicated that, there was a significant ($P<0.001$) increment of soil pH by 1.8, 1.18, and 0.93 when plots were treated with swine manure + TSP, chicken + TSP, and cattle + TSP respectively, in respect to base line value of 6.17. TSP and controls increased the soil pH by 0.54 and 0.11 but, this increment was significant ($P<0.05$) for only TSP (*Table 5*)

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Table 4: Effect of farmyard manure integrated with TSP on organic matter and soil pH content of the soil

Treatments	Organic matter (%)[a]	Difference[b]	Soil pH[a]	Difference [b]
Swine manure + TSP	4.00	1.51*	7.29	1.18***
Chicken manure + TSP	3.48	0.99*	7.97	1.80***
Cattle manure + TSP	3.27	0.78NS	7.10	0.93***
TSP	2.52	0.03NS	6.62	0.45*
Control	1.83	-0.66NS	6.28	0.11NS

*[a] Means obtained after application of treatment, [b] difference between treatment and baseline (2.49%) for organic matter and (6.17) Ph, *** represents that the difference between treatment effect and baseline is significant at (P<0.001), * represents that the difference between treatment effect and baseline is significant at (P<0.05), [NS] not significant.*

Table 5: Effect of farmyard manure and TSP on nitrogen, phosphorus, and potassium content in the soil

Treatments	Nitrogen (%)[a]	Difference (%)[b]	Phosphorus (ppm)[a]	Difference (%)[b]	Potassium (%)[a]	Difference (%)[b]
Swine manure + TSP	2.50	1.88***	4.02	2.60***	2.45	1.22***
Chicken manure + TSP	2.18	2.20***	3.52	2.10***	2.06	0.83**
Cattle manure + TSP	1.29	1.09*	3.04	1.62***	2.10	0.88**
TSP	0.55	0.25NS	6.62	5.2***	0.97	-0.26NS
Control	0.76	0.46NS	1.32	0.1NS	1.11	0.31*

*[a] Means obtained after application of treatment, [b] difference between treatment and baseline value 0.3% Nitrogen, 1.42P MM phosphorus and 1.23% potassium *** represents that the difference between treatment effect and baseline is significant at (P<0.001), ** significant at (P<0.01) *, * represents that the difference between treatment effect and baseline is significant at (P<0.05), [NS] not significant.*

Results presented in *Table 5* revealed that, application of chicken manure+ TSP and swine manure + TSP significantly (P<0.001) improved nitrogen content by 2.20% and 1.88% from baseline nitrogen value of 0.3%. Similarly, amendment of the study plots by Cattle + TSP also significantly (P>0.05) increased nitrogen content by 1.09%. On Contrary, plots that received one nutrient or no amendment were not significant (P>0.05) from baseline.

Results on phosphorus in *Table 5* indicated that, all plots either amended with TSP alone or TSP integrated with swine, chicken or cattle manure recorded significantly (P<0.001) higher P content except control that was not amended.

Results of this study indicated that application of swine + TSP, chicken + TSP and cattle + TSP significantly (P<0.01) improved potassium content by 1.22%, 0.83% and 0.88% respectively, in relation to baseline of 1.23%. Correspondingly, in control treatment potassium content was also significantly (P<0.05) improved by 0.31%. However, application of TSP alone reduced potassium content to value -0.26%.

Effect of Farmyard Manure Integrated with TSP on Yield

Results here showed that swine manure + TSP recorded the highest harvest index (71%), followed by chicken manure + TSP (54%) and the least was recorded under cattle manure+ TSP (49%) among integrated treatments. TSP and Control recorded less than 45% values of harvest index. Though all treatments caused high significant (P<0.001) difference on harvest index.

Findings on number of pods as influenced by farmyard manure integrated with TSP indicated a high significant (p<0.001) difference among treatments. Swine manure + TSP recorded the highest number of pods among other treatments *Table 6* and *Plate 6* and *7*.

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Table 6: Effect of farmyard manure integrated with TSP on yield parameters

Treatments	Harvest index (%)	No. of pods	No. of seeds	Pod length (cm)	Weight 100 seeds (gm)	Grain yield ($kgha^{-1}$)
Swine manure + TSP	71	14	4	10.71	32.93	1843
Chicken manure + TSP	54	10	4	9.53	30.21	1469
Cattle manure + TSP	49	8	3	9.14	29.68	1253
TSP	44	7	3	8.53	27.67	909
Control	42	6	3	7.75	26.19	650
$LSD_{(5\%)}$	4	1	0.3	0.66	0.71	184.4

Plate 1: Number of pods on Naro bean 1

a

b

Source: (Author 2021)

Plate 2: Number of pods on Naro bean

a

b

Source: (Author 2021)

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In the study to find out effect of farmyard manure integrated with TSP, application of treatments swine manure+ TSP and chicken manure + TSP resulted in high numbers of seeds per pod as compared to cattle manure + TSP and control treatment. Though, there was a high level of significance (P<0.001) as presented in *Table 6*.

Results of the study showed that, application of swine manure + TSP significantly improved pod length followed by chicken manure + TSP, cattle manure +TSP, TSP, and control (*Table 6*). However, application of all treatments significantly affected (p<0.001) length of pods.

Results further indicated that, the highest weight of 100 seeds was obtained in swine manure + TSP followed by chicken manure + TSP, cattle manure + TSP, TSP and lastly control treatment in the descending order (*Table 6*). Though application of all treatments significantly (p<0.001) influenced weight of 100 seeds.

Application of swine manure + TSP recorded maximum yield followed by chicken manure + TSP and lastly cattle manure + TSP among integrated treatments compared to both controls (*Table 6*). However, all treatments had a significant (p<0.05) effect on yield.

Table 7: Effect of Bean genotypes on yield parameters

Bean genotypes	Harvest index (%)	No. of pods	No. of seeds	Pod length (cm)	Weight 100 seeds (gm)	Grain yield ($kgha^{-1}$)
Naro bean 1	53	10	3	9.40	35.84	1432
Naro bean 3	51	9	3	8.89	23.49	1109
Nabe 16	52	9	3	9.99	28.49	1134
$LSD_{(5\%)}$	3	1	0.2	0.51	1.09	142.9

Results on effect of bean genotypes on harvest index showed that, Naro bean 1 recorded numerically the highest harvest index value, compared to Nabe 16 and Naro bean 3 that recorded low harvest index. However, there was no significant difference (P>0.05) among bean genotypes for harvest index (*Table 7*).

Results on effect of bean genotype on number of pods presented in *Table 7* indicated that, Naro bean 1 registered higher number of pods (10). Interestingly, NARO bean 3 and NABE 16 recorded the same number of pods (9). The variation between genotypes for number of pods was significant (P<0.001).

There was no variation on number of seed per pod among bean genotypes (*Table 7*). Similarly, there was no significant difference (P>0.05) between bean genotypes and number of seeds per pod.

Results on effect of bean genotypes on pod length showed that there was no significant (P>0.05) difference between bean genotypes and pod length. NABE 16 recorded maximum pod length (9.99 cm) as compared to Naro bean 3 that registered the lowest pod length (8.89 cm). However, NARO bean 1 and NABE 16 statistically the same (*Table 7*).

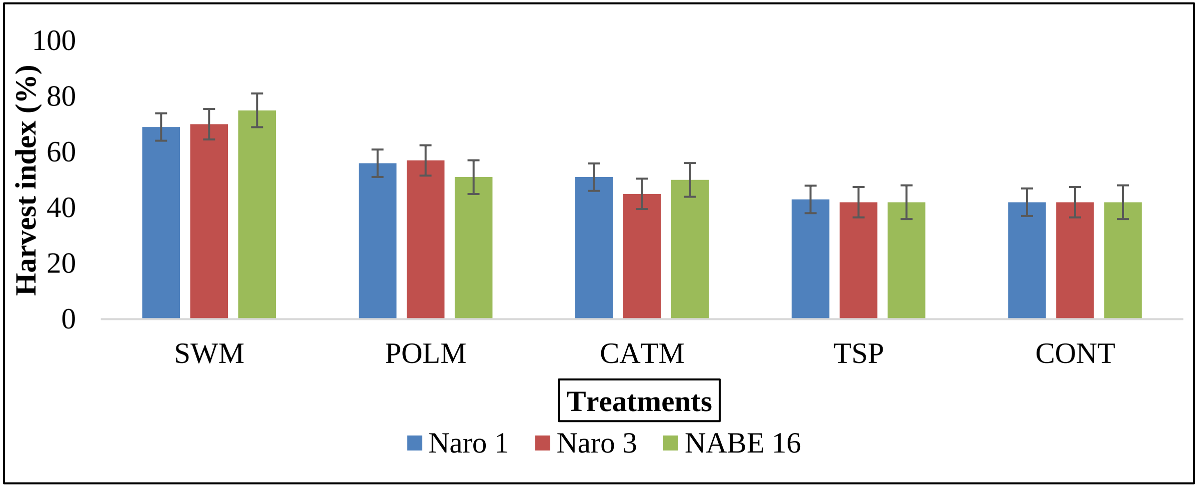
Results also showed that, the highest weight of 100seeds was observed on NARO bean 1 followed by local check and NARO bean 3 (*Table 7*). Although, influence of bean genotypes on weight of 100 seeds was significant (p<0.001).

Results further revealed that NARO bean 1 was significantly superior in yield over NARO bean 3 and local check (*Table 7*). Although, yield was significantly (P<0.05) difference among bean genotypes.

Interaction between Treatments and Bean Genotypes on Harvest Index

Results of interaction between treatments and studied bean genotypes as presented in *Figure 1* revealed that, interaction between treatments and bean genotypes influence on harvest index was not significantly (p>0.05). Though Nabe 16 registered high harvest index than Naro bean1 and 3 when grown in treatment swine manure + TSP. These was followed by bean genotypes that received Chicken, cattle + TSP, control and TSP alone respectively.

Figure 1: Harvest index as influenced by interaction between treatments and bean genotypes

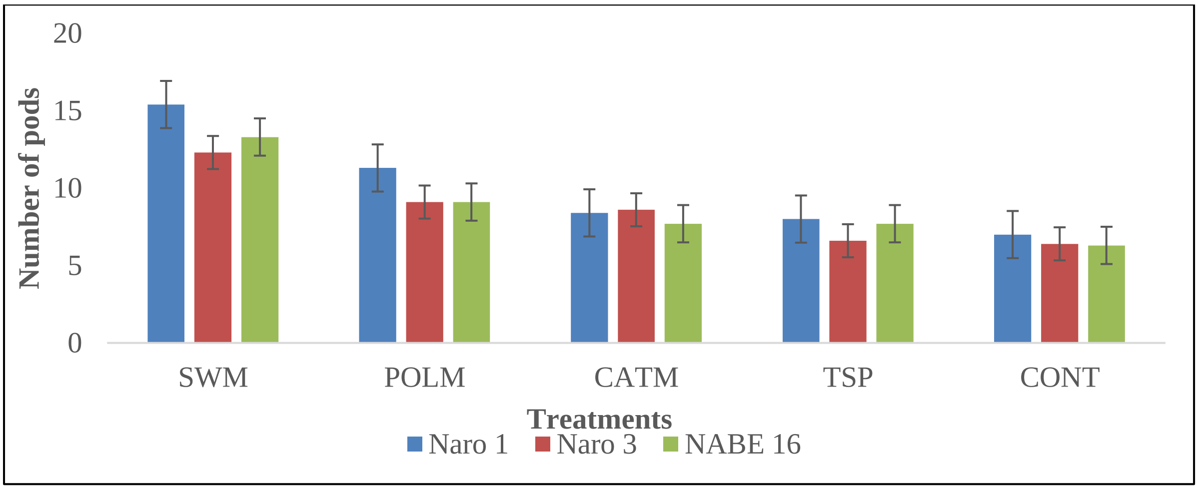


SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between Treatments and Bean Genotypes on Number of Pods

Results in *Figure 2* indicated that there was no significant difference (P>0.05) between treatments and bean genotype interaction on number of pods. NARO bean 1 maintained its superiority when treated with swine manure + TSP on number of pods across all bean genotypes (*Plate 1* and *2*), followed by chicken + TSP and cattle + TSP among farmyard manure integrated TSP. Conversely, lowest average number of pods was recorded on control treatments.

Figure 2: Number of pods as influenced by interaction between treatments and bean genotypes.



SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between Treatments and Bean Genotypes on Number of Seeds Per Pod

Despite the number of seeds per pod ranging from 2 to 5 (*Figure 3*), performance of swine + TSP recorded a maximum number of seeds per pod in Nabe 16 as compared to other treatments and bean genotype. Although, there was no significant (P>0.05) difference between treatments and bean genotypes interaction on number of seeds per pod.

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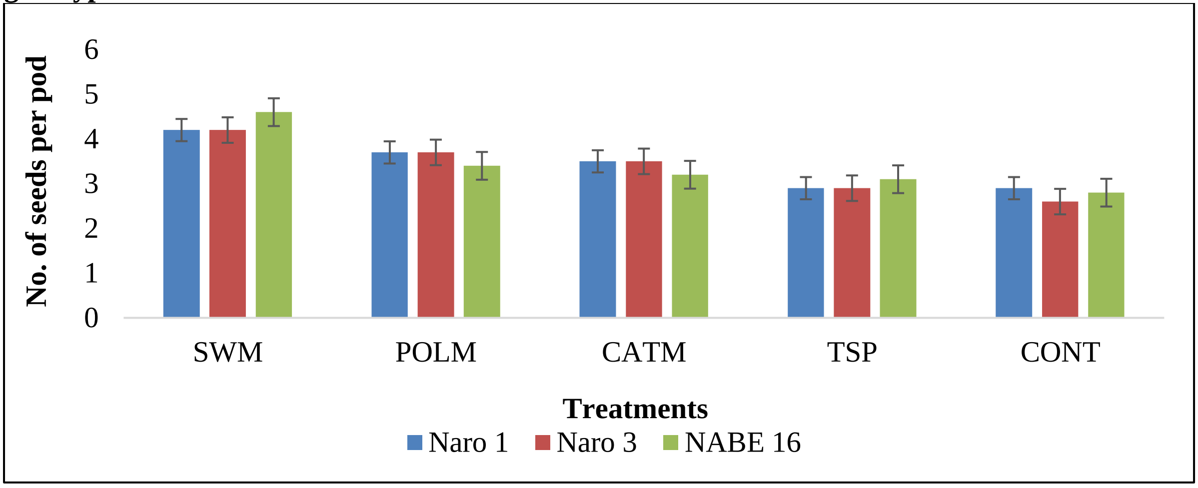
Figure 3: Number of seeds per pod as influenced by interaction between treatments and bean genotypes.

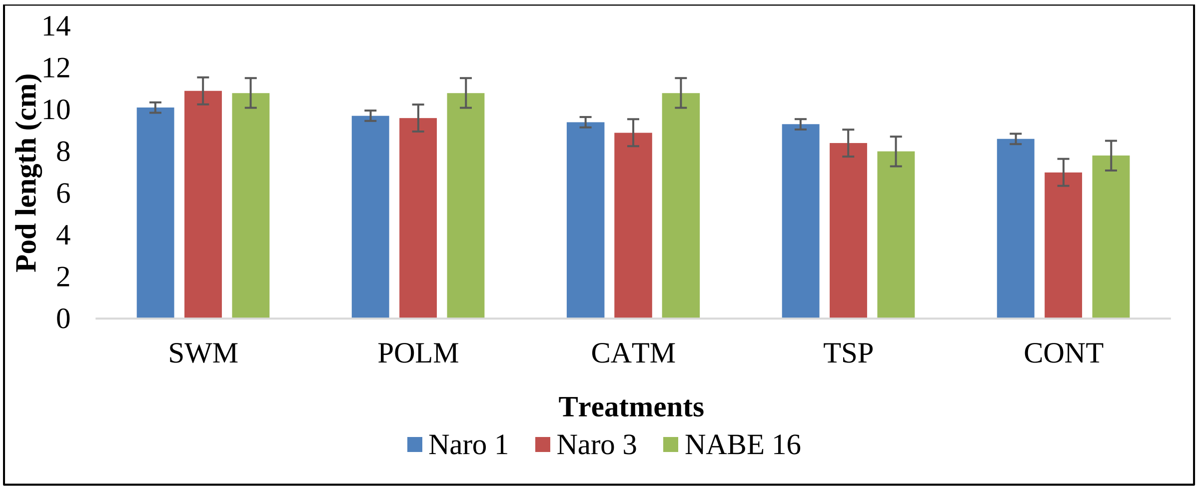


SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between Treatments and Bean Genotypes on Pod Length

In the study conducted to find out effect farmyard manure integrated with TSP (*Figure 4*), bean genotypes that received Swine + TSP recorded the longest pods. This observation was noted in bean genotype Naro bean 3 (10.86 cm), followed by local check (10.77 cm) and Naro 1(10.15 cm). Contender chicken + TSP tied up with cattle + TSP in local check by producing similar length of pods. Still under the same observation, there was a very little variation in pod length between Naro bean 1 and Naro bean 3 in treatment with Cattle + TSP. Contrary, TSP and control recorded shorter pods across all bean genotypes, though there was no significant (P>0.05) difference between treatments and bean genotype interactions on pod length.

Figure 4: Pod length as influenced by interaction between treatments and bean genotypes.



SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between Treatments and Bean Genotypes on Weight of 100 Seeds

The interactive effect between treatments and bean genotypes had a high significant effect (P<0.001) on weight of 100 seeds. Mean values obtained on interaction between bean genotypes and treatments showed high performance of NARO bean 1 followed by Nabe 16 in respect to weight of 100 seeds. But this was not the case with NARO bean 3, although, swine + TSP, was

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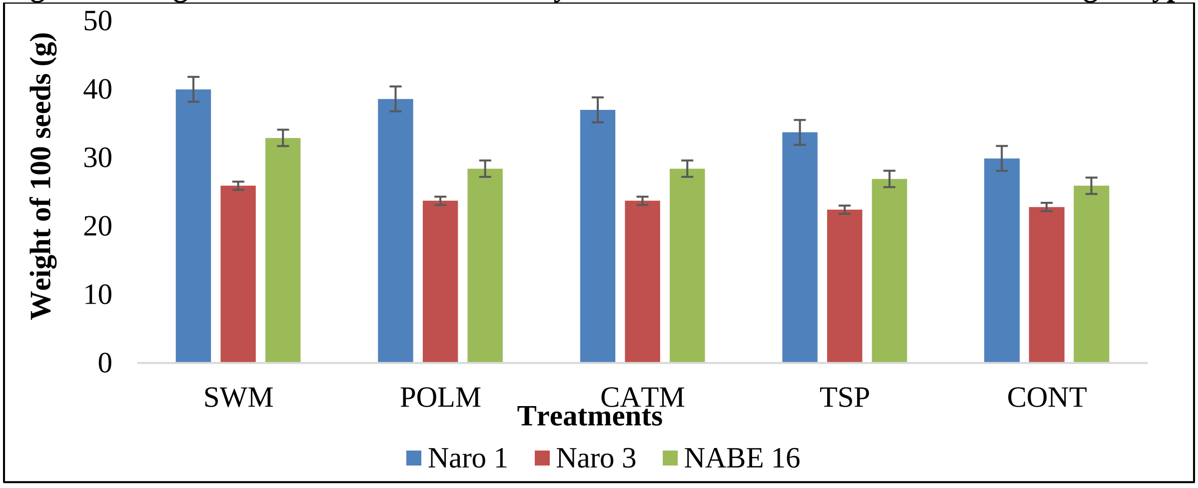
superior on weight of 100 seeds across all treatment (*Figure 5*).

Figure 5: Weight of 100 seeds as influenced by interaction between treatments and bean genotypes

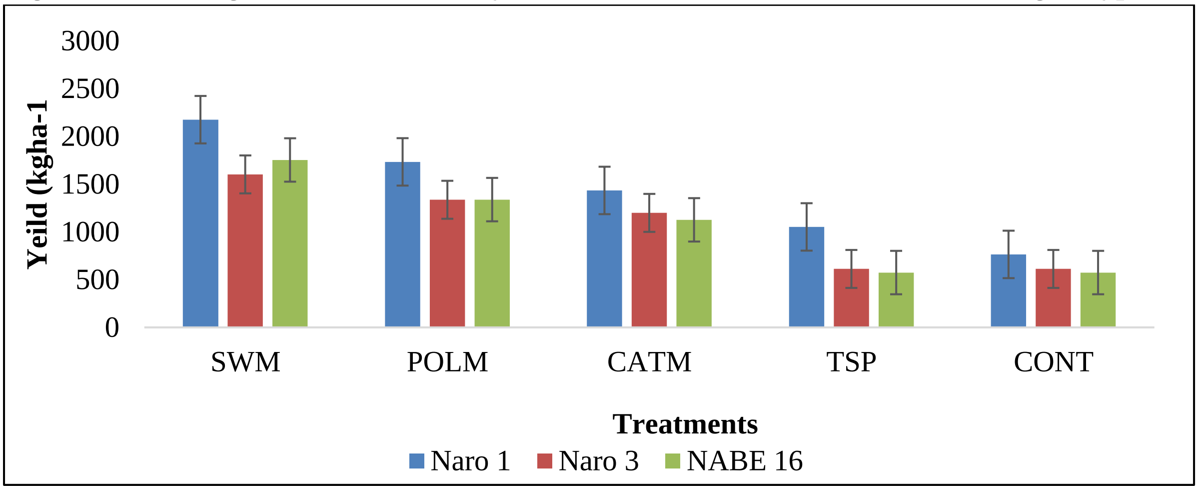


SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between Treatments and Bean Genotypes on Yield (kg/ha)

Interaction between treatments and bean genotypes did not significantly (p>0.05) affect grain yield *Figure 6*. The highest yield (kg/ha) was observed in Naro bean 1 when swine + TSP was applied compared to other bean genotypes and treatments.

Figure 6: Yield (kgha^{-1}) as influenced by interaction between treatments and bean genotypes



DISCUSSION

Soil Condition

Organic matter increase in field plots that received swine swine manure + TSP might have been attributed to existence of more carbon in swine manure (*Table 2* and *3*) as these favoured the existence of nitrogen in the soil. Which in turn probably attracted more microorganisms to break down organic matter which increased carbon turn over pool (Nisha & Sneh, 2018). When swine manure is integrated with TSP, breakdown of TSP energizes microorganisms inform of ATP to speed up decomposition and mineralization process hence more availability of organic carbon (Bot & Benites, 2005). The findings of this study concur with (Liu et al., 2017) who reported an increase in organic matter when swine manure was integrated with NPK. The low amounts of organic matter in field plots that received no treatment was due to lack of fertilizers, which resulted into reduced soil organic carbon due to mineralization and

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oxidation processes (Bot & Benites, 2005). The findings of this study are in agreement with Liu et al. (2017) who also observed low organic matter in unfertilized fields

pH considerable improvement in field plots amended by chicken manure with TSP observed from baseline value, probably could have been attributed to production and fixation of more nitrogen by organic matter from chicken, on addition to N_2 fixed by beans which resulted into release of more ammonium, hence increased soil pH (Suarez & Dorivar, 2007). This study agrees with (Ano & Ubochi, 2010) who reported the same information.

Nitrogen. An improvement in concentration of N_2 in plots amended with chicken+TSP could have been due to, the existence of nitrogen in chicken droppings in form of uric acid which is a store for a commendable amount nitrogen. This increased the amount of nitrogen, on addition to what was fixed by beans and Nitrobacter in mineralization process (Suarez & Dorivar, 2007). This study is in conformity with results reported by (Ghosh, et al., 2003; Kwadwo and Larbi (2015) as they observed more nitrogen in plots amended by poultry manure than cattle manure.

P concentration considerably increased in plots that received TSP alone, might be due to more fossils and phosphates that were used in the manufacture of TSP fertilizers (Kaiser & Pagliari, 2021). TSP fertilizers released more phosphorus that disintegrated slowly into the soil hence, this increased its circulation. However low amounts phosphorus in control was due to uptake by bean plants or fixation or chelation by the acidic conditions of the soil because of no amendments (Brittany, 2019). This study contradicts with (Withers, 1999) findings of integration of poultry manure and NPK increased phosphorus content because, inorganic fertilizers like TSP contains high amounts of P up to 50% which even dissolves slowly than any other fertilizer therefore this increased P availability in the soil.

K concentration: improved in plots amended with swine + TSP, certainly because of high organic matter in pig or swine manure that exists in form of micelle, which increased stability and potentiality of swine manure to hold more potassium than other treatment (Choudhary & Grant, 1996). The current results agree with findings of (Hentz, *et al*., 2016) who reported 1% increment in potassium in plots amended by swine manure than plots that received poultry manure.

Bean Genotypes Yield Attributes

Harvest index. Increase might have been due to high adaptability and response of Nabe16 to swine manure + TSP. Additionally high concentration of nutrients in swine manure (*Table 2* and *3*) promoted a high photosynthetic process that resulted into more assimilation of photosynthates into biological and economic plant parts of bean genotypes (Choudhary & Grant, 1996). This finding is in agreement with (Gina, *et al*., 2006) who reported an increase in harvest index of soya beans grown in swine manure.

Number of pods: improvement was certainly because of existence of more calcium plots amended with swine (*Table 4* and *5*) that increased absorption of nitrogen, Magnesium, and phosphorus (Carl, 1972). These elements are majorly involved in chlorophyll formation and protein synthesis therefore, this supported the plant to make more sinks to store photosynthates than sink abscission. Equally increased potassium in swine manure, (*Table 2*, *3* and *5*) balanced the osmotic processes hence longer stomatal opening and more efficient carbon dioxide fixation (Pole, 2020). This study findings are supported by Teppei et al. (2012) who reported high calcium, Phosphorus and potassium in swine manure ashes increases yield.

Number of seeds per pod: improvement might have been due to possession of more phosphorus and nitrogen nutrients in swine manure which are major nucleic acid components, directly involved in cell wall formation, flowering, fruiting and seed formation (Pole, 2020). Therefore, due to this, Swine manure registered more seeds in pods than chicken manure that had lower phosphorus (*Table 5*). likewise, the increased conductivity pull,

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diffusion and mass flow for Phosphorus, could have been pulled and transformed to nitrogen, by mineral transforming enzymes (Weisany et al., 2013) hence, this resulted into more photosynthates, inform of seeds. This finding is in agreement with report by (Gina, *et al*., 2006).

Pod length: Certainly increased, because of higher amounts of calcium in swine manure as noted in (*Table 2, 3* and *5*). Calcium increased absorption of nitrogen, Magnesium, and phosphorus (Carl, 1972). These minerals are majorly involved in chlorophyll formation and protein synthesis. Therefore, this increased affinity for the plant to make more sinks to store photosynthates in form of seeds which increased the length of pods (Pole, 2020). This finding disagrees with report by (Mohanty *et al.* 2017; Jayashri 2014)), who reported improvement of pod length of French beans grown in cattle manure integrated NPK because cattle manure contains low nutrient concentration due to rumination and yet bean plants has affinity for high amounts of Phosphorus than nitrogen for ATP during nodulation and seed formation (Broadley, 2009).

Weight of 100 seeds: significant improvement could have been attributed to high nutritive mineral substances in swine manure like magnesium, zinc, phosphorus, potassium, and nitrogen (Choudhary & Grant, 1996). That are greatly involved in grain filling. Also, high nitrogen availability refers to *Table 2, 3 and 5* in swine manure, led to adequate vegetative growth that increased carbon dioxide assimilation and translocation. Which in turn was directed to sinks for storage with aid of minerals like, phosphorus for ATP, nitrogen and zinc as amino acid carriers and magnesium for packing photosynthates (CI MMYT, 2019) than other treatments. This study disagrees with (Khalifeh *et al.,* 2016) who reported an increase on weight of 100 seeds in chicken manure when integrated with NPK. This is because bean growth and yield are limited to phosphorus which is highly concentrated in swine manure *Table 2, 3* and *5* than chicken manure rich in nitrogen, once applied more will be translocated to vegetative parts than storage in sinks (Brittany, 2019).

Grain yield: Increase in grain yield in plots that received swine manure + TSP might have been attributed to high phosphorus and potassium content in swine manure on addition to what was supplied by TSP (*Table 2*, *3* and *5*). This significantly improved photosynthetic process hence more photosynthates that supported grain formation than abissicion (pole, 2020). Chicken+ TSP coming second as seen in *Figure 6*, was as result of low quantities of minerals nutrients apart from nitrogen which was high (*Table 2* and *3*) as this increased biological mass than economic yield (USDA 2019). This study is in agreement with (Gina *et al*.,2006) who revealed improvement on yield of soya bean when grown under swine manure.

CONCLUSIONS

It was concluded from findings of the study that, among integrated nutrients swine manure integrated with TSP at the rate of 10t/ha manure: 30 kg/ha TSP, improved organic matter, soil pH, nitrogen, phosphorus, and potassium content of the soil. As well as superior performance on harvest index, number of pods, number of seeds in the pod, pod length, weight of 100 seeds of bean genotypes. But application of TSP displaced organic matter and potassium content in the soil. Whereas, Chicken manure+ TSP only improved nitrogen content in the soil. Furthermore, bio-fortified bean genotype Naro bean1 showed maximum performance on yield attributes than Naro bean 3 and NABE 16. Interaction of treatments with bean genotypes showed the best performance of swine + TSP with Naro bean 1.

Recommendations

The study recommends that, among nutrients combinations applied as integrated nutrients, swine manure + TSP, is the best option for peri-urban and urban farmers intending to grow Naro bean 1 as it has high nutrient composition which increases productivity per unit area as well as improved fertilizer use efficiency.

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Further research is needed to enhance productivity of beans under, different levels of farmyard manure integrated with TSP in different agro-ecological zones of Uganda. Also, similar study should be carried out on different crops while integrating the plant limiting factor with farmyard manure to boost yield such that compromising improved wellbeing and zero hunger is not there come 2030.

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