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Optimization of goat manure against use of N-Minjingu Nafaka Plus fertilizer for improved lablab growth and yield in semi - arid areas of Northern Tanzania

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ABSTRACT

The study was conducted in Northern Tanzania from the 2022–2023 cropping seasons to develop a cropping model that farmers can use to improve their lablab production. The field experiments were conducted at the Tanzania Agricultural Research Institute, Selian station and was laid down in a Split Plot Designs with main factor being tillage system and sub-factor being fertilizer type (Goat manure and Minjingu Nafaka Plus). The trials consisted of three treatments (goat manure, Minjingu Nafaka Plus and the control-no fertilizer) replicated thrice. There were significant differences (p=<0.001) among the number of pods per plant, plant height and lablab grain yield. The highest grain yield (3952 g and 3933 g) with net benefit of (1,290,210Tshs and 1,249,175Tshs) was recorded in a plot treated with (Minjingu Nafaka Plus) fertilizer in Conventional and Zero tillage system compared with (Goat manure) which had (3944 g and 3928 g) with net benefit of (1,306,710Tshs and 1,292,675Tshs) in Conventional and Zero tillage practices. Conclusively, the study revealed that there were high net benefits under zero tillage compared to conventional tillage based on input-output costs analysis at both TARI - Selian and Saweni sites. Zero tillage was more economically viable than conventional tillage practices as becomes more friendly for the resource-constrained farmers in increasing their potential yield.

Introduction

Lablab (*Lablab purpureus* (L.) Sweet) is a drought-tolerant herbaceous legume crop with a semi-erect prostrate growth habit (Sarkar, 1990). As a drought-tolerant crop, lablab has been recommended for production in semi-arid areas (Forsythe, 2019). Even in areas with erratic rains which hardly reach 550 mm per year, lablab can produce substantial grain yields of up to 1.5tons per ha-1, making it ideal for drought-prone areas (Forsythe, 2019). However, the average lablab yield attained under smallholder farmers, who are the major lablab producers depends on cultivar, different fertilizer sources, environment, and daily field management, resulting to the yield which may range between 1 and 2.5 tons per ha^{-1} based on tillage practices (Raihan, 2021). The fertilizer requirements of lablab plants are essential for growth and grain yield production (Forsythe, 2019). Conventionally use of inorganic fertilizers in lablab production has been practiced several times by smallholder farmers to address issues of food security and households' income (Lema, 2009). Among commonly applied in-organic fertilizers in lablab production worldwide includes Di-Ammonium Phosphate (DAP), Triple Super Phosphate (TSP), Minjingu Nafaka Plus, Urea, Calcium Ammonium Nitrate (CAN), and Sulphate of Ammonium (SA) (Komarek et al., 2021).

However, recently the use of organic fertilizer e.g., goat manure in producing lablab crops has gained more importance globally in the last few decades to alleviate worries on human health status, food security, and smallholder farmers' income (Komarek et al., 2021). Application of organic fertilizers during sowing lablab seeds has been shown to improve and help to maintain the quality and yield component of a crop (Pagliai et al., 2004). A sufficient amount of nutrients is needed for lablab growth and development, otherwise, growth habits, pod quality, and yield can be affected (Pagliai et al., 2004).

Therefore, the research study was conducted to determine the effects of goat manure against use of Minjingu Nafaka plus fertilizer on lablab growth and yield parameters, under smallholder farmers' production conditions in semi-arid areas in the northern part of Tanzania (Raihan, 2021). Aiming at assessing the best and friendly fertilizer among the

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two, to be suggested and applied by smallholder farmers, which should be minimal in terms of accessibility and costs under production, further be friendly to the environment with high net benefit for optimal lablab production, while improving lablab yield in northern Tanzania (Raihan, 2021).

A summary of available literature indicates that lablab bean contains an average of protein content of 20.06 to 24.22% (wet) and 22.91 to 27.21% (dry) lablab grain. Dry lablab beans are an excellent source of minerals, 100 g of dry beans hold copper 148% calcium 13%, iron 64%, magnesium71%, manganese 68%, phosphorus 53% and zinc 84%, 100 g of beans hold 1235 mg or 26% potassium (Maass et al., 2010).

Lablab bean is one among good cover crops and the major source of nutritious food for both humans and livestock as it is rich in protein, fiber, vitamins, and minerals (*Belief Modification in Cognitive Therapy Modificación de Las Creencias Disfuncionales En La,* 2011). Therefore, females from Kenya's Kikuyu region use them nutritionally as cooked beans whereby women are given to eat during their reproductive stages, particularly after pregnancy, since it keeps them well during and after pregnancy (History and Robertson, 2014). While in Kilimanjaro and Arusha regions in Tanzania lablab beans are commonly consumed as cooked beans with ugali (Missanga et al., 2023).

Materials and methods

Description of the research experimental sites

The experiment (Fig. 1) was conducted in two different locations during the study period one experiment was located at Tanzania Agricultural Research Institute TARI - Selian center, based in Arusha District Council, and similar experiment was caried out at Saweni site in Same district from (March 2022 to September 2022). The two different sites were selected to represent potential lablab growing areas of the Arusha and Kilimanjaro regions in Northern Tanzania.

Experimental design and treatments

The experiment was carried out using a split-plot design, followed by three treatments layout, preparation. The treatments involved were; GM = Goat manure (Organic manure 250 g per hole, equivalent to 25tons ha-1); MNP = Minjingu Nafaka Plus Fertilizer (In-organic fertilizer 5 g per hole equivalent to 245 kg ha^{-1}) and NF = No fertilizer as a (control) of the experiment. Row to row distance was 65 cm and hole-to-hole distance 60 cm, sown at 5 cm deep, and yield an average of 1500 kg/ha. Further 16 holes prepared in each subplot. Fertilizers were applied in each 3 sub-plots, while the other 3 sub-plots in both tillage practices were planted without fertilizer, totaling 18 sub-plots, 9 from each. Conventional and zero tillage main plots were prepared in both two experiments, based on two factors (Fertilizer and tillage system) i.e., main factor being a tillage and fertilizer as a sub factor). The main plots had a 6m^2 size, which was inter-spaced by 2 m in between conventional and zero tillage plots, sole sub-plots treatments were measured 2 m by 2 m with 1 m path between each plot, in every sub-plot (Triplett and Dick, 2008). TARI-Selian center farm and Saweni village in the Arusha DC and Same districts served as the sites for two replicated experiments, where zero tillage model was best and beneficial in practice to smallholder farmers.

Land preparation and planting

The land was prepared one month prior to onset of rainfall for planting, a land was well plowed at tilt condition, both disk plow and harrow were used in conventional tillage plot, while in zero tillage plot the land was only cleared (De Ponti et al., 2012). By following the process 9 subplots were prepared separately in each tillage practice.

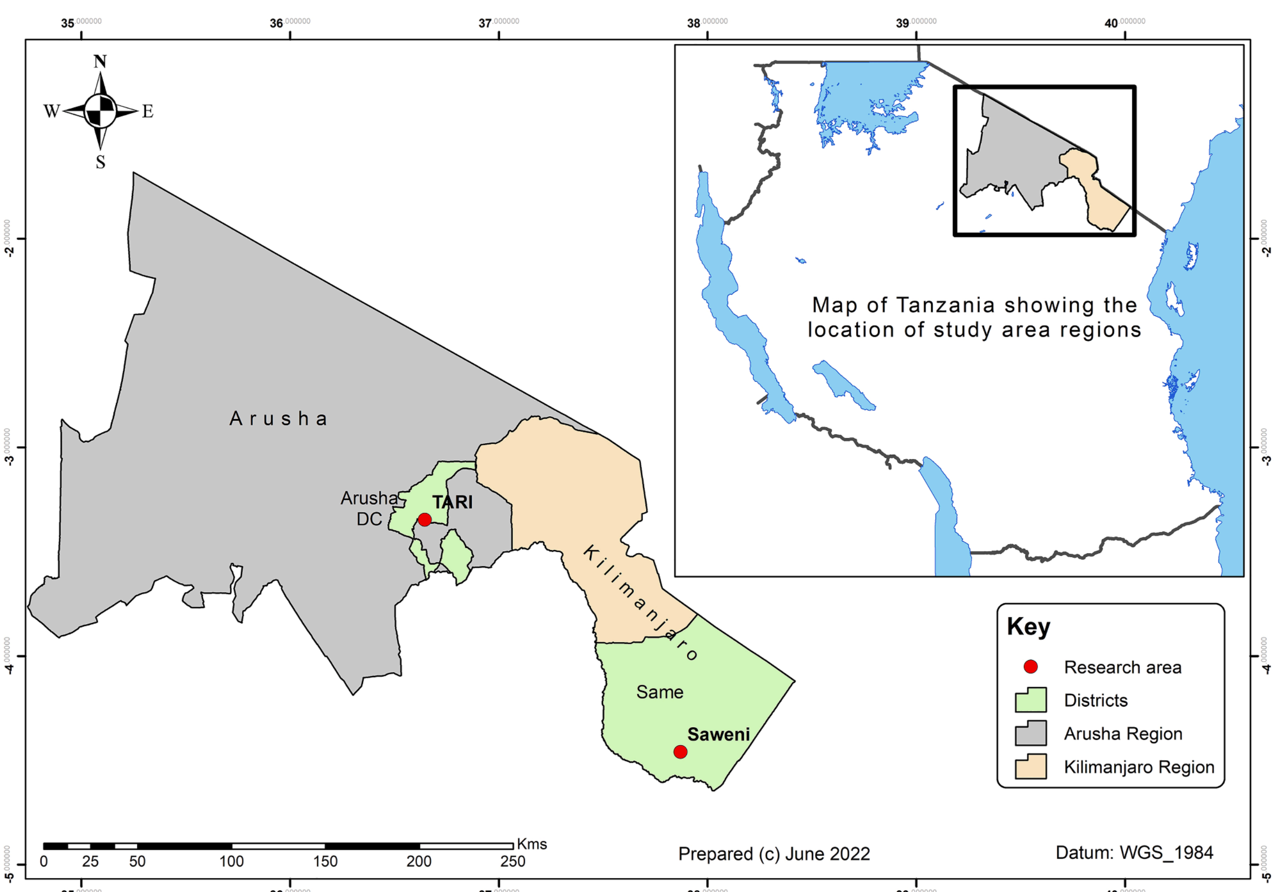

Fig. 1. Map of Tanzania indicating the location of TARI - Selian and Saweni experimental sites in Arusha and Same districts.

Goat manure and Minjingu Nafaka Plus fertilizer except Urea were applied during the final land preparation according to treatments. Thereafter, three lablab seeds were simultaneously sown at a depth of approximately 5 cm deep at a rate of 16 kg ha^{-1} both at TARI-Selian and the Same sites plots on March 26 in 2022. (Khamxaykhay and Tivet, 2012). After seed germination, one seedling was thinned living with two plants per hole. Field operations were approximately done when required and harvesting was done regularly and from time to time (Dauer, and Fox, 2007)

Data collection

Three lablab plants were selected randomly from each subplot and labelled. Data of the following parameters on different sampled plants were recorded from the experimental plots. The collected data included; Germination percent (%), Days to 50% flowering, Number of pods per plant, plant height (cm), number of seeds per pod, lablab grain yield in kilogram per ha, and weight of 100 lablab seeds in (kg).

Data analysis

All lablab plant data were subjected to analysis of variance (ANOVA) using GenStat 15th Edition (64bit) software version under the analysis procedures (Steel and Torrie, 1980). Microsoft Office Excel 2013 was also used to find out the significant difference among the treatments. The analysis was further performed by T-test and separated by least significant difference (LSD) at 0.05% level of probability to determine the significance of the difference between treatment means.

Results

Growth and yield parameters output at TARI-Selian center field experiment - Arusha DC

Lablab germination percent (%)

The results in Table 1 below, showed no significant difference in lablab seed germination percent (%) at TARI - Selian experiment ($p>0.05$) with a mean germination percent of (98.57) in both goat manure and Minjingu Nafaka Plus fertilizer under conventional and zero tillage practices. Germination percent% of lablab seeds, under application of Minjingu Nafaka Plus fertilizer, appeared to perform slightly better in conventional tillage than in zero tillage (98.71a) and (98.69a), which may be due to differences in soil structure and texture arrangement which allows variation of moisture, temperature and water holding capacity. Goat manure fertilizer application performed secondly on seed germination percent with (98.59a) and (98.54a) under conventional and zero tillage practices, while in no fertilizer sub-plot treatments, lablab seeds germination percent% under Minjingu Nafaka Plus fertilizer was (98.48a) and (98.43a) both at conventional and zero tillage practices, the results found in the study corresponds to the findings by (Owenya et al., 2011), in which similar findings was observed.

Days at 50 percent flowering

The findings in Table 1 below, indicated that there were no significant differences in days at 50 percent flowering plant at TARI - Selian experiment ($p<0.05$) with a mean of (46.35) under the application of both goat manure and Minjingu Nafaka Plus fertilizer on given tillage practices. Days at 50% flowering, appeared to perform slightly better after Minjingu Nafaka Plus fertilizer application (46.61a) and (46.59a), at both conventional and zero tillage practices, furthermore the better days at 50% flowering were observed under goat manure (46.57a) and (46.55a) application in conventional than in zero tillage practices. While in no-fertilizer application the 50% flowering occurred at (45.93a) and (45.84a) days under conventional and zero tillage practices. Therefore, there were more pods in conventional than in zero tillage practices due to the situation that, early flowering may be led by stimulation of physical soil particles for active nutrient uptake which can lead to a high yield per plant, These findings relates to the results obtained by (History and Robertson, 2014), which was found that different type of fertilizers have different effects on flowering as indicated in (Fig. 2) below.

Fig. 2. Zero tillage sole lablab crop plot applied with goat manure and Minjingu Nafaka Plus fertilizer at TARI, Selian station. Photo by Barnaba D.M, NM-AIST, Arusha, Tanzania.

Table 1
ANOVA for different growth and yield parameters after application of Minjingu Nafaka plus and goat manure fertilizers used on tillage practices, in lablab experiment at TARI - Selian site.

Tillage practices	Fertilizer Treatment	Germination percent (%)	Days at 50% flowering	Number of pods/plants	Plant height (cm)	Pod length (cm)	Number of seeds/pods	Lablab Grain yield kg/ ha	Weight of 100 lablab seeds (kg)
Conventional Tillage	Minjingu Nafaka plus	98.71a	46a	77.89a	62.61a	4.88a	4.94a	3952a	0.03372a
	No-fertilizer	98.48a	44a	74.56b	55.72c	4.50a	3.38a	3946b	0.03344a
	Goat manure	98.59a	45a	76.56ab	57.28b	4.61a	4.72a	3950ab	0.03353a
Zero Tillage	Minjingu Nafaka plus	98.69a	46a	77.78a	58.06b	4.83a	4.82a	3933a	0.03367a
	No-fertilizer	98.43a	44a	74.11b	50.94b	3.54a	3.27a	3925b	0.03341a
	Goat manure	98.54a	45a	75.11ab	57.06	4.55a	4.61a	3927ab	0.03351a
Mean		98.57	45	76	56.94	4.28	4.28	3950	0.03272
LSD (0.05)		4.2	1.48	1.1	2.654	0.989	0.989	1.877	0.002027
CV%		2.3	1.8	1.533	2.6	12.9	12.9	0	3.4
P-value		0.95	0.97	<0.001	<0.001	0.03	0.009	<0.001	0.033

Values followed by the same letters (a and b) within the column are not significantly different ($p < 0.05$). CV is the coefficient of variation. LSD is the Least Significance Difference.

Number of pods per plant

The findings in Table 1. below showed a significant difference in the number of pods per plant at TARI-Selian experiment ($p<0.001$) with a mean of (76) under the application of Minjingu Nafaka Plus fertilizer and goat manure fertilizer treatments under tillage practices (conventional and zero tillage). Minjingu Nafaka Plus fertilizer appeared to perform slightly better than goat manure in conventional tillage than in zero tillage (77.89a, 77.78a respectively), which may be due to differences in soil structure and texture stability within the fertile soil layer (Turner et al., 2001). Goat manure fertilizer application performed second on both conventional and zero tillage (76.56ab) and (75.11ab), as a greater number of pods were seen in Minjingu Nafaka Plus fertilizer followed by goat manure in conventional tillage than in zero tillage following the easily release of plant nutrients in Minjingu Nafaka Plus fertilizer followed by goat manure. Additionally, there were more pods in conventional tillage practices than in zero tillage practices due to the well-organized soil structures in the soil production layer that allow for proper nutrient distribution in soil (Ariga and Jayne, 2011). In no fertilizer plots, had (74.56b) compared to (74.11b) of both conventional and zero tillage practices. The above results highlighted relates to the study findings observed by (Ariga and Jayne, 2011), with similar results.

Plant height in (cm)

The findings in Table 1. below also showed that the lablab plant height at the TARI – Selian experiment had a significant difference ($p<0.001$) with a mean of (56.94) for conventional and zero tillage practices, across Minjingu Nafaka Plus and goat manure fertilizer treatments. Under varying fertilizer applications, lablab plants generally seemed to grow more rapidly under conventional tillage than in zero tillage approaches. Additionally, the plants responded well to treatments applied with Minjingu Nafaka Plus fertilizer (62.61a) under conventional tillage than in zero tillage practices (57.06a). Height performance under goat manure fertilizer treatments was (57.28b) under conventional tillage followed by (57.06b) at zero tillage practice, which may also be caused by variations in soil characteristics e.g., Soil texture and structure. Finally, no fertilizer treatments in conventional tillage had (55.72c) compared to (50.94b) at zero tillage, therefore there was a large plant height in conventional than in zero tillage practice due to easily uptake of plant nutrients, the findings above relates to the results by (Almas and Aquifer, 2009) as highlighted in most of studies.

Pod length (cm)

After the application of Minjingu Nafaka Plus and goat manure fertilizer under zero and conventional tillage practices, there has been a significant difference ($p<0.001$) in a mean pod length of (4.28), with a maximum pod's length of (4.88a) and (4.83a), both under Minjingu Nafaka Plus fertilizer application followed by (4.61a) and (4.55a) in goat manure, compared to no fertilizer treatment of (4.50a) and (3.54a) Table 1. in which all showed variation in pod length; therefore, with an application of Minjingu Nafaka plus fertilizer and goat manure lead to increase in pod length due to difference in levels following different in nutrients uptake among the two fertilizers per plant resulting to slightly different in lablab yields the results of this study matches to the findings given by (Almas and Aquifer, 2009), who noted that there is a correlation between the fertilizer applied verse's pod length.

Number of seeds per pod

The number of seeds per pod showed no significant differences ($p>0.05$) both on Minjingu Nafaka Plus fertilizer and goat manure fertilizer application, based on zero and conventional tillage plots with a mean of 4. The number of seeds per pod varied in all plots applied with both fertilizers, i.e. Minjingu Nafaka plus fertilizer and goat manure fertilizer respectively. The number of seeds per pod was high in plots with Minjingu Nafaka Plus fertilizer compared to goat manure as shown in Table 1. Regardless of being planted in conventional and zero tillage practices. This showed that lablab crop does not rely heavily on applied organic manure or inorganic fertilizer when producing seeds because the plant can fix its nitrogen in the soil through plant nodules in the absence of both fertilizers, still, smallholder farmers can harvest a crop yield, although when they apply fertilizers can raise yield potential. Also applying the aforementioned inputs may primarily enhance the quality of the seeds produced per pod, these results were also found by (Shelton et al., 1982), on the relationship between the number of seeds per pod.

Lablab grain yield in kg per hectare

With a mean grain yield of 3950 kg/ha, there were significant differences ($p<0.001$) in the application of Minjingu Nafaka plus fertilizer and goat manure between zero tillage and conventional tillage practices indicated in Table 1. Where the application of Minjingu Nafaka plus fertilizer yielded (3952a) and (3933a), followed by (3950ab) and (3927ab) of organic fertilizer, while (3946b) and (3925b) on no fertilizer treatments. Nevertheless, the outcomes showed that the grain yield in both fertilizer application sub-plots, under zero and conventional tillage practices were somewhat comparable. This demonstrated that there was improved plant performance in terms of kg per hectare at TARI-Selian experiment site through fertilizer application in both tillage practices, the concluded findings from the study correlates to the findings by (Turner et al., 2001), who worked on lablab yield.

Weight of 100 lablab seeds

In findings showed that there were no significant differences ($p>0.05$) in Minjingu Nafaka plus fertilizer and goat manure fertilizer application with the mean of (0.03272) of the 100 wt of lablab seeds. While Minjingu Nafaka plus fertilizer had (0.03372a) and (0.03367a), followed by (0.03353a) and (0.03351a) under goat manure fertilizer, also all sub-plots with no fertilizer had (0.03344a) and (0.03341a) weight of 100 lablab seeds. However, there was a small difference in the weight of 100 lablab seeds whether treated with Minjingu Nafaka plus fertilizer (MNP), goat manure fertilizer (GM), or no fertilizer (NF) both in zero tillage and conventional tillage practices Table 1. following the addition of soil plant nutrients essential for lablab growth and yield as the legume crop has also a tendency of fixing nitrogen through its nodules around the roots, the results obtained in the above parameter goes hand by hand with the findings acquire by (Tadele and Assefa, 2012), about the weight of lablab based on the number of seeds, as shown in (Fig. 3) below.

Fig. 3. Lablab threshed grain yield at Saweni site. Photo by Barnaba D.M, NM-AIST, Arusha, Tanzania.

Table 2
ANOVA for different growth and yield parameters after application of Minjingu Nafaka plus and goat manure fertilizers based on tillage practices, in lablab experiment at Saweni site.

Saweni Tillage practices	Fertilizer Treatment	Germination percent (%)	Days at 50% flowering	No.of pods/ plants	Plant height (cm)	Pod length (cm)	No. of seeds/pod	Lablab Grain yield kg/ha	Weight of 100 lablab seeds (kg)
Conventional Tillage	Minjingu Nafaka plus	98.63a	45a	77.17a	55.89a	5.00a	4.83a	3944a	0.03353a
	No fertilizer	98.38a	43a	72.83b	50.44b	4.42a	3.17a	3937b	0.03332a
	Goat manure	98.45a	44a	75.50ab	52.43ab	4.66a	4.50a	3941a	0.03348a
Zero Tillage	Minjingu Nafaka plus	98.51a	45a	76.81a	53.44ab	4.67a	4.82a	3928b	0.03347a
	No fertilizer	98.36a	43a	72.79b	49.22b	3.33a	3.16a	3921c	0.03331a
	Goat manure	98.49a	44a	75.17ab	51.31ab	4.55a	4.49a	3924c	0.03343a
Mean		98.46	44	75.06	52.11	4.33	4.17	3932	0.03244
LSD (0.05)		2.8	1.63	1.979	3.369	0.989	1.171	1.877	0.002382
CV%		1.7	1.9	1.5	3.6	12.7	15.6	0	4.1
P-value		0.789	0.827	<0.001	0.014	0.019	0.019	<0.001	0.714

Values followed by the same letters (a and b) within the column are not significantly different ($p < 0.05$). CV is the coefficient of variation. LSD is the Least Significance Difference.

Growth and yield parameters output at saweni field experiment – same district

Lablab germination percent (%)

The results in Table 2 below, showed no significant difference (p>0.05) in lablab seeds germination percent (%) at Saweni experiment, with a mean germination percent of (98.46) in both goat manure and Minjingu Nafaka Plus fertilizer under conventional and zero tillage practices. Germinatio1n percent (%) under application of Minjingu Nafaka Plus fertilizer appeared to perform slightly better with (98.63a) and (8.51a), followed by (98.49a) and (98.45a) under goat manure fertilizer, while (98.38a) and (98.36a) in no fertilizer treatment, goat manure fertilizer application performed secondly in terms of germination percent, while in no fertilizer plots ranked thirdly, germination percent wise at both conventional and zero tillage practices, might be probably due to differences in soil structure and texture stability with moisture and water holding capacity, the upshot from the learning associate with the collection prevail by (Ewansiha et al., 2017) explaining on legumes germination percentage.

Days at 50 percent flowering

The findings in Table 2. indicated that there was no significant difference (p> 0.05) in days at 50 percent flowering plant at Saweni experiment with a mean of (45.44) under the application of both goat manure and Minjingu Nafaka Plus fertilizer on given tillage practices. Days at 50% flowering, appeared to perform slightly better after Minjingu Nafaka Plus fertilizer application which had (45.56a) and (45.54a), at both conventional and zero tillage practices, furthermore the better days at 50% flowering were observed under goat manure (45.52a) and (45.51a) application in conventional than in zero tillage practices. While in no-fertilizer application the 50% flowering occurred at (45.45a) and (45.42a) days under conventional and zero tillage practices. Therefore, there were more pods in conventional than in zero tillage practices due to the situation that, early flowering may lead to good pod filling hence high yield per plant, the results prevail in this study affiliated to the aggregation presented by (Jaja and Barber, 2017) basing on the days at flowering period.

Number of pods per plant

The findings in Table 2. below showed a significant difference (p<0.001) in the mean number of pods (75.06) under the application of Minjingu Nafaka Plus fertilizer and goat manure fertilizer, both in conventional and zero tillage practices, the number of pods per plant under Minjingu Nafaka Plus fertilizer experiment was highest (77.17a) and (76.81a), followed by (75.50ab) and (75.17ab) of goat manure fertilize. However, under no fertilizer, the number of pods per plant was (72.83b) and (72.79b). This could be due to differences in the release of soil nutrients in the soil that may influence soil structure and efficient distribution of soil nutrients, based on the rate of water-holding capacity, the findings from the acquisition links to the outcome highlighted by (History and Robertson, 2014) with regard to number of pods per plant.

Plant height in (cm)

The findings revealed that the Saweni experiment's lablab plant height with a mean of (52.11) varied significantly (p< 0.001) under Minjingu Nafaka Plus fertilizer and goat manure fertilizer application in both conventional and zero tillage practices Table 2. Further, plants performed best in treatments with Minjingu Nafaka Plus fertilizer application which had (55.89a) and (53.44ab), followed by treatments with goat manure which had plant height of (52.43ab) and (51.31ab), and treatments with no fertilizer had lablab plant height of (50.44b) and (49.22b) with the lowest plant height under both conventional and zero tillage practices, the results from the study mulches to the findings given by (Tadele and Assefa, 2012), which found that there is a correlation between a plant height in respect to applied fertilizer.

Pod length

The results revealed that there had been no significant difference (p>0.05) in pod length per plant with a mean (4.33) pod length under Minjingu Nafaka Plus fertilizer and goat manure fertilizer application, at both conventional and zero tillage practices, the pod length in Minjingu Nafaka Plus fertilizer appeared to be (5.00a) and (4.67a), followed with a pod length of (4.66a) and (4.55a) in goat manure fertilizer application. Furthermore, pod length under no fertilizer sub-plots was (4.42a) and (3.33a) in both conventional and zero tillage practices in Table 2. However, the longer the pod indicates that there is a high yield of lablab production (AGRA, 2019).

Number of seeds per pod

There was no significant difference (p>0.05) in the number of seeds per pod under Minjingu Nafaka Plus fertilizer and goat manure application in zero and conventional tillage with a mean of (4) number of seeds per pod. The largest number of seeds per pod after Minjingu

Nafaka Plus fertilizer application was (4.83a) and (4.82a), followed by the number of seeds per pod with (4.50a) and (4.49a) under application of goat manure, furthermore (3.17a) and (3.16a) number of seeds per pod were observed in no fertilizer treatment Table 2. The grain filling in pods depends on nutrients accessed by the lablab plant apart from plant spacing between plants at both zero and conventional tillage practice, for the number of seeds per pods to be high in lablab plant depends on the above factors (Forsythe, 2019).

Lablab grain yield

There were significant variations ($p<0.001$) in lablab grain yield, with a mean number of (3932). However, the results showed under Minjingu Nafaka plus fertilizers, were (3944a) and (3928b) grain yield, while after application of goat manure fertilizer had (3941a) and (3924c) grain yield, while in no fertilizer treatments, there were (3937b) and (3921c) grain yield in kg per hectare in both zero and conventional tillage practices Table 2. Hence the larger the lablab grain the higher the yield while small lablab grain leads to low yield, following good crop cover lablab habit reserves moisture which is used in improving the grains as allows proper nutrients absorption (Turner et al., 2001).

Weight of 100 lablab seeds

According to the findings in Table 2. there were no appreciable variations($p>0.05$) in the weight of 100 lablab seeds, with the mean weight (0.03244), after applying Minjingu Nafaka plus fertilizers and goat manure fertilizer. The largest weight of 100 lablab seeds was observed after Minjingu Nafaka plus fertilizers application of (0.03353a) and (0.03347a), followed by goat manure fertilizer application which had (0.03348a) and (0.03343a), while the weight of lablab seeds under no fertilizer was (0.03332a) and (0.03331a) respectively, which may have been caused by variations in field topography and management techniques, leading to favorable or detrimental effects on the weight of lablab seeds (Turner et al., 2001).

Difference between, minjingu nafaka plus fertilizer and goat manure fertilizer on lablab growth and yield parameters under tillage practices at TARI-Selian and saweni experiments

Lablab germination percent (%)

The study indicated that there were no statistically significant differences ($p>0.05$) existed among all treatments for a lablab germination percent% per plot (Fig. 4). Data showed that the highest germination% was (98.71 and 98.63) observed under the Minjingu Nafaka Plus fertilizer application, followed by (98.54 and 98.45) observed under organic manure fertilizer treatments, while the lowest germination% was (98.48 and 98.38) under no-fertilizer (Control). On the other hand, the germination percent% of lablab plants were (98.69 and 98.51) under Minjingu Nafaka plus fertilizer application, followed by (98.59 and 98.49) under goat manure application, and (98.48 and 98.36) in no fertilizer (control) application, whereas both were recorded on conventional and zero tillage practices at TARI – Selian and Saweni sites. However, the observed lowest germination percent% of plants were under no fertilizer treatment as a control compared to goat manure fertilizer treatments, which were led by Minjingu Nafaka Plus fertilizer treatments.

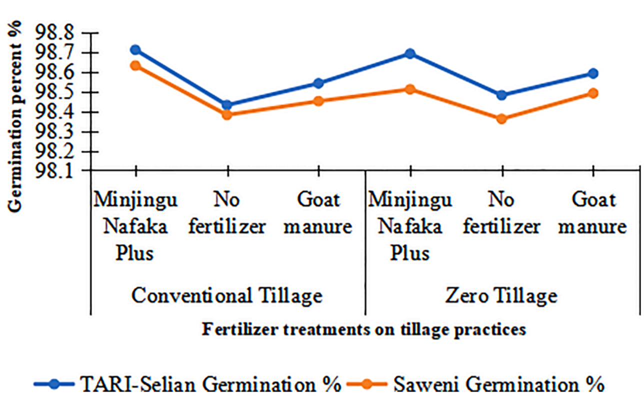

Fig. 4. Effects of goat manure, Minjingu Nafaka Plus, and no-fertilizer on lablab seeds germination percent, using LSD at 5% probability based on tillage practices.

Days at 50 percent flowering

The study indicated that there were no statistically significant differences existed among all treatments for the days at 50 percent flowering of the lablab plant (Fig. 5). Data showed the maximum number of days at 50 percent of flowering (46 and 45) observed under Minjingu Nafaka Plus fertilizer application, followed by (45 and 44) under goat manure fertilizer application treatments, while the minimum days at 50 percent flowering were (44 and 43) under no fertilizer (Control). Furthermore (46 and 45) under Minjingu Nafaka Plus fertilizer application, followed by (45 and 44) days at 50 percent flowering under goat manure fertilizer application, while (44 and 43) information under no - fertilizer application was recorded on both conventional and zero tillage practices at TARI – Selian and Saweni sites. However, the number of days at 50% flowering was observed under no fertilizer treatment as a control followed by treatments that were applied with goat manure which were led by treatments under Minjingu Nafaka Plus fertilizer.

Number of pods per plant

The study indicated that there were statistically significant differences ($p<0.001$) existed among all treatments for an average number of lablab pods per plant (Fig. 6). Data showed the highest number of pods per plant (77.89 and 77.78) observed under Minjingu Nafaka Plus fertilizer application, followed by the number of pods per plant (76.11 and 75.17) under goat manure, while the lowest number of pods per plant was (74.56 and 74.11) under no fertilizer (Control) treatments; On the other hand (77.1 396 7 and 76.81) the number of pods per plant was observed and recorded under Minjingu Nafaka Plus fertilizer, followed by (75.50 and 75.17) number of pods under goat manure application, while (72.83 and 72.79) number of pods per plant under no fertilizer was as well recorded on conventional and zero tillage practices both at TARI – Selian and Saweni sites.

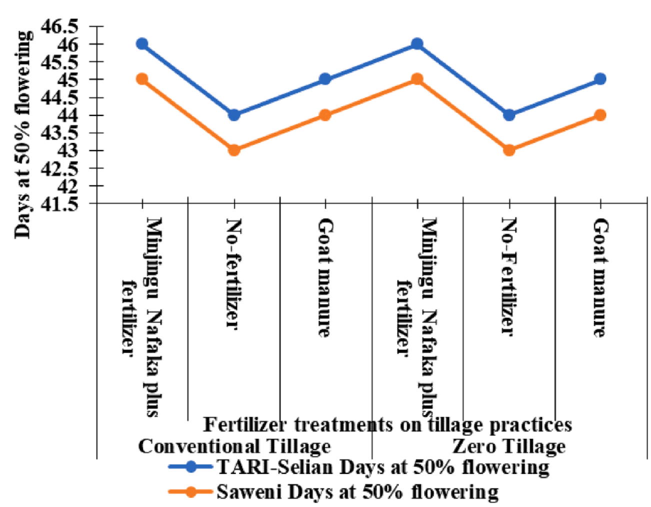

Fig. 5. Effects of goat manure, Minjingu Nafaka Plus, and no-fertilizer on days at 50% flowering, using LSD at 5% probability based on tillage practices.

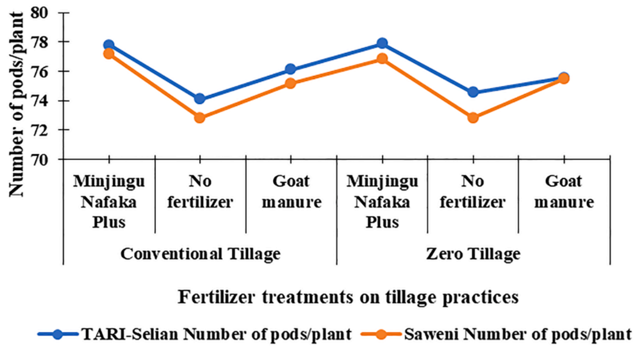

Fig. 6. Effects of goat manure, Minjingu Nafaka Plus, and no-fertilizer on a number of pods per plant using LSD at 5% probability based on tillage practices.

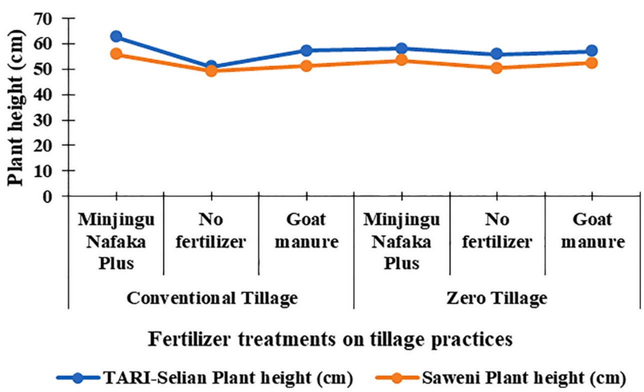

Fig. 7. Effects of goat manure, Minjingu Nafaka Plus, and no-fertilizer (control) on lablab plant height per plant using LSD at 5% probability based on tillage practices.

Plant height (cm)

Individual plant height of lablab bean varied significantly ($p<0.001$) among the different treatments of Minjingu Nafaka Plus fertilizer, goat manure and no fertilizers (control) (Fig. 7). Lablab plant height was recorded maximum as (62.61 and 58.06) under Minjingu Nafaka Plus fertilizer, followed by (57.28 and 57.06) under goat manure fertilizer application, while it was observed and recorded (55.72 and 50.94) plant height under no fertilizer (Control) treatments. In the other practice, plant height was recorded at (55.89 and 53.44) after the application of Minjingu Nafaka Plus fertilizer, followed by (52.43 and 51.31) under goat manure fertilizer application, while (50.44 and 49.22) under no fertilizer application had low plant height based on convention and zero tillage practices at both TARI - Selian and Saweni sites.

Pod length (cm)

In respect of individual lablab pod length, there was no variation ($p>0.05$) found among the treatments (Fig. 8). The maximum length of the pod was (4.88 and 4.61) after Minjingu Nafaka Plus fertilizer application, followed by (4.83 and 3.54) found under goat manure fertilizer treatment; the minimum pod length was (4.50 and 3.50) under no fertilizer treatment. Moreover, (5.00 and 4.67) pod length was observed under Minjingu Nafaka plus fertilizer application, followed by (4.66 and 4.55) under goat manure fertilizer treatments while (4.42 and 3.33) were recorded under no fertilizer (control) treatment in both conventional and zero tillage practices at TARI-Selian and Saweni sites.

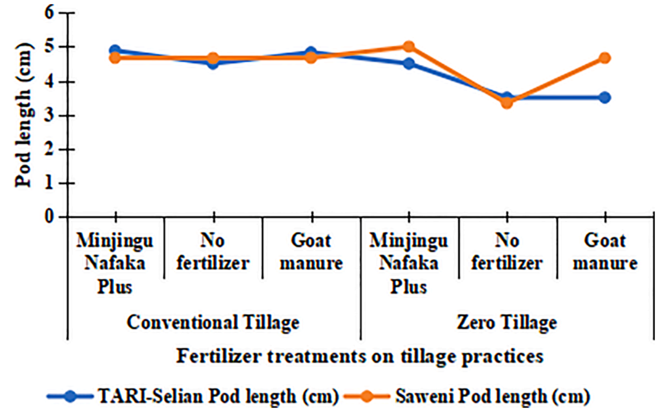

Fig. 8. Effects of goat manure, Minjingu Nafaka Plus fertilizer, and no-fertilizer on lablab pod length using LSD at 5% probability based on tillage practices.

Number of seeds per pod

The results showed a significant difference in the number of seeds per pod in (Fig. 9). The maximum number of seeds per pod was (4.94 and 4.83) under Minjingu Nafaka plus fertilizer application, followed by (4.72 and 4.61) number of seeds after the application of goat manure fertilizer, while (3.38 and 3.27) number of seeds per pod was observed and recorded under no fertilizer application. Furthermore, the minimum number of seeds per pod was (4.83 and 4.82) under Minjingu Nafaka Plus fertilizer application, followed by (4.50 and 4.49) under goat manure treatments, and (3.17 and 3.16) number of seeds per pod recorded under no-fertilizer (control) treatments. Based on conventional and zero tillage practices respectively at TARI - Selian and Saweni sites.

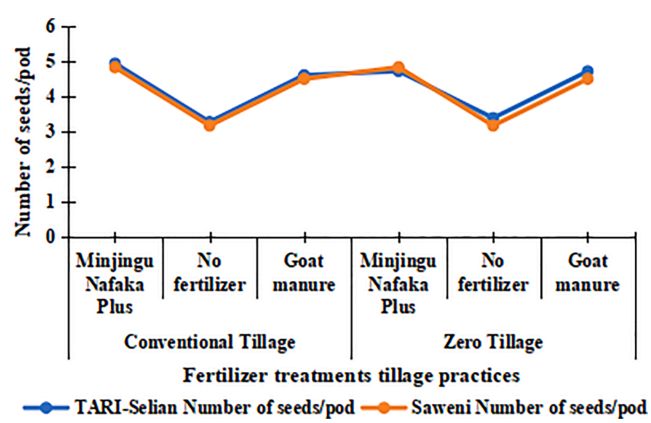

Fig. 9. Effects of goat manure, Minjingu Nafaka Plus fertilizer, and no-fertilizer on a number of seeds per pod using LSD at 5% probability based on tillage practices.

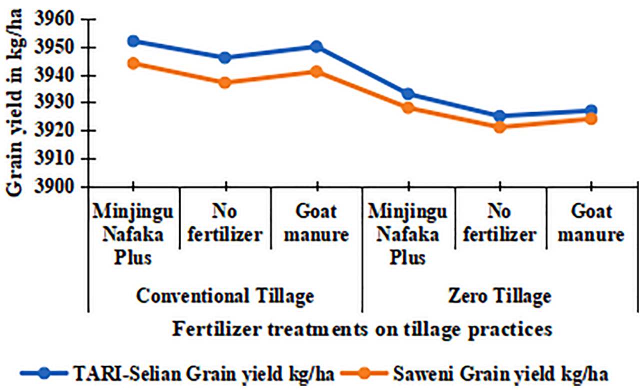

Fig. 10. Effects of goat manure, Minjingu Nafaka Plus fertilizer, and no-fertilizer on grain yield in kg using LSD at 5% probability based on tillage practices.

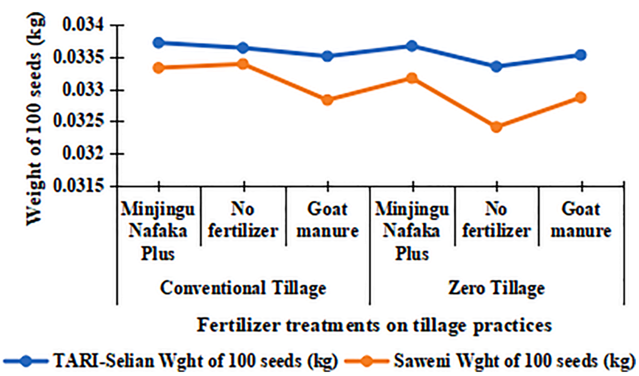

Fig. 11. Effects of goat manure, Minjingu Nafaka Plus fertilizer, and no-fertilizer on the weight of 100 seeds in kg using LSD at 5% probability based on tillage practices.

Lablab grain yield in kg per hectare

There was a significant difference ($p<0.001$) in lablab grain yield (Fig. 10). The highest grain yield was (3952 and 3933), under Minjingu Nafaka Plus fertilizer treatments, followed by (3950 and 3927) grain yield under goat manure fertilizer, while the lowest grain yield under no fertilizer (control) treatment was (3946 and 3925). Furthermore, lablab grain yield (3944 and 3928) was recorded under Minjingu Nafaka Plus fertilizer treatments, followed by (3941 and 3924) under goat manure fertilizer application, while (3937 and 3921) observed and recorded under no fertilizer application, both in conventional and zero tillage practices at TARI-Selian and Saweni sites. Therefore, better grain yield was obtained at TARI - Selian center as compared to the Saweni experiment, under the application of Minjingu Nafaka Plus in which the nutrients were easily released followed by goat manure fertilizer that released the nutrients slowly, though can stay in the soil for a long time than that from Minjingu Nafaka Plus fertilizer.

Weight of 100 lablab seeds per kg

The results indicated no significant differences in the weight of 100 seeds per kg observed and recorded in (Fig. 11). The maximum weight of 100 seeds per kg was (0.03372 and 0.03367) under Minjingu Nafaka Plus fertilizer, followed by (0.03364 and 0.03353) recorded under goat manure fertilizer treatments, while the minimum weight of 100 seeds per kg was (0.03351 and 0.03335) under no fertilizer (control) treatments. Furthermore, the weight of 100 seeds per kg (0.03353 and 0.03347) under Minjingu Nafaka Plus fertilizer, followed by the weight of 100 lablab seeds (0.03348 and 0.03343) recorded under goat manure fertilizer application, while (0.03332 and 0.03331) weight of lablab seeds had no fertilizer application based in conventional and zero tillage practices at TARI-Selian and Saweni site.

Generally, the results showed that in both TARI - Selian center and Saweni experimental sites, there were significant differences ($p<0.001$) in growth and yield parameters of lablab bean after application of Minjingu Nafaka Plus fertilizer, goat manure, and no-fertilizer at the treatments under conventional and zero tillage practices, in a cropping year 2022. However, the growth and yield data performed well at TARI-Selian center site than at Saweni site, this was due to variations in climate conditions in two experimental locations.

Comparative evaluation of input - output costs under conventional and zero tillage practices

According to the input and output results (Tables 1 and 2), zero tillage practice showed the highest net benefits over conventional tillage practice under both Minjingu Nafaka Plus fertilizer and goat manure fertilizer treatments. For instance, conventional tillage with an organic fertilizer at TARI-Selian site produced a significant net benefit (1306,710 Tsh), while zero tillage had (1292,675 Tsh) net benefit. Based on the costs of production zero tillage practice was economically viable as stated by (Publications et al., 2013) since some of production costs are minimized.

Furthermore, goat manure fertilizer was observed to be more cost-effective than Minjingu Nafaka Plus fertilizer because it is largely and easily accessible at lower costs with the majority of smallholder farmers. Generally, TARI-Selian site fertilized with Minjingu Nafaka Plus fertilizer was observed to have the larger gains followed by goat manure fertilizer while the lowest net benefit was at no-fertilizer treatments (control). Zero tillage had the highest net benefit, followed by conventional tillage practice. These results are comparable to those published by (Publications et al., 2013), who found that the residual effects of lablab had beneficial effects on yield and yield components of the preceding lablab crop harvest. The tallest plants and the largest weight of 100 seeds were observed and recorded under the application of Minjingu Nafaka Plus fertilizer treatments followed by goat manure fertilizer treatments both in zero and conventional tillage respectively. While the

Table 3
Comparative evaluation of input - output costs of the tillage practices at TARI-Selian site lablab experimental site. (Source: Saglam et al., 2020).

Cost (Tsh.)	Conventionaltillage	Zerotillage
TARI - Selian site		
Fuel consumption@ Tsh. 3000 15ltr	45,000	22,500
Lubricant at 15% of diesel cost (Tsh.)	6750	3375
tractor hired @ tsh 40,000 ha^{-1}	40,000	30,000
labor cost		
Skilled 10 labor@ Tsh. 6818 per day for sowing	68,180	34,090
Skilled 20 lobour@ Tsh. 6818 per day for harvesting	136,360	136,360
Seed 18 kg ha^{-1} @ Tsh. 6000	108,000	108,000
Fertilizer inputs cost		
Minjingu Nafaka Plus fertilizer per bag@ 74,000	185,000	185,000
No – fertilizer 0 kg ha $^{-1}$	00.00	00.00
Goat manure fertilizer 10 tons @ Tsh. 50,000	50,000	50,000
Total cost of production (a)		
Minjingu Nafaka Plus fertilizer kg ha $^{-1}$	589,290	519,325
No – fertilizer 0 kg ha $^{-1}$	404,290	334,325
Goat manure fertilizer 10,000 kg ha^{-1}	454,290	384,325
Gross income (b) sells @ Tsh.1500/100kg^{-1}		
Minjingu Nafaka Plus per ha^{-1}	1879,500	1768,500
No – fertilizer 0 kg ha $^{-1}$	1593,000	1426,500
Goat manure fertilizer 10 tons @ Tsh. 50,000	1761,000	1677,000
Net income (b – a) Tsh.		
Minjingu Nafaka Plus fertilizer per ha $^{-1}$	1290,210	1249,175
No – fertilizer 0 kg ha $^{-1}$	1188,710	1092,175
Goat manure fertilizer 10,000 kg ha^{-1}	1306,710	1292,675

Table 4
Comparative evaluation of input and output of the tillage practices at Saweni lablab experimental site. (Source: Saglam et al., 2020).

Cost (Tsh.)	Conventional tillage	Zero tillage
Saweni site		
Fuel consumption@ Tsh. 2700 15ltr	40,500	20,250
Lubricant at 15% of diesel cost (Tsh.)	6075	3038
tractor hired @ tsh 35,000 ha^{-1}	35,000	25,000
labor cost		
Skilled 10 labor@ Tsh. 5000 per day for sowing	50,000	25,000
Skilled 20 lobour@ Tsh.5000per day for harvesting	100,000	100,000
Seed 18 kg ha^{-1} @ Tsh. 6000	108,000	108,000
Fertilizer inputs cost		
Minjingu Nafaka Plus fertilizer per bag @ 74,000	185,000	185,000
No – fertilizer 0 kg ha^{-1}	00.00	00.00
Goat manure fertilizer 10 tons @ Tsh. 30,000	30,000	30,000
Total cost of production (a)		
Minjingu Nafaka Plus fertilizer kg ha^{-1}	524,575	466,288
No – fertilizer 0 kg ha^{-1}	339,575	281,288
Goat manure fertilizer 10,000 kg ha^{-1}	369,575	311,288
Gross income (b) sells @ Tsh.1500/100 kg-1		
Minjingu Nafaka Plus fertilizer per ha^{-1}	1711,500	1593,000
No – fertilizer 0 kg ha^{-1}	1383,000	1264,500
Goat manure fertilizer 10 tons @ Tsh. 50,000	1638,000	1,518,000
Net income (b – a) Tsh.		
Minjingu Nafaka Plus fertilizer kg ha^{-1}	1186,925	1126,712
No – fertilizer 0 kg ha^{-1}	1043,425	983,212
Goat manure fertilizer 10,000 kg ha^{-1}	1268,425	1206,712

lowest plant height and weight of 100 seeds, were observed in no fertilizer treatments both at zero and conventional tillage treatments, which also produced the lowest yields in comparison to Saweni Site based in Same district. TARI - Selian Site had the highest plant height and largest weight per 100 seeds hence increasing high yield. On the other hand, lablab potential yields mainly are based on variations of rainfall amount in a cropping season.

In all fertilizer levels of application i.e., Minjingu Nafaka Plus, followed by goat manure at Saweni and TARI Selian sites (Flow, 1981), the comparison of input and output cost analysis for two sites showed that high net-benefits were realized under zero tillage followed by low net-benefits under conventional tillage practice. This was determined by costs incurred in both tillage practices.

The least costly practice was taken and compared to the second cheapest option by subtracting the total discounted benefits for each project and dividing this by the difference in the total discounted costs for each cropping practice.

Incremental BCR = (Σ B1 - Σ B2) / (Σ C1 - Σ C2)

Where:

ΣB1 = total benefits for crop practice ‘1′

ΣC1 = total costs for practice ‘1′

CBA for TARI-Selian experiment results was as below;

IBCR = (1,306,710 - 1,292,675) / (1,447,870 - 1,237,975)

14,035 / 209,895 = 0.06687 equivalent to 6.687 Tsh.

CBA for Saweni experiment results was as below;

IBCR = (1,268,425 –1,206,712) / (1,233,725 - 1,058,864)

61,713 / 174,861= 0.3529 equivalent to 35.29 Tsh.

Therefore, TARI Selian experiment had little production cost difference from Saweni experiment, which also indicated that zero tillage performed well at Saweni site in Same district than at TARI Selian in Arusha district. Hence zero tillage is advised to be practised in drought areas.

Discussion

This study has indicated the significance of using goat manure in lablab bean production rather than relying heavily on application of Minjingu nafaka Plus fertilizer which has health, environmental, and economic impacts. Furthermore, it has been indicated that, production of lablab legume, may require sufficient amount of macro and micro plant nutrients needed for their growth and development (Raihan, 2021).

Application of both goat manure and Minjingu Nafaka Plus Fertilizer were done once during planting, to ensure that seedlings are healthy and effective in yield production. The results revealed that, the application of goat manure fertilizer performed secondly to application of Minjingu Nafaka Plus Fertilizer. Goat manure had shown to improve soil aeration and water infiltration, as well improved both water and nutrients holding capacity of the soil. In both experiments it has shown to increase water retention by the soil and are important in maintaining soil tilt as indicated by (Jaja and Barber, 2017). According to, (Karuku et al., 2018) explained that goat manure is responsible for the formation of soil aggregates which are very essential in maintain soil fertility.

Livestock manure supplies all major nutrients (N, P, K, Ca, Mg, S) necessary for plant growth, as well as micro nutrients stated by (Jaja and Barber, 2017). Goat manure application in a given year will influence crops in the succeeding years, because the decomposition of organic matter is not completed within one season (Jaja and Barber, 2017). Application of organic materials i.e.; fertilizers provide growth regulating substances and improves the physical, chemical, and microbial properties of the soil (Karuku et al., 2018).

With regard to factors influencing adoption of fertilizer use, lack of knowledge on the use of and market information of fertilizer due to limited access to fertilizer and specific extension services was found to be the most limiting factor irrespective of the fertilizer type. Empirical literature suggests that fertilizer use is sensitive to changes in its price as well as the price of crops to which it is applied (Ariga and Jayne, 2011). According to (Maass et al., 2010), the demand for fertilizer is often weak in Africa because incentives to use fertilizers are undermined by the low level and high variability of crop yields on one hand and the high level of fertilizer prices relative to crop prices on the other hand. However, (Jaja and Barber, 2017) noted that farmers in Africa require 6–11 kg of grain to purchase one kg of nitrogenous fertilizer compared with about 2–3 kg of grain in Asia.

The results agreed by that the poor performance of normal lablab plant on number of pods per plant is highly associated with poor rainfall distribution and a drought spell in late February to mid - April 2022. Our results align with findings by (Kumar, 2019) that water deficit might have stopped lablab growth, due to early flowering compared to early and late planting dates. Also, the study by (Jaja and Barber, 2017), revealed that limited water availability to lablab plant at flowering growth stage affected its physiological status as it caused decline in photosynthetic rates and plant growth. Reduction of leaf number under water deficits is a result of reduced leaf appearance rate and reduced plant height as well as accelerated leaf senescence (Khaliq. T, T. Mahmood, J. Kamal, 2004).

Morphological characterization is the groundwork step that generates key information by assessing both the Lablab growth and yield parameters.

(a) Lablab growth parameters;

Plant height (cm)

The majority of studies had shown that using Minjingu Nafaka Plus fertilizer can result in slightly highest plant height followed by goat manure. This variation can be due to environmental variation such as soil, temperature, and moisture of the area, as the study conducted by (Abduselam et al., 2017) showed. Similarly to the study reported on increase in plant height in response to higher levels of nitrogen which has been confirmed by the previous findings of (Ali et al., 2015) and (Almas and Aquifer, 2009).

Days at 50 percent flowering

Further, the number of days at 50% flowering was observed under no fertilizer (control) treatment, followed by treatments that were applied with goat manure which were slightly led by treatments under Minjingu

Nafaka Plus fertilizer. The early lablab flowering signifies the proper and better gain filling (Raihan, 2021). Hence there was an increase in number of days at 50% flowering in response to higher levels of nitrogen as has been confirmed by the previous findings. The results further reported by (Kumar, 2019) that an increase in number of days at 50% was contributed by higher levels of nitrogen. These findings relates to the results obtained by (History and Robertson, 2014), which stated that different type of fertilizers have different effects on flowering.

Number of pods per plant

The lowest number of pods per plant was observed under no fertilizer treatment as a control compared to goat manure followed by Minjingu Nafaka plus fertilizer application. Hence there was an increase in the number of pods per plant in response to higher levels of nitrogen as has been confirmed by the previous findings (Jaja and Barber, 2017), large number of pods signifies the maximum lablab yield (Raihan, 2021). Moreover, the above results highlighted relates to the study findings observed by (Ariga and Jayne, 2011),

Pod length (cm)

Within each individual lablab pod length, variation found among the treatments was very slightly, or no variation (p>0.05). The maximum length of the pod was observed after Minjingu Nafaka Plus fertilizer application, since the fertilizer have high rate of releasing nutrients in the soil, followed by goat manure, the minimum pod length was observed under no fertilizer treatment, in both conventional and zero tillage practices at TARI-Selian and Saweni sites. Therefore, growth characters of the country lablab bean were significantly influenced by Minjingu nafaka plus fertilizer followed by, goat manure respectively. This study have been supported by (Raihan, 2021) who stated that the longer the pod the higher the yield. The study also matches to the results acknowledged by (Legume Society, 2016), showing the association between pod length and fertilizer applied. Moreover, the results of this study matches to the findings given by (Almas and Aquifer, 2009), who noted that there is correlation between the fertilizer applied verse's pod length.

(b) Lablab yield parameters;

Lablab germination percent (%)

In both types of fertilizers germination percent had no significant differences p>0.05) between Minjingu Nafaka plus fertilizer and goat manure with respect to the fact that the germination process is not highly fevered by the presence of any kind of fertilizer. However, the observed slightly lowest germination percent% of plant was under no fertilizer treatment as a control compared to goat manure fertilizer treatments, which were led by Minjingu Nafaka Plus fertilizer treatments. Hence there was a slightly increase in germination percent per plant in response to higher levels of nitrogen as has been confirmed by the previous findings stated by (Tadele and Assefa, 2012) showed the relationship between the number f plant germinated against level of yield. Also the results found in the study corresponds to the findings by (Owenya et al., 2011), in which reported that there is a correlation between germinated plants against yield potential.

Number of seeds per pod

The higher the number of seeds per pod the higher the lablab yield. The increase in the number of seeds per pod is correlated with the increase in a high level of nitrogen as confirmed by (Ali et al., 2015). Therefore, better grain yield was obtained at TARI - Selian center as compared to the Saweni experiment, in both Minjingu Nafaka Plus and goat manure fertilizers. Similarly the study showed that increasing level of nitrogen correlated with the increased number of seeds per pod (Summit, 2006). These results were also found by (Shelton et al., 1982), on the relationship between the number of seeds in relation to lablab yield.

Lablab grain yield in kg per hectare

Analysis of variance showed a significant difference on lablab grain yield. The highest grain yield was observed under Minjingu Nafaka Plus fertilizer application, followed by application of goat manure fertilizer, while the lowest grain yield under no fertilizer had lowest grain yield, this is due to variation of plant nutrients available in the soil, similar studies was observed by (Maass et al., 2010) that the grain yield is highly maximized by application of plant nutrients. Furthermore, the granted effect is similar to the findings outlined by (Legume Society, 2016), on effect of different levels of fertilizers in lablab grain yield.

Weight of 100 lablab seeds per kg

The parameter indicated no significant differences on the weight of 100 seeds per kg in measuring lablab grains. However the slightly maximum weight of 100 seeds per kg was indicated under Minjingu Nafaka Plus fertilizer, followed by goat manure fertilizer treatments, while the minimum weight of 100 seeds per kg was under no fertilizer (control) treatments. Furthermore, weight of 100 seeds per kg was justified to be highly influenced by type of the fertilizer applied with high macro and micro nutrients, complemented (Raihan, 2021). This indicates that, the more the release of nutrients of a given fertilizer in a crop compared to other fertilizes leads to large weight of lablab grains, the study findings relates to the results concurred by (Ariga and Jayne, 1990) who narrated on the important of using fertilizers in increasing weight of seeds. Similarly the results obtained in the above parameter goes hand by hand with the findings acquire by (Tadele and Assefa, 2012), about the weight of lablab based on the number of seeds as a yield component.

When comparing the two sites, an overall large weight of 100 seeds was found at TARI-Selian experiment under Minjingu Nafaka Plus followed by goat manure as compared to the Saweni experiment. This could be due to additional fertilizer with a support of higher amount of rainfall to allow completion of lablab plant cycle, as compared to Saweni experiment which has very lower rainfall as indicated by (Turner et al., 2001). who observed that the subsequent use of Minjingu Nafaka Plus fertilizer and goat manure yielded a maximum weight of 100 seeds.

Conclusion and recommendations

Conclusion

Separately, goat manure and Minjingu Nafaka Plus fertilizers can perform a better yield and optimum growth on lablab plant species. According to our findings, it can be said that the manure performed best in lablab bean production, as it helps in proper plant growth and pod yield. Therefore, goat manure is highly recommended because of its easy availability, economic friendly, and cost-effectiveness to smallholder farmers. Furthermore, more studies should be conducted on goat manure to see how it can maintain soil fertility through improved biological and physical properties of the soil compared to Minjingu Nafaka Plus fertilizer. Furthermore, on field experiments, it was discovered that it is not economical and healthy to apply Minjingu Nafaka Plus fertilizer in a given lablab field as it is too costly to poor resource farmers. Instead, goat manure fertilizer should be applied to the field since it is easily accessible by a large number of smallholder farmers because of low costs and yields better slightly similar to Minjingu Nafaka Plus fertilizer. Also, lablab plants tend to fix their nitrogen, while improving soil texture, and structure and preserving moisture in the soil for proper lablab growth, especially during dry spells. The study has also revealed that it is possible to save machine labor and irrigation water under zero tillage than under conventional tillage practice. Since zero tillage practice tends to lose a small amount of water compared to conventional tillage practice. Lastly following financial resource-saving, net return has been observed to be significantly higher in zero tillage practices compared to conventional tillage practices. Hence, zero tillage practice is an important alternative to save available scarce resources, such as money, labor and water to enhance the net farm income under lablab production, especially when it is applied in high drought areas. Zero tillage practices can contribute to an increasingly wide range of lablab crop harvest by 48 percent by smallholder farmers and thus could save scarce resources and reduce the cultivation cost.

Recommendations

i. The use of goat manure fertilizer based on cropping in semi-arid areas should be promoted to improve lablab production and build resilience.
ii. To understand the influence of rainfall uncertainty on lablab crop production, more studies are recommended to investigate the relationship between climatic variability.
iii. Introduction of policies that favor zero tillage practices with the application of goat manure in semi-arid conditions of Sub-Sahara Africa including Tanzania.
iv. More findings are required to improve households' ability to adapt while delivering resilience and environmental benefits in semi-arid areas that are vulnerable to climate change.
v. However, the adoption to use goat manure rather than Minjingu Nafaka plus fertilizer on zero tillage practices will partly depend on the benefits to the farmers, a detailed cost-benefit analysis of implementing zero tillage practices with the application of goat manure should be conducted.
vi. There must be a focused discussion on the agronomic, weed, soil and yields quality impacts that can result from zero tillage and other conservation measures are adopted. Eg., use of goat manure while reducing the application of Minjingu Nafaka Plus fertilizer.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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