COMPARING EFFECTS OF LEGUME INTERCROPPING AND GREEN LEAF MANURING ON PERFORMANCE OF MAIZE AND RESIDUAL SOIL PROPERTIES

ABSTRACT

In Nepal, there is a significant disparity between demand and supply for maize. Given that the most smallholder farmers lack resources and hence cannot afford to purchase the necessary quantity of fertilizer. Hence, use of different legumes intercropping and green leaf manure incorporation could be alternatives for increasing maize yield, and enhancing soil properties. A field experiment was conducted at Lamjung Campus, Sundarbazzar, from March to July 2023 to study the response of maize to different legumes intercropping and green leaf manure incorporation, and effect on soil residual nutrients. The experiment was laid out in a randomized complete block design with five treatments (maize as a control, cowpea + maize, french bean + maize, soybean + maize, and green leaf manure + maize) and four replications. Nitrogen fertilizer was applied 60 kg ha-1 (half of recommended dose), phosphorous and potassium was applied 15 kg ha-1 and 10 kg ha-1 (one-fourth of recommended dose) respectively as its availability was already high in soil. All the maize yield related attributes were higher ($P < 0.05$) in intercropping as compared to control. Significantly higher maize yield was obtained in green leaf manuring (2.21 times more than control), followed by soybean, cowpea and french bean with 0.65, 0.25 and 0.09 times higher than control. In addition, nitrogen (2.25%) and organic matter (4.8%) were found higher in green leaf manure than others. It can be concluded that input of green leaf manure to the soil enhances the yield of maize and soil properties.

Keywords: Green leaf manure, Intercropping, Maize yield, Soil properties

1. Introduction

Smallholder farmers cultivate several species for food and sale, and yields are the most important considerations in crop choices (Smithson & Giller, 2002). Increasing soil productivity can be achieved by boosting organic matter. It is crucial in triggering soil fertility through biological activities, thereby enhancing the physical, chemical, and biological properties of soil (Ziblim et al., 2013). Forage legumes are frequently used as green manure crops in crop rotations to boost soil fertility and crop yields. They improve the cycle of phosphorus and other nutrients for succeeding crops and are a good source of nitrogen(Turgut et al., 2005). Green manures can boost soil health by improving organic matter, reducing bulk density, enhancing microbial biomass, and water infiltration, as well as supplying nitrogen when legumes are turned under (McGuire et al., 1998). Green manure works as a source and buffer of nutrients through the process of decomposition and its role in providing soil organic matter and soil microbes. Furthermore, the application of green manure can increase the organic matter and nutrient content of the soil, resulting in improved soil physical, chemical, and biological qualities, as well as greater soil productivity and erosion resistance (Rayns & Rosenfeld, 2010).

Malabar nut (Justicia adhatoda L.) is a small, herbaceous, evergreen plant that belongs to the Acanthaceae family. It is well-known in Ayurvedic and Unani systems of medicine due to its unique phytochemistry (Nawaz et al., 2018). The leaves can be used as green manure due to their high levels of potassium nitrate. Additionally, while the alkaloid vasicine found in the leaves can be harmful to cold-blooded species such as fish, it is harmless to mammals (Adhaota Vasica (Malabar Nut), n.d.).

Intercropping (IC) is a centuries-old multiple-cropping technique that is popular among smallholder farmers in poor countries today because to its higher land and nutrient usage efficiency, higher economic returns, and reduced pest and disease incidence as compared to solitary crops(HUANG et al., 2019). The general direction and extent of changes in soil physical characteristics can be managed via cropping strategies that generate significant amounts of crop residues as a source of organic matter(Latif et al., 1992). In an intercropping system, all environmental resources are capitalized to maximize crop yield per unit area per unit time while also minimizing risk. While the majority of intercropping research have focused on cereal-based intercropping and demonstrated the efficacy of intercropping (H. Seran & Brintha, 2010). The poor management technology, lack of judicious use of nitrogen and high cost of cultivation are major causes for low production of maize in Nepal resulting wide gap between supply and demand of maize in Nepal. The main target of this research is to enhance the productivity and effectiveness of maize while enhancing soil properties and compare the yield of crops under green leaf manuring and legume Intercropping. So that the results obtained can be a great piece of information for Nepali farmers.

2. Materials and Methods

The experiment was carried out on Institute of Agriculture and Animal Science, Lamjung Campus, Nepal (28.2765 ^{o}N, 84.3542 ^{o}E, altitude 625 m above sea level). Average of 30 years rainfall was 2800 mm and temperature were 18º C. A factorial field experiment at randomized complete block design with four replications was carried out to investigate the effect of three cropping systems (maize vs. maize intercropped with legumes vs. green leaf manuring) with constant dose of NPK (60, 60, and 40 respectively). Five rows with five plants each were sown in each 3.0 m long by 1.25 m wide plot. Total plots were 20 covering 180 square meter area (20 m x 9 m). The treatments detail is given below.

Table 1. Table presenting treatments

Treatments	
T_1	Maize
T_2	Maize + Cowpea
T_3	Maize + French bean
T_4	Maize + Soybean
T_5	Maize + Green leaf manuring

The land was ploughed one month earlier to sowing for leaf decomposition. Irrigation for leaf decomposing plot was practiced daily. Plot was designed by that time. Further, final plot preparation was performed 2 days prior to sowing for more pulverized soil. All the stubbles and weeds were removed. Maize (Rampur composite) was sown in the second week of Chaitra. Maize resowing was performed as per requirements. And other intercrops were sown after 1 month of maize sown. The row spacing was 60 cm, while the plant spacing was 25 cm.

Farm Yard Manure (FYM) was applied by farmer procedure (about 15 t/ha), each plot received 5kg manure. Before ploughing the field, well-decomposed manure was incorporated into the soil. Potassium and phosphorus were applied exactly as suggested, but nitrogen was applied at half the required rate since we assumed legumes and leaf manuring would meet the remaining demand. The first half of the nitrogen dosage was applied at planting, followed by the second half six weeks later.

NPK = 60: 60: 40 kg/ha

Weeding was performed as per requirements and earthing up was done 45 days after sowing. In early stage of maize growth, cutworm was a problem so to control it, we applied Cartap hydrochloride was used as recommended. Harvesting was performed manually in the last week of Ashar and there by data was collected. Nitrogen, Phosphorous, Potassium, pH and Organic matter level of experimental site's soil were examined.

Table 2. Nutrients status before research

Experimental site	Nitrogen %	Phosphorous %	Potassium %	Organic matter %	Soil pH
IAAS, Sundarbazar	0.1	529	872	2.1	6.2

3. Results

3.1 Anthesis silking interval

The finding showed that intercropping and green manuring had no significant effect on ASI. Despite that, ASI of maize incorporated with green leaf manuring was the shortest as compared to others. ASI of maize in green manuring was shifted 2 days earlier as compared to control, however, highest ASI of maize was observed in French bean which was slightly longer than control though significant difference was not observed as shown in Figure 1**.**

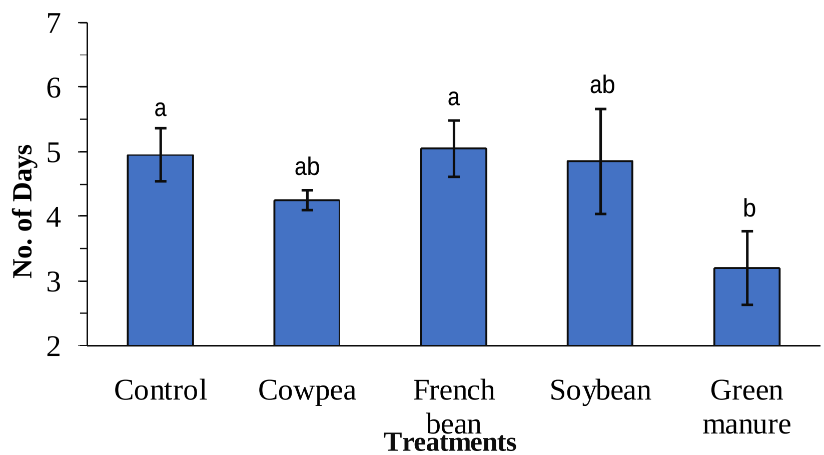

Figure 2. Effect of Intercropping and green manuring on ASI on maize

3.2 Maize yield

Different intercropping and green leaf manuring showed significant difference in maize grain yield. Maize grain yield under green leaf manuring was 2.21 times more as compared to control then followed by intercropping with soybean and cowpea yielded 0.65 and 0.25 times respectively as shown in Figure 3. French bean enhanced only 0.9 times more yield as compare to control. Maize yield in intercropping was lower than green manure was due to competition of intercropping legumes with maize while there was no competition in green leaf manuring during maize growth stages. Besides high and slow release of nutrient (primarily N) by green leaf manuring to the soil ultimately increased the yield than others.

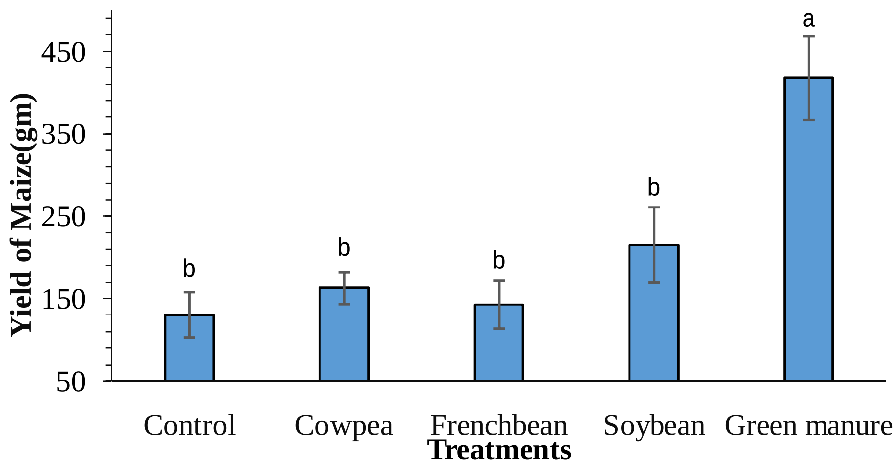

Figure 4.Effect of Intercropping and green leaf manuring on Maize yield

3.3 Intercrop yield

As represented in figure 3, yield of cowpea significantly differed with other intercropping. Cowpea yield was found 1.6 times more as compare to French bean yield (which was the lowest). Soybean yield was slightly higher than French bean though significant difference was not observed. Intercropping French beans with maize does not significantly impact maize yield but drastically reduces the output of French beans.

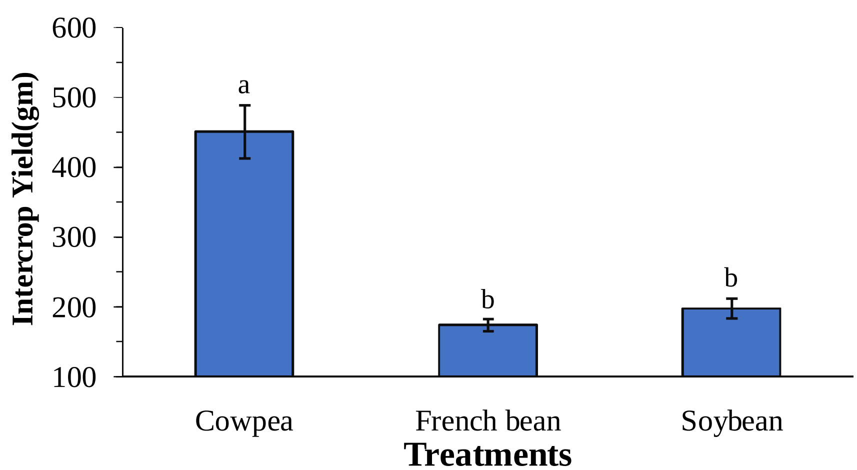

Figure 5. Yield of different intercrop legumes.

3.5 Soil nutrients and ph

The Nitrogen level in the soil was measured at 0.1% before planting maize in the field. As the soil was intercropped with various nitrogen-fixing crops, the soil nitrogen content ranged from 1.01% to 2.25%. The soil intercropped with green manure had higher N (2.25%), while the soil with no intercropping had lower N (1.01%). The remaining inter-cropped soils fell in between these two extremes, as indicated in Figure 4. Total N level in green leaf manuring was higher as Justicia Adhatoda provides potassium nitrate in decomposition and also enhanced OM which ultimately increased total N.

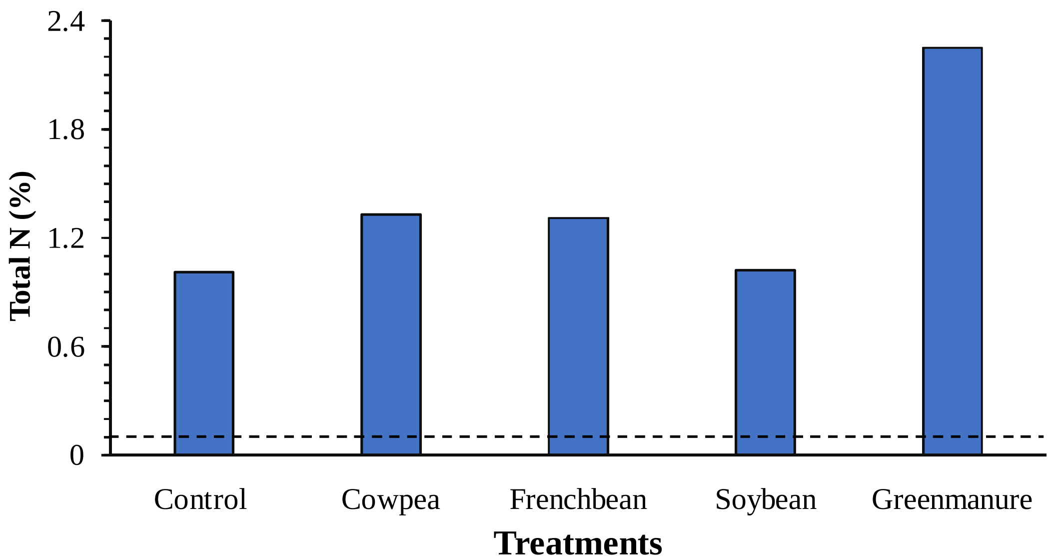

Figure 6. Changes in total N in soil due to different types of intercropping and green manuring in maize field. Dash line in the figure indicates the level of total N in soil (which is 0.1%) before intercropping

The initial Phosphorus and Potassium level in the soil were measured 529 kg/ha and 872 kg/ha respectively. P and K fertilizer were applied as required only due its high availability in soil. Across various intercropped soil types in the field, the recorded P & K level ranged from 200 to 301 kg/ha and 302.36 to 375.45 kg/ha respectively. Among these, the soil intercropped with green leaf manure exhibited higher P & K content i.e. 301 kg/ha & 375.45 kg/ha, while the soil with no intercropping had lower P & K content i.e. 200 kg/ha & 302.36 kg/ha respectively. The remaining inter-cropped soils showed P & K level that fell between these two extremes, as represented in Figure 5

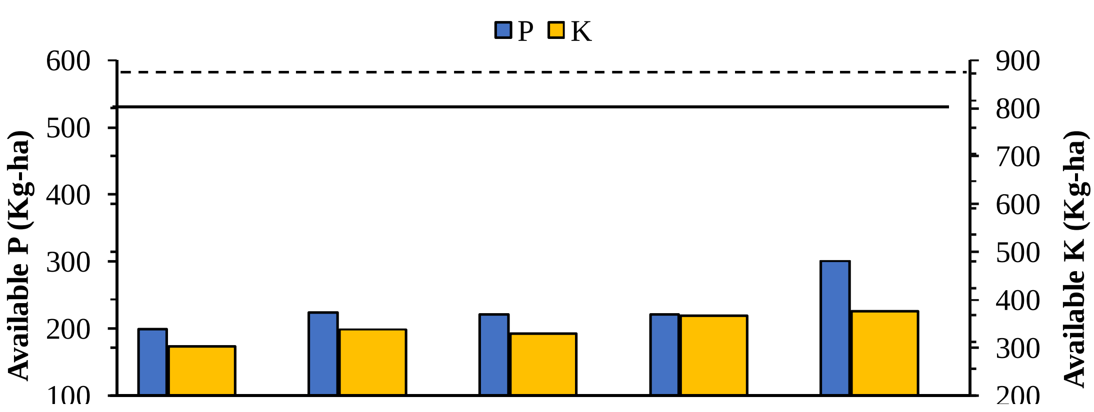

Figure 7.Changes in available P & K in soil due to different types of intercropping and green leaf manuring in maize field. Straight line in the figure indicates the level of initial available P in soil (which is 529). Dash line in the figure indicates the level of initial available K in soil (which is 872).

The organic matter (OM) percentage in the soil before maize planting was recorded at 2.1%. After planting and implementing various intercropping practices, the OM % in the field ranged from 2.1% to 4.8%. Notably, the soil intercropped with green manure exhibited higher OM % (4.8%), while the soil in the control group maintained its OM % at the initial 2.1%. In the control group, the OM percentage remained constant before and after maize plantation. Figure 7 illustrates that the other intercropped soils displayed OM percentages that fell between these two extremes. OM in green leaf manure was high due to well decomposition of manure and slow release of nutrient in soil.

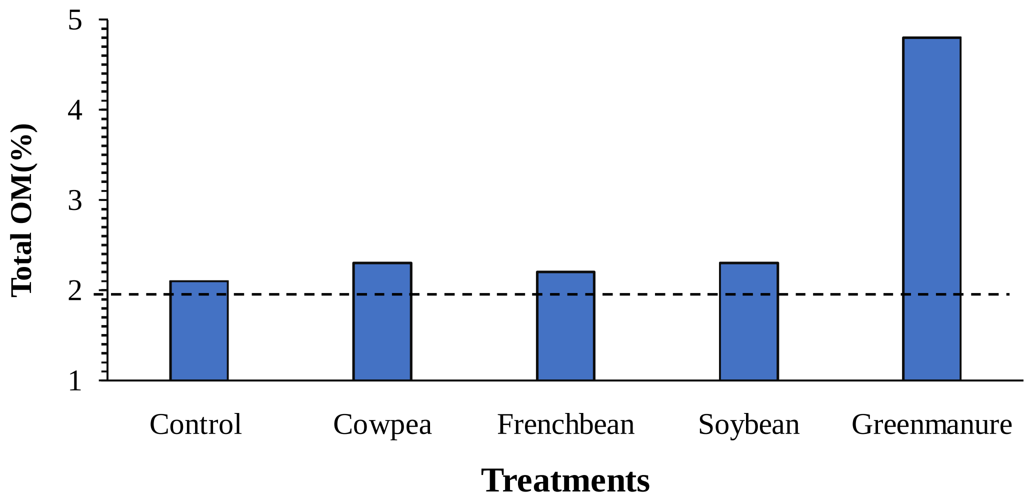

Figure 8. Effects of various intercropping and green leaf manuring on total OM % in soil.

The initial soil pH level was noted 6.2. The pH values in the field ranged from 4.8 to 6.5 after maize planting and the use of various intercropping strategies. Notably, the soil intercropped with French beans had higher pH level at 6.5, suggesting a more neutral state, while the soil with green manure had lower pH level at 4.8, indicating excessive acidity. Excess acidity in green manure was due to use of Malabar nut which provides potassium nitrate (*Adhaota Vasica (Malabar Nut)*, n.d.). P Singh et al, (2011) reported that *Justicia adhatoda L.* contains major elements Ca, Na, Mg, and K, as well as trace elements Ni, Co, Cd, Cr, Mn, Fe, Zn, Pb, and Cu. The pH level in the control group was stable before and after maize planting. Due to present of such elements might increase acidity and lowers soil pH. Figure shows that the remaining intercropped soils had pH values ranging from acidity to neutral.

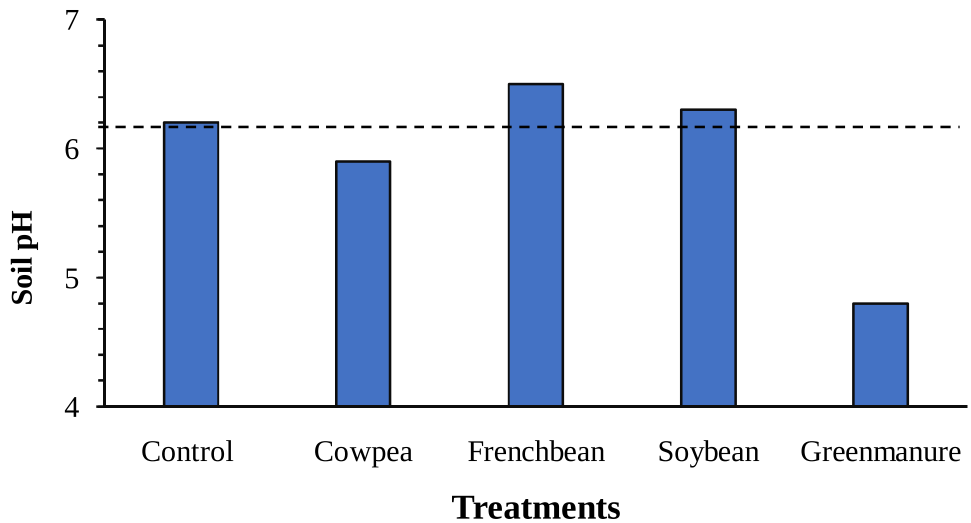

Figure 9. Effects of different intercropping and green leaf manuring on soil pH.

Table 3. Nutrient status after research

Treatments	Nitrogen %	Phosphorous Kg/ha	Potassium Kg/ha	Organic matter %	Soil pH
Maize	1.01	200	302.36	2.1	6.2
Maize + Cowpea	1.33	224	338.61	2.3	5.9
Maize + Frenchbean	1.31	221	329.26	2.2	6.5
Maize + Soybean	1.02	220.8	367.21	2.3	6.3
Maize + Green leaf manure	2.25	301	375.45	4.8	4.8

Table 4. Effects of maize- legumes intercropping and green leaf manuring on ASI and yield of maize and legumes

Factors	Intercrop yield	Maize yield	ASI
T_1	0.00[c]	130.0[b]	4.95[a]
T_2	450.50[a]	162.5[b]	4.25[ab]
T_3	173.75[b]	142.5[b]	5.05[a]
T_4	197.50[b]	215.0[b]	4.85[ab]
T_5	0.00[c]	417.5[a]	3.20[b]
Sem±	17.31	37.60	0.53
LSD	53.35	115.87	1.62
CV	21.069	35.24	23.53
F-test	***	***	NS
MS error	1199	5656	1.1013

Means followed by the common letter within each column are not significantly different at 5% level of significance by Duncan Test. (‘***’= 0.001, ** = 0.01 and * = 0.05)

4. Discussion

The impact of intercropping of maize with cowpea, French bean, soybean was not significant in terms of ASI, although there was a marginal delay, which again illustrated the impact of the stress factors due to competition, which delays ASI (Westgate et al., 2000). Furthermore, the research showed there is no influence of intercropping in drought tolerant despite, it is influenced by green manuring slightly.Intercropping with green manure is the option to enhancing maize yield even in nitrogen-depleted soil (H. Li et al., 2023). Instead of creating accessible N for the maize, legumes in the intercropped plot may compete for soil N. Hiebsch(1981), who researched corn-soybean intercropping systems, found evidence of probable N competition by a legume in a grass-legume intercropping system. The production of accessible N by a legume through biological N2 fixation for an adjoining grass was not advantageous for intercropping in the same season. Further, discussing about intercropping, greater influence might be seen on next cropping as nutrient release in soil is slow process. In a maize-soybean intercropping system, the taller maize crop alters the light environment perceived by the lower soybean crop in terms of both light quantity and quality, resulting in reduced branching of soybean plants and ultimately, poorer soybean output (Liu et al., 2017). The primary advantage of intercropping is that it optimizes resource utilization and enhances total production compared to individual crops (Hamd Alla et al., 2014).Unkovich& Pate (2000) stated that the percentage of nitrogen in a legume is not only influenced by the connection between the bean genotype and its rhizobia but also by the relationship between soil nitrogen availability and legume growth. In addition to this, initial N% in soil was found low in the plot which might be the reason for lower N% in intercrop plot. Further research might be needed to conduct to find for more reason.Cavigelli& Thien (2003) reported that green manure has been shown to boost phosphorus availability from rock phosphate in rice. In general, we can conclude that they increase phosphorous availability and utilization. Maize being a heavy nutrient feeder, it absorbed P & K from soil and also intercropping and green leaf manuring help to mobilize nutrient in soil. P Singh et al, (2011) reported that *Justicia adhatoda L.* contains major elements Ca, Na, Mg, and K, as well as trace elements Ni, Co, Cd, Cr, Mn, Fe, Zn, Pb, and Cu. The pH level in the control group was stable before and after maize planting. Due to present of such elements might increase acidity and lowers soil pH.

5. Conclusions

The study conducted at IAAS, Lamjung Campus in March 2023 evaluated the effects of legume intercropping and green leaf manuring on the Rampur Composite variety of maize.The results showed a significant improvement in grain yield and soil nutrients under green leaf manuring, attributed to the slow and consistent nutrient release during decomposition. Although soil pH remained slightly acidic, green leaf manuring enhanced soil biological quality, nutrient availability, and maize productivity compared to legume intercropping.Green leaf manuring is a cost-effective and sustainable approach for smallholder farmers to improve maize yield and soil health. However, further trials are recommended to comprehensively evaluate its long-term effects on soil physical, chemical, and biological properties.

References

1. Adediran, J. A., & Banjoko, V. A. (1995). Response of maize to nitrogen, phosphorus, and potassium fertilizers in the savanna zones of nigeria. *Communications in Soil Science and Plant Analysis*, *26*(3–4), 593–606. https://doi.org/10.1080/00103629509369320
2. *Adhaota Vasica (Malabar Nut)*. (n.d.).
3. Amanullah, & Shah, P. (2011). Nitrogen rates and its time of application influence dry matter partitioning and grain yield in maize planted at low and high densities. *Journal of Plant Nutrition*, *34*(2), 224–242. https://doi.org/10.1080/01904167.2011.533324
4. Ananthi, T., Amanullah, M. M., Rahman, A., & Al-Tawaha, M. S. (2017). A review on maize-legume intercropping for enhancing the productivity and soil fertility for sustainable agriculture in India. *Advances in Environmental Biology*, *11*(5), 49–63. http://www.aensiweb.com/AEB/http://creativecommons.org/licenses/by/4.0/
5. Ayele, H. M. (2020). Evaluation of the effect of maize-legume intercropping on soil moisture improvement in arid area of Bena-Tsemay district, South omo zone, Southern Ethiopia. *International Journal of Agricultural Research, Innovation and Technology*, *10*(1), 80–86. https://doi.org/10.3329/IJARIT.V10I1.48097

6. BUCKMAN, H. O. B., & NYLE, C. (1969). *THE NATURE AND PROPERTIES OF SOILS/HARRY O. BUCKMAN AND NYLE C. BRADY; REV. NYLE C. BRADY.*

7. Bundy, L. G., & Carter, P. R. (2013). *(1988) Corn Hybrid Response to Nitrogen Fertilization in the Northern Corn Belt (JPA)*. *1*(2).

8. Cavigelli, M. A., & Thien, S. J. (2003). Phosphorus Bioavailability following Incorporation of Green Manure Crops. *Soil Science Society of America Journal*, *67*(4), 1186–1194. https://doi.org/10.2136/sssaj2003.1186

9. Cherr, C. M., Scholberg, J. M. S., & McSorley, R. (2006). Green Manure Approaches to Crop Production: A Synthesis. *Agronomy Journal*, *98*(2), 302–319. https://doi.org/10.2134/AGRONJ2005.0035

10. Edmeades, G. O., & Daynard, T. B. (1979). The development of plant-to-plant variability in maize at different planting densities. *Canadian Journal of Plant Science*, *59*(3), 561–576.

11. Fageria, N. K. (2007). Green manuring in crop production. *Journal of Plant Nutrition*, *30*(5), 691–719. https://doi.org/10.1080/01904160701289529

12. Ganajaxi, Halikatti, S. I., Hiremath, S. M., & Chittapur, B. M. (2010). Intercropping of maize and French bean - a review. *Agricultural Reviews*, *31*(4), 286–291. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=caba6&AN=20133080163http://oxfordsfx.hosted.exlibrisgroup.com/oxford?sid=OVID:cabadb&id=pmid:&id=doi:&issn=0253-1496&isbn=&volume=31&issue=4&spage=286&pages=286-291&date=2010&title=Agric

13. Gebru, H. (2015). A Review on the Comparative Advantage of Intercropping Systems. *Journal of Biology, Agriculture and Healthcare*, *5*(9), 28–38. http://www.iiste.org/Journals/index.php/JBAH/article/view/21387

14. *Green leaf manuring and green manuring*. (n.d.).

15. Gul, S., Khan, M. H., Khanday, B. A., & Nabi, S. (2015). Effect of Sowing Methods and NPK Levels on Growth and Yield of Rainfed Maize (Zea mays L.) . *Scientifica*, *2015*, 1–6. https://doi.org/10.1155/2015/198575

16. H. Seran, T., & Brintha, I. (2010). Review on Maize Based Intercropping. *Journal of Agronomy*, *9*(3), 135–145. https://doi.org/10.3923/ja.2010.135.145

17. Hamd Alla, W. A., Shalaby, E. M., Dawood, R. A., & Zohry, A. A. (2014). Effect of Vigna sinensis with Maize Intercropping on Yield and its Components. *Internetional Science Index*, *8*(11), 1170–1176.

18. Heng, Z., Qiao, W., XinHua, Z., Qi, D., Yue, Z., XiaoGuang, W., ChunJi, J., ShuLi, Z., MinJian, C., HaiQiu, Y., & DaWei, W. (2014). Effects of different nitrogen applications on soil physical, chemical properties and

yield in maize (Zea mays L.). In *Agricultural Sciences* (Vol. 5, Issues 14 PG-1440–1447, pp. 1440–1447). email: haiqiuyu@163.com%5Cwdawei@vip.126.com NS -

19. Hiebsch, C. K. (1981). Principles of intercropping: effects of nitrogen fertilization, plant population, and crop duration on equivalency ratios in intercrop versus monoculture comparisons. *Dissertation Abstracts International*, *B*, *41*(12). http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=caba1&AN=19820745611http://oxfordsfx.hosted.exlibrisgroup.com/oxford?sid=OVID:cabadb&id=pmid:&id=doi:&issn=0419-4217&isbn=&volume=41&issue=12&spage=4337&pages=4337&date=1981&title=Disser
20. HUANG, C. dong, LIU, Q. qing, LI, X. lin, & ZHANG, C. chun. (2019). Effect of intercropping on maize grain yield and yield components. *Journal of Integrative Agriculture*, *18*(8), 1690–1700. https://doi.org/10.1016/S2095-3119(19)62648-1
21. Hue, N. V, & Silva, J. A. (2000). Organic Soil Amendments for Sustainable Agriculture: Organic Sources of Nitrogen, Phosphorus, and Potassium. *Plant Nutrition in Hawaiss's Soil for Tropical and Subtropical Agriculture*, 133–144.
22. Iqbal, N., Hussain, S., Ahmed, Z., Yang, F., Wang, X., Liu, W., Yong, T., Du, J., Shu, K., Yang, W., & Liu, J. (2019). Comparative analysis of maize–soybean strip intercropping systems: a review. *Plant Production Science*, *22*(2), 131–142. https://doi.org/10.1080/1343943X.2018.1541137
23. Johansen, C. A. (Carl A. ., Lee, K. K., Sahrawat, K. L., & International Crops Research Institute for the Semi-Arid Tropics. (1991). *Phosphorous nutrition of grain legumes in the semi-arid tropics*.
24. Khoshgoftarmanesh, A. H., & Eshghizadeh, H. R. (2011). Yield response of corn to single and combined application of cattle manure and urea. *Communications in Soil Science and Plant Analysis*, *42*(10), 1200–1208. https://doi.org/10.1080/00103624.2011.566964
25. Latif, M. A., Mehuys, G. R., Mackenzie, A. F., Alli, I., & Faris, M. A. (1992). Effects of legumes on soil physical quality in a maize crop. *Plant and Soil: An International Journal on Plant-Soil Relationships*, *140*(1), 15–23. https://doi.org/10.1007/BF00012802
26. Li, H., Fan, Z., Wang, Q., Wang, G., Yin, W., Zhao, C., Yu, A., Cao, W., Chai, Q., & Hu, F. (2023). Green manure and maize intercropping with reduced chemical N enhances productivity and carbon mitigation of farmland in arid areas. *European Journal of Agronomy*, *145*, 126788.
27. Li, L., Yang, S., Li, X., Zhang, F., & Christie, P. (1999). Interspecific complementary and competitive

interactions between intercropped maize and faba bean. *Plant and Soil*, *212*(2), 105–114. https://doi.org/10.1023/A:1004656205144

28. Liu, X., Rahman, T., Song, C., Su, B., Yang, F., Yong, T., Wu, Y., Zhang, C., & Yang, W. (2017). Changes in light environment, morphology, growth and yield of soybean in maize-soybean intercropping systems. *Field Crops Research*, *200*, 38–46.
29. Lulie, B. (2017). Intercropping Practice as an Alternative Pathway for Sustainable Agriculture: A review. *Academic Research Journal of Agricultural Science and Research*, *5*(6), 440–452. https://doi.org/10.14662/ARJASR2017.057
30. Macrae, R. J., & Mehuys, G. R. (1985). The effect of green manuring on the physical properties of temperate-area soils. *Advances in Soil Science. Vol. 3*, *3*, 71–94. https://doi.org/10.1007/978-1-4612-5090-6_2
31. McGuire, A. M., Bryant, D. C., & Denison, R. F. (1998). Wheat yields, nitrogen uptake, and soil moisture following winter legume cover crop vs. fallow. In *Agronomy Journal* (Vol. 90, Issue 3, pp. 404–410). https://doi.org/10.2134/agronj1998.00021962009000030015x
32. Mobasser, H. R., Vazirimehr, M. R., & Rigi, K. (2014). *Effect of intercropping on resources use, weed management and forage quality. International Journal of Plant, Animal and Environmental Sciences, 4(2), 706-713.April.*
33. Nawaz, H., Khan, S., & Nadeem, F. (2018). Use of Malabar Nut (Justicia adhatoda L.) from Traditional Medicine to Current Pharmacopeia-A Review Study. *Ijcbs*, *13*, 46–51. www.iscientific.org/Journal.html
34. Odhiambo, J. J. O., Ogola, J. B. O., & Madzivhandila, T. (2010). Effect of green manure legume - maize rotation on maize grain yield and weed infestation levels. *African Journal of Agricultural Research*, *5*(8), 618–625. https://doi.org/10.5897/AJAR09.394
35. Onasanya, R., Aiyelari, O., Onasanya, A., Oikeh, S., Nwilene, F., & Oyelakin, O. (2009). Growth and yield response of maize (Zea mays L.) to different rates of nitrogen and phosphorus fertilizers in southern Nigeria. *World Journal of Agricultural Sciences*, *5*(4), 400–407.
36. P Singh, T., M Singh, O., & B Singh, H. (2011). Adhatoda vasica Nees: phytochemical and pharmacological profile. *The Natural Products Journal*, *1*(1), 29–39.
37. Pikul, J. L., Aase, J. K., & Cochran, V. L. (1997). Lentil green manure as fallow replacement in the semiarid northern Great Plains. *Agronomy Journal*, *89*(6), 867–874. https://doi.org/10.2134/agronj1997.00021962008900060004x

38. Rayns, F., & Rosenfeld, A. (2010). Green manures – effects on soil nutrient management and soil physical and biological properties. *Soil Grown Crops*, *24/10*. http://www.organicresearchcentre.com/manage/authincludes/article_uploads/iota/technical-leaflets/green-manures-effects-on-soil-nutrient-management-and-soil-physical-and-biological-properties.pdf

39. Sharma, A. R., & Behera, U. K. (2010). Green leaf manuring with prunings of Leucaena leucocephala for nitrogen economy and improved productivity of maize (Zea mays)-wheat (Triticum aestivum) cropping system. *Nutrient Cycling in Agroecosystems*, *86*(1), 39–52. https://doi.org/10.1007/s10705-009-9272-9

40. Singh, S., Singh, H., Kumar, P., Singh, V., Kumar, S., & Singh, R. (2021). Effect of NPK levels with bio-fertilizers on productivity of maize (Zea mays L.). *International Journal of Chemical Studies*, *9*(1), 1476–1479. https://doi.org/10.22271/chemi.2021.v9.i1u.11431

41. Singh, Y.-S., Khind, C. S., & Singh, B. (1991). Efficient Management Of Leguminous Green Manures In Wetland Rice. *Advances in Agronomy*, *45*, 135–189. https://doi.org/10.1016/S0065-2113(08)60040-1

42. Smithson, P. C., & Giller, K. E. (2002). Appropriate farm management practices for alleviating N and P deficiencies in low-nutrient soils of the tropics. *Plant and Soil*, *245*(1), 169–180. https://doi.org/10.1023/A:1020685728547

43. Tao, J., Liu, X., Liang, Y., Niu, J., Xiao, Y., Gu, Y., Ma, L., Meng, D., Zhang, Y., Huang, W., Peng, D., & Yin, H. (2017). Maize growth responses to soil microbes and soil properties after fertilization with different green manures. *Applied Microbiology and Biotechnology*, *101*(3), 1289–1299. https://doi.org/10.1007/s00253-016-7938-1

44. Tejada, M., Gonzalez, J. L., García-Martínez, A. M., & Parrado, J. (2008). Effects of different green manures on soil biological properties and maize yield. *Bioresource Technology*, *99*(6), 1758–1767. https://doi.org/10.1016/j.biortech.2007.03.052

45. Turgut, I., Bilgili, U., Duman, A., & Acikgoz, E. (2005). Effect of green manuring on the yield of sweet corn. *Agronomy for Sustainable Development*, *25*(4), 433–438.

46. Unkovich, M. J., & Pate, J. S. (2000). An appraisal of recent field measurements of symbiotic N2 fixation by annual legumes. *Field Crops Research*, *65*(2–3), 211–228.

47. Waddington, S. R., Mekuria, M., Siziba, S., & Karigwindi, J. (2007). Long-term yield sustainability and financial returns from grain legume-maize intercrops on a sandy soil in subhumid north central Zimbabwe. *Experimental Agriculture*, *43*(4), 489–503. https://doi.org/10.1017/S0014479707005303

48. Welcker, C., Boussuge, B., Bencivenni, C., Ribaut, J. M., & Tardieu, F. (2007). Are source and sink strengths genetically linked in maize plants subjected to water deficit? A QTL study of the responses of leaf growth and of Anthesis-Silking Interval to water deficit. *Journal of Experimental Botany*, *58*(2), 339–349. https://doi.org/10.1093/jxb/erl227

49. Westgate, M., Boote, K., Edmeades, G., Bolaños, J., Elings, A., Ribaut, J.-M., Bänziger, M., & Westgate, M. (2000). *The Role and Regulation of the Anthesis-Silking Interval in Maize*. https://doi.org/10.2135/cssaspecpub29.c4

50. Ziblim, I., Paul, G., & Aikins Khan, T. (2013). Assessing soil amendment potentials of Mucuna pruriens and Crotalaria juncea when used as fallow crops. *Journal of Soil Science and Environmental Managment*, *4*, 28–34.