10(1), 8–11.

Wondwosen, Tena, and Sheleme, Beyene. (2011). Identification of growth-limiting nutrient (s) in Alisos: soil Physic-chemical properties, nutrient concentrations and biomass yield of maize. American Journal of plant nutrition and fertilization technology, 1(1), 23-35.

7. Effect of Inorganic Fertilizers and Green Manuring on the Yield of Subsequent crops of Irrigated and Rain fed System in the Lowland Areas of North Shewa

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Abstract

The experiment was carried out in the low land areas of north Shewa of Kewet district, Yelene -2018/19 main and irrigation cropping seasons to evaluate the effect of green manuring and inorganic fertilization on yield and yield components of subsequent crops. This research was designed using Split Plot Design. The main plot used green manures which consisted of three levels, i.e: without green manure, incorporation of Crotalaria juncea and Tepherosia vogelii as green manure. The subplot was inorganic Nitrogen and Phosphorus (NP) fertilizer rate consisted of three levels: without NP fertilizer (control), 50% recommended fertilizer (RF) dose of NP and 100%RF dose of NP for onion and mung bean. The results showed that fertilization of inorganic NP and application of crotalaria green manure increase the yield of onion. Application of 50% recommended NP with Crotalaria juncea green manure gave 33.7 tha^{-1} onion yield compared to the same dose of NP without green manure (20.3 tha^{-1}). Based on this study, 50% recommended NP fertilizer with crotalaria juncea green manure is recommended for the production of onion in the study area. Therefore, promotion and expansion of the finding to sustainable production of the crop is critically important.

Keywords*: Crotalaria, green manure, onion, sorghum, tephrosia*

Introduction

Agricultural production is dependent on the soil and its level of fertility status and the supply of adequate nutrients. Inadequate nutrient supply and poor soil structure in most cases are some of the major constraints in our agricultural system as it seriously affects the resource poor farmers that practice low- input agriculture (Jaja *et al.,* 2015). The application of green manures to soil is considered a good management practice in any agricultural production system because it can increase cropping system sustainability by reducing soil erosion and ameliorating soil physical properties, increasing soil organic matter and othe plant nutrients, increasing nutrient retention, and reducing global warming potential (Tejada *et al.,* 2008).

Decline in soil fertility is one of the primary constraints to agricultural production in sub-Saharan Africa (Sanchez and Jama, 2002). In Ethiopia, farmers typically apply insufficient inputs to the soil, usually below the recommended rates of nutrients and organic fertilizers as a result soils of Ethiopia are in decline trends of their fertility status (IFPRI, 2010). Therefore, maintenance of soil fertility is a pre-requisite for long term sustainable crop production and soil health. The maintenance of soil organic matter is desirable for satisfactory crop production (Debnath, *et al.*, 2014). According to the report of soil fertility map of Amhara region by ATA (2016), cultivated soils of the region were on lower range of organic matter. Even old research reports indicated that the nutrient status Ethiopian soils is low (Hailu, 1988; Asnakew, 1994). The situation could be improved through various mechanisms including by the addition of different sources of organic manure to the soil, such as, farm yard manure, compost, crop residues, and organic wastes as well. Green manure is the cheapest source of organic manure that supplies Nitrogen, and other nutrients for crop production. The combined application of green manure and inorganic fertilizers increases the yield of crops and improve availability of nutrients in the soil as well as increase the nutrient recovery (Abedin and Mukhopadhaya, 1990). Moreover, green manuring along with inorganic fertilizer helps to release nutrient elements slowly during the period of crop growth (Singh *et al.*, 1990). Reports of different findings on integration of green manure and chemical fertilizers indicate significantly higher yield increase in wheat than that of sole application of chemical fertilizer (Akter *et al.*, 1993). Similarly research findings of green manuring on the *nitosols of Ethiopia was reported by Birhanu et al., (2012).*

Generally, green manuring has recently been under practice in different parts of the world.

Estimates suggest that a 40-50 days old green manure crop can supply up to 80-100 $Kgha^{-1}$ N. Some of the potential green manuring legumes are, *crotalaria juncea*, *cowpea*, and *mung bean*, etc.. *Crotalaria juncea*, and mung bean grown as green manure crops have been reported to contribute 8-21 tons of green matter and 42-95 $Kgha^{-1}$ N (Mishra and Naik, 2004). Crotalaria juncea has higher rate of biomass production and can produce dry matter to the extent of 16 to 19 tha^{-1} within a short period of 45-60 days and on an average about 5tha^{-1} dry matter can easily be produced, which is sufficient for meeting out nutritional demand of a crop during growing season (Lokesh *et al.,,.2015).* Fertilizer with doses of 135 Kg N ha^{-1} + 66 Kg P_2O_5 ha^{-1} and application of Crotalaria juncea green manure yield of maize obtained as many as 7.234 tha^{-1}, (Subaedah *et al.,* 2015). Crotalaria juncea is a strong Nitrogen fixer, resistant to root knot nematodes, and can be incorporated into the soil after little more than a month of growth. It can be used in rotation between primary crop plantings in both irrigated and dry land fields (Rutherford, 2009). Although it is well known that green manure plants are used worldwide as a source of organic fertilizer (green manure), they have not been fully utilized by farmers, particularly resource-poor farmers. Therefore, this study was conducted to evaluate the effect of green manuring and inorganic fertilization on yield and yield components of subsequent crops

Materials and Methods

Description of Experimental Site: The experiment was carried out at low land areas of north Shewa of Kewet district, Yelene farmers' training center (FTC) irrigation scheme in the 2017/18-2018/19 main and irrigation cropping seasons. The study site, Kewet, is located about 225 km from Addis Abeba in the north east direction, at an altitude of 1252 m.a.s.l and at 09^0 9' to 10^0 03'N latitude and 40^0 02' to 38^0 9'E longitude. The average annual rainfall is 760.2 mm and the mean maximum and minimum temperatures are 31.5 and 14.5^oC, respectively. The rainfall distribution across months and main crop growing seasons during the two experimental years was indicated below in Figure 1.

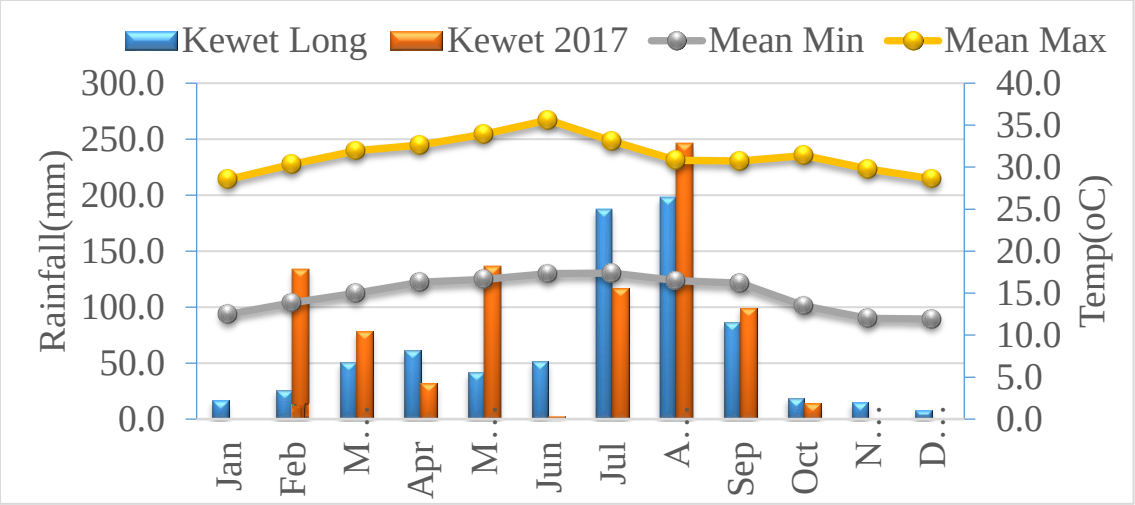

Figure 1. Rainfall distribution across months in the three experimental seasons

Experimental Design and Procedures: The experiment was conducted with two factors of split plot with three replications. It consisted of two green manure species and control as main plot and three rates of NP (0, 50% and 100% recommended dose). Plant species used for green manure were Crotalaria juncea and Tophrosia vogelli. The land was divided in to three blocks. Each block also was divided in to three main plots, and then each of the main plots were further divided in to 3 subplots with a size of 2.6m by 3m. The size of each main plot was 11m by 3m. The distance between the main plots and subplots were 1.5m and 1m respectively. Seed of green manure was drilled to a depth of 1cm between rows of sorghum in the rainy season as an inter crop at flowering plants were chopped and incorporated into the soil. On fresh and dry weight basis 5.93 and 1.48 tha^{-1} of crotalaria juncea green manure was incorporated but biomass of Tophrosia green manure was low to estimate its amount due to poor performance (Table 2). After harvesting of main season sorghum at December 1, 2017 the land was prepared and onion seedlings were transplanted on January 4, 2017. Recommended fertilizer 242 and 100 $Kgha^{-1}$ NPS and urea was applied. Then, before 20 days of harvesting of first irrigation crop green manure crops were drilled for second time as cover crops with irrigation (short fallow between 1st and 2nd irrigation-for about 8 weeks period) and was incorporated before the second irrigation). In the beginning of April 2018 yield data of onion such as marketable and unmarketable were collected. The general performance of both green manure species were not well established as compared to the first (main) season incorporated but already existed biomass was chopped and incorporated and irrigated.

After one month at the beginning of May 2018 the land was prepared and mung bean was sown at the rate of 40 $Kgha^{-1}$ of seed rate with 121 Kg of NPS fertilizer as full recommendation of NP (100%), half of the recommended NP (50%) and 0% (no fertilizer). During the growing season of mung bean there was excess rainfall that determined the dry matter production of mung bean especially the development of pods that contribute for yield production. Harvesting of mung bean with data of plant height and straw yield was done on first July of 2018. Land was prepared on October 2018 and onion seedlings was transplanted on November first and harvested on mid-January of 2019 for last time.

To measure soil pH, Av. P, OC, TN, Av. K, and texture, soil samples were taken before to the experiment's commencement and following harvesting from each experimental treatment. Following Van Reeuwijk's (1992) instructions, the pH of the soil was measured in H_2O (pH-H_2O) using a pH meter and a 1:2.5 soil to solution ratio. the organic content of the soil, which was examined using Walkley and Black's methodology (1934). Jackson (1958) introduced the modified Kjeldahl approach that was used to determine the total Nitrogen (TN) content of soils. The Olsen extraction method was used to extract the available Phosphorus from soil samples (Olsen *et al.*, 1954). Using a spectrophotometer, the extract's P content was determined in accordance with Murphy's (1968) method.

Data Analysis: Collected data of onion and mung bean were analyzed using LSD at 0.05% of probability.

Partial Budget Analysis: A partial budget analysis using marginal rate of return and dominance was performed (CIMMYT, 1988). The average market price for onions and mung beans over the course of two consecutive years was used to calculate the output's economic worth. The labor force and average input cost applied to the inorganic and green manure fertilizers are utilized to determine the economic advantage of integrated fertilizer use.

Results and Discussion

Soil Chemical Properties: The proportions of sand, clay and silt were 68, 20 and 12 and its textural class was clay (Table 1). The pH value of the soils of the study site was alkaline. Percent soil organic carbon content was below critical level and available Potassium was medium to very high level (Table 1). Organic carbon content of the soil after green manure incorporation was found well improved. Ghoous *et al.,* (2018) reported that soil organic carbon increased proportionaly to the added organic matter.

There were statistically significant variations in the available Phosphorus content when the effects of green manure species were examined using analysis of variance. The findings are displayed in Table 1, with the mean available Phosphorus concentration for each treatment of green manure. Tephrosia had the greatest mean accessible Phosphorus value of 20.76 ppm, whereas crotolaria had the lowest mean available Phosphorus content of 17.89 ppm. By comparison, the lowest mean accessible Phosphorus level of 16.19 ppm was obtained with the treatment of none green manure. Numerous variables, including as soil fertility, nutrient availability, and the application of green manure, affect Tephrosia's growth rate and biomass output. Leguminous plants like tephrosia are frequently grown as green manure crops to increase soil fertility and fix Nitrogen. However, in comparison to other green manure crops like crotalaria, its growth rate and biomass output can be lower. The availability of Phosphorus in the soil has been found to be one factor influencing Tephrosia's low and slow development rate (Vanlauwe *et al.,* 2014).

Table 1. Selected physical and chemical properties of the experimental soil before planting and after harvesting

Before planting	pH (1:2.5)	OC (%)	TN (%)	Av. P (ppm)	Exch. K ($cmolKg^{-1}$)	Clay	Silt	Sand	Textural Class
	7.74	1.44	0.11	13.01	2.35	68	20	12	Clay
After harvesting									
Crotalaria juncea	7.75	1.57	0.129	17.89					
Tephrosia	7.70	1.53	0.124	20.76					
Sole	7.79	1.50	0.123	16.19					

Effects of Intercropping Green Manure on the Growth and Yield Components of Sorghum

The grain yield of sorghum was not significantly affected by intercropping and averaged 6002 $Kgha^{-1}$ in crotalaria, 6802 $Kgha^{-1}$ in tephrosia, and 5424 $Kgha^{-1}$ in sole was obtained. Plant height and thousands kernel weight of sorghum was also not significantly affected by intercropping, and averaged plant height and thousands kernel weight of sorghum were 250.7 cm and 25.4 g in crotalaria juncea, 254.5 cm and 26.2 g in tephrosia vogeli and 260.8 cm and 26.3 gm in sole green manuring intercropping respectively (Table 2)

Table 2. Mean response of Sorghum growth and yield parameters for intercropping of green manure at Kewet District, 2017/18

Treatment	Fresh/Dry biomass green manure (tha^{-1})	PH (cm)	Grain Yield ($Kgha^{-1}$)	TKW (g)
1.Crotalaria juncea	5.93 (1.48)	250.67	6002.2	25.43
2.Tephrosia	-	254.50	6802.2	26.18
3.Sole	-	260.77	5424.2	26.28
CV (%)		4.30	13.45	11.65
LSD (0.05)		ns	ns	ns

The results showed that, at first irrigation 2017/18 after incorporation of green manure marketable yield of onion was affected significantly ($p<0.05$) by different fertilizer dose of fertilizer and green manure application. As the dose of recommended fertilizer increases the marketable yield of onion was also increased and the highest marketable yield (42.2 tha^{-1}) was obtained by the application of full recommended dose of fertilizer and crotalaria green manure incorporation followed by full dose of fertilizer application with sole green manure incorporation (39.4 tha^{-1}). This result is consistent with the results of research conducted by Sukartono *et al.,* (2011) who report the increase in the levels of organic carbon and Nitrogen with organic fertilizer application.

Table 3. Mean response of onion and mug bean growth and yield component for application of green manure and inorganic fertilization on different Irrigation season at Kewet district, 2018

Green Manure	2017/18 Marketable onion (tha^{-1})			2018 Mung bean ($Kgha^{-1}$)			2018/19 Marketable onion yield (tha^{-1})		
	0%RF	50%RF	100%RF	0%RF	50%RF	100%RF	0%RF	50%RF	100%RF
Crotalaria	25.0^{bc}	36.0^{bb}	42.2^{aa}	586.3^{ab}	380.5^{cd}	302.6^{d}	15.6^{c}	31.3^{a}	30.7^{a}
Tephrosia	19.3^{c}	26.1^{bc}	35.0^{ab}	472.5^{bcd}	508.7^{bc}	509.2^{bc}	18.3^{bc}	26.5^{ab}	34.2^{a}
Control	20.9^{c}	33.2^{aba}	39.4^{a}	551.6^{abc}	724.3^{a}	571.0^{abc}	15.8^{c}	29.2^{a}	30.4^{a}
CV (%)	20.9			21.7			19.4		
LSD (5%)	11.15			220.6			8.51		

Table 4. Mean response of onion marketable yield for application of green manure and inorganic fertilization on irrigation season at Kewet district, 2018

GreenManure	Marketable onion		
	0%RF	50%RF	100%RF
Crotalaria	20.3^{cd}	33.7^{a}	36.4^{a}
Tephrosia	18.8^{d}	26.3^{bc}	34.6^{a}
Sole	18.3^{d}	31.2^{ab}	34.9^{a}
CV (%)	20.4		
LSD (5%)	6.7		

Economic Analysis: The partial budget analysis data of the various treatments is presented in Table 5. The highest net benefit (70,761 ETB) with marginal rate of return (MM) of 912.4% was obtained from only half dose of recommended inorganic fertilizer utilization, while the next higher net benefit (70,493 ETB) with MMR of 340% was obtained from dose of recommended inorganic fertilizer utilization treatment only. But as integrated soil fertility management perspective using green manure in the farming system is incomparable with sole utilization of inorganic fertilizer but using integration of both nutrients sources is indispensable. From this study 50% recommended fertilizer with crotalaria juncea as green manure material is advantageous with the benefit of sustainable production system.

Table 5 Partial budget analysis

Treatment	TVC	[redacted]	NB	MRR%
Tephrosia + 0%	1200			

ARARI 2/MCID 3/TJETOO EMC q294.17 678.1 86.424 20.64 re52 nBT/F1 12 Tf1 0 0 1 262.97 666.46 Tm0 G65 698.8TJET

References

1. Abedin, M. Z. and Mukhopadhaya D. 1990. Cropping system-based fertilizer recommendation and soil fertility investigation in farmer's field, OFRD. Food and Agriculture Organization of the United Nations, Dhaka, pp. 30-33.
2. *Akter, M.S., M.K.S. Hasan, R.C. Adhikery, M.K Chowdhury. 1993. Integrated management of Sesbania rostrata and urea-Nitrogen in rice under a rice-rice cropping system. Ann. Bangladesh Agric. 3 (2): 189-114.*
3. Anteneh Abewa1, Birhanu Agumas1, Tesfaye Feyisa, Tadele Amare1 and Tamiru Dagnachew .2012. Effect of Green Manuring Plants on Yield. In Tesfaye Feyisa and Menelik Getaneh (Eds.). 2014. Proceedings of the 6th Annual Regional Conference on Completed Research Activities on Soil and Water Management, 25 – 27, January 2012 & Teshome Tesema, Abrham Abiyu, Belayeneh ayele, Beyen Belay (eds.). 2014. Proceedings of the 6th Annual Regional Conference on forestry Completed Research Activities, 25 – 27, January 2012, Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia. PP21-31.
4. Asnakew Woldeab, 1994. Soil fertility and management in the dry lands. Pp.70-81. In: Reddy, M.S. and Kidane G. (eds.). Development of Technologies for the Dry land Farming Areas of Ethiopia. Proceeding of the First National Workshop on Dryland Farming Research in Ethiopia, 26
5. *ATA (Agricultural Transformation Agency).2016. Soil Fertility Status and Fertilizer Recommendation Atlas of Amhara National Regional State, Ethiopia August 2016. Pp154-155*
6. *Debnath, et al., 2014. An Effect of fertilizer management practices on the yield of T. a man rice under tidal ecosystem. American Journal of Agriculture and Forestry 1(4): 74-79.*
7. Ghous Ali, Ch. Pulla Rao, A.S. Rao and Ashoka Rani, Y. 2018. Effect of in-situ Incorporation Green Manures on Soil Organic Carbon, pH, Bulk Density and Economics Involved in Its Incorporation. Int.J.Curr.Microbiol.App.Sci. 7(09): 62-67. doi: https://doi.org/10.20546/ijcmas.2018.709.008

8. Hailu Gebrekidane, 1988. Sustaining crop production in the semi-arid areas of Ethiopia. Ethiopian J. Agric. Sci.

9. IFPRI (International Food Policy Research Institute) (2010) Report on Fertilizer and Soil Fertility Potential in Ethiopia: Constraints and opportunities for enhancing the system.

10. Jackson, M.L. 1958. Soil chemical analysis. Prentice Hall, Inc., Englewood Cliffs. N.J. Sixth Printing 1970. 498pp.

11. Jaja, E.T.and Ibeawuch 2015.Effect of Organic and Inorganic Manure Mixture Rates on the Productivity of Okra. Int'l Journal of Agric. and Rural Dev. Volume 18 (1): 2085-2091

12. Olsen, S.R., Cole, V., Watanabe, F.S. and Dean, L.A. 1954. Estimations of available Phosphorus in soils by extractions with sodium bicarbonate. U.S. Dept. Of Agric. Cric.939, USDA, Washington, DC

13. Sanchez, P.A. & Jama, B.A. 2002. Soil fertility replenishment takes off in East and southern Africa. In: Integrated nutrient management in sub-saharan Africa: from concept to practice (Eds B. Vanlauwe, N. Diels, N. Sanginga & R. Merkx), pp. 26–43. CAB International, Wallingford, UK.

14. Sukartono, Utomo, W.H., Kusuma, Z., Nugroho, W.H., 2011. Soil fertility status, nutrient uptake, and maize (Zea mays L.) yield following biochar and cattle manure application on sandy soil of Lombok, Indonesia. J. of Tropical Agriculture 49(1-2), 47-52.

15. Van der Velde M, Folberth C, Balkovic J, Ciais P, Fritz S, Janssens IA, Obersteiner M, See L, Skalsky R, Xiong W, Peñuelas J. African crop yield reductions due to increasingly unbalanced Nitrogen to Phosphorus consumption. Glob Change Biol. 2014; 20:1278–88.

16. Vanlauwe, B., Descheemaeker, K., Giller, K.E., & Merckx, R. (2014). Integrated soil fertility management: Operational definition and consequences for implementation and dissemination. Outlook on Agriculture, 43(3), 165-172. (Web)

17. Walkley, A.J. and Black, I.A. 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 37: 29-38.