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Determination of appropriate fertilizer rate for forage and seed yields of fodder beet (*Beta vulgaris*) in the central highland areas of Ethiopia

Gezahagn Kebede[1]*, Getnet Assefa[2], Fekede Feyissa[1], Alemayehu Mengistu[3], Muluneh Minta[1] and Tadesse Tekletsadik[1]

[1]Holetta Agricultural Research Center, P. O. Box 31, Holetta, Ethiopia
[2]Ethiopian Institute of Agricultural Research, P.O. Box 2003, Addis Ababa, Ethiopia
[3]Forage and Rangeland Scientist, Urael Branch, P.O. Box 62291, Addis Ababa, Ethiopia
*Corresponding author: gezk2007@yahoo.co.uk

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The study was conducted to determine the optimum level of chemical and farm yard manure fertilizer mixture for fodder beet (*Beta vulgaris)* production in the central highlands of Ethiopia. The experiment was designed in a factorial arrangement of four chemical fertilizer rates (0, 5/13, 10/23, 15/33, kg N/P_2O_5 ha^{-1}) and four farm yard manure fertilizer rates (0, 3, 6 and 9 t ha^{-1} in dry matter basis) in a randomized complete block design with three replications. The result showed that the interaction between inorganic and organic fertilizers application levels had significant ($P<0.05$) effect for all measured agronomic traits at Meraro. The establishment performance of fodder beet was very poor both at Holetta and Jeldu using direct seeding method of planting in the first year of production. But, using seedlings raised at nursery as a planting material at Holetta and Jeldu improved the plant survival rate by 52% and 49% respectively. Unlike at Holetta and Jeldu, establishment performances of fodder beet at Meraro using seeds as a direct planting material was promising and found to be an appropriate establishment method. The result showed that application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers as a mixture gave the highest plant survival rate (81.9%), plant height (30.3 cm), leaf DM yield (2.7 t ha^{-1}), tuber DM yield (10.3 t ha^{-1}) and total DM yield (13.0 t ha^{-1}) while the lowest values of the above traits were recorded from the control treatment. Application of fertilizers mixture at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} increased the survival rate, plant height, leaf DM yield, tuber DM yield and total DM yield by 34, 57, 286, 296 and 294% over the control treatment. But, the highest seed yield (3.0 qt ha^{-1}) was obtained by applying the highest level of fertilizer mixture (15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1}) which gave 900% seed yield advantage over the control treatment. Therefore, applying 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} and 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizer mixture were found to be the optimum fertilizers mixture rate for forage and seed yields of fodder beet. Therefore, this preliminary result recommends using FYM alongside with mineral fertilizers to increase forage and seed yields of fodder beet. However, further experimental research works should be carried out for more seasons and locations to verify this research findings.

Keywords: fertilizer rate, fodder beet, forage yield, inorganic fertilizer, organic fertilizer, seed yield

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INTRODUCTION

Fodder beet (*Beta vulgaris*) is a productive and well adapted biennial root crop for livestock feed in the highlands of Ethiopia. It needs a long growing season, 6-7 months and grows best in a cool wet climate like that found between 2000-3000 masl and if plants are not harvested, they will flower and set seed in their second years of planting and the roots decrease in size. When seed of fodder beet is ready for harvest, stripping is used for seed collection. But, seed production is best at an altitude of 2500-2700 masl on fertile and well drained soils. It can produce 8-12 t ha^{-1} DM yield (root and leaf DM combined) and must be chopped up before use as a fed for cattle. It is a dry season feed that could help to overcome feed shortage during the critical periods and this in return has a national benefit in having sustainable production throughout the year. It is highly palatable, nutritious and can produce large amount of digestible dry matter per unit area. Because of the high energy content, the roots have a potential as an energy supplement to roughage based diets but roots are low in protein with crude protein values of 6% whereas the tops are modest in energy levels and reasonably high in crude protein compared with the root. The result obtained by Gavornskii (1982) with lactating cattle indicated that for cows with annual milk yield of 3000-3500 kg of milk, 8-10 kg of fodder beet could replace a kilogram of concentrate in the diet. Fresh fodder beet at the rate of 8 kg per kg of concentrate can replace half or three quarters of the concentrate ration of milking cows with no significant reduction in milk yield, milk fat and protein percentages (Seyoum et al., 1989). Considering the high cost of concentrate and its unavailability, 50% replacement of concentrate by fodder beet could be beneficial to the small scale or state dairy farms (Seyoum et al., 1989).

Use of chemical fertilizers to address the declining soil fertility remains minimal due to farmer's low income which limits their ability to purchase fertilizers. According to Heisey and Mwangi (1996), high cost of fertilizer, lack of credit, delays in delivery of fertilizer due to poor transport and marketing infrastructure, and lack of know how about their usage have individually or jointly constrained fertilizer optimal use. Farm Yard Manure (FYM) improves soil physical, chemical and biological properties, and thereby helps in making soils highly productive and sustainable (Ahmad et al., 2006; Naeem et al., 2009). FYM not only increases the beneficial activities of microorganisms but also reduces nitrogen (N) losses by increasing Cation Exchange Capacity (CEC) of the soil and improves soil structure by adding organic matter, and also minimize phosphorus (P) and Potassium (K) fixation in all types of soil (Gill et al., 1998). Integrated Soil Fertility Management (ISFM) options for increasing soil fertility and agronomic efficiency of applied inputs have been recommended by several researchers (Sanginga and Woomer, 2009; Vanlauwe et al., 2010). The ISFM practices comprise the use of inorganic and organic fertilizers in an integrated manner in order to maximize their soil productivity, crop yields, and human health through efficient utilization of plant nutrients. Advantages of using organic and inorganic fertilizers in a synergetic fashion are numerous and scientifically well established. Research results indicated that crop yields are improved if organic manure is supplemented with mineral fertilizers (Kanchikerimath and Singh, 2001). Ahmad et al., (2002) observed that root length and nutrient uptake of wheat increased significantly by combining organic and N fertilizer, which ultimately enhanced grain and straw yields. So, it is crucial to use both types of nutrient sources synergistically for overcoming the problem of soil fertility, escalating price of chemical fertilizers and environmental pollution. This experiment was therefore designed to determine suitable optimum level of chemical and FYM fertilizer mixture for fodder beet, to evaluate the effect of different mixed fertilizer rates on forage and seed yields of fodder beet, and to evaluate the possibility of cultivation and yielding potential of fodder beet for forage and seed yields in the central highlands of Ethiopia.

MATERIALS AND METHODS

Description of the study sites

The studies were conducted at Holetta Agricultural Research center and Meraro the sub-center of Kulumsa research center. Holetta is located at 9°00'N latitude, 38°30'E longitude at an altitude of 2400 masl. It is 34 km west of Addis Ababa on the road to Ambo and is characterized with the long term average annual rainfall of 1055 mm, average relative humidity of 60.6% and average maximum and minimum air temperatures of 22.2 °C and 6.1 °C respectively. The rainfall is bimodal and about 70% of the precipitation falls in the period from June to September while the remaining 30% falls in the period from March to May. The soil type of the area is predominantly red nitosol, which is characterized by an average organic matter content of 1.8%, total nitrogen 0.17%, pH 5.24 and available phosphorus 4.55 ppm (Gemechu, 2007). Meraro sub center is located at 187 km far from Addis Ababa and located in the Arsi Zone of the Oromiya Region to the south of Bekoji. It has a latitude and longitude of 7°41′N and 39°25′E respectively with an elevation of 3,030 masl. The average annual rainfall, the average maximum and minimum air temperature of the area is 1196 mm, 18.1 °C and 5.7 °C respectively and the site is generally characterized as high frost prone area. The soil type of the area is red nitosol which has a pH of 5.01.

Experimental design and treatments

A clean and well prepared seed bed was used for fodder beet establishment. Seeds of fodder beet variety obtained from Kulumsa research center was KF-31 and planted at Holetta and Kulumsa in a factorial RCBD arrangement with three replications. Based on experimental design, each treatment combination was assigned randomly to the experimental units within a block. A 4 x 4 factorial arrangement of two factors, namely inorganic fertilizer and FYM, each with four levels was employed to analyze the yield and yield components of fodder beet. Four inorganic fertilizer and FYM levels used as a treatments were 0, 5/13, 10/23, 15/33, kg N/P_2O_5 ha^{-1} and 0, 3, 6 and 9 t ha^{-1} respectively (Table 1).

The fresh samples of FYM were taken and oven dried at 65 ^{o}C for 72 hours for moisture content determination. The FYM was weighed and applied on dry matter basis after moisture content was determined. The plots which received FYM was applied 20 days before sowing and mixed thoroughly in the upper 15-20 cm soil depth but inorganic fertilizer was applied at planting. Seeds were planted in June at 2 cm sowing depth in the first year and seedlings were transplanted from nurseries 2- 3 months after planting in the second year at Holetta. At Meraro, direct seeding was applied to establish fodder beet in both years. The spacing used was 40 cm between rows and 25 cm between plants in both establishment methods on a plot size of 2.4 m x 1.75 m, which consisted of 6 rows. The first hand weeding was made after 30 days of crop emergence and the second weeding was done 30 days after the first weeding. Measurements on establishment performance, plant height, leaf DM yield, tuber DM yield and seed yield were taken from the interior four rows for analysis.

Statistical Analysis

The two factors each with four fertilizer levels were used to analyze the plant survival rate, plant height, leaf yield, tuber yield, total forage yield and seed yield of fodder beet at Meraro. The data were subjected to analysis of variance (ANOVA) procedures of SAS general linear model (GLM) to compare treatment means (SAS, 2002). Least square means at 5% significance level was used for comparison of means. The statistical model employed for the analysis of data was:

$$\mathbf{Y_{ijk} = \mu + I_i + O_j + (IO)_{ij} + B_k + e_{ijk}}$$

Where, Y_{ijk} = the response variable, µ = overall mean, I_i = the effect of i^{th} inorganic fertilizer levels, O_j = the effect of j^{th} organic fertilizers levels, IO_{ij} = the interaction effect of i^{th} inorganic fertilizer and j^{th} organic fertilizer levels, B_k = the effect of k^{th} block, and e_{ijk} = random error.

RESULTS AND DISCUSSION

Establishment performance

Study on establishment performance is an important consideration during forage crop cultivation due to substantial effect on forage productivity. Establishment performance of fodder beet has been found to be very poor both at Holetta and Jeldu using direct seeding method of planting in the first year of production. At Jeldu, some seedlings were emerged in early days but all the seedlings died in the latter stage of growth. Even though all the seedlings not died, the survival rate at Holetta was also very low (31%) using direct method of planting. As a result, seedlings were raised at nursery and used as a planting material at Holetta and Jeldu for the second year of planting to improve establishment and growth performances of the crop. At Holetta, this system improved establishment performance and the survival rate was 52% and generally the percent increment in fodder beet survival rate was 68% using this system of planting method (Figure 1). At Jeldu, complete failure of the crop using seeds as a direct planting material was improved by 49% survival rate using the raised seedlings as a planting material. Unlike Holetta and Jeldu, establishment and growth performances of fodder beet at Meraro (Arsi) using seeds as a direct planting material was an appropriate system. Data collected from Holetta and Jeldu locations were not used for analysis because a lot of plots were missed due to unfavorable environmental condition during experimental period. So, most data presented in this study were collected from Meraro (Arsi) site, however, survival rate collected from all testing sites. Generally, application of inorganic and FYM fertilizers mixture improved the survival rate of the seedlings at all locations.

The interaction between inorganic and organic fertilizers application was found to be significant ($P<0.05$) for survival rate of fodder beet at Meraro (Table 2). The result showed that application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture gave the highest (81.9%) fodder beet survival rate followed by application of 5/10 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture which gave 77.5% plant survival rate. On the other hand, the lowest plant survival rate (61.2%) was recorded from the control treatment. Generally, application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture improved plant survival rate by 33.8 % when compared to the control treatment. According to Roy et al., (2001), application of 30 t FYM ha^{-1} + 270 kg N ha^{-1} chemical fertilizers to potatoes produced statistically significant and positive cumulative effects. As described by Pal (2004), seed size, sowing depth, land preparation, and environment influences the emergence of seedlings. According to Fekede (2004), high germination rate, vigorous growth and dense establishment are among the

Table 1: Inorganic fertilizer and farm yard manure levels used as a treatment for the experiment

No	Treatment combination	Inorganic fertilizer level N/P_2O_5 (kg ha^{-1})	Farm yard manure level (t ha^{-1})
1	1A	0	0
2	1B	0	3
3	1C	0	6
4	1D	0	9
5	2A	5/13	0
6	2B	5/13	3
7	2C	5/13	6
8	2D	5/13	9
9	3A	10/23	0
10	3B	10/23	3
11	3C	10/23	6
12	3D	10/23	9
13	4A	15/33	0
14	4B	15/33	3
15	4C	15/33	6
16	4D	15/33	9

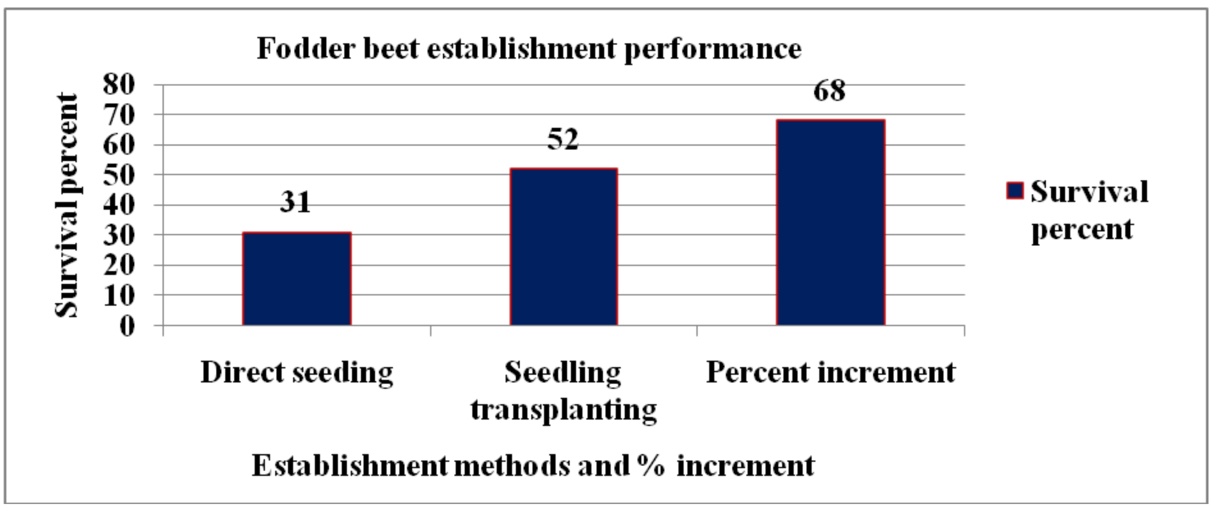

Figure 1: Mean survival rate (%) of fodder beet in response to different establishment methods using chemical and FYM fertilizer combinations

desired characteristics for forage crop. The present study indicated that, application of inorganic and FYM fertilizers mixture is very crucial to improve the establishment performance of fodder beet.

Plant height

Plant height is one of the important agronomic traits which affects the production and productivity of all forage crops. It is mainly affected by variation in genetic, soil fertility, climate and all agronomic managements. The interaction between inorganic and organic fertilizers mixture application on plant height of fodder beet was significantly ($P<0.05$) different at forage harvesting stage at Meraro (Table 3). The result indicated that application of fertilizers mixture at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} gave the highest (30.3 cm) plant height followed by application of 5/10 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1}fertilizers mixture which produced 29.2 cm plant height. While in case of control treatment (no fertilizer), minimum plant height of 19.3 cm was recorded. Application of fertilizers mixture at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} which produced the highest

Table 2: Least square means with standard errors of fodder beet survival rate (%) in the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	$61.2\underline{+}1.6^{g}$	$64.8\underline{+}1.6^{fg}$	$67.0\underline{+}1.6^{ef}$	$70.7\underline{+}1.6^{cde}$
5/ 10	$63.0\underline{+}1.6^{g}$	$72.9\underline{+}1.6^{cd}$	$74.9\underline{+}1.6^{bc}$	$77.5\underline{+}1.6^{ab}$
10/23	$67.7\underline{+}1.6^{ef}$	$74.0\underline{+}1.6^{bcd}$	$77.0\underline{+}1.6^{b}$	$81.9\underline{+}1.6^{a}$
15/33	$69.6\underline{+}1.6^{de}$	$75.5\underline{+}1.6^{bc}$	$75.2\underline{+}1.6^{bc}$	$72.6\underline{+}1.6^{cd}$

$^{a-g}$ Means within a column and row followed by different superscript letters vary significantly (P<0.05)

Table 3: Least square means with standard errors of fodder beet plant height (cm) in the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	$19.3\underline{+}0.9^{f}$	$22.7\underline{+}0.9^{e}$	$25.3\underline{+}0.9^{cd}$	$28.5\underline{+}0.9^{ab}$
5/ 10	$21.4\underline{+}0.9^{ef}$	$25.8\underline{+}0.9^{bcd}$	$26.2\underline{+}0.9^{bcd}$	$29.2\underline{+}0.9^{a}$
10/23	$23.9\underline{+}0.9^{de}$	$26.5\underline{+}0.9^{bcd}$	$27.2\underline{+}0.9^{bc}$	$30.3\underline{+}0.9^{a}$
15/33	$25.9\underline{+}0.9^{bcd}$	$26.9\underline{+}0.9^{bc}$	$27.6\underline{+}0.9^{bc}$	$26.1\underline{+}0.9^{cd}$

$^{a-f}$ Means within a column and row followed by different superscript letters vary significantly (P<0.05)

plant height showed 57% increment in plant height over the control treatment. This indicates that application of inorganic and organic fertilizers mixture has a remarkable contribution on growth and development of fodder beet. In general, application of fertilizers mixture at a rate of 5/10 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} and 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} increased plant height by 13 and 17% respectively over the highest sole 15/33 kg N/P_2O_5 ha^{-1}fertilizer application. Khan and Joergensen, (2009) reported that application of 20 t FYM ha^{-1} + 60 kg N ha^{-1} increased plant height, 1000 grain weight, leaf area index and yield of maize over sole 120 kg N ha^{-1}. According to Delden (2001), plant height can be improved using organic and inorganic fertilizer combinations. Zada et al., (2000) also reported that plant height increases with the increase in FYM and nitrogen doses. Ahmad et al., (2002) observed that plant height and leaf area of wheat significantly increased by combining organic and inorganic N fertilizers. Manure is a source of nutrients, which are released through mineralization, thus supplying the necessarily elements for plant growth (Chiezey and Odunze, 2009), and when combined with inorganic fertilizers it increased nutrient supply which enhanced vegetative growth, affecting plant height and yields (Umoetok et al., 2007).

Leaf dry matter yield

The above ground biomass yield of fodder beet has substantial contribution for livestock feed in different parts of the world. The leafiness of any forage crop varies from place to place due to soil fertility status, climatic conditions and agronomic managements. Leaf dry matter (DM) yield of fodder beet was significantly (P<0.05) affected by the interaction of inorganic and organic fertilizers mixture application after six months of planting (forage harvesting stage) at Meraro (Table 4). The result showed that the highest leaf DM yield (2.7 t ha^{-1}) was obtained by applying 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture followed by 15/33 kg N/P_2O_5 ha^{-1} + 6 t FYM ha^{-1} fertilizers mixture which produced 2.4 t ha^{-1} leaf DM yield. The control treatment gave the lowest (0.7 t ha^{-1}) leaf DM yield. Application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t

Table 4: Least square means with standard errors of fodder beet leaf DM yield (t ha^{-1}) in the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	0.7 ± 0.2^{h}	0.8 ± 0.2^{gh}	1.3 ± 0.2^{efg}	1.6 ± 0.2^{def}
5/ 10	1.1 ± 0.2^{fgh}	1.3 ± 0.2^{efg}	1.5 ± 0.2^{def}	1.7 ± 0.2^{de}
10/23	1.2 ± 0.2^{fgh}	1.8 ± 0.2^{cde}	2.1 ± 0.2^{bc}	2.7 ± 0.2^{a}
15/33	1.7 ± 0.2^{de}	1.9 ± 0.2^{cd}	2.4 ± 0.2^{b}	1.8 ± 0.2^{cde}

$^{a-h}$ Means within a column and row followed by different superscript letters vary significantly (P<0.05)

Table 5: Least square means with standard errors of fodder beet tuber DM yield (t ha^{-1}) of the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	2.6 ± 0.4^{i}	5.8 ± 0.4^{g}	7.0 ± 0.4^{ef}	8.6 ± 0.4^{bcd}
5/ 10	3.7 ± 0.4^{h}	6.5 ± 0.4^{fg}	8.7 ± 0.4^{bcd}	9.0 ± 0.4^{bc}
10/23	5.4 ± 0.4^{g}	7.7 ± 0.4^{de}	9.4 ± 0.4^{ab}	10.3 ± 0.4^{a}
15/33	6.0 ± 0.4^{fg}	8.6 ± 0.4^{bcd}	9.9 ± 0.4^{ab}	7.7 ± 0.4^{de}

$^{a-i}$ Means within a column and row followed by different superscript letters vary significantly (P<0.05)

FYM ha^{-1} fertilizers mixture improved leaf DM yield by 59% over the highest sole 15/33 kg N/P_2O_5 ha^{-1} inorganic fertilizer application. Fertilizers mixture applied at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} gave 286% leaf DM yield advantage over the control treatment. According to Bokhtiar and Sakurai (2005), application of organic manure in combination with chemical fertilizer has been reported to increase absorption of N, P and K in sugarcane leaf tissue in the plant and ratoon crop, compared to chemical fertilizer alone. The NPK contents in maize leaves and grains were improved with the combined use of organic and chemical fertilizers (Sial et al., 2007). Palm (1995) also obtained significant increase in crop yields when a combination of organic and mineral fertilizers was applied compared with sole application of organic or mineral fertilizer. Synergistic use of organic and inorganic nutrient sources exhibits multiple effects, and synchronizes nutrient release and absorption by the plants (Palm et al., 1997). Sutanto et al., (1993) in their studies on acid soils for sustainable food crop production noted that farmyard manure and mineral fertilizer produced excellent responses. Generally, fertilizer is one of the most important inputs contributing to crop production because it increases productivity and improves yield quantity and quality.

Tuber dry matter yield

Tuber DM yield of fodder beet was also respond differently (P<0.05) for the interaction of inorganic and organic fertilizers mixture application after six months of planting (forage harvesting stage) at Meraro (Table 5). Application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture produced the highest tuber DM yield (10.3 t ha^{-1}) while the lowest (2.6 t ha^{-1}) tuber DM yield was recorded from the control treatment. Application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture gave 296 and 72% tuber DM yield advantage over the control treatment and application of the highest sole (15/33 kg N/P_2O_5 ha^{-1}) inorganic fertilizer level respectively. This indicates that application of inorganic and organic fertilizers mixture has a tremendous contribution on tuber yield of fodder beet. Application of different sole FYM fertilizer rates gave about 42% mean tuber yield advantage over the different sole inorganic

Table 6: Least square means with standard errors of fodder beet total (Tuber and leaf) DM yield (t ha^{-1}) in the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	3.3 ± 0.4^{g}	6.6 ± 0.4^{e}	8.3 ± 0.4^{d}	10.2 ± 0.4^{c}
5/ 10	4.8 ± 0.4^{f}	7.8 ± 0.4^{d}	10.2 ± 0.4^{c}	10.7 ± 0.4^{bc}
10/23	6.6 ± 0.4^{e}	9.5 ± 0.4^{c}	11.5 ± 0.4^{b}	13.0 ± 0.4^{a}
15/33	7.7 ± 0.4^{de}	10.4 ± 0.4^{bc}	12.3 ± 0.4^{a}	9.5 ± 0.4^{c}

[a-g] Means within a column and row followed by different superscript letters vary significantly (P<0.05)

fertilizer levels. Because manure is an excellent source of major plant nutrients such as N, P, K and also provides many of the secondary nutrients that plants require. However, the actual nutrient value of manure from a particular operation will differ considerably due to the type of animals, its food ration, manure collection, storage, application procedures, and climate (Risse et al., 2008). Manure effect on soil physical properties include increased infiltration (Risse et al., 2008), water holding capacity (Liang et al., 2011) and reduced compaction and soil erosion (Salahin et al., 2011). Moreover, the high yields observed under manure application may be as a result of its ability for improving soil biological and physical properties which increase soil water retention and enhance nutrient uptake (Nwachukwu and Lkeadigh, 2012). Ahmad et al., (2002) observed that root length and nutrient uptake of wheat increased significantly by combining organic manure and chemical fertilizer, which ultimately enhanced grain and straw yields. Similarly, an increase from 83.9 to 108.7% in yield of maize grain was recorded with the integration of organic and inorganic fertilizers (Sial et al., 2007). Hati et al., (2006) observed that using 10 t FYM + NPK in soybean for three years improved the seed yield (103%), water use efficiency (76%) and root length density (70.5%) as compared to control. According to Negassa et al., (2001), low rate of NP fertilizer integrated with 5 t ha^{-1} organic manure is the most economical practice for maize production. Other studies indicated that, application of chemical fertilizer + 15 t FYM ha^{-1} to sugarcane produced the highest leaf area index, chlorophyll content, cane yield and sugar content (Bokhtiar and Sakurai, 2005).

Total dry matter forage yield

The response of total (leaf and tuber) DM yield of fodder beet also affected by the different fertilizer rates as well as fertilizer types. The interaction between the two fertilizer types each with four rates was significantly (P<0.05) different for total DM yield of fodder beet at Meraro (Table 6). The highest total DM yield (13 t ha^{-1}) was obtained from application of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture while the control treatment produced the lowest (3.3 t ha^{-1}) total DM yield. The result indicated that application of fertilizers mixture at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} gave 294 and 69% total DM yield advantage over the control treatment and the highest sole inorganic fertilizer application rate respectively. Application of both inorganic and FYM fertilizers mixture is very important to improve soil physical, chemical and biological properties. Tuber yield of fodder beet was significantly improved through application of FYM which improves the overall soil conditions. Research results indicated that use of organic sources along with chemical fertilizers improves soil physical conditions, soil microbial biomass and dehydrogenase activity (Bhattacharyya et al., 2008). Prasad and Sinha (2000) found that integrated use of FYM and inorganic fertilizer improved the soil aggregation, porosity and water holding capacity. Application of 5 t FYM ha^{-1} every year significantly improved the soil organic content and total porosity (Rassol et al., 2007). Kanchikerimath and Singh (2001) reported that crop yield; soil organic carbon (C), total N and mineralizable C and N were improved by the addition of organic + chemical fertilizers. Hati et al., (2006) observed that three years application of 10 t FYM ha^{-1} along with recommended NPK to soybean improved the soil organic carbon and reduced its bulk density. Incorporation of FYM in soil increases microbial activity, biomass C and N, mineralization of C and N that improve moisture conservation in the soil (Naeem et al., 2009). Santhy et al., (2001) found that FYM + inorganic fertilizers increased all organic N fractions in soil. Integrated application of inorganic and organic fertilizers

Table 7: Least square means with standard errors of fodder beet seed yield (*qt ha^{-1}) in the interactions of inorganic and organic fertilizers

Inorganic fertilizer levels (N/P_2O_5 kg ha^{-1})	Organic fertilizer levels (farm yard manure t ha^{-1})			
	0	3	6	9
0/0	0.3±0.1[h]	1.3±0.1[fg]	1.9±0.1[de]	2.4±0.1[bc]
5/ 10	0.9±0.1[g]	1.8±0.1[de]	2.5±0.1[bc]	2.7±0.1[ab]
10/23	1.7±0.1[efg]	2.1±0.1[cd]	2.8±0.1[ab]	2.9±0.1[a]
15/33	2.0±0.1[de]	2.3±0.1[c]	2.8±0.1[ab]	3.0±0.1[a]

[a-h] Means within a column and row followed by different superscript letters vary significantly (P<0.05)
*1 qt= 100 kg

was found to be the best in terms of crop yield, nutrient uptake, gross return, net return and benefit cost ratio against their sole application and as farmers' practice. Generally, both the leaf and tuber yields of fodder beet were used as forage for livestock however; the DM yield of the leaf is very low when compared to the tuber yield. The present study also indicated that, 79 % of the forage yield was contributed by tuber yield while the leaf contributed the remaining 21% of the forage yield.

Seed yield

Seed yield is the outcome of collectively contribution of various yield components, which is affected by different growing conditions and crop management practices. Seed yield of fodder beet also significantly (P<0.05) affected by the interaction of inorganic and FYM fertilizers application at Meraro (Table 7). The result showed that the seed yield of fodder beet ranges from 0.3–3.0 qt ha^{-1}. The increase in seed yield continued up to the highest level of the fertilizers mixture (15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1}). Thus, the highest seed yield was attained at the highest rate of the nutrient application. The result indicated that application of 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture gave the highest (3.0 qt ha^{-1}) seed yield followed by application of fertilizers mixture at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} which produced 2.9 qt ha^{-1} seed yield. On the other hand, the lowest seed yield (0.3 qt ha^{-1}) was obtained from the control treatment. Application of different sole FYM fertilizer rates gave 22% mean seed yield advantage over the different sole inorganic fertilizer application rates. Application of the highest (9 t ha^{-1}) sole FYM gave 20% seed yield advantage over the highest (15/33 kg N/P_2O_5 ha^{-1}) sole inorganic fertilizer application rate. Application of fertilizers mixture at a rate of 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} produced 900% seed yield advantage over the control treatment. Chiroma et al., (2006) reported that the improved growth and yield of maize in the FYM combined with N fertilizer were attributed to greater soil water content, higher nutrient availability, and more protection from erosion compared to control treatment. The enhanced growth observed in the FYM treatments over the control could be partly due to more favorable moisture regime in the root zone and partly due to more efficient utilization of nutrients released from decomposition of the added FYM (Chiroma et al., 2006). Ahmad et al., (2002) also obtained more maize grain and straw yields with combined use of organic and inorganic fertilizers. This is most likely because manures application not only improve soil physical properties but also enhances microbial activities and provides stable supply of both macro- and micro-nutrients (Jilani et al., 2007). Kanchikerimath and Singh (2001) also reported that maize crop yield was improved when organic manure is applied along with inorganic fertilizers. Gondek and Mazur (2005) observed that use of mineral fertilizer with FYM produced better yield of maize crop as compared to FYM alone. Ahmad et al., (2002) observed that nutrient uptake by wheat was significantly increased with the combined use of organic and inorganic N sources, which lead to enhanced grain and straw yields.

CONCLUSION AND RECOMMENDATION

Use of organic fertilizers alone could not be a perfect substitute for chemical fertilizers as these are not as much quick nutrient supplier as chemical fertilizers, so integrated use of FYM along with chemical fertilizer has proved more beneficial. However, perfect balance should be maintained between FYM and chemical fertilizer for maximum productivity. The current study indicated that, combined application of FYM and chemical fertilizers had a remarkable effect on fodder beet production. All the measured agronomic traits were significantly affected by the interaction of organic and inorganic fertilizers rates. Compared to the control treatment, plant survival rate, plant height, leaf yield, tuber yield, and total forage yield obtained at a rate of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers mixture increased by 34%, 57%, 286%, 296%, and 294% respectively. Therefore, applying 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} was found to be the optimum fertilizers mixture rate for the above aforementioned agronomic traits of fodder beet crop. However, the seed yield increased by 900% when the crop was applied with the highest fertilizers mixture rate when compared to the control treatment thus, applying 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} was found to be the optimum fertilizers mixture rate for better fodder beet seed production. The study led to the conclusion that the combined application of the organic and inorganic fertilizers results in yields higher than sole application of each nutrient source. From the results of the current experiment, it could be concluded that combined applications of 10/23 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} and 15/33 kg N/P_2O_5 ha^{-1} + 9 t FYM ha^{-1} fertilizers resulted in improvement of nutrient balances that may lead to the highest forage and seed yields respectively. Therefore, this preliminary result recommends the use of FYM alongside with mineral fertilizers to increase forage and seed yields of fodder beet. However, more experimental research works should be carried out for more seasons and locations to verify this research findings.

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