Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.13, 2015

Effects of different levels of inorganic fertilizers applications on the production of Enset *(Ensete ventricosum (Welw) Cheesman)*

Abay Ayalew
Department of Natural Resources Research
Hawassa Agricultural Research Center, Southern Agricultural Research Institute
Hawassa, Southern Nations Nationalities and Peoples' region, Ethiopia

Abstract
Enset is one of the major food crops supporting many people in Southern Nations, Nationalities and People's Regional State. The crop requires intensive management and high amount of nutrients; however, only limited research has been conducted on fertilizer requirement of the crop. An experiment was conducted to determine rate and frequency of N and P fertilizers application for enset production at Areka, Wolaita, in Southern Ethiopia. Three levels of N (46, 92 and 138 kg/ha), three levels of P (20, 40 and 60 kg/ha), two levels of frequency of application (one time and two times), and absolute control treatment were arranged in factorial experiment with randomized complete block design replicated three times. Phosphorus was applied as DAP and N was applied as Urea and DAP. Data on plant height, pseudo stem height, pseudo stem circumference, leaf sheath number, corm weight, central shoot, bula weight, unsqueezed and squeezed kocho were collected and analyzed. The result indicated that application of N and P increased enset production at Areka. Application of 138 kg N and 20 kg P/ha per year two times in the life of the crop gave the highest enset production in all the above parameters. Beside increasing enset production, application of 138 kg N and 20 kg P/ha per year for two consecutive years enabled the enset to mature three years earlier as compared to the farmers experience in the area, which takes five years to mature. In conclusion, application of N and P more than one time in the life of enset is important to increase its production and reduce its maturity period. Therefore, application of 138 kg N and 20 kg P/ha per year for two consecutive years is recommended for better production of enset at Areka.
Keywords: Enset, Banana, Maturity, Bulla, Fertilizer

1. Introduction

Enset *(Ensete ventricosum)* is a huge perennial herbaceous plant that grows 4-11 m in height. I t is commonly known as "false banana" for its close resemblance to the domesticated banana plant and it is the edible species of the separate genus of the banana family (Shank and Chernet, 1996). It is the most important root crop and a traditional staple food crop in the densely populated south and southwestern parts of Ethiopia in particular (George, 2004). Enset grows best at altitudes above 1600 meters above sea level, not because it cannot withstand heat, but because it needs adequate moisture. According to Brandt et al. (1997), enset grows best at elevations between 2000 and 2750 mters. It is adapted to deep fertile soils and ample rain fall areas (Shank and Chernet, 1996; Brandt et al., 1997).

Enset cultivation is among the tremendous potential of the country to withstand the rapidly increasing percentage of population portion below food poverty line. It supports more than 10 million people in the South and South-western parts of Ethiopia (George, 2004). Mostly the enset crop is cultivated for food, animal feed and conservation of natural resources. The different plant parts and the by-product of the enset plant have also various uses. Enset has multipurpose uses and nothing will be left from the plant and can be dependable source of income. Thus, farmers in enset growing areas describe the importance of enset by saying that it is everything for us: our food, cloths, beds, houses, cattle feed and plates (Brandt et al., 1997). In enset-based cultivation, enset (ensete ventricosum) traditionally ranked first in importance as cultivated food crop and it is an important staple food. It is the main food source among Gurage, Sidama and related groups. It is not only staple food, but exists side by side as a co-staple to other crops, tuber crops or cereals, among Gamo, Hadiya, Wolaita and Gedeo. Farmers say: "Enset is the enemy of hunger, and human and livestock life is impossible without it" (Admasu, 2002). The central statistical authority as cited by Admasu (2002), estimated the area cultivated with enset to be about 37, 000, 18, 000 and 13, 000 ha in Sidama, Hadiya, and North Omo (where wolaita is located), respectively. The presence of enset in the farming system contributes significantly to the stability of the food supply by several mechanisms. Enset can: 1) be stored for long periods; 2) be harvested at any time during the year; 3) be harvested at any stage over a several year period; and 4) survive stress years that reduce other food sources. The three major products utilized as food are commonly known as Kocho, Bulla and Amicho. Kocho is a fermented product from the scrapped parenchymatic tissue of leaf sheath and pulverized corm. Bulla is made by dehydrating the juice arising from the mixture of scrapped parenchymatic tissue of leaf sheaths, pulverized corm and granted stalk of inflorescence. Amicho is the stripped corm of younger plants of enset which is boiled and consumed in a way similar to Irish potato, sweet potato and cassava.

The crop takes 5-7 year to mature (Shank and Chernet, 1996) and this prolonged time of maturation

together with acute land shortage forced farmers in Wolaita area to consume immature plants. Hence farmers were overexploiting their enset reserves thereby causing gradual losses and disappearance of the false banana as an important household food security crop. This situation could be reversed by shortening the maturity period of the crop through improving the fertility of the soil where it grows. Although the yield of enset is higher than the yield of cereals, it is far below the yield potential due to different yield limiting factors among which soil fertility decline is the major one (Admasu, 2002). Yeshi (1995) reported that the average squeezed kocho yield of enset is 27 kg/plant/growing years. Traditionally, enset is fertilized with manure, household waste and mulch of enset residue, which could maintain soil fertility better than adjacent fields. However, with decreasing pasture and forage resources, declining cattle numbers and available manure, the need for application of chemical fertilizers is becoming apparent (Shank and Chernet, 1996). A preliminary observation on effect of different sources of fertilizers on growth of enset suckers at Areka indicated that vigorous growth was observed when P, NP, and farm yard manure (FYM) were applied. Though farmers in wolaita area grow enset crop closest to their house, where they can easily fertilize it with cow dung and house refuse, cow dung has got limitation of availability to most farmers. Therefore, the use of chemical fertilizers is important. The objective of this study was to determine the rate of NP nutrients and their application frequency for enset around Areka.

2. Materials and methods

The experiment was conducted on Haplic Alisols of Areka. Enset clone "Halla" was used for the study. The suckers of the Enset were propagated and transplanted to the main field after one year. Three levels of N (46, 92 and 138 kg/ha), three levels of P (20, 40 and 60 kg/ha) and two levels of application time (once and twice applications) were used in factorial experiment with RCB design replicated three times. A spacing of 3 x 1.5 m between rows and plants, respectively, was used. Sources of N were Urea and DAP, while the source of P was only DAP. The fertilizers were applied around the plant during transplanting and yearly on wards as per the treatments. All the other agronomic managements (weeding, cultivation etc) were carried out properly and equally for all treatments. Plant and pseudo stem heights, pseudo stem circumference, leaf sheath number, corm weight, maturity time, bulla yield, fiber yield, un-squeezed and squeezed kocho were recorded. Finally, the data were analyzed using SAS.

3. Results and Discussion

Enset production was very highly significantly ($p<0.0001$) influenced by application of fertilizer.

Application of N significantly reduced the maturity time of enset (Table 1). Maturity time was decreased with increasing application of N. The shortest maturity time was recorded with application of 138 kg N /ha, whereas the longest maturity time was obtained with application of no nitrogen (control). Bulla yield was also increased due to application of N. Nitrogen also significantly increased the fiber, un-squeezed and squeezed kocho yields of enset. The highest yields were obtained from the largest N rate (138 kg N/ha), whereas the lowest yields were obtained from the non-fertilized plot (control). Central shoot weight, corm weight, leaf sheath number, pseudo stem circumference, plant height and pseudo stem height were increased due to application of N though not significantly (Table 1). The highest values of all the aforementioned parameters were recorded with application of 138 kg N/ha. Application of P also significantly affected the above parameters (Table 2). Phosphorus significantly reduced the maturity time of enset. The longest maturity time was attained with no P application, whereas the shortest maturity time was achieved with application of all P rates. All rates of P gave significantly higher bulla, fiber, and both squeezed and un-squeezed kocho yields as compared to the control, the highest enset yields being obtained with application of 40 kg P/ha. However, there is no significant differences in yields between application of 20 kg and 40 kg P/ha. Central shoot weight, corm weight, plant height and pseudo stem height also were increased due to application of P although not significantly. Frequency of fertilizer application also showed significant effect on the production of enset affecting all parameters considered (Table 3).

Table 1.Mean of different enset parameters as influenced by application of nitrogen

N (kg/ha)	Mean central shoot weight (kg/ha)	Mean corm weight (kg/ha)	Mean leaf sheath no.	Mean pseudo stem circumference	Mean plant height	Mean pseudo stem height	Maturity time (year)	Bulla yield (t/ha/y)	Fiber yield (t/ha/y)	Unsqeezed kocho (t/ha/y)	Squeezed Kocho (t/ha/y)
0	45000a	45741a	20.67a	1.31a	4.72a	1.64a	4.8a	0.36c	0.09c	1 13.06c	8.48c
46	45105a	44802a	19.41a	1.28a	5.19a	1.61a	2.7b	0.83ab	2 0.20ab	28.05ab	18.43ab
92	44366a	50396a	19.67a	1.28a	5.10a	1.63a	2.4c	0.75b	0.17b	25.53b	17.30b
138	51501a	51095a	20.11a	1.32a	5.43a	1.71a	2.3c	0.98a	0.22a	31.92a	21.48a
CV (%)	29.94	37.05	22.18	21.22	22.06	23.36	14.9	45.0	39.5	31.2	32.9

Table 2.Mean of different enset parameters as influenced by application of phosphorus

P (kg/ha)	Mean central shoot weight (kg/ha)	Mean corm weight (kg/ha)	Mean leaf sheath no.	Mean pseudo stem circumference	Mean plant height	Mean pseudo stem height	Maturity time (year)	Bulla yield (t/ha/y)	Fiber yield (t/ha/y)	Unsqeezed kocho (t/ha/y)	Squeezed Kocho (t/ha/y)
0	45000a	45741a	20.67a	1.31a	4.72a	1.64a	4.8a	0.36c	0.09c	13.06c	8.48c
20	48179a	50953a	19.74a	1.29a	5.34a	1.71a	2.5b	0.89ab	0.22a	29.50ab	19.88ab
40	50525a	50873a	20.41a	1.37a	5.46a	1.70a	2.4b	0.96a	0.20a	30.71a	20.45a
60	42269a	44466a	19.04a	1.22a	4.92a	1.53a	2.6b	0.71b	0.18a	25.29b	16.88b
CV (%)	29.94	37.05	22.18	21.22	22.06	23.36	31.2	32.9	14.9	45.0	39.5

Table 3.Mean of different enset parameters as influenced by frequency of fertilizer application

Frequency	Mean central shoot weight (kg/ha)	Mean corm weight (kg/ha)	Mean leaf sheath no.	Mean pseudo stem circumference	Mean plant height	Mean pseudo stem height	Maturity time (year)	Bulla yield (t/ha/y)	Fiber yield (t/ha/y)	Unsqeezed kocho (t/ha/y)	Squeezed Kocho (t/ha/y)
0	45000a	45741a	20.667a	1.31a	4.72a	1.6433a	4.8a	0.36c	0.09c	1 13.06c	8.48c
1	43550a	48966a	19.926a	1.26a	5.11a	1.6178a	2.6b	0.75b	0.17b	26.21b	17.4ab
2	45303a	46484a	19.036a	1.27a	5.09a	1.5707a	2.3c	0.96a	0.23a	32.01a	21.21a
CV (%)	29.94	37.05	22.18	21.22	22.06	23.36	14.9	45.0	39.5	31.2	32.9

Means with the same letter are not significantly different

Two times application of fertilizers (both N and P nutrients) resulted in significantly higher enset products. Bulla, fiber and kocho yields were significantly increased when N and P were applied two times during the growing periods. Two times application of N and P also significantly reduced the maturity time of enset. During planning, frequency of fertilizer application was designed to be applied up to three times. But all enset plants that received fertilizer were matured (flowered) after two times application of fertilizers. As a result the third application was excluded. This indicates that around Areka area, two times application of fertilizers is enough for production of enset (clone Halla) and no need to go beyond this.

The interaction of N and P very highly significantly improved enset production. All parameters considered were significantly influenced by the interaction of N and P (Table 4). This is in agreement with Kelsa (1996), who indicated that application of N and P gave superior enset yield components than the non- fertilized plot (control). Abay and Tesfaye (2011) also reported similar findings on potato. Significant yield increases also were reported by Abay (2011) in maize and Abay et al. (2011) in tef due to application of N and P. Application of N and P significantly reduced the maturity time of enset, and increased yields. Bulla, fiber, and kocho (squeezed and un-squeezed) yields were very highly significantly increased due to application of N and P. The interaction of N and P at all rates significantly reduced maturity time of enset. The longest (about 5 years) maturity time was obtained from the non-fertilized plot, whereas the shortest maturity time (about 2 years) was obtained with two times applications of N and P at different rates. Around Areka, although farmers grow enset crop near their home in order to easily access farm yard manure, due to shortage of farm yard manure, the crop takes about five years to mature (flower) as the soil fertility is very low resulted from repeated (continuous) cultivation. This is too long period to address food security problem in this densely populated area, where land shortage is a serious problem. The result of this study clearly indicated that increasing the fertility of the soil is very important to significantly shorten the maturity time of enset. This is great news to the farmers around Areka as it has a very important meaning to them to attain their food security. Since the shortage of farm land does not allow the farmers to plant a large number of enset on their farm and wait for five years, enset cultivation is very much decreased in the area. The application of fertilizer reduced the maturity time in the area at least by half, which can give an opportunity to the crop to be considered which thereby contributes a lot to food security of the area. Its drought tolerance (Dereje, 2009) gave to enset a special place in Areka area, especially during the seasons of drought when it is difficult to grow other crops. Therefore, it is important to increase yields and shorten the maturity time of this food security crop.

Application of 138 kg N and 20 kg P/ha twice per the life cycle of the crop significantly increased all bulla, fiber and kocho yields. The highest yields of bulla (1.47t/ha/y), fiber (0.36 t/ha/y), un-squeezed kocho (43.07 t/ha/y) and squeezed kocho (29.11 t/ha/y) were obtained with twice application of 138 kg/ha N and 20 kg/ha P. Whereas, the lowest yields of bulla (0.36 t/ha/y), fiber (0.09 t/ha/y), un-squeezed kocho (13.06 t/ha/y) and squeezed kocho (8.4 t/ha/y) were obtained from the non- fertilized plot. Due to twice application of 138 kg/ha N and 20 kg/ha P, the increments of enset yields as compared to the control were 408.33% for bulla, 400% for fiber, 329.78% for un-squeezed kocho, and 346.55% for squeezed kocho. Nitrogen and frequency of fertilizers application were positively but non-significantly correlated with all enset production parameters

considered (Table 5).

Table 4.Mean of different enset parameters as influenced by the interactions of applied N, P and frequency of application

N / P (kg/ha) x frequency	Mean central shoot weight (kg/ha)	Mean corm weight (kg/ha)	Mean leaf sheath no.	Mean pseudo stem circumference	Mean plant height	Mean pseudo stem height	Maturity time (year)	Bulla yield (t/ha/y)	Fiber yield (t/ha/y)	Unsqeezed kocho (t/ha/y)	Squeezed Kocho (t/ha/y)
46 /20 once	5.26	1.63	1.23	20.00	47870.37	44255.55	2.59	0.68	0.15	25.23	16.10
46/20 twice	5.36	1.70	1.32	20.33	37000.00	46925.92	2.24	0.86	0.26	32.092	21.74
46/40 once	5.08	1.60	1.32	20.67	40370.37	43740.74	2.34	0.75	0.17	26.17	17.22
46/40 twice	5.73	1.70	1.38	19.67	50870.37	50875.93	2.14	1.15	0.23	35.48	23.13
46/60 once	5.49	1.66	1.36	21.67	50877.78	46296.30	2.62	0.78	0.19	26.07	17.71
46/60 twice	3.41	1.09	0.87	14.00	36537.04	31574.07	2.49	0.75	0.16	26.19	17.32
92/20 once	5.23	1.70	1.29	19.67	56457.41	45392.59	2.78	0.69	0.18	23.84	16.21
92/20 twice	3.50	1.17	0.88	12.67	37022.22	28037.04	2.27	1.02	0.21	32.59	21.78
92/40 once	4.87	1.53	1.18	20.00	49259.26	36392.59	3.00	0.54	0.13	20.20	13.14
92/40 twice	5.57	1.80	1.50	22.33	54759.26	49809.26	2.31	0.99	0.20	31.98	20.35
92/60 once	5.32	1.69	1.32	20.67	57225.93	43022.22	2.89	0.77	0.16	28.01	18.24
92/60 twice	5.06	1.53	1.26	19.33	43281.48	35429.63	2.46	0.92	0.23	28.08	19.71
138/20 once	5.82	1.88	1.38	21.00	60966.66	50911.11	2.55	0.84	0.22	27.96	19.17
138/20 twice	5.55	1.72	1.34	21.25	49847.22	50006.94	2.36	1.47	0.36	43.07	29.11
138/40 once	5.28	1.77	1.33	20.67	47092.59	50272.22	2.34	0.86	0.19	27.31	19.47
138/40 twice	6.14	1.82	1.53	21.33	70574.07	65611.11	2.12	1.60	0.29	40.84	28.51
138/60 once	3.65	1.11	0.89	15.00	30574.07	31666.67	2.40	0.84	0.18	31.08	19.66
138/60 twice	5.32	1.56	1.29	19.67	37340.74	47888.89	2.30	0.64	0.20	24.39	16.18
0/0	4.72	1.64	1.31	20.67	45740.74	45000.00	4.81	0.36	0.09	13.06	8.48

Table 5. Correlation among different parameters of enset

	N	P	frequency	Plant height	Pseudo stem height	Pseudo stem circumference	Leaf sheath no.	Corm weight	Central shoot weight	Bula weight	Fiber weight	unsqueezed kocho weight	Squeezed kocho weight
N	1	0.18	0.16	0.11	0.1	0.06	0.04	0.14	0.17	0.06	0.08	0.11	0.14
P		1	0.19	-0.1	-0.17	-0.09	-0.08	-0.12	-0.14	-0.18	-0.13	-0.12	-0.13
Frequency			1	0.17	0.13	0.14	0.01	0.05	0.23	0.14	0.19	0.15	0.15
Plant height				1	0.96***	0.92***	0.86***	0.78***	0.85***	0.73***	0.75***	0.83***	0.82***
Pseudostem ht.					1	0.89***	0.87***	0.81***	0.88***	0.72***	0.80***	0.85***	0.85***
Pseudostem circ.						1	0.88***	0.65***	0.79***	0.64***	0.62***	0.72***	0.72***
Leaf sheath no							1	0.63***	0.74***	0.60***	0.61***	0.71***	0.71***
Corm weight								1	0.77***	0.81***	0.80***	0.88***	0.89***
Central shoot wt.									1	0.75***	0.86***	0.90***	0.89***
Bula weight										1	0.78***	0.81***	0.83***
Fiber weight											1	0.89***	0.90***
Unsq. kocho wt.												1	0.98***
Sq. kocho weight													1

Sq. = squeezed; unsq. = unsqeezed; ht. = height; wt. = weight; circ. = circumference

But P was negatively correlated with all enset production parameters indicating that enset production was increased up to a certain level of P application and then decreased. There was very highly significant correlation among enset production parameters indicating that they are highly interdependent.

Application of N and P did not influence the soil N and P contents (Table 6). The soil analysis result indicated that the N and P contents of the soil after harvest are similar under all treatments. The N and P contents of the soil were very low and not influenced by the different amounts of fertilizers and frequency of fertilizers application, which could be attributed to uptake by the crop, leaching of N and fixation of P by the soil as the soil is acidic.

Table 6. Effect of N and P fertilizers application on N and P contents of the soil

No.	Treatments	N (%)	P (mg/kg)
1	46/20 once	0.20	0.80
2	46/20 twice	0.20	0.90
3	46/40 once	0.20	0.90
4	46/40 twice	0.20	1.30
5	46/60 once	0.20	0.90
6	46/60 twice	0.16	0.80
7	92/20 once	0.20	0.80
8	92/20 twice	0.20	1.10
9	92/40 once	0.50	1.00
10	92/40 twice	0.20	0.80
11	92/60 once	0.20	0.80
12	92/60 twice	0.20	0.90
13	138/20 once	0.20	1.20
14	138/20 twice	0.20	0.70
15	138/40 once	0.20	0.80
16	138/40 twice	0.21	0.80
17	138/60 once	0.15	1.10
18	138/60 twice	0.20	1.10
19	0/0	0.20	1.50

4. Conclusion and recommendation

Soil fertility decline not only decreases enset yields but it also delays the maturity of the crop. Therefore, increasing soil fertility, besides increasing yields, significantly shortens the maturity period of enset. As enset is a food security crop especially around Areka where land shortage is a critical problem, shortening the maturity period of enset has a great place in securing food in the area. The use of chemical fertilizers for enset production is obligatory as the use of farm yard manure is very low due to its limited availability. As the use of chemical fertilizers hastens enset maturity, it prevents consumption of immature enset that inspires famers to grow enset widely which confirms food security. Thus, to increase enset yields and hastens its maturity, twice application of 138 kg N and 20 kg P/ha throughout the life of enset is recommended for Areka area.

Acknowledgements

I would like to acknowledge Mr. Tesfaye Dejene for his assistance in data collection and other activities during the course of the experiment.

5. References

Abay Ayalew (2011), “The Influence of Applying Lime and NPK Fertilizers on Yield of Maize and Soil Properties on Acid Soil of Areka”, Southern Region of Ethiopia, Innovative Systems Design and Engineering 2(7):33-42.

Abay Ayalew, Kelsa Kena and Tesfaye Dejene (2011), “Application of NP Fertilizers for Better Production of Teff (Eragrostis tef (zucc.) trotter) on Different Types of Soils in Southern Ethiopia”, Journal of Natural Sciences Research 1(1): 6-15.

Abay Ayalew and Tesfaye Dejene (2011), “Integrated Application of Compost and Inorganic Fertilizers for Production of Potato (Solanum tuberosum l.) at Angacha and Kokate in Southern Ethiopia”, Journal of Biology, Agriculture and Healthcare 1(2):15-20.

Admasu Tsegaye (2002), “Indigenous production, genetic diversity and crop ecology of enset (ensete ventricosum (Welw) Cheesman)”, PhD thesis, Wageningen University.

Brandt, Steven A., Anita Spring, Clifton Hiebsch, McCabe Terrence J., Endale Tabogie, Mulugeta Diro, Gizachew Wolde-Michael, Gebre Yntiso, Masayoshi Shigeta, and Shiferaw Tesfaye (1997), “The tree against hunger, Enset- Based Agricultural systems in Ethiopia”.

Dereje Fekadu (2009), “Characterizing farming practices from three regions of Ethiopia on which enset (Ensete ventricosum) is widely profited as a multipurpose crop plant”, Livestock research for Rural Development 21 (12), Ethiopia.

George Jacob (2004), “Enset- The “false banana” as food security, Ethiopia”

Kelsa Kena (1996), “Soil problems associated with enset production, Enset-Based sustainable Agriculture in Ethiopia”, In Tsedeke Abate, Clifton Hiebsch, Steven A.

Brandt and Seifu Gebremariam (eds.), Proceedings from the International Workshop on Enset held in Addis

Ababa, Ethiopia, 13-20 December 1993.

Shank, R.and Chernet Ertiro (1996), "A Linear Model for Predicting *Enset* Plant Yield and Assessment of *Kocho* Production in Ethiopia", United Nations development programme Emergencies Unit for Ethiopia.

Yeshi Chiche (1995), "Assessment of *Enset* and root crops contribution to food supply in Ethiopia", FAO, Addis Ababa.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar