Review of Soil Fertility Improvement and Crop Responses to Application of Fertilizers in the Southern Ethiopia

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Abstract
Soil fertility is declining most rapidly and resulted in low crop yields and livestock numbers that led to reduced food security and increased poverty in the highlands of Southern Ethiopia, which are characterized by high population, high rainfall and sloppy lands. Improving soil fertility and productivity can be achieved through applications of manure, other organic materials, inorganic fertilizers, lime and the inclusion of legumes and crop rotations in the cropping systems, or a combination of these. There are a number of site and crop specific fertilizer recommendations made for different crops being grown in southern nations nationalities and people's region (SNNPR). However, they are not collected together in such a way that the extension workers and end users can easily access them. Collecting together and documenting these technologies can greatly help both the distributers and the end users in using the technologies to increase crop production and productivity. Therefore, this review work was conducted to assemble fertilizer recommendations made on different crops in SNNPR for making accessible for disseminators. Fertilizers recommendations made for different crops including teff, maize, sorghum, barley, wheat, haricot bean, potato, enset and sweet potato in various areas of the region were collected from different literatures and summarized.
Keywords: Fertilizer recommendation, Soil fertility, Manure, Productivity, Response

1. Introduction

The sustainable productivity of a soil mainly depends upon its ability to supply essential nutrients to the growing plants as plants take their nutrients mostly from soil, which can be considered a box from which nutrients are removed (output) and in which nutrients are entered (input) (Tamene et al., 2017). The soils in Sub-Saharan Africa (SSA) are inherently infertile and have been used for agricultural production for many decades with little or no addition of nutrient resources, leading to declining soil fertility (Bationo et al., 1998; Bekunda et al., 1997). Nutrient depletion is the major environmental problems in the highlands of Ethiopia making the country the most seriously affected among SSA. Declining soil fertility is the principal environmental factor behind declining food production, farm incomes and per capita production in Ethiopia. The national averages of nutrient balances were estimated at -41 kg N, -6 kg P and -26 kg K per ha per year, which is among the highest nutrient depletion rates for sub-Saharan Africa (Stoorvogel and Smaling 1993) urging for soil fertility restoration. Soil fertility is declining most rapidly and resulted in low crop yields and livestock numbers that led to reduced food security and increased poverty in the highlands of Southern Ethiopia, which are characterized by high population, high rainfall and sloppy lands (Tilahun Amede *et al.*, 2006). Tamene et al. (2017) reported that in agricultural ecosystem nutrients are removed not only through erosion and leaching but also with crop yield and residues. According to Pound and Ejigu Jonfa (2005), causes of soil fertility decline are clearing of forests, removal of crop residues from the fields, land fragmentation, overgrazing, low fertilizer inputs, cultivation of slopes not suited to agriculture without adequate soil conservation, cropping of marginal lands, poor soil management, increased pressure on land due to increased population and reduced in livestock numbers (and therefore manure). Continued cultivation of crops with low levels of nutrient inputs being the major cause for the declining in soil fertility (Zingore, 2011), the washing away of the fertile top soil by water erosion is also decreasing the productivity of arable lands in the highlands. Cation exchange capacity is the dominant factor in measuring soil fertility which affects exchange of ions on the clay surface. Taye Belachew and Yifru Abera (2010) reported that wheat yield was declined due to low CEC value, which caused soil fertility degradation.

Meeting societal demand for food is a global challenge as recent estimates indicate that global crop demand will increase by 100 to 110% from 2005 to 2050 (Tilman *et al.*, 2011). FAO (2009) has estimated that the world will need 60% more cereal production between 2000 and 2050 equivalent to maintaining a proportional rate of increase of more than 2.4% per year. Sustainably meeting such demand is a huge challenge, especially when compared to historical cereal yield trends which have been linear for nearly half a century with slopes equal to only 1.2 to 1.3% of 2007 yields (FAO, 2009). The full potential of crops is never realized if a shortage of nutrients occurs at any time during the growth cycle (Koopmans and Goldstein, 2001). Improving soil fertility and productivity is among today's most critical issues to meet the aforementioned food demands. Increasing crop productivity on erosion prone or eroded soils cannot be realized only through nutrient application but also through soil conservation. According to Abay (2011) soil conservation practices conducted at Gununo in Wolaita improved the soil productivity and yields by 22 % on some farms and 15 fold on other farms within one year of soil bund construction and by >50 % after three years of soil bund construction with similar farming practices. A fertile soil is one that contains an adequate supply of all the nutrients required in balanced proportion for the successful production of plant life (Koopmans and Goldstein, 2001).

The use of balanced fertilizers and additions of organic matter are necessary to restore soil fertility and achieve high crop productivity in degraded soils. These can be achieved through applications of manure, other organic materials, inorganic fertilizers, lime and the inclusion of legumes and crop rotations in the cropping systems, or a combination of these (Taye Belachew and Yifru Abera, 2010; Zingore, 2011). Studies in SSA showed that fertilizer use is consistently more profitable and efficient. The increased use of mineral fertilizers, particularly nitrogen (N) and phosphorus (P) resulted in increased productivity of crops. According to Tamene et al. (2017), maize yield has increased from about 1.7 t ha^{-1} in 1993 to the current 3.4 t ha^{-1}, and wheat grain yield increased by 80 to 300% on vertisols and by 45 to 15% on nitosols in response to the application of higher rates of nitrogen fertilizers. The authors also reported that different nitrogen and phosphorus rates for barley production on different soils. Accordingly, N: P2O5 rates of 25:45 kg ha^{-1} for nitisols, 20:55 kg ha^{-1} for black soils, 20:45 kg ha^{-1} for red soils and 30:35 kg ha^{-1} for brown soils were recommended.

Long-term experiments show that with no fertilizer use, yields declined rapidly from an initial level of 5 tha^{-1} when native woodlands are cleared for cultivation, to about 1 tha^{-1} after 3 years (Zingore, 2011). The quantity of organic matter is a major indicator of soil quality as it improves soil fertility, structure, water infiltration and holding capacity, drainage, aeration, and root penetration increasing water availability to crop during drought periods and preventing soil erosion (Koopmans and Goldstein, 2001). Organic manures supply plant nutrients and contribute towards soil fertility. However, the quantities of plant nutrients available in manures are insufficient to meet crop requirements. It is estimated that animal manures provide about 11 percent of the total N required for global food production. In many countries, most manure is produced some distance from where it is required for application in agriculture, and the transport of manure is difficult and expensive. In many developing countries, a substantial proportion of the available manure is used for purposes other than application in agriculture, e.g. as fuel. The nutrient content of manures varies considerably and, if poorly stored, most of the N may be lost, polluting the atmosphere. Integrated application of organic manures with inorganic fertilizers can solve these shortcomings while improving the soil fertility and productivity. Integrated soil fertility management (ISFM) is becoming an important strategy to improve crop productivity (Tamene et al., 2017). Many authors in SSA have reported the positive interaction between fertilizers and manure (Zingore et al., 2007; Mtambanengwe and Mapfumo, 2005). A study conducted on fertilizer and manure application on low and medium soil fertility conditions indicated that combined application of N fertilizers and manure led to increased productivity above fertilizer treatments alone and this is most pronounced on degraded soils (Zingore, 2011).

The high degree of variability in landscape positions, agro-ecologies, soil characteristics, management practices and crop types results in variability in crop response to nutrients and amendments which calls for site and crop specific fertilizer recommendations. Accordingly, a number of site and crop specific soil fertility improvement works have been carried out to improve soil fertility and productivity in the southern nation's nationalities and people's region (SNNPR) of Ethiopia.

Site and crop specific fertilizer recommendation is very useful for easy adoption of technologies as it better increases productivity as compared to the blanket recommendation. The site and crop specific recommendation is resulted from solving the real production constraints in the specific area. Adoption of blanket fertilizer recommendation is limited for the blanket recommendation does not base on effective matching of fertilizer applications to soil fertility problems. Tamene et al. (2017) reported that blanket application of nutrients, without targeting crop types, landscape position and drought regimes results in limited returns prompting smallholder farmers not to adopt this practice. There are a number of site and crop fertilizer recommendations for different crops in SNNPR. However, they are not collected together in such a way that the extension workers and end users can easily access. Collecting together and documenting these technologies can greatly help both the distributers and the end users in using the technologies to increase crop yields. Therefore, the objective of this review work is to assemble fertilizer recommendations made on different crops in SNNPR for making accessible for disseminators. Below we present the major findings of a review of fertilizer recommendations for different crops in SNNPR.

2. Crop responses to application of fertilizers in SNNPR

2.1. Teff response to fertilizer application

A fertilizer trial was conducted at Hossana, Areka and Hawassa on Profondic Luvisols, Haplic Alisols and Vitric Andosols (Abaineh, 2003), respectively, and at Bensa for production of teff. The soils at Hossana and Areka were strongly acidic with pH of below 5.5, whereas the soil at Hawassa ranged from slightly acidic to neutral. Results indicated that at Hossana, teff grain yield was highly significantly increased due to phosphorus (P) fertilizer application, whereas the straw yield was highly significantly increased with the use of both N and P fertilizers (Table 1) (Abay et al., 2011).

Table 1. Effect of N and P application on grain and straw yields of teff at Hossana

Yields ($kgha^{-1}$)	Rate of applied N ($kgha^{-1}$)				LSD (5%)	Rate of applied P ($kgha^{-1}$)					LSD (5%)	CV (%)
	0	23	46	69		0	10	20	30	40		
Grain yield of teff	1329	1440	1403	1370	NS	999	1329	1461	1571	1557	131.7	16.6
Straw yield of teff	7708	8505	8434	8514	598.2	6260	7940	8693	9372	9177	597.6	

Source: Abay et al. (2011)

The authors also reported that there was no response to N application for teff production on Haplic Alisols of Areka. However, both grain and straw yields were highly significantly increased due to application of P (Table 2). The economic analysis result indicated that the gross benefits were considerably increased with application of P until the level of 20 kg/ha at both Hossana and Areka, but increased at a decreasing rate with further increase of P up to 30 and 40 kg/ha at Hossana and Areka, respectively. Thus, application of 10 to 20 kg/ha P was recommended depending on the availability of the fertilizer and affordability of the farmers for teff production at Hossana and Areka.

Table 2. Effect of N and P application on grain yield of teff at Areka

Yield ($kgha^{-1}$)	Rate of applied N ($kgha^{-1}$)			LSD (5%)	Rate of applied P ($kgha^{-1}$)					CV (%)
	0	23	46		0	10	20	30	40	
Grain yield of teff	1085	1093	1112	NS	706c	1100b	1201a	1232a	1245a	16.47

Source: Abay et al. (2011)

On the other hand, application of both nitrogen and phosphorus did not influence teff production at Vitric Andosols of Hawassa (Table 3). The study at Bensa revealed that applying only N and P is not adequate for better teff production calling for application of balanced nutrients (Table 4). Therefore, application of balanced nutrients including 64 kg N + 30 kg P + 25 kg K+ 13 kg S + 2.4 kg Zn+ 1 kg B/ha was recommended for production of teff at Bensa (Abay and Mulugeta, 2017).

Table 3. Effect of N and P application on grain yield of teff at Hawassa

Yield ($kgha^{-1}$)	Rate of applied N ($kgha^{-1}$)			LSD (5%)	Rate of applied P ($kgha^{-1}$)					LSD (5%)	CV (%)
	0	23	46		0	10	20	30	40		
Grain yield of teff	985	986	985	NS	973	983	978	1005	989	NS	15.73

Source: Abay et al. (2011)

Table 4. Response of teff to application of different nutrients at Bensa

Applied nutrients ($kgha^{-1}$)	Grain yield ($kgha^{-1}$)	Straw yield (t/ha)	No. of tillers
64N + 30 P (recommended amount of NP)	1187.0bc	3.27b	6.83ab
28N+18P+25K[@]+13S[#]+2.4Zn[&]+1B[*]	1081.3c	3.20b	6.70ab
46N+20P+16S+2.6Zn	1243.3bc	3.83ab	6.17b
64N+18P+25K+13S+2.4Zn+1B	1365.4ab	4.50a	7.17a
28N+30P+25K+13S+2.4Zn+1B	1207.4bc	3.52ab	7.30a
64N+30P+25K+13S+2.4Zn+1B	1502.5a	4.13ab	6.83ab
64N+20P+16S+2.6Zn	1280.8abc	3.43b	6.03b

Source: Abay and Mulugeta (2017) [@]K=potassium; [#]S=sulpher; *B=boron; & [&]Zn=zinc

2.2. Maize response to fertilizer application

A study conducted by Fanuel and Gifole (2012) in Wolaita indicated that integrated fertilization of maize with compost and inorganic fertilizers increased maize yields (Table 5). The authors recommended combined use of compost with inorganic fertilizers at rates of 5 t ha^{-1} compost + 50 kg urea ha^{-1} + 100 kg DAP ha^{-1} for better yield of maize around Wolaita. Abay (2011) reported that application of lime in combination with N and P fertilizers significantly increased maize yield at Areka in Wolaita Zone of Southern Ethiopia (Table 6). Accordingly, the author recommended the use of 69 kg N + 20 kg P + 1800 kg lime ha^{-1} for better production of maize at Areka.

Table 5. Grain yield (t ha^{-1}) of maize at Two Locations (Dendo and Chifisa) in 2009 and 2010 cropping seasons as influenced by application of integrated fertilizers

Treatments	2009		2010	
	Dendo	Chifisa	Dendo	Chifisa
1. No fertilizer	3.17c	3.08c	3.04b	3.47c
2. 100kg Urea ha^{-1} and 100kg DAP ha^{-1}	6.38ab	6.41a	5.95a	6.79a
3. 5ton compost ha^{-1} alone	3.83c	3.17c	2.98b	3.46c
4. 5 ton compost ha^{-1} + 25kg urea ha^{-1}+ 100 DAP ha^{-1}	5.80b	5.15b	5.58a	5.35b
5. 5 ton compost ha^{-1} + 50kg urea ha^{-1} + 100 DAP ha^{-1}	6.70ab	6.53a	5.49a	5.36b
6. 5 ton compost ha^{-1} + 75kg urea ha^{-1}+ 100 DAP ha^{-1}	6.95a	5.99ab	6.05a	5.86ab
LSD (5%)	1.04	1.24	1.33	1.31
CV (%)	12.58	16.22	18.22	17.20

Source: Fanuel and Gifole (2012)

Table 6. Mean grain yield of maize in kg ha^{-1} as influenced by application of lime-NPK

No.	Treatments	Grain yield (Kg ha^{-1})
1	Control (without fertilizer and lime)	2841.23
2	No fertilizer and 900 kg lime/ha	2740.47
3	No fertilizer and 1800 kg lime/ha	2021.21
4	69kg N + 20kg P + 0 lime/ha	4179.7
5	69kg N + 20kg P + 900kg lime/ha	1847227
6	69kg N + 20kg P + 1800kg lime/ha	5742.57
7	69kg N + 75kg K + 0 lime/ha	2775.97
8	69kg N + 75kg K + 900kg lime/ha	3071.1
9	69kg N + 75kg K + 1800kg lime/ha	3734.63
10	20kg P + 75kg K+ 0 lime/ha	3529.63
11	20kg P + 75kg K+ 900kg lime/ha	4339.07
12	20kg P + 75kg K+ 1800kg lime/ha	3923.87
13	69kg N + 20kg P + 75kg K + 0 lime/ha	3745.97
14	69kgN+20kgP+75kgK+900kg lime/ha	3595.07
15	69kg N + 20kg P + 75kg K1800 kg lime/ha	4419.53
	LSD (5%)	866.61
	CV (%)	

Source: Abay (2011)

2.3. Sorghum response to fertilizer application

An experiment was conducted by Nebyou and Muluneh (2016) in Derashe special district to determine N and P requirement for the production of sorghum in the area. The result obtained depicted that sorghum yield obtained without the application of N and P is very low calling for the application of the nutrients (Table 7). The authors indicated that the use of 92 kg N and 30 kg P ha^{-1} resulted in significantly higher sorghum yield in the above mentioned area.

Table. 7. Response of sorghum to N and P fertilizers

N,P	Grain yield ($kgha^{-1}$)	N,P	Grain yield ($kgha^{-1}$)
0,0	812.5f	46,20	2562.5abcde
0,10	1375ef	46,30	2625abcde
0,20	1541.7cdef	69,0	2854.2abcde
0,30	1520.8edf	69,10	2875abcde
23,0	1937.5bcdef	69,20	2979.2abcd
23,10	1958.3bcdef	69,30	2979.2abcd
23,20	2104.2bcdef	92.0	3000abcd
23,30	2187.5bcdef	92,10	3083.3abc
46,0	2312.5bcdef	92,20	3458.3ab
46,10	2500abcde	92,30	3895.8a
CV (%)	38.782		

Means with the same letter are not significantly different!

Source: Nebyou and Muluneh, 2016

2.4. Barley response to fertilizer application

A study result reported by Abay and Tesfaye (2012) indicated that combined application of NPK fertilizers and farm yard manures significantly increased barley yield at Fereze, Gurage Zone. Accordingly, the authors recommended the use of 46 kg N + 40 kg P + 50 kg K + 20 t FYM ha^{-1} for better barley production at Fereze.

2.5. Wheat response to fertilizer application

An experiment was conducted at Hula District of Sidama Zone by Mulugeta and Abay (2017) to provide balanced fertilizer recommendations for wheat production in the area. Accordingly the authors recommended application of 69 kg N + 40 kg P ha^{-1} or 46 kg N, 20 kg P, 8 kg S and 1.3 kg Zn ha^{-1} for better wheat production at Hula. Another experiment conducted by Bekalu and Mamo (2016) at Chencha in SNNPR revealed that application of N and P significantly increased wheat yield. Accordingly, the authors recommended the use of 69 kg N and 46 kg P_2O_5 ha^{-1} for production of wheat at Chencha. Woldeyesus et al. (2012) also recommended application 110 kg N and 46 kg P_2O_5 ha^{-1} for wheat production at Hadiya, Kembata-Tembaro, Wolaiyta & Dawro zones of the region. Related studies at Hossana and Hagereselam in Southern Ethiopia also exhibited that application of lime alone or in combination with 46-92 kg N-P_2O_5 ha^{-1} significantly influenced wheat yield at Hagerselam, but application of lime alone did not affect the wheat grain yield at Hossana (Abay Ayalew et al., 2010). Accordingly the authors recommended the use of 46 kg N and 92 kg P_2O_5 ha^{-1} for wheat production at Hagereselam. Damene (2003) recommended application of 69 kg N and 30 kg P ha^{-1} for wheat production at Gozo-Bamushi in Dawro Zone of the Southern region.

Leaf of Erythrina bruci having 4.83, 0.38 and 2.24% N, P and K, respectively, could significantly increased yield of wheat when applied at 10 t ha^{-1} in combination with half of the recommended dose of inorganic fertilizers (23/20 kg N/P ha^{-1}) at Kokate, Wolaita area and recommended to the area (Wassie Haile, 2012). Another study by Wassie Haile et al. (2010) revealed that the integrated application of farm yard manure (FYM) and inorganic fertilizers also significantly increased wheat yield at Hagereselam. Consequently, the authors recommended the use of 20 t FYM with 46 kg N and 40 kg P ha^{-1} for better production of wheat at Hagereselam. Recent study conducted on fertilization of wheat in Hagereselam revealed that all types and amounts of fertilizers applied resulted in significantly higher yields than the none fertilized plot indicating that the use of fertilizers is compulsory for wheat production in the area, the highest yield being obtained by application of 120.5, 25, 50, 10.5 and 500 kg/ha N, P, K, S, Lime, respectively (unpublished material).

2.6. Haricot bean response to fertilizer application

As zinc (Zn) is an essential trace element for plants, animals, and humans, and its deficiency retards the growth and yield of plants and causes illness and death in human beings, increasing the concentrations of Zn in grains is a high priority research task (Cakmak, 2002). In this regard Abay et al. (2015) conducted a study on increasing the concentration of Zn in haricot bean through application of fertilizer in Halaba, Bodity and Butajira and a significant increase in Zn concentration was obtained due to Zn fertilization. Accordingly, the authors recommended a foliar application of 0.5% heptahydrated zinc sulphate ($ZnSO4 \cdot 7H2O$) at a volume of 100 L ha^{-1} three weeks and six weeks after the sowing date for the quality bean production. Iron (Fe) fertilization study was also conducted by the same authors on haricot bean in the same locations and resulted in an increase of Fe in the grain. The authors recommended that foliar application of heptahydrated iron sulphate (FeSO4.7H2O) three times at 15 days intervals starting at 15 days after planting at a volume of 100 L ha^{-1} per each application date for haricot bean production with high grain Fe concentration. A study by Gifole et al. (2011) revealed that fertilizer application significantly increased yield of haricot bean at Areka in Wolaita. Accordingly, the authors recommended the use of 60 kg N ha^{-1} and 10 kg P ha^{-1} for better production of haricot bean at Areka. However, a study conducted latter on by Mesfin et al. (2014) on the same location put a different recommendation on fertilizer application for haricot bean production. The recommendation made was 30 kg P ha^{-1} with 23 kg N ha^{-1} for haricot bean production at Areka and Gununo in Wolaita zone of SNNPR.

2.7. Horticultural crops response to fertilizer application

A study on integrated soil fertility management, where combined compost and inorganic fertilizers were applied, was conducted for potato (*Solanum tuberosu* l.) production at Angacha (in Kembata) and Kokate (in Wolaita) in SNNPRS. Results indicated that application of all rates of N and P fertilizers resulted in significantly higher tuber yields compared to the control (with no fertilizer) at both locations (Tables 8 and 9). Therefore, it was recommended that farmers in the study areas should apply N and P fertilizers at rates ranging from 37 – 111 kg N ha^{-1} and 13– 39 kg P ha^{-1}depending on the availability of money to purchase the fertilizers for potato production. However, as higher rates gave higher economic benefit, application of 10 t ha^{-1} compost + 73.4 kg N + 26 kg P ha^{-1}, or 111 kg N + 39 kg P ha^{-1} was recommended for better potato yield (Abay and Tesfaye, 2011). Another study on the influence of potassium (K) fertilizer on the production of potato at Angacha depicted that the soil in the study area contained adequate amount of K and as a result application of K was not required for potato production at Angacha area (Abay and Sheleme, 2011). However, the authors suggested that periodic checks for K status of the soil and the response of potato to K are necessary as potato is a highly K demanding crop. A different research conducted by Gezahegn et al. (2014) at Delbo watershed in Wolaita on sweet potato showed that yield and yield components of the crop were enhanced by the combined use of Farm Yard Manure (FYM) and inorganic fertilizers. According to the authors more than 24 t ha^{-1} of root yield was obtained due to application of 46 kg ha^{-1} N and 5t ha^{-1} FYM. Accordingly, they recommended the use of 46 kg N and 5 t FYM ha^{-1} for better production of sweet potato at the Delbo watershed of Wolaita. Wassie and Shiferaw Boke (2011) reported that application of lime only did not increase potato tuber yield on acidic soils of Chencha and Hagereselam, however, significantly increased when integrated with fertilizers although not significantly higher than application of fertilizers only. This indicates reclamation of soil acidity by itself doesn't increase yields where soils are deficient in nutrients. Accordingly, the authors recommended application of 110, 40, and 100 kg N, P, and K, respectively for better production of potato in Chencha and Hagereselam.

According to Abay (2015), application of N and P fertilizers significantly shortens the maturity period (hastens maturity) and increases the yield of enset (Table 10). From the result of a study conducted at Areka, the author recommended twice application of 138 kg N and 20 kg P ha^{-1} throughout the life of enset to increase the yields of the crop at the study site.

Table 8. Potato tuber yield (t ha-1) as influenced by compost and NP fertilizers at Angacha

Compost rate (t ha-1)		N/P rate (kg ha-1)				Compost mean
	0/0	36.7/13	55/19.6	73.4/26	111/39	
0	-	-	-	-	34.01	-
2.5	25.64	25.74	29.90	28.89	-	28.17
5.0	20.55	25.83	24.17	29.07	-	26.16
7.5	22.03	26.11	29.16	28.69	-	28.37
10	23.52	28.42	27.49	31.84	-	30.32
N/P mean	22.94	26.53	27.68	29.62	34.01	
	Compost	N/P	N/P x compost interaction			
LSD (5%)	NS	4.033	NS			
CV (%)	20					

Source: Abay and Tesfaye (2011)

Table 9. Potato tuber yield (t ha-1) as influenced by compost and NP fertilizers at Kokate

Compost rate (t ha-1)	N/P rate (kg ha-1)					Compost mean
	0/0	36.7/13	55/19.6	73.4/26	111/39	
0	-	-	-	-	30.54	-
2.5	19.01	20.92	24.18	25.74	-	23.09
5.0	15.64	21.07	22.54	24.40	-	22.16
7.5	15.33	23.56	24.25	26.21	-	24.21
10	16.37	22.77	24.56	29.81	-	25.88
N/P mean	16.59	22.08	23.88	26.54	30.54	
	Compost	N/P	N/P x compost interaction			
LSD (5%)	NS	3.23	NS			
CV (%)	19.54					

Source: Abay and Tesfaye (2011)

Table 10. Mean of different enset parameters as influenced by application of phosphorus

Measured parameters	N (kg/ha)				P (kg/ha)				Frequency			CV (%)
	0	46	92	138	0	20	40	60	0	1	2	
Maturity time(year)	4.8a	2.7b	2.4c	2.3c	4.8a	2.5b	2.4b	2.6b	4.8a	2.6b	2.3c	14.9
Bulla yield (t/ha/y)	0.4c	0.8ab	0.8b	1.0a	0.4c	0.9ab	1.0a	0.7b	0.4c	0.8b	1.0a	45
Fiber yield (t/ha/y)	0.1c	0.2ab	0.2b	0.2a	0.1c	0.2a	0.2a	0.2a	0.1c	0.2b	0.2a	39.5
Kocho yield (t/ha/y)	13.1c	28.1ab	25.5b	31.9a	13.1c	29.5ab	30.7a	25.3b	13.1c	26.2b	32.0a	31.2

Means followed by the same letter(s) within a row are not significantly different at $P \leq 0.05$

Source: Abay (2015)

Conclusion

A number of soil fertility improving works have been conducted in the southern nation nationalities and people's region. These include management of soil acidity, chemical fertilizers and integrated nutrients recommendations. A number of fertilizer recommendations made for various crops in the region were reviewed and compiled in this paper. However, the author of this paper doesn't believe that this review work included all the fertilizer recommendations made for the different crops being grown in the southern nation's nationalities and people's regional state. Therefore, the fertilizer recommendations made for the region should be exhaustively reviewed to make accessible for producers of the various crops in the region.

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