Journal of Agricultural Science and Food Research

Zewide, et al., J Agri Sci Food Res 2018, 9:1

Research Article Open Access

Effect of Combined Use of Cattle Manure and Inorganic Nitrogen and Phosphorus on Yield Components Yield and Economics of Potato (*Solanum tuberosum* L.) in Belg and Meher Season at Abelo Area Masha District, South-Western Ethiopia

Isreal Zewide[1*], **Tamado Tana**[2], **Lemma Wog**[3] **and Ali Mohammed**[4]

[1]*Department of Horticulture, Mizan-Tepi University, PO Box 260, Mizan Teferi, Ethiopia*

[2]*School of Plant Sciences, Haramaya University, PO Box 138, Dire Dawa, Ethiopia*

[3]*School of Natural Resources Management and Environmental Sciences, Haramaya University, PO Box 138, Dire Dawa, Ethiopia*

[4]*Department of Post-Harvest Management, Jimma University College of Agriculture and Veterinary Medicine, PO Box 37, Jimma, Ethiopia*

[*]**Corresponding author:** Isreal Z, Department of Horticulture, Mizan-Teppi University, PO Box 260, Mizan Teferi, Ethiopia, Tel: +251473360035; E-mail: zewideisreal@gmail.com

Rec date: January 29, 2018; **Acc date:** March 13, 2018; **Pub date:** March 29, 2018

Abstract

Soil fertility decline is considered as one of the major causes for resulting in reduced yield of potato production in Abelo area Masha district Sheka zone of south-western Ethiopia. Hence, a field experiment was conducted in Belgnand Meher season, in Abelo area, Masha district south-western Ethiopia, to investigate the effect of combined use of application of Cattle Manure (CM) with mineral NP on growth, yield components, yield, the economics of potato, and on selected soil physio-chemical characteristics. The treatments comprised combinations of three rates (2.5,5, 7.5 tha^{-1}) of CM with 25%, 50% and 75% of recommended rates of mineral NP, respectively. In addition, 100% recommended rate of mineral NP (165 kg N ha^{-1} and 137 kg P_2O_5 ha^{-1}) and zero rates were used for comparison. The experiment was laid out in a randomized complete block design with three replications. The results revealed that applying 7.5 tha^{-1} CM combined with 75% mineral NP gave significantly. the highest marketable tuber numberhill^{-1}(9.72 and 8.7064) and total tuber number hill^{-1}(13.29 and 11.076) and marketable tuber yield (27.491 and 28.700 kg ha-1) and total tuber yield (4020 and 34221) of potato in Belg and Meher season, respectively. The application of 7.5 tha^{-1} CM in combination with 75% mineral NP has increased tuber yield by 55.9% and 43.45% in Belg and by 51.19%, and 36.64% in Meher over the control and the application of 100% recommended rate of NP fertilizers, respectively. Similarly, the economic evaluation showed that the application of 7.5 ha^{-1} CM plus 75% mineral NP offered the highest net return of 91704.60 Birr ha^{-1} in Belg and 119887 Birr ha^{-1} in Meher season. Therefore, it can be concluded that, the use of combined application of CM (7.5 t ha^{-1}) together with 75% of recommended rates of mineral NP (123.75 kg N ha^{-1} and 103.05 kg P_2O_5 ha^{-1}) can significantly increase potato yield, gave a high economic return and improve soil health.

Keywords: Cattle manure; Nitrogen; Phosphorous; Yield component; Tuber yield; Economic analysis; Characteristics

Introduction

Potato (*Solonaum tuberosum* L.) which belongs to the Solanaceae, family, genus Solanum which also includes tomato eggplant and pepper etc., is one of the most important tuber crops in the world. It is a cool-season crop, most dependable and early maturing root and tuber crop Potato tuber consists of main carbohydrates, proteins, and lipids. The tuber is used locally alone or with meat, and vegetables as substituent with pulse in stew preparation in Sheka Zone, southwestern Ethiopia, the potato is one of the widely grown and major cultivated tuber crops. It is a preferable crop in the study area due to that it can be produced more than twice per year [1].

inadequate agronomic management practices specifically, inadequate and inappropriate application of fertilizers, low nutrient reserves in arable soils, a negative nutrient balance on crop and by potato growers are factors Contributing to the low yield of potato in study areas. Potato is one of the heavy feeders requiring relatively large quantities of fertilizers. However, scarcity use of only chemical fertilizers without supplementing with organic sources due to the high cost of chemical fertilizers and limited availability for the smallholder farmers accompanied with a high amount of rainfall that might have caused leaching of macro- and micro-nutrients significantly reduced soil fertility and crop productivity in the study area.

In addition to the high cost, use of mineral fertilizers constantly lead to decline soil chemical and physical properties, biological activities and thus, overall, the total soil health [2-4]. Due to this, nutrients supplied exclusively through chemical sources, though enhance yield initially, and lead to unsustainable productivity over the years [2,5]. Thus, the undesirable impacts of chemical fertilizers, coupled with their high prices, have prompted the interest in the use of organic fertilizers as a source of nutrients. The combined use of Organic together with mineral fertilizer application has been reported to improve crop growth by supplying plant nutrients including micro-nutrients as well as improving soil physical, chemical, and biological properties there by provide a better environment for root growth by improving the soil structure [6].

Many research findings have shown that neither mineral fertilizers nor organic sources alone can result in sustainable productivity [5,7]. Furthermore, the price of mineral fertilizers is increasing and becoming unaffordable for resource-poor smallholder farmers. The best remedy for soil fertility management is, therefore, a combination of both mineral and organic fertilizers, where the mineral fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil [7,8]. The combined application of mineral and organic fertilizers, usually termed as integrated nutrient management, is widely recognized as a way of increasing yield and or improving the productivity of the soil sustainably [2,9]. Several researchers have verified the beneficial effect of integrated nutrient management in moderating the deficiency of several macros- and micro-nutrients. In view of this fact, identifying the optimum dose of integrated nutrients application is crucial and is required for maintaining sufficient amount of nutrients for increased yield of the crop [2,10-12].

Cattle manure is a decayed mixture of the dung and urine of cattle or other livestock with the straw and litter used as bedding and residues from the fodder fed to them. Whatever is collected for manuring is usually heaped on the ground surface with residues from fodder and other house sweepings. The nitrogen in the manure is subject to volatilization and leaching losses and the material that finally will be spread on the field may have low nitrogen content. The application of well-decomposed manure is more desirable than using fresh materials [13,14].

Daniel and Niguse reported high tuber yield of potato was obtained when CM (cattle manure) at the rate of 10 qha^{-1} was combined with mineral nitrogen at 111 kg N ha^{-1} and phosphorous at 90 kg P_2O_5 ha^{-1} on Nitosol, of Bako Ethiopia. Shiferaw, 2014 reported that the highest potato tuber yield was attained by combined Application of 15 t ha^{-1} CM with the application of 100% recommended rate NPK (100-100-100 kg ha^{-1}) and NP (100/100 kg ha^{-1}) increased tuber yield over control by 567.9 and 393.9%, respectively as compared to the application of organic or mineral fertilizers in isolation.

Biruk stated that application of 30 t ha^{-1} cattle manure along with nitrogen at 120 kg N ha^{-1} and phosphorous at 92 kg P_2O_5 ha^{-1} gave yield advantage of 8.4 t ha^{-1} in North-Eastern Ethiopia. However, research on integrated nutrient management for potato production has not been yet conducted at Masha district Sheka Zone, southwestern Ethiopia. Thus, this study was conducted to determine the effect of combined application of CM with mineral NP fertilizers on the growth, yield components, yield of potato and physico-chemical characteristics of the soil, and to determine appropriate rates of combined CM with mineral NP fertilizers for better productivity of the potato [15-18].

Materials and Methods

Description of the study site

The experiment was conducted at the abelo area in Masha district of Sheka Zone, southwestern Ethiopia, in 2016 main cropping season from July to November. The study site of Masha district located at UTM WGCs 1984 Zone 36 N between 861,000 MN-873,000 MN latitude. Longitude Attitudinally 1642 to 2025 [19].

The rainfall pattern of these areas is characterized by monomodal distribution with small rainy season in Belg (February -May) and main rainy season's Meher (June October) [19,20].

Experimental materials

A potato variety called 'Belete' was used as a test crop. The variety was released in 2009 by Holeta Agricultural Research Center, Ethiopia, for its high yield and promising agronomic performances. The variety matures in 90-120 days. The yield ranges from 29.13 t ha^{-1} under farmers 44.8 t ha^{-1} under research Source [21].

Potato variety Belete, obtained from Holleta Agricultural Research Center, was used for the experiment. Belete is one of the potential potato cultivars for south-west highlands such as Masha woreda and it has the following characteristics (Table 1).

Year of release	Research station	Altitude	Rain falls	Maturity	Yield (tha^{-1})	
		m.a.s.l	(mm)	(days)	Research	Farmers
2009	Holleta	1600-2800	750-1000	90-120	44.8	29.13

Table 1: Some characteristics of potato variety Belte. Source: EARO (Ethiopian Agricultural Research Organization), 2009.

Urea (46% N) and TSP (46% P_2O_5) were used as mineral N and P sources whereas Cattle manure was used as an organic fertilizer. Cattle manure was collected from those farmers trained and supervised by the teppi soil testing research Centre under the financial aid of sustainable land management (SLM) project in Masha distinct Sheka Zone; Urea and TSP were collected from Teppi Soil Testing Research Center.

Treatments and experimental design

The treatments consisted of combinations of three rates of CM (2.5, 5, 7 t ha^{-1}) and with three rates (25%, 50%, and 75%) of recommended mineral NP fertilizers. In addition, 100% recommended rate of mineral NP fertilizer (165 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}) and zero rates were used for comparison. Thus, there were 11 treatments. The experiment was laid out in a randomized complete block design with three replications.

Each block and plots within a block were spaced 1 m and 0.5 m apart, respectively. Each plot had 12 rows of 75 cm apart each with 3.6 m length. The gross plot size was, therefore, 3.6 m × 4.5 m (16.2 m^2). The first rows from each side of the plots were considered as a border. The second rows from each side of the plot were designated as sampling rows. In each plot, 1.5 and 0.6 m row length at the end of each row and column were left as a border to avoid the border effect. Therefore, the net plot size was 3 m × 3 m (9 m^2).

Soil sampling and analysis

Before planting, surface (0-20 cm) soil samples, from five spots across the experimental fields, were collected in a zigzag pattern, composited and analyzed for soil physico-chemical properties and the results are depicted in Table 2. The soil sample was air dried and crushed to pass through a 2-mm mesh size and soil physico-chemical properties were analyzed in Teppi soil testing laboratory, following the procedures depicted below.

Soil texture was determined using Bouyoucos hydrometer method; soil pH and electrical conductivity of the soils were measured in water (1: 2.5 soil: water ratio). by digital pH and Ec meter; soil organic carbon by wet digestion method and total N by Kjeldhal method.

Available phosphorous was determined. The cation exchange capacity (CEC) was determined using 1 M-neutral ammonium acetate [22-26].

Exchangeable acidity (Al and H) was determined by saturating the soil samples with 1 M KCl solution and titrated with 0.02 M NaOH as described by Rowell [27]. From the same extract, exchangeable Al was titrated with standard solution of 0.02 M HCl. Finally, exchangeable H was obtained by subtracting exchangeable Al from exchangeable acidity (Al+H).

Experimental procedures

To have fine seedbed for good root development, the experimental field was plowed three times using a pair of oxen and the plots were leveled manually. Cattle manure (CM) was applied on dry weight basis three weeks before to planting and totally mixed with the soil in the field. The potato tuber was planted in rows spaced 30 cm apart by hand drilling at the seed rate of 20 Q ha^{-1} in the first week of February 2016.

Crop data collection

Yield components and yield: Total tuber numbers/hill: was obtained by adding up the number of marketable and unmarketable tubers. This parameter constituted all tubers: small, medium, large, diseased, deformed etc., that were produced by the plants. Marketable tuber number/hill: the number of tubers was counted as marketable which is greater or equal to 25 g, free from disease and insect attack in each plot and divided by the respective number of plants harvested.

Unmarketable tuber number/hill: the number of tubers counted as unmarketable which were diseased, insect attacked, deformed and weight less than 25 g. Marketable tubers yield (t ha^{-1}): these were recorded as the weight of marketable tubers that remain from diseases, insect pests, and above or equal to 25 g in weight [28]. These were taken from hills in the net plot area at harvest and changed to t ha^{-1}. Unmarketable tubers yield (t ha^{-1}): tubers yield recorded as unmarketable which were diseased, insect attacked, deformed and weight less than 25 g. Total tubers yield (t ha^{-1}): it was recorded as the sum of marketable and unmarketable tuber yield from net plot area harvested and changed into t ha^{-1}.

Statistical data analysis

The agronomic and post-harvest soil data were subjected to analysis of variance (GLM procedure) using SAS software program version 9.2 [29]. Homogeneity of variances was calculated using the F-test as described by Gomez and Gomez [30] and since the F-test has shown heterogeneity of the variances of the two seasons for most of the agronomic parameters, a separate analysis was used for the two seasons. The Fisher's protected least significant difference (LSD) test at 0.05 probability level was employed to separate treatment means where significant treatment differences occurred.

Partial budget analysis

The partial budget analysis as justified by CIMMYT (1988) was done to determine the economic feasibility of the fertilizer application. It was computed by considering the additional input costs (variable costs) involved and the gross benefit gained from different treatments. The variable costs also included in the cost (Urea, TSP) and its application, cattle manure preparation, and application and cost of fungicide in the Meher season as this varied according to the treatment. A wage rate of 25.0 Birr per man-day was assumed where ten and two-man days were considered for preparation and application of one ton of Cattle manure the average marketable yield adjusted downward by 10% was used to reflect the difference between the experimental field and the expected yield at farmers' fields and with farmers' practices from the same treatments. This is because of experimental yields, even from on-farm experiments under representative conditions, are often higher than the yields farmers could obtain using the same treatments. For determining the gross benefit, the prevailing local market price at the harvest of potato (4 and 5.00 Birr kg^{-1} in Belg and Meher, season respectively) was used for computation. (1 ETB=0.043 USD Gross field benefit(GFB), total variable cost (TVC) and net benefit (NB) were some of the concepts used in the partial budget analysis. The dominance analysis was also carried out to select potentially profitable treatments and a percentage marginal rate of return (% MRR) was calculated for the non-dominated treatments.

Results and Discussion

Initial soil properties and cattle manure compositions

These results of the initial soil test analysis showed that the soils at the sites were low in fertility, acidic, with low amounts of total N, organic carbon, total and extractable phosphorous and exchangeable bases (Table 2). This could be attributed to the poor management of crop residue, thus resulting in nutrient reduction and the decline in soil fertility. The crop response to added organic and mineral fertilizer at different season is expected to show responses on crops and soils.

Prior to planting, surface (0-20 cm) soil samples, from five spots across the experimental fields, were collected in a zigzag pattern, in 2016 Belg and Meher cropping seasons composite, and analyzed in teppi soil testing, research Centre for soil physico-chemical properties as per the procedures given in experiment I (Table 2).

Analysis of composition of soil and cattle manure reveled better nutrient composition in Belg than in Meher season (Tables 2 and 3).

Farmers in masha mostly use cattle manure as the organic source. The de- composition rate of these materials in soil depends on the chemical composition of the material (C:N ratio), soil temperature, soil moisture, method of application (surface applied, soil incorporated, etc.), and rate of application.

The soil physico chemical analysis of the study sites revealed that the soils of the experimental field were loam in texture in both Belg and Meher cropping season. The results also indicated that the soil of Belg and Meher cropping season are strongly and very strongly acidic with pH of 5.2 and 4.8, respectively. The soils have low organic carbon, total N (g kg^{-1}) and available P (ppm) and medium in exchangeable base except trace in sodium, CEC and high in micronutrient cation Fe, Mn, Cu, Zn both in Belg and Meher season.

The soil physico-chemical analysis of the study areas revealed that the soils of the experimental field were loam in texture in both Belg and Meher season in abelo area with pH of 5.01(Strongly acidic) in Belg season and 4.8 (Very Strongly acidic) in Meher season.

The soil had also relatively high content of exchangeable acidity and aluminum (3.83 and 3.82 cmolc kg^{-1}) in belg and Al (2.01 and 2.46) cmolc kg^{-1}). In meher season.

The soils of both study sites have medium CEC of 20 Cmol (+) kg^{-1}) in Belg season and 19.3 Cmol (+) kg^{-1}), in Meher season low organic carbon content of 1.2 and 1.15 (g kg^{-1} and Following the rating of total N of <0.05% as very low, 0.05-0.12 low, 0.12-0.25 Medium, >0.25 high N status as indicated that the surface Soils of both the Belg and Meher season qualify low status of N. low total N of 0.1 and 0.08 (g kg^{-1} content in Belg and Meher season, respectively The analysis also revealed that the available P of the soils was 5.5 and 5 ppm in Belge and Meher, season respectively. Thus, the soils of the experimental sites are low in available P content both in Belge and Meher season (Table 3) according to the rating of [31].

Just after harvesting the crop, composite surface (0-20 cm) soil samples were collected from three spots for each plot from every replication. These samples were composited to yield one representative sample per replication from each plot for determination of CEC, pH, total N, available P, available K and organic carbon contents using procedures indicated for pre-sowing soil analysis. The extract of K was analyzed using flame photometer. The bulk density (Db) of the soil was measured from the undisturbed soil samples collected from each plot using core sampler, which was weighed at field moisture, and after drying the pre-weighed core soil sample to a steady weight in an oven at 105°C [33]. while particle density (βs) was measured using psychnometer [34].

$$Totalporosity(\%) = [1 - (\frac{BD}{PD})] * 100$$

where, BD=bulk density; PD=particle density [35].

Cattle manure Because of its alkalinity and elevated contents of alkali and alkaline earth elements, cattle manure can be utilized to raise the pH of acid soils. Therefore, cattle manure can be used as an alternative to lime either by itself or as a mixture of mineral NP. The cattle manure in Belg season has also relatively higher content of total P compared to cattle manure in Meher season [36].

The organic carbon, N, P, K pH, Electrical conductivity, Total Ca, Total Mg, Total K, Total Na, CEC and moisture contents of the CM at different season used in the experiments were determined and depicted in Table 3.

Soil parameters	**Soil Belg (short rain season - February to May)**	**Rating**	**Soil meher (long rain season- June to October)**	**Rating**	**References**
Bd (g cm^{-3})	1.37	Medium	1.38	Medium	[34]
PD (g cm^{-3})	2.58	Medium	2.6	Medium	[34]
%porosity	46.8		46.92		[35]
%Sand	57	Textural Class	56	Textural class	
%Silt	18	Sandy clay loam	16	Sandy clay loam	
%Clay	25	Sandy clay loam	28	Sandy clay loam	
pH	5.01	Strongly acidic	4.8	Very strongly acidic	[31]
EC(μs/cm)	169	Very low	85	Very low	[37]
N (g kg^{-1})	0.1	low	0.08	Low	[31]
Exchangeable Ca (Cmol (+) kg-1 soil)	6.5	Medium	6.3	Medium	[38]
Exchangeable Mg (Cmol (+) kg^{-1} soil)	2.1	Moderate	1.4	Moderate	[38]
Exchangeable K (Cmol (+) kg^{-1} soil)	0.42	High	0.36	High	[38]
Exchangeable Na (Cmol (+) kg^{-1} soil)	0.06	Very low	Nil	Very low	[39]
CEC (Cmol (+) kg^{-1} soil)	20	Medium	19.3	Medium	[40]
Pbs (%)	45.4	Medium	41.7	Medium	[40]
Exchangeable Al (Cmol (+) kg^{-1} soil)	2.01	High	2.46	High	[40]
Exchangeable acidity (Cmol (+) kg^{-1} soil)	3.83	High	3.82	High	[40]
O:C (g kg^{-1})	1.2	Low	1.02	Low	[31]
N (g kg^{-1})	0.1	low	0.08	Low	[31]
C:N	12	low	12.75	low	[40]
Available P (mg kg^{-1})	5.5	Low	5	Low	[41]
Cu (mg kg^{-1}) (DTPA)	8	High	6	High	[41]
Fe (mg kg^{-1}) (DTPA)	120	High	80	High	[41]
Zn (mg kg^{-1}) (DTPA)	1.5	High	1.2	High	[41]
Mn(mgkg^{-1}) (DTPA)	25	High	20	High	[41]

Table 2: Selected physico-chemical characteristics of soil of the experimental sites.

Cattle manure(CM)		
Parameters	**Belg (short rain season-February to May)**	**Meher (long rain season- June to October)**
pH	6.8	7.1
Electrical conductivity (mS cm^{-1})	182	148
Organic carbon (g kg^{-1})	25	22
Total N (g kg^{-1})	1.92	1.6
C: N	01:13.0	1;13.75
Totoal phosphorous P_2O_5(%)	1.374	1.19

Total CaO cmol (+) kg^{-1}	7.854	6.748
Total Mg MgO cmol (+) kg^{-1}	1.33	0.99
Total K K_2O cmol (+) kg^{-1}	4.674	5.22
Total Na cmol (+) kg^{-1}	0.07	0.09
CEC (cmol (+) kg^{-1}	38	32
Moisture content (%)	78	81

Table 3: Organic matter, N, P, K, pH, Total N, Ca, Mg, K, Na, CEC, EC and moisture content of of the substrates used in the experiment in Belg and Meher season at Abelo area masha district south west Ethiopia.

Yield components and yield

Effect of combined use of cattle manure with mineral NP dosages on yield component and yield parameter parameters at masha in Belg and Meher season: The effect of increased combined rate was found highly significant (p<0.001) on yield parameters such as Marketable tuber number and total number and average tuber weight (Table 4).

Total tuber number (count/hill): Increasing the application of dosage of cattle manure and mineral NP increased total tuber number per hill from 10.4880 -13.2975 counthill-1 and 9.504- 11.076 counthill^{-1} in Belg and Meher season respectively (Table 4). This can be attributed to the increased vegetative growth of the potato plant and then potato tubers set per unit. The current result is inconsistent with the work of many researchers in addition to others who reported that combined had use of 5.0 t/ha CM+50% RDF increases tuber number as compared to 100% Mineral NP and zero application of fertilizers. In the present study, raising the rate of applied Cattle manure from 0-7.5 t CM+75% RDF ha^{-1} increased total tuber number by 26.7 and 18.1% in Belg and Meher season respectively. It was observed at both seasons, Total tuber number increased when highest rate of cattle manure (7.5 tha^{-1}) was combined with the highest rate (75%) of the recommended mineral NP. whereas the lowest total tuber number (10.4880 counthill^{-1}) in Belg season and (9.504 counthill^{-1}) in Meher season was recorded at zero application of mineral NP and 7.5 tha^{-1} cattle manure in lined with this. It is reported the lowest marketable tuber number was obtained in the zero application of fertilizers.

Treatment*	2016 Belg season			2016 Meher season		
	Marketable tuber number counthill^{-1}	Unmarketable tuber number counthill^{-1}	Total tuber number	Marketable tuber number	Unmarketable tuber number counthill^{-1}	Total tuber number counthill^{-1}
T3	6.92^{ef}	3.9	10.82^{d}	7.94^{c}	2.25	10.198^{cd}
T4	7.25^{de}	3.72	10.97^{d}	8.220^{ab}	2.0128	10.23^{bcd}
T5	7.92^{d}	3.12	11.04^{d}	8.251^{ab}	2.0115	10.262^{bcd}
T6	8.06^{cd}	3.12	11.18^{cd}	8.280^{ab}	1.995	10.27^{bcd}
T7	8.08^{bcd}	4.1	12.18^{cd}	8.298^{ab}	1.9827	10.28^{bcd}
T8	8.96^{bac}	3.26	12.22^{bc}	8.354^{ab}	2.4689	10.823^{abc}
T9	9.04^{ba}	3.2	12.24^{ab}	8.685^{a}	2.1428	10.828^{abc}
T10	9.20^{a}	3.93	13.09^{ab}	8.692^{a}	2.2041	10.89^{ab}
T11	9.72^{a}	3.57	13.29^{a}	8.706^{a}	2.3702	11.076^{a}
T2	6.87^{ef}	3.82	10.70^{d}	7.591^{c}	2.2649	9.856^{de}
T1	6.20^{f}	4.28	10.49^{d}	7.372^{c}	2.132	9.504^{e}
LSD (5%)	0.97	0.58	1.054	0.583	0.62	0.669
Sig	**	NS	**	**	Ns	**
CV (%)	7.124	25.35	5.3	4.17	49.75	3.78

Values sharing similar letters in a column do not differ significantly at P<0.05, according to Fisher's LSD test LSD least significant difference, CV coefficient of variation, T1= Control, T2=100%RDF, T3=2.5 t CM+25%RDF, T4=2.5 t CM +50% RDF, T5=2.5 t CM+75% RDF, T6. =5 t CM+25% RDF, T7=5 t CM+50% RDF, T8=5 t CM+75% RDF, T9=7.5 t CM+25% RDF, T10=7.5 t CM+50% RDF, T11=7.5 t CM+75% RDF.

Table 4: Marketable tuber number (MTN), Unmarketable tuber number (UTN) and total tuber number (TTN) of potato as influenced by the integrated nutrient management in Belgand Meher, season at abelo area Masha district sheka zone southwestern Ethiopia.

Marketable tuber number (counthill^{-1}): Marketable tuber number increased with the increased rate of cattle manure and mineral NP. Hence, increasing rate of Cattle manure and mineral NP application from 0-7.5 t CM+75% RDF ha^{-1} increased marketable tuber number from 6.2046-9.72 and 9.50-11.08/hill without affecting the unmarketable tuber number (Table 4). This could be probably since marketable tuber number increases at the highest integration rate because the combined use of warm-compost and mineral NP can trigger the vegetative growth and development. Application of 7.5 t CM+75% RDF ha^{-1} increased marketable tuber number by 56.7% and 50.2% in both Belg and Meher season as compared to control or no cattle manure and mineral NP application [42,43].

Total tuber yield: Increasing the application rates of combined use of cattle manure and mineral NP resulted in increasing the total tuber yield from 25.780 to 40.202 t ha^{-1} and22.634-34.221 (Table 5). While the highest yield was obtained at 7.5 t CM+75% RDF ha^{-1} but the lowest yield was obtained at zero dosage of cattle manure and mineral NP application. Increasing the application rates of cattle manure and mineral NP from zero to 7.5 t YM+75% RDF ha^{-1} increased total tuber yield by 55.9%, 42.90% and 51.19%, 36.64% in both Belg and Meher season as compared to zero and 100% Mineral NP application of fertilizers respectively. This show there is an opportunity for additional gain in tuber yield through the further application of more rates of combined cattle manure with mineral NP fertilizers above 7.5 t CM +75% RDF ha^{-1}, respectively. This result is in line with the finding of researchers who reported that Combined administration of cattle manure and mineral fertilizers increased the total tuber yield [44-46].

Results have shown that all the treatments increased Total tuber yield in both Belg and Meher season as compared to control in both Belg and Meher season but the increment in total tuber yield is higher in Belg season than Meher season.

According to the current investigation the results obtained in terms of the following yield parameters such as marketable tuber yield (MTY), unmarketable tuber yield (UMTY), and total tuber yield (TTY), average tuber weight (ATW) of potato as influenced by combined use

Treatment*	2016 Belg season				2016 Meher season			
	Marketable yield (ghill^{-1})	Unmarketable yield (ghill^{-1})	Total Tuber yield (tha^{-1})	Average tuber mass (ghill^{-1})	Marketable yield (ghill^{-1})	Unmarketable yield (ghill^{-1})	Total yield (tha^{-1})	Average tuber mass g/hill^{-1}
T3	21.940^{ef}	7.358	29.30^{de}	60.91^{bcd}	21.51^{de}	5.029	26.54^{de}	58.64^{de}
T4	22.368^{ef}	3.863	29.90^{d}	61.33^{bcd}	22.26^{cd}	5.722	27.98^{d}	61.59^{cde}
T5	22.807^{def}	7.426	30.29^{d}	61.66^{abcd}	22.87^{cde}	5.223	28.25^{d}	61.82^{cd}
T6	23.129^{def}	7.858	30.98^{d}	62.46^{abc}	23.092^{bcde}	5.223	28.31^{d}	62.00^{cd}
T7	24.018^{cde}	11.049	35.06^{c}	64.85^{ab}	24.22^{bcd}	4.514	28.73^{cd}	63.12^{bc}
T8	24.734^{bcd}	11.261	35.99^{bc}	66.235^{ab}	24.66^{bc}	6.219	30.88^{bc}	64.15^{bc}
T9	25.903^{abc}	10.867	36.77^{abc}	67.54^{ab}	24.86^{bc}	6.27	31.13^{b}	64.65^{bc}
T10	26.895^{ab}	12.703	39.60^{ab}	68.07^{a}	25.876^{ab}	6.583	32.459^{ab}	67.06^{ab}
T11	27.491^{a}	12.711	40.20^{a}	68.08^{a}	28.700^{a}	5.521	34.221^{a}	69.53^{a}
T2	21.118^{f}	7.019	28.137^{de}	59.16^{cd}	21.42^{de}	3.592	25.044^{e}	57.24^{ef}
T1	14.045^{g}	11.735	25.780^{e}	55.312^{d}	21.280^{e}	1.354	22.63^{f}	53.61^{f}
LSD (5%)	4.5849	1.423	3.78	6.73	2.88	0.96	2.26	4.43
Sig	**	NS	**	**	**	NS	**	**
CV (%)	6.68	9.06	8.77	3.67	7.14	7.31	4.62	4.19

Table 5: Cattle manure and mineral NP in Belg and Meher season at Abelo area mash district, southwestern Ethiopia.

Marketable tuber yield: The highest marketable tuber yield (27.491 and 28.700 t ha^{-1}) were recorded at 7.5 t CM in combination with 75% RDF ha^{-1} but the lowest marketable tuber yield (14.045 and 21.280 tha^{-1} was obtained from the combination of zero levels of cattle manure and mineral NP. The combined application of cattle manure and mineral NP showed significant differences in marketable tuber yield (Table 6), indicating that the effect of different levels of cattle manure and mineral NP on marketable tuber yield is dependent on the levels of cattle manure and mineral NP. This may be due to the positive interaction and Complementary effect between cattle manure and mineral NP in affecting and increasing the marketable tuber yield.

Average tuber weight: The highest average weight of tubers (68.08 g and 69.53 g) were found in the treatment that received 7.5 t CM with 75% RDF ha^{-1} in Belg and Meher season respectively and this value was Statistical similar with the application of and the lowest average weight of tubers (55.31 g and 53.61 g) were obtained in the treatments that received no cattle manure and mineral NP. The increased application rate of combined use of Cattle manure and mineral NP from 0-7.5 t CM with 75% RDF ha^{-1} increased average tuber weight by 23.08 and 29.68% as compared to the control in both Belg and Meher season respectively.

Citation: Isreal Z, Tana T, Wogi L, Mohammed A (2018) Effect of Combined Use of Cattle Manure and Inorganic Nitrogen and Phosphorus on Yield Components Yield and Economics of Potato (*Solanum tuberosum* L.) in Belg and Meher Season at Abelo Area Masha District, South-Western Ethiopia. J Agri Sci Food Res 9: 214.

Economic evaluation

In this study, fixed costs were not considered and the highest net return of 91704.6, Birr ha^{-1} in Belg and (119887 ETBha^{-1}) in a Meher season was recorded at the same rate (Tables 7 and 8). Further, the Net benefit increased with increasing dosage of farmyard manure and mineral NP application that was most probably due to better improvement of soil condition that consequently resulted in increased tuber yield. Again, there was variation between two seasons in net benefit because of higher market price in Meher season thought the yield is generally less from Belg season though there were additional input costs fungicide application whereas the highest total variable cost of (7263, ETBha^{-1}) in Belg and (9263, ETBha^{-1}) in Meher was recorded from the combined use of 7.5 t CM+75% RDF further except for the four treatments (T2, T5, T7, T8) in Belg and five treatments (T3, T2, T5, T7, T8) in Mhere all other treatments (T1, T3, T4, T6, T9, T10, T11) in Belg and (T1, T4, T6, T9, T10, T11) in Meher were found to be non-dominated and thus, selected for the analysis of the marginal rate of return (MRR).

Moreover, the highest marginal rate of return (Tables 3 and 4) was recorded for the latter treatment T7. 5 t CM+50% RDF, (1974.02%) followed by T6. 5 t CM+25% RDF (1043.88%), T3. 2.5 t CM+25%RDF (929.59%) in Belg season and the highest marginal rate of return of T9. 7.5 t CM+25% RDF (1552.33%) followed by T6. 5 t CM+25% RDF (1463.257), T11. 7.5 t CM+75% RDF (908.17%) in Meher season

This indicates that, for every 1 Birr ha^{-1} invested in the respective treatments, there was a rate of return of 197.40 Birr ha^{-1}, 104.388 Birr ha^{-1}, and 92.96 Birr ha^{-1}. In Belg and 15.52 Birr ha^{-1}, 146.32 Birr ha^{-1}, 90.81 Birr ha^{-1}.

In this study, fixed costs were not considered and the highest net return of 91704.6, Birr ha^{-1} in Belg and (119887 ETBha^{-1}) in a Meher season was recorded at the same rate. Further, the Net benefit increased with increasing dosage of farmyard manure and mineral NP application that was most probably due to better improvement of soil condition that consequently resulted in increased tuber yield. Again, there was variation between two seasons in net benefit because of higher market price in Meher season thought the yield is generally less from Belg season though there were additional input costs fungicide application whereas the highest total variable cost of (7263, ETBha^{-1}) in Belg and (9263, ETBha^{-1}) in Meher was recorded from the combined use of 7.5 t CM+75% RDF further except for the four treatments (T2, T5, T7, T8) in Belg and five treatments (T3. T2 T5. T7 T8) in Mhere all other treatments (T1, T3, T4, T6, T9, T10, T11) in Belg and (T1, T4, T6, T9, T10, T11) in Meher were found to be non-dominated and thus, selected for the analysis of the marginal rate of return (MRR).

Moreover, the highest marginal rate of return (Tables 3 and 4) was recorded for the latter treatment T7. 5 t CM+50% RDF, (1974.02%) followed by T6. 5 t CM+25% RDF (1043.88%), T3. 2.5 t CM+25%RDF (929.59%) in Belg season and the highest marginal rate of return T9. 7.5 t CM+25% RDF (1552.33%) followed by T6. 5 t CM+25% RDF (1463.257), T11. 7.5 t CM+75% RDF (908.17%) in Meher season.

This indicates that, for every 1 Birr ha^{-1} invested in the respective treatments, there was a rate of return of 197.40 Birr ha^{-1}, 104.388 Birr ha^{-1}, and 92.96 Birr ha^{-1}. In Belg and 15.52 Birr ha^{-1}, 146.32 Birr ha^{-1}, 90.81 Birr ha^{-1}.

Treatment *	A.Y (kg/ha)	Adjusted yield (kg ha	Gross field Benefit (4 Birr kg^{-1})	Cost of cattle manure preparation (25 Birr man-day^{-1})	Cost of cattle manure application (25 Birr manday^{-1})	Cost of Urea (8 ETB)	Cost of TSP (10.00 k)	Cost of fertilizer application (25 Birr man-day $^{-1}$)	Total variable cost (Eth. Birr)	Net benefit ETBha^{-1}	D
T1	14.045	12640.5	50562	0	0	0	0	0	0	50562	ND
T3	21.94	19746	78984	500	1000	718	442.5	100	2760.5	76223.5	ND
T4	22.368	20131.2	80524.8	500	1000	1436	885	200	4021	76503.8	ND
T6	23.129	20816.1	83264.4	1000	2000	718	442.5	100	4260.5	79003.9	ND
T9	25.903	23312.7	93250.8	2154	1327.5	718	442.5	100	4742	88508.8	ND
T2	21.118	19006.2	76024.8	0	0	2872	1770	400	5042	70982.8	ND
T5	22.807	20526.3	82105.2	500	1000	2154	1327.5	300	5281.5	76823.7	D
T7	24.018	21616.2	86464.8	1000	2000	1436	885	200	5521	80943.8	D
T10	26.895	24205.5	96822	2154	1327.5	1436	885	200	6002.5	90819.5	ND
T8	24.734	22260.6	89042.4	1000	2000	2154	1327.5	300	6781.5	82260.9	D
T11	27.491	24741.9	98967.6	2154	1327.5	2154	1327.5	300	7263	91704.6	ND

D=dominant, ND=non-dominant, 1 Ethiopian Birr=0.043 United States Dollar (June,2016), T1=Control, T2=100%RDF, T3=2.5 tCM+25%RDF, T4=2.5 tCM+50%RDF, T5=2.5 tCM+75% RDF, T6=5 t CM+25% RDF, T7=5 t CM+50% RDF, T8=5 t CM+75% RDF, T9=7.5 t CM+25% RDF, T10=7.5 t CM+50% RDF, T11=7.5 t CM+75% RDF, RDF=Recommended Dose of mineral NP Fertilizer, CM=Cattle Manure in t ha^{-1}.

Table 6: Results of partial budget analysis to estimate the net benefit of combined use of cattle manure and mineral NP of potato in 2016 Belg season, at abelo area Masha district sheka zone southwestern Ethiopia.

Citation: Isreal Z, Tana T, Wogi L, Mohammed A (2018) Effect of Combined Use of Cattle Manure and Inorganic Nitrogen and Phosphorus on Yield Components Yield and Economics of Potato (*Solanum tuberosum* L.) in Belg and Meher Season at Abelo Area Masha District, South-Western Ethiopia. J Agri Sci Food Res 9: 214.

In line with this result, it is also reported that the application of 120 kg N+92 kg P+30 t CM ha^{-1} on potato Variety belte 2012 and 2013 cropping season Clay loam soils at Kobo District North-Eastern Ethiopia. Gave the highest net return of 218% as compared to the control in addition, reported that smallholder farmers should apply higher rates of CM together with inorganic fertilizers to improve cost of potato production [47-51] (Tables 7-9).

Treatment*	Total Variable cost (Eth. Birr)	Marginal costs (Eth. Birr)	Net benefit (Eth. Birr)	Marginal net benefits (Eth. Birr)	Marginal rate of return (%)
T1	0		50562		
T3	2760.5	2760.5	76223.5	25661.5	929.5961
T4	4021	1260.5	76503.8	280.3	22.23721
T6	4260.5	239.5	79003.9	2500.1	1043.883
T7	4742	481.5	88508.8	9504.9	1974.019
T10	6002.5	1260.5	90819.5	2310.7	183.3161
T11	7263	1260.5	91704.6	885.1	70.23

T1=Control, T3=2.5 t CM+25%RDF, T4=2.5 t CM +50% RDF T6. 5 t CM+25% RDF, T7=5 t CM+50% RDF T10. 7.5 t CM+50% RDF T10=7.5 t CM+50% RDF, T11. 7.5 t CM+75% RDF, RDF=Recommended Dose of mineral NP Fertilizer, CM=Cattle Manure in t ha^{-1}.

Table 7: The marginal rate of return for NP fertilizers and Cattle manure for potato production in Belg season.

Treatment *	A.Y (kg/ha)	Adjusted yield (kg ha	Gross field Benefit (5 Birr kg^{-1})	Cost of cattle manure preparation (20 Birr man-day $^{-1}$)	Cost of cattle manure application (20 Birr $Monday^{-1}$)	Cost of Urea (8 ETB)	Cost of TSP (10.00 k)	Cost of fertilizer application (25 Birr man-day $^{-1}$)	cost application of fungicide	Total variable cost (Eth. Birr)	Net benefit (Eth. Birr)	D
T1	21.28	19152	95760	0	0	0	0	0	2000	2000	93760	ND
T3	21.51	19359	96795	500	1000	718	442.5	100	2000	4760.5	92034.5	D
T4	22.26	20034	100170	500	1000	1436	885	200	2000	6021	94149	ND
T6	23.092	20782.8	103914	1000	2000	718	442.5	100	2000	6260.5	97653.5	ND
T9	24.86	22374	111870	2154	1327.5	718	442.5	100	2000	6742	105128	ND
T2	21.42	19278	96390	0	0	2872	1770	400	2000	7042	89348	D
T5	22.87	20583	102915	500	1000	2154	1327.5	300	2000	7281.5	95633.5	D
T7	24.22	21798	108990	1000	2000	1436	885	200	2000	7521	101469	D
T10	25.876	23288.4	116442	2154	1327.5	1436	885	200	2000	8002.5	108439.5	ND
T8	24.66	22194	110970	1000	2000	2154	1327.5	300	2000	8781.5	102188.5	D
T11	28.7	25830	129150	2154	1327.5	2154	1327.5	300	2000	9263	119887	ND

T1=Control, T3=2.5 t CM+25%RDF, T4=2.5 t CM +50% RDF, T6=5 t CM+25% RDF, T9=7.5 t CM+25% RDF, T2=100%RDF, T5. 2.5 t CM+75% RDF, T7=5 t CM+50% RDF, T10=7.5 t CM+50% RDF, T8=5 t CM+75% RDF=T11. 7.5 t CM+75% RDF.

Table 8: Results of partial budget analysis to estimate net benefit of combined use of cattle manure and mineral NP of potato in 2016 Meher season, at abelo area Masha district sheka zone southwestern Ethiopia.

Treatment*	Total variable cost (Eth. Birr)	Marginal costs (Eth. Birr)	Net benefit (Eth. Birr)	Marginal net benefits (Eth. Birr)	Marginal rate of return (%)
T1	2000		93760		
T4	6021	4021	94149	389	9.67421
T6	6260.5	239.5	97653.5	3504.5	1463.257
T9	6742	481.5	105128	7474.5	1552.336
T10	8002.5	1260.5	108440	3311.5	262.7132
T11	9263	1260.5	119887	11447.5	908.1714

T1=Control, T4=2.5 t CM+50% RDF, T6=5 t CM+25% RDF, T9=7.5 t CM+25% RDF, T10=7.5 t CM+50% RDF, T11=7.5 t CM+75% RDF.

Table 9: The marginal rate of return for NP fertilizers and Cattle manure for potato production in Belg season at abelo area Masha district sheka zone southwestern Ethiopia.

Conclusion

Potato growth, development and high yield depend on soil properties, climatic conditions, The result of most of growth, yield component yield, quality economic evaluation and soil analysis indicated the fertility of the soil at Masha is very low and that is why all treatments with the combined use of cattle manure and mineral NP gave a higher tuber yield than the treatment with either no fertilizer or sole application of mineral NP, which gave a very low yield. Application of CM has a residual effect for the next cropping seasons. The combined application of mineral NP and cattle manure (CM) gave a better result than the application of sole, which indicates integrated nutrient management is the best method for soil fertility management. This is due to cattle manure contains more calcium and magnesium and raises the pH electrical conductivity, exchangeable bases present pore space and reduces bulk density and particle density per ton on a dry weight basis. Therefore, applying manure to acid soils not only supply much needed nutrients and organic matter for plant growth but also reduce soil acidity, thus improve phosphorus availability and reduce aluminum toxicity. In Masha south west Ethiopia, many fields are acidic, and cattle manure would be a good amendment. Hence, the usage of 165 kg N 60 kg P+7.5 t CMha^{-1} can be recommended for better potato production, productivity, economic feasibility at abelo area Masha District. Yields varied slightly due to seasonal effects Yields were slightly higher in the short rainy (Belg) season than the long rainy (Meher) season.

Acknowledgements

We thank Ministry of Education (MoE), Ethiopia for Financial support and Haramaya University and Teppi and Hawsa soil Testing Research Center also deserve special thanks for facilitating the finance and for providing the required research supply, respectively. We also acknowledge the staff members, especially laboratory technicians at Teppi Soil Testing research Centre the sustainable land management (SLM) project in Masha District Sheka zone is highly acknowledged for providing Cattle manure and sponsoring the laboratory cost incurred for this work.

References

1. Zewide I, Mohammed A, Tulu S (2012) Effect of different rates of nitrogen and phosphorus on yield and yield components of potato (Solanum tuberosum L.) at Masha District, Southwestern Ethiopia. International Journal of Soil Science 7: 146.
2. Mahajan AN, Bhagat RM, Gupta RD (2008) Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. SAARC Journal of Agriculture 6: 29-32.
3. Compaore E, Cattan P, Taonda JB (2011) Effect of Continuous Mineral and Organic Fertilizer Inputs and Plowing on Groundnut Yield and Soil Fertility in a Groundnut–Sorghum Rotation in Central Burkina Faso. In: Innovations as Key to the Green Revolution in Africa, pp: 597-603.
4. Tadesse T, Dechassa N, Bayu W, Gebeyehu S (2013) Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. American Journal of Plant Sciences 4: 309.
5. Satyanarayana V, Vara Prasad PV, Murthy VR, Boote KJ (2002) Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. Journal of Plant Nutrition 25: 2081-2090.
6. Mengistu DK, Mekonnen LS (2012) Integrated agronomic crop managements to improve Tef productivity under terminal drought. In: Water Stress. In Tech.
7. Godara AS, Gupta US, Singh RA (2012) Effect of integrated nutrient management on herbage, dry fodder yield and quality of oat (Avena sativa L.). Forage Research 38: 59-61.
8. Yadav SK, Babu S, Yadav MK, Singh K, Yadav GS, et al. (2013) A review of organic farming for sustainable agriculture in Northern India. International Journal of Agronomy, pp: 1-8.
9. Zhao J, Ni T, Li J, Lu Q, Fang Z, et al. (2016) Effects of organic–inorganic compound fertilizer with reduced chemical fertilizer application on crop yields, soil biological activity and bacterial community structure in a rice–wheat cropping system. Applied Soil Ecology 99: 1-12.
10. Agegnehu G (2009) Ameliorating effects of organic and inorganic fertilizers on crop productivity and soil properties on reddish-brown soils. In: Improved natural resource management technologies for food security, poverty reduction, and sustainable development. Proceedings of the 10 th conference of the Ethiopian Society of Soil Science, pp: 25-27.
11. Farah GA, Dagash YM, Yagoob SO (2014) Effect of Different Fertilizers (Bio, Organic and Inorganic Fertilizers) on Some Yield Components of Rice (Oryza Sativa L.). Universal Journal of Agricultural Research 2: 67-70.
12. Agegnehu G, Amede T (2017) Integrated soil fertility and plant nutrient management in tropical agro-ecosystems: A review. Pedosphere 27: 662-680.
13. Zhu K, Christel W, Bruun S, Jensen LS (2014) The different effects of applying fresh, composted or charred manure on soil N_2O emissions. Soil Biology and Biochemistry 74: 61-69.
14. Castellanos-Navarrete A, Tittonell P, Rufino MC, Giller KE (2015) Feeding, crop residue and manure management for integrated soil fertility management–A case study from Kenya. Agricultural Systems 134: 24-35.
15. Mekonnen D, Pant LM, Dechassa N (2006) Effects of integrated nutrient management on agronomic performance of potato (Solanum tuberosum. L.) and fertility of nitosol at Bako. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University, p: 76.
16. Boke S (2014) Effect of organic and inorganic fertilizer application and seedbed preparation on potato yield and soil properties on alisols of Chencha. International Journal of Natural Sciences Research 2: 123-132.
17. Masrie B, Dechassa N, Tana T, Alemayehu Y, Abebie B (2015) The Effects of Combined Application of Cattle Manure and NP Fertilizers on Yield and Nutrient Uptake of Potato in North-Eastern Ethiopia. Journal of Science and Sustainable Development 3: 1-23.
18. Ameneshewa W (2015) Department of Geography and Environmental Studies (Doctoral dissertation, Addis Ababa University).
19. Gizaw B (2009) Geographical location and agro-ecological variation of Kaffa Zone. MSc. Thesis. Addis Ababa University, Addis Ababa, Ethiopia.
20. Kassa H, Dondeyne S, Poesen J, Frankl A, Nyssen J (2017) Transition from forestbased to cerealbased agricultural systems: A review of the drivers of land use change and degradation in Southwest Ethiopia. Land Degradation & Development 28: 431-449.
21. MoARD (Ministry of Agriculture and Rural Development) (2012) Crop Development Department of Crop Variety Register. Issue No. 10. Addis Ababa, Ethiopia.
22. Day PR (1965) Hydrometer method of particle size analysis. In: Methods of soil analysis. Agronomy Part I, No. 9, American Society of Agronomy. Madison, Wisconsin, USA, pp: 562-563.
23. Page AL (1982) Methods of Soil Analysis. Part II. Chemical and Microbiological Properties. Madison, USA.
24. Walkley A, Black IA (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.
25. Jackson ML (1958) Soil Chemical Analysis. Prenstice-Hall, Inc., Engle Wood Cliffs. New Jersey, pp: 183-204.
26. Bray RH, Kurtz LT (1945) Determination of total, organic, and available forms of phosphorus in soils. Soil science 59: 39-46.
27. Rowell DL (1994) Soil Science: Methods and Applications. Addison Wesley Longman Limited, England, p: 350.
28. Lung'aho C, Lemaga B, Nyongesa M, Gildermacher P, Kinyale P, et al. (2007) Commercial seed potato production in eastern and central Africa. Kenya Agric, Inst p: 140.
29. SAS (Statistical Analysis System) (2003) SAS Version 9.1.2 © 2002-2003". SAS Institute, Inc., Cary, North Carolina, USA.

30. Gomez KA, Gomez AA (1984) Statistical procedures for Agricultural research. John Wiley & Sons.
31. Tadesse T, Haque I, Aduayi EA (1991) Soil, plant, water, fertilizer, animal manure and compost analysis manual. ILCA/PSD Working Document (ILCA).
32. Black CA (1965) Methods of soil analysis. American Society of Agronomy 1: 1570-1572.
33. Okalebo JR, Gathua KW, Woomer PL (2002) Laboratory methods of Soil and Plant Analysis: a working manual second edition. Sacred Africa, Nairobi, Kenya.
34. Barauah TC, Barthakulh HP (1997) A textbook of Soil Analysis. Vikas Publishing House, New Delhi, India, p: 334.
35. Hillel D (2003) Introduction to environmental soil physics. Elsevier.
36. Edwin R, Murdock L (2015) Lime and Nutrient Recommendations, Cooperative extension service University of Kentucky College of Agriculture. Food and Environment, Lexington, USA, p: 40546.
37. EthioSIS (Ethiopia Soil Information System) (2014) Soil fertility status and fertilizer recommendation atlas for Tigray regional state, Ethiopia.
38. FAO (Food and Agriculture Organization) (2006) Plant nutrition for food security: A guide for integrated nutrient management. FAO, fertilizer and plant nutrition bulletin 16, Rome, Italy.
39. Landon JR (1991) Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York, p: 474.
40. Hazelton P, Murphy B (2016) Interpreting soil test results: What do all the numbers mean? CSIRO publishing.
41. Jones JB (2003) Agronomic Handbook: Management of Crops, Soils, and Their Fertility. CRC Press LLC, Boca Raton, FL, USA, p: 482.
42. Jamaati-e-Somarin S, Zabihi-e-Mahmoodabad R, Yari A (2010) Response of agronomical, physiological, apparent recovery nitrogen use efficiency and yield of potato tuber (Solanum tuberosum L) to nitrogen and plant density. American-Eurasian J Agric Environ Sci 9: 16-21.
43. Mekonen S, Bekele B, Tadesse T, Gurmu F (2016) Evaluation of exotic an d locally adapted sweet potato cultivars to major viruses in Ethiopia. Greener J Agric Sci 6: 69-78.
44. Najm AA, Hadi MR, Fazeli F, Darzi MT, Rahi A (2012) Effect of integrated management of nitrogen fertilizer and cattle manure on the leaf chlorophyll, yield, and tuber glycoalkaloids of Agria potato. Communications in Soil Science and Plant Analysis 43: 912-923.
45. Balemi T (2012) Effect of integrated use of cattle manure and inorganic fertilizers on tuber yield of potato in Ethiopia. Journal of soil Science and Plant Nutrition 12: 253-261.
46. Kabira JN (2017) Effect of inorganic fertilizer and cattle manure on growth and yield of two Kenyan potato varieties. International Journal of Agronomy and Agricultural Research 10: 65-72.
47. Dasgupta S, Sarkar A, Chaitanya AK, Saha A, Dey A, et al. (2017) Response of Potato Crop to Integrated Nutrient Management in the Indo-Gangetic Alluvial Soils of West Bengal, India, 16: 1-10.
48. Detebo A, Dechassa N, Tana T (2014) Influence of np fertilizer and cattle manure on performance of potato (solanum tuberosum l.) In: meta district, eastern ethiopia, MSc Thesis, Haramaya University, Haramaya, Ethiopia.
49. Ferdous Z, Anwar M, Uddin N, Ullah H, Hossain A (2017) Yield performance of Okra (Abelmoschus esculentus) through integrated nutrient management. International Journal of Biosciences 10: 294-301.
50. Kakraliya SK, Jat RD, Kumar S, Choudhary KK, Prakash J, et al. (2017) Integrated Nutrient Management for Improving, Fertilizer Use Efficiency, Soil Biodiversity and Productivity of Wheat in Irrigated Rice Wheat Cropping System in Indo-Gangatic Plains of India. International Journal of Current Microbiology and Applied Sciences 6: 152-163.
51. N'Dayegamiye A, Nyiraneza J, Giroux M, Grenier M, Drapeau A (2013) Manure and paper mill sludge application effects on potato yield, nitrogen efficiency and disease incidence. Agronomy 3: 43-58.