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The Effects of Combined Application of Cattle manure And Mineral Nitrogen And Phosphorus Fertilizer on Growth, Biomass Yield, And Quality of Potato (*Solanum Tuberosum L*) Tuber in Abelo area at Masha District sheka Zone, South-Western Ethiopia

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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 Belgand 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, biomass yield, quality, of potato tuber. The treatments comprised combinations of three rates (2.5,5, 7.5t ha^{-1}) of CM with 25%, 50% and 75% of recommended rates of mineral NP, respectively. In addition, 100% recommended rate of mineral NP for the experimental site (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 t ha^{-1} CM combined with 75% mineral NP gave significantly Days to 50% flowering by 7 daysi.e. From 56-6 and14 daysi.e. from 51-65, days to 50% maturity by 5 daysi.e. from (101-106) and 13 days from (95-108) and increases plant height from 56-69 and 63-78, Increase shoot fresh weight by 39.66% from (1274.59- 1780.2 $ghill^{-1}$) and 36.66% from (1213.91 -1658.99 $ghill^{-1}$) and shoot dry weight by 46.8% from (40.4 ghill-1 to 59.333 $ghill^{-1}$) and 41.66% from (40 to 56.667 $ghill^{-1}$),increased dry matter content from (21.085-25.782) and (22.36 to 24.47), specific gravity from (1.083- 1.107) and (1.092 -1.101) reduces small tuber size percentage Form (27.306 to 17.069) and (43.946 -14.267) and improves medium size tubers from (65.56 to 74.79) and (44.58 to 80.26) in Belg and Meher season as compared to zero application. Respectively. 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 (123.75kg N ha^{-1} and 103.05kg P_2O_5 ha^{-1}) can significantly increases growth, biomass yield, improvement in tuber quality.

Keywords: Biomass Yield; Cattle Manure; Nitrogen; Phosphorous; Tuber Quality

Introduction

Potato(*Solonaumtuberosum 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 cropland 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 [2,3,4].

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 thereby provide a better environment for root growth by improving the soil structure [6,7].

Many research findings have shown that neither mineral fertilizers nor organic sources alone can result in sustainable productivity [5,8,9]. 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 [9]. 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 [47,39]. Several researchers [2,10,11,12] have verified the beneficial effect of integrated nutrient management in moderating the deficiency of a number of 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.

Cattle manure is adecayed 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].

reported high tuber yield of potato was obtained when CM (cattle manure) at the rate of 10qha^{-1} was combined with mineral nitrogen at 111 kg t ha^{-1} and phosphorous at 90 kg P_2O_5 ha^{-1} on Nitosol, of Bako Ethiopia[15].

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^{-1}00^{-1}00 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[16].

stated that application of 30 t ha^{-1} cattle manure along with nitrogen at 120kg 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. In addition, Isreal etal 2012 recomende 165Kg N and 60 Kg P205 is optimum for potato production at masha districets outhe westen Ethiopia [17].

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.

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 Belg (February- to May) and Meher (June to October). The study site of Masha district located at UTM WGCs 1984 Zone 36N between 861,000MN - 873,000MN latitude and 105,000 - ,000ME. Longitude Attitudinally1642 to 2025 m.a.s.l (Isreal et al 2018)

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) [65].

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^{-1}20 days. The yield ranges from 29.13 t ha^{-1}under farmers 44.8 t ha^{-1} under research Source (MARD, et, al 2012)

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 2.1).

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 Mashadistinct 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 for specific site (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. Where T1= Control, T2 =100%RDF, T3=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+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 the experiment was laid out in a randomized complete block design with three replications.

Each block and plots within ablock 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 × 3m (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 2.2. 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 [20]; soil pH and electrical conductivity of the soils were measured in water (1: 2.5 soil: water ratio). by digital pH and Ec meter[21]; soil organic carbon by wet digestion method and total N by Kjeldhal method[23,24]. Available phosphorous was determined by the Cation Exchange Capacity (CEC) was determined using 1M-neutral ammonium acetate [25,26].

Exchangeable acidity (Al and H) was determined by saturating the soil samples with 1M KCl solution and titrated with 0.02 M NaOH as described by [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

In order 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 20q ha^{-1} in the first week of February 2016.

Crop data collection

Data on crop phenology, growth, yield components and yield were measured from randomly selected plants on a plot basis. Net plot size was used for measuring yield and yield components of potato. The data recording and measurements for each character were carried out as follows.

Phenological parameters

Days to 50% flowering: it was recorded as the number of days from planting when 50% of the plants in each plot produced flowers.

Days to 50% physiological maturity: it was recorded when 50% of leaves from different treatments were turned to yellow.

Growth parameters

Average stems number per hill: the actual numbers of main stems per hill were recorded as the average stem count of five hills per plot at 50% flowering. Only stems that emerged independently above the soil as single stems were considered as main stems. Stems branching from other stems above the soil were not considered as main stems.

Plant height (cm): refers to the height from the base to the apex of the plant. It was measured using a measuring tape at 90% physiological maturity from the main stem originating directly from mother tubers to the apex of the plant by taking five sample plants from each plot.

Tuber quality attributes

Tuber size distribution in weight: at harvest, tubers were collected from five randomly selected plants from each plot and were categorized as small (25-38g); medium (39-75g); and large (>75 g) [28]. The proportion of the weight of tubers in the different tuber size categories was converted to percentages.

Tuber dry matter content (%): five potato tubers were randomly selected from each plot, chopped into small (1-2 cm cubes), mixed fully, and two fresh sub-samples each weighing 200 g were taken for drying to a constant weight. To each sub-sample was placed in a paper bag and put in an oven at 70 OC for 72 hours. Each sub-sample was immediately weighed and the mean was recorded as dry weight. Percent dry matter content for each sub-sample was calculated based on the formula described by [29].

$$DM(\%) \quad \frac{WAD*100}{IW}$$

where WAD = Weight of sample after drying in (g); Iw = Initial Weight of the sample (g)

The specific gravity of tubers: this was determined by the weight of air and weight in water method. Five kilograms of tubers of all shapes and sizes were randomly chosen from each plot. The wanted tubers were washed with water. The samples were then being first weighed in air and then re-weighed suspended in water. Specific gravity was computed using the following formula which developed by [2].

$$Sg = \frac{Wa}{Wa - Ww}$$

where Sg = Specific gravity; Wa = Weight in the air; Ww=Weight in water

Statistical data analysis

The agronomic data were subjected to analysis of variance (GLM procedure) using SAS software program version 9.2 [30]. Homogeneity of variances was calculated using the F-test as described by Gomez and Gomez (1984) and since the F-test has shown heterogeneity of the variances of the two seasons for all 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.

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 2.5). 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 Belgand Meher cropping seasons composite, and analyzed in teppi soil testing, research Centre for soil physico-chemical properties as per the procedures given in the results are depicted in (Table 2.2).

Analysis of composition of soil and cattle manure reveled better nutrient composition in Belg than in Meher season (Table 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 sandy clay 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 physicco-chemical analysis of the study areas revealed that the soils of the experimental field were sandy clay 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 (3.83and 3.82cmolc kg^{-1}) in belg and Al (2.01 and 2.46) cm olc kg^{-1}). In mehre 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 Mehre 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 the surface Soils of both the Belg and Meherseason qualify low status of N. low total N of 0.1 and 0.08 (g kg^{-1} content in Belg and Mehre season , respectively The analysis also revealed that the available P of the soils was 5.5and 5 ppm in Belge andMeher, season respectively. Thus, the soils of the experimental sites are low in available P content both in Belge and Meher season (Table 2.2) 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 [32]. 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 105^0 C according to the procedure described by (Okalebo et, al.) while particle density (þs) was measured using psychometer [33].

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

where, BD =bulk density; PD= particle density(Hillel, 2004).

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 [34]. 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 Mehre season

The organic carbon, N, P, KpH,Electrical conductivity,Total Ca, Total Mg,Total K,Total Na, CEC and moisture contents of the CM at different seasonused in the experiments were determined and depicted in Table 2.2.

Phonological and growth parameters

Effect of combined use of cattle manure and mineral NP on growth and phonological parameter the result of the present study showed There was a significant difference ($p < 0.05$) in the number of days to flowering maturity and plant height due to the application of different rates of CM in combination with rates of mineral NP both in Belg and Mehere seasons Though, the application of fertilizers non-significantly ($P > 0.05$) affects steam number/hill in both Belg and Mehre season as compared to zero fertilizer application (Table 4).

Table 1: Some characteristics of potato variety Belte

Variety	Year of release	Research station	Altitude m.a.s. l	Rainfalls (mm)	Maturity (days)	Yield (tha-¹)	
						Research	Farmers
Belte	2009	Holleta	1600-2800	750-1000	90-120	44.8	29.13

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

Soil parameters	Soil Belg (short rain season-February to May)	Rating	Soil Maher (long rain season-June to October)	Rating	References
Bd (g cm^{-3})	1.37	Medium	1.38	Medium	Barauah and Barthakulh,(1997)
PD (g cm^{-3})	2.58	Medium	2.6	Medium	Barauah and Barthakulh, (1997)
%porosity	46.8		46.92		Hillel, (2004).
% Sand	57	-	56	-	
% Slit	18	-	16	-	
pH	5.01	Strongly acidic	4.8	Very strongly acidic	Tekalignet al. (1991)
EC(us/cm)	169	Very low	85	Very low	EthioSIS (2014)
N (g kg^{-1})	0.1	Low	0.08	Low	Tekalignet al. (1991)
Exchangeable Ca (Cmol (+) kg^{-1} soil)	6.5	Medium	6.3	Medium	FAO (2006)
Exchangeable Mg (Cmol (+) kg^{-1} soil)	2.1	Moderate	1.4	Moderate	FAO (2006
Exchangeable K (Cmol (+) kg^{-1} soil)	0.42	High	0.36	High	FAO (2006)
Exchangeable Na (Cmol (+) kg^{-1} soil)	0.06	Very low	Nill	Very low	Landon (1991)
CEC (Cmol (+) kg^{-1} soil)	20	Medium	19.3	Medium	Hazelton and Murphy (2007)
Pbs (%)	45.4	Medium	41.7	Medium	Hazelton and Murphy (2007)
Exchangeable Al (Cmol (+) kg^{-1} soil)	2.01	High	2.46	High	Hazelton and Murphy (2007)
Exchangeable acidity (Cmol (+) kg^{-1} soil)	3.83	High	3.82	High	Hazelton and Murphy (2007))
O.C(g kg^{-1})	1.2	Low	1.02	Low	Tekalignet al. (1991)
N (g kg^{-1})	0.1	Low	0.08	Low	Tekalignet al. (1991)
C: N	12	Low	12.75	Low	Hazelton and Murphy (2007)
Available P (mg kg^{-1})	5.5	Low	5	Low	Jones, J. Benton (2003)
Cu (mg kg^{-1}) (DTPA)	8	High	6	High	Jones, J. Benton (2003)
Fe (mg kg^{-1}) (DTPA)	120	High	80	High	Jones, J. Benton (2003)
Zn (mg kg^{-1}) (DTPA)	1.5	High	1.2	High	Jones, J. Benton (2003)
Mn(mgkg^{-1}) (DTPA)	25	High	20	High	Jones, J. Benton (2003)

(DTPA: Diethylene Triamine Pentaacetic Acid, Pbs (%) =percent base saturation, Bd=bulk density, Pd-particle density)

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

	Cattle manure(CM)	
Parameters	**Belg (short rain season-February to May)**	**Maher (long rain season-June to October)**
pH	6.8	7.1
Electrical conductivity (us $cm\_^{1}$)	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
Total phosphorous P_2O_5 (%)	1.374	1.19
Total CaO cmol (+) kg^{-1}	7.854	6.748
Total Mg Mg Ocmol (+) kg-	1.33	0.99
Total K K2O 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 4: Days to 50% flowering (D50%), days to 50% maturity (Dm) and Average plant height (cm) of potato as influenced by the combined use of farmyard manure and mineral NP fertilizers in Belg and Meher season, at abelo area Masha district sheka zone southwestern Ethiopia

Treatment*	**2016 Belgseason**			**2016 Meherseason**		
	Days to 50% flowering	**Days to 50% maturity**	**Average plant height (cm)**	**Days to 50% flowering**	**Days to 50% maturity**	**Average plant height (cm)**
T_3	56^{cd}	102.33^{de}	$60.^{de}$	55.66^{g}	99.33^{fg}	68.03^{fg}
T_4	56^{cd}	102.67^{cde}	61.3^{de}	57.00^{gf}	100.67^{ef}	69^{ef}
T_5	57^{cd}	103^{bcde}	61.967^{cd}	58.00^{ef}	102.00^{de}	70^{def}
T_6	58.66^{c}	103.33^{abcde}	63.633^{bcd}	$58.66d^{ef}$	102.67^{de}	71.33^{cde}
T_7	57.33^{bcd}	104.67^{abcd}	63.70^{bcd}	59.66^{cde}	103.67^{dc}	72.07^{dc}
T_{8}.	58.33^{abcd}	105^{a}	65.63^{abc}	60.33^{cd}	105.00^{bc}	73^{c}
T_9	60^{abc}	105.33^{ab}	65.87^{ab}	61.33^{bc}	106.33^{ba}	73.9^{bc}
T_{10}	61^{ab}	105.67^{a}	68.3^{a}	62.66^{b}	107.67^{a}	76.33^{ab}
T_{11}	63^{a}	105.67^{a}	69.33^{a}	65.00^{a}	108.33^{a}	78.67^{a}
T_2	55.33^{cd}	102.33^{de}	57.97^{ef}	55.33^{g}	97.67^{g}	65.67^{gh}
T_1	51^{d}.	101^{e}	55.967^{f}	51.00^{h}	95.33^{h}	63.33^{h}
LSD (5 %)	4.97	2.48	3.79	2.3232	2.32	2.34
Sig	**	**	**	**	**	**
CV (%)	5.051	1.4	3.53	1.85	1.33	2.34

Means followed by the same letter within a column are not significantly different at P > 0.05 level of significance; * CM = Cattle Manurein t ha-1, RDF = Recommended Dose of mineral NP Fertilizer, T1= Control, T2 =100%RDF, T3=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+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 Manurein t ha^{-1}

Days to 50% flowering

Application of 7.5 t CM+75% RDF delayed the time required to reach 50% flowering from 56-63 by 7 days and 51-65 days 14 days which is Statistical at par with T10, T9 and T8 in Belg season (Table 2.5). This is because high dosage cattle manure with mineral NP levels promoted excessive vegetative growth and delayed flowering. both in Belg and Meher season while the earliest time to flowering was recorded at control both in Belg and Meher season which is Statistical the same as T2, T3, T4 and T5 in Belg season and T10 and T9 in Meher season. This could be cattle, manure combined with mineral NP can result in the improvement of soil characteristics (physical and biological) this in turn increases nutrient availability encourage vegetative growth there by photsynsty is This result is similar with the findings of [35,36] they reported excessive vegetative growth and delayed flowering due to high nutrient dosage levels, in addition, [37] reported that the application of N and P fertilizers delayed the time required to attain flowering of potato.

It was observed at both seasons days to 50% flowering delayed when organic fertilizer sources were combined with the highest rate (75%) of the recommended mineral NP. but the delay is higher in Meher season

Days to 50% maturity (Dm)

Increasing the application dosage of cattle manure with Mineral NP resulted in delaying the time to reach 50% maturity by 5 days from (101-106) and 13 days from (95-108) which is Statistical the same as T10, T9, T8, T7and T6 in Belg season (Table 2.5). This is due to the fact that increased level of combined use of Cattle Manure with mineral NP increased significant role in crop establishment, promoting vegetative growth, and there by the leaf area which in turn increased the amount of solar radiation intercepted and subsequently delays days to 50% physiological maturity

The earliest time attained for 50% maturity was at zero application of cattle manure and mineral NP which is Statistical the same as T2, T3, T4, T5 and T6 in Belg season

The observation of the present investigation supports the earlier studies on the effect of combined use of cattle manure on days to 50% maturity [38,39] where increased combined use of cattle manure with increased mineral NP was reported to be related to delaying maturity of potato. In both seasons days to 50% maturity delayed when cattle manure was combined with the highest rate (75%) of the recommended mineral NP. but the delay to rech 50% maturity is higher in Meher season

Plant height (Ph) (cm)

The highest plant height of potato (69.33and 78.66cm) in Belgand Meher season was obtained at combined application of 7.5 t CM with 75% RDF which is Statistical at par with T10,T9 and T8 in Belg season and T10 in Meher season, application of 7.5 t CM with 75% RDF, increases plant height from 56-69 and 51-65cm in Belgand Meher season respectively while the shortest plants were from the control treatment where no mineral NP and cattle manure is applied both in Belgand Meher season respectively(Table 4).

It was observed at both season plant height increased when cattle manure was combined with the highest rate (75%) of the recommended mineral NP. but the increment in height is higher in Meher season this is in lined with work of [40,41].

The possible reason for higher plant height in increase rate of CM plus mineral NP treatment might be due to the fact that the cattle macronutrret combine with mineral fertilizer would have provided the micronutrients in an optimum range for the plant This increases the better efficiency of mineral NP fertilizer the mineral NP sources fulfilled the NP requirements at early growth stages while cattle manure provided the crop with nutrients in later stages due to their slow releasing nature.

The result of this experiment was in agreement with the finding of they reported that t the highest values of plant height, stem diameter and leaf size were detected with plants which were fertilized with cow dung at the rate of 20t ha^{-1}. and NPK at the rate of (20: 10: 10) compared with sole application of cow dung or NPK mineral fertilize the shortest plants height were recorded from the control treatment [42].which is Statistical the same as T2 in both Belg and Meher season

Similarly, reported that plant height of potato increased with organic manure application as compared to mineral fertilizer alone.[43,44] also reported that the use of organic manures in combination with mineral fertilizers increased the plant height of potato than the application of mineral fertilizers alone.

Potato tuber size categories

The percentage of small and medium-sized tubers were highly significantly ($P < 0.01$) affected by combining the use of Cattle Manure and mineral NP fertilizer, but Percentage of large tuber size was non-significantly ($P > 0.05$) affected by combining the use of cattle manure and mineral NP fertilizers in both in Belg and Meher seasons (Table 5).

Small tuber size number (%)

Significantly the highest percentage of small-sized tubers (27.36 and 27.306%) were obtained at no application of cattle manure and mineral NP, and the average small sized tuber percentage (22.14 and27. 07%) whereas the lowest percentage of small potato tubers (17.06 and14. 26%) were found at 7.5 t CM+75% RDF, (Table 5). This might be at low nutrient dosage there could be weak competition for light, water, and nutrients from their sources and this reduced photoassimilate production and redistribution to the tubers and finally, the highest number of small-sized tubers produced.)[45] also concluded that in a low nutrient dosage bulking rate of individual tubers decreased, and these resulted in the higher proportion smaller size tuber. (Biruke *et, al.* 2015) reported that the number of small-sized tubers was reduced by increasing the nutrient dosage.

Table 5: Means for tuber size category (small, medium, and large) of potato as affected by combining use of cattle manure and mineral NP in Belgand Meher season at abelo area Masha district sheka zone southwestern Ethiopia

Treatment*	Number of tubers 2016 Belgseason			Number of tubers 2016 meherseason		
	Large size tuber (>75g)	Medium Size tuber(75-39g)	Small Size Tuber(<39g)	Large size tuber (>75g)	Medium Size tuber(75-39g)	Small SizeTuber (<39g)
T_3	6.175	67.185^{gh}	26.640^{ab}	8.724	54.394^{def}	36.882^{a}
T_4	8.257	67.654^{fgh}	24.089^{bc}	9.715	56.621^{de}	33.664^{abc}
T_5	8.651	68.916^{efg}	22.433^{cd}	10.218	63.217^{cd}	26.565^{bcd}
T_6	7.852	69.962^{def}	22.186^{cde}	8.255	68.372^{bc}	23.373^{cd}
T_7	8.815	70.943^{cde}	20.242^{def}	4.923	73.021^{ab}	22.056^{cd}
T_{8}.	8.714	71.895^{bcd}	19.391^{def}	4.604	75.700^{ab}	19.696^{d}
T_9	7.809	73.266^{abc}	18.925^{ef}	5.313	76.865^{ab}	17.822^{d}
T_{10}	8.204	74.070^{ab}	17.726^{f}	3.621	79.147^{ab}	17.232^{d}
T_{11}	8.145	74.786^{a}	17.069^{f}	5.471	80.260^{a}	14.269^{d}
T_2	6.451	65.932^{h}	27.617 ^{a}	8.578	49.149^{ef}	42.273^{a}
T_1	7.135	65.559^{h}	27.306a	11.472	44.582^{f}	43.946^{a}
LSD (5 %)	2.73	2.729	3.402	2.65	11.356	12.511
Sig	NS	**	**	Ns	**	**
CV (%)	23.21	2.28	9.02	23.76	10.168	27.13

Means followed by the same letter within a column are not significantly different at P > 0.05 level of significance; * CM = Cattle Manurein t ha-1, RDF = Recommended Dose of mineral NP Fertilizer,

T1= Control, T2 =100%RDF, T3=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+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 Manurein t ha^{-1}

It was observed at both season, that the proportion of Small tuber size number decreased when cattle manure were combined with the highest rate (75%) of the recommended mineral NP. But the decrease in proportion of small tuber size is higher in Meher season than in Belg season

Medium tuber size number (%)

The medium tuber size number ranged from (65.56 and44.58%) (zero application of Cattle manure and mineral NP) to74.78and 80.26percentagein Belgand Meher season respectively. The maximum mean medium tuber size number obtained with the combined application of 7.5tCM+75% RDF had no significant difference with (T10)7.5tCM+50% RDF (T9) 7.5tCM+25% RDF in Belg season and (T10)7.5tCM+50% RDF, (T9)7.5tCM+25% RDF, 5tCM+75% RDF, (T8) 5tCM+50% RDF in Meher season and the lowest proportion of medium size tubers(65.559) in Belg season and (44.582) in Meher season was obtained at zero application of cattle manure and minral NP which is stasticalley the same as application of T2,T3, and T4 in Belg season and T2, and T3 in Meher season (Table 5).

It was indicated at, that the proportion of Medium tuber size number increased when cattle manure was combined with the highest rate (75%) of the recommended mineral NP. both in Belgand Meher seasons but the increase in the proportion of Medium tuber size number is higher in Meher season than in Belg season similarly combined the use of 5.0 tha^{-1} Cm + 50% RDF improved medium size potato tuber from zero application (53.29) to 62.88% at Jimma Arjo Ethiopia [46].

Significantly the highest percentage of medium-sized potato tubers (74.7 and80.26%)) were recorded at the application of 7.5tCM+75% RDF but the lowest percentage (65.56 and 44.58) were obtained at zero application of cattle manure and mineral NP in both Belgand Meher seasons (Table 2.6).

Biomass Yield Parameters

Shoot fresh and Dry biomass yield

Shoot fresh and dry weight were highly significant (P < 0.01) affected by combining the use of cattle manure and mineral NP in both Belg and Meher season (Table 6).

Significantly the highest shoot fresh (1780.2$ghill^{-1}$ and 1658.99 $ghill^{-1}$) and dry (59.333 ghill-1and56.667$ghill^{-1}$) weight was recorded at the higher dosage level of 7.5 t CM+75% RDF whereas the lowest shoot fresh Wight (1274.59$ghill^{-1}$and 1213.91$ghill^{-1}$) and dry weight (40.4$ghill^{-1}$ and 40$ghill^{-1}$) in Belg and Meher season were obtained at zero application of cattle manure and mineral NP and the mean average shoot fresh and dry weight were (1471.72$ghill^{-1}$and1425.12$ghill^{-1}$)

in Belg, 47.78ghill^{-1},and47.9ghill^{-1}) recorded in Belgand Meher season respectively(Table 2.7). This might be in the higher nutrient dosage there could also lead to better plant coverage for a high radiation interception, optimum foliage development subsequently increased the photosynthetic efficiency of the plant and finally resulting in increased shoot fresh weight. Appropriate use of nitrogen fertilizer can lead to the accomplishment of optimum foliage development and consequently promotes tuber yield.

Similar to the result of the current investigation Ahmed [47] also reported that maximum above ground fresh and dry biomass yield of tubers per plant was obtained with the combined use of 20tha^{-1}cattle manure with different mineral nitrogen fertilizer. In a similar manner,[48] also indicated that combined use of Nitrogen and Phosphorous gave the highest above ground fresh and dry biomass yield number of tubers per hill. In addition, [49] also reported that shoot fresh and dry weight of potatoper hill increased at the higher rate of cattle manure Nitrogen and phosphorous

It was indicated at, that Shoot fresh and Dry biomass yield increased when cattle manure was combined with the highest rate (75%) of the recommended mineral NP.both in Belg and Meher seasons but the increment is higher in Belg season than in Meher season

The mean values of the Shoot fresh weight, shoot dry weight (ghill^{-1}) of the soil is also presented in Table 6As can be seen from the Table 2.7, regardless of the chemical fertilizer, the biomass yield of potato increased with the added rate of cattle manure the highest and lowest biomass yield of potato of each of these nutrients was recorded for plots treated with 7.5t CM+75% RDF and those which did not receive cattle manure and mineral NP at any rate, respectively. several searchers [50,51,52] who reported the significant increase biomass yield of potato after cattle manure and Mineral NP application support the finding of the present study

According to the current investigation the results obtained in terms of the following biomass yield parameters such as shoot fresh weight, shoot dry weight, root, fresh weight, root dry weight, and harvest index in Belg and Mehre season were presented (Table 6) and discussed as follows

Root, fresh and Dry biomass yield

Root, fresh and dry biomass yield were significantly (*P < 0.01*) influenced by the combined application of cattle manure and mineral NP both in Belge and Meher season (Table 6). Accordingly, the application of 7.5 t ha^{-1}CM in combination with 75% mineralNP gave the highest root, fresh and dry biomass yield of (177.394 and 171.55g hill^{-1}.)In Belge and (9.343 and 9.594g hill^{-1}.) in Mehre, season which is Statistical at par with T10, T9 in

Table 6: Means for shoot fresh weight, and shoot dry weight of potato as affected by combining use of cattle manure and mineral NP Belg and Maher season at Abelo area Masha district sheka zone southwestern Ethiopia

Treatment*	**2016 Belgseason**		**2016Meher season**	
	Shoot fresh weight g hill^{-1}.	**Shoot dry weight g hill^{-1}.**	**Shoot fresh weight g hill^{-1}.**	**Shoot dry weight g per hill^{-1}.**
T_3	1292.40^{g}	41.067^{g}	1302.93^{fg}	43.333^{fg}
T_4	1310.20^{fg}	41.733^{fg}	1320.73^{fg}	44.000^{fg}
T_5	1354.71^{f}	43.400^{f}	1365.24^{ef}	45.667^{ef}
T_6	1434.82^{e}	46.400^{f}	1400.85^{de}	47.000^{de}
T_7	1497.13^{d}	48.733^{d}	1436.45^{cd}	48.333^{cd}
$T_{8.}$	1559.45^{c}	51.067^{c}	1498.76^{c}	50.667^{c}
T_9	1648.46^{b}	54.400^{b}	1569.98^{b}	53.333^{b}
T_{10}	1753.50^{a}	58.333^{a}	1650.09^{a}	56.333^{a}
T_{11}	1780.21^{a}	59.333^{a}	1658.99^{a}	56.667^{a}
T_2	1283.49^{g}	40.733^{g}	1258.42^{gh}	41.667^{gh}
T_1	1274.59^{g}	40.4^{g}	1213.91^{h}	40h
LSD (5 %)	2.086	2.28	69.57	2.6
Sig	**	**	**	**
CV (%)	2.42	2.8	2.86	3.19

Means followed by the same letter within a column are not significantly different at P > 0.05 level of significance; * CM = Cattle Manurein t ha-1, RDF = Recommended Dose of mineral NP Fertilizer, T1= Control, T2 =100%RDF, T3=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+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 Manurein t ha^{-1}

Belg T10, T9, T8 in Meher season for fresh and dry root biomass yield whereas the lowest fresh root biomass yield (133.19 and 99.18g hill^{-1}.) and dry root biomass yield (6.676and 5.23g hill^{-1}.) in Belg and Meher season was recorded at zero application of cattle manure and mineral NP which is stasticalley the same as T2, T3, T4 for root fresh biomass yield in Belg and Meher season T2,T3,T4,T5,T6 for root fresh and dry weight in Meher season. (Table 6).

Generally, the combined application of cattlemanure and mineral NP fertilizers have resulted in a higher fresh and dry underground biomass yield than the application of 100% recommended arate of mineralNP alone. This implies that in the study area the integrated use of cattlemanure and mineral NP fertilizers responded better to increase productivity than the use of mineralfertilizer alone Likewise, suggested that Farmers who use ISFM technology at low applicationrates may not see yield differences from a sole inputapplication in a combined application. Application of mineral fertilizer alone led to yields equivalent to control yields, regardless of application rate[53].

It was indicated that Root, fresh and Dry biomass yield increased when cattle manure was combined with the highest rate (75%) of the recommended mineral NP. both in Belgand Meher seasons but the increment is higher in Belgs eason than in Meher season

by the use of mixed mineral and cattle manure fertilizers not only production can be kept at an optimum level, but also the amount of mineral fertilizer to be used can be reduced. Plant bio-chemical activities improve by absorption of nutrients from the soil and this, in turn,increases biomass yield plant^{-1}[54].

Table 7: Root fresh weight, root dry weight and harvest index of potato as influenced by combined use of cattle manure and mineral fertilizers at Masha in Belg and Maher season at abelo area Masha district sheka zone southwestern Ethiopia

Treatment*	2016 Belg season			2016 Mehreseason		
	Root fresh weight g per hill.	Root dry weight g per hill.	Harvest index (%)	Root fresh weight g per hill.	Root dry weight g per hill.	Harvest index (%)
T_3	139.15^{ef}	7.04^{ef}	0.8	111.44^{e}	5.96^{de}	0.723
T_4	141.92^{def}	7.20^{def}	0.8	114.81^{de}	6.17^{de}	0.738
T_5	152.02^{cde}	7.81^{cde}	0.78	125.91^{cde}	6.84^{cde}	0.733
T_6	154.40^{bcd}	7.96^{bcd}	0.78	129.78^{bcde}	7.07^{bcde}	0.727
T_7	155.39^{bc}	8.02^{bc}	0.759	136.29^{bcd}	7.46^{bcd}	0.721
T_8.	159.26^{bc}	8.25^{bc}	0.753	146.73^{abc}	8.09^{abc}	0.711
T_9	166.92^{ab}	8.71^{ab}	0.741	157.5^{4ab}	8.75^{ab}	0.706
T_{10}	175.79^{a}	9.24^{a}	0.736	167.41a	9.34^{a}	0.704
T_{11}	177.39^{a}	9.34^{a}	0.728	171.55^{a}	9.59^{a}	0.705
T_2	134.3^{f}	6.74^{f}	0.834	104.04^{e}	5.52^{e}	0.733
T_1	133.19^{f}	6.676^{f}	0.868	99.18^{e}	5.23^{e}	0.735
LSD (5 %)	13.18	0.7957	5.28	30.75	1.86	0.036
Sig	**	**	Ns	**	**	Ns
CV (%)	5.04	5.9	8.41	13.56	14.97	2.97

Means followed by the same letter within a column are not significantly different at P > 0.05 level of significance; * CM = Cattle Manurein t ha-1, RDF = Recommended Dose of mineral NP Fertilizer, T1= Control, T2 =100%RDF, T3=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+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 Manurein t ha^{-1}

Quality Parameters

Dry matter content and specific gravity

Also, there was significant ($P < 0.01$) effect of combined application of o faryared manure and mineral NP on specific gravity gcm^{-3} and dry matter content inboth in Belge and Meher season (Table 8). It was observed that the combined application of farmyard manureand mineral NP fertilizers reduced specific gravity gcm^{-3} and drymatter contentpercent both in Belge and Meher season.

As a result, the application of 7.5 t ha^{-1}cattle manure with 75% mineral NP resulted in the highest specific gravity of (1.107 and 1.111gcm^{-3}) and dry matter content percentage of (25.78 and 24.47) in Belgand Meher season, respectively. This treatment gave 2.23% and 2.19% improvement of specific gravity in gcm^{-3} over the control treatment in Belge and Meher season respectively (Table 8). This might be due to the increased rate of CM which might have attributed to the increased availability of NPK, improvement of soil, water holding capacity, and reduction of volatilization of nitrogenous fertilizer to NH3 gas. Similarly, reported m the maximum specific gravity (1.07) was recorded in (CM) in combination with mineral Nitrogen [55].

It was also observed that as the rate of mineral NP increased from 25 to 75%, there was an increase in the number of dry matter content both in Belge and Meher. season the improvement in a proportion of dry matter content at higher NP rates might be due to vigorous growth and development of the crop because the nutrients applied from mineral sources coupled with organic sources might have attributed to more availability of N that played a vital role in cell division. Similarly, reported lower dry matter content of tubers in the plot that receive nitrogen and P fertilization compared to the plot that did not receive N and P fertilizers in jalene potato variety. also reported low specific gravity of tubers at higher levels of NP of potato[56,57].

Table 8: Dry matter content, and Specific gravity of potato as influenced by combined use mineral NP and cattle manure in Belg and Meher season, at abelo area Masha district sheka zone southwestern Ethiopia

Treatment*	2016 Belgseason		Meher Season	
	Specific gravity (gcm^{-3})	Dry matter content (%)	Specific gravity (gcm^{-3})	Dry matter content (%)
T_3	1.089^{ef}	21.906^{efg}	1.092^{de}	22.571^{de}
T_4	1.090^{ef}	22.121^{ef}	1.092^{de}	22.599^{de}
T_5	1.091^{de}	22.38^{e}	1.092^{de}	22.641^{de}
T_6	1.092^{cde}	22.718^{de}	1.093^{cde}	22.768^{cde}
T_7	1.095^{cd}	23.303^{cd}	1.095^{bcd}	23.274^{bcd}
$T_{8.}$	1.095^{cd}	23.349^{cd}	1.097^{bc}	23.563^{bc}
T_9	1.097^{bc}	23.687^{c}	1.098^{ab}	23.837^{ab}
T_{10}	1.101b	24.527^{b}	1.099^{ab}	23.935^{ab}
T_{11}	1.107^{a}	25.782^{a}	1.101^{a}	24.470^{a}
T_2	1.086^{fg}	21.325^{fg}	1.091^{e}	22.473^{de}
T_1	1.083^{g}	21.085^{g}	1.092^{de}	22.360^{e}
LSD (5 %)	0.0047	0.83	0.0042	0.8923
Sig	**	**	**	**
CV (%)	0.25	2.12	0.23	2.26

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=2.5t CM+25%RDF, T4=2.5tCM +50% RDF, T5. =2.5tCM+75% RDF, T6. =5t CM+25% RDF, T7=5t CM+50% RDF, T8. =5t CM+75% RDF, T9=7.5t CM+25% RDF, T10=7.5t CM+50% RDF, T11=7.5t CM+75% RDF,RDF = Recommended Dose of mineral NP Fertilizer, CM = Cattle Manure in t ha^{-1}

Conclusion

Potato growth, development and high yield depend on soil properties, climatic conditions, the result of most of growth, biomass yield and quality of potato and 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 biomass yield than the treatment with either no fertilizer or sole application of mineralNP, 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. Hence, the usage of 165kg N + 60 kg P + 7.5t $CMha^{-1}$ 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

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