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Effect of Integrated Use of NPS Blended Fertilizer and Cattle Manure on Growth, Yield and Quality of Potato (*Solanumtuberosum* L.) at Dabo Ghibe Kebele, Southwest Ethiopia

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ABSTRACT

Irish potato (Solonaumtuberosum L.) is an important food security and cash crop for smallholder farmers in Ethiopia.The yield of the crop is low at national as well as regional level which is constrained mainly by low soil fertility. A new blended fertilizer (NPS) containing nitrogen (19% N), phosphorous (38% P2O5), and sulfur (7% S) is recently introduced aiming at substituting DAP in Ethiopian agriculture. There is a need to optimizethis fertilized to boost the yield of potato at Dabo-Ghibe Kebele, Sekaweradaunder irrigation. The objective of this study was to determine the optimum rate of mineral NPS blended fertilization and CM rate on growth, yield and quality of potato. The treatments consisted of four NPS blended fertilizer levels (0, 50,100 and 150kg ha-1) and four Cattle Manure levels (0, 10, 20, and 30t ha-1).The experiment was laid out as a RCBD in a factorial arrangement and replicated three times. Phonological and yield data were collected and subjected to SAS version 9.3 software. Results revealed that the highest total tuber yield (40.23 t ha-1) was obtained by applying 150 kg ha-1 NPS blended fertilizers+30tha-1CM. Based on the partial budget analysis, thecombined application of 100 kg ha-1NPS bended fertilizers+30tha-1CM gave the maximum net return of Birr 138,513 ha-1 with an acceptable marginal rate of return (51.1%). In conclusion, the combined application of 150 kg ha-1NPS fertilizers and CM at 30 t ha-1 significantly increased total tuber yield (40.23tha-1) of potato and restore N, P, and organic carbon of soil, and economically, the combined application of 100 kg ha-1NPSblended fertilizers and 30tha-1CM is found economically feasible and can be recommended for potato growers around Seka Wereda and areas with similar agro-ecology.

Keywords: *Mineral fertilizer, Organic fertilizer, Tuber quality, Tuber Yield*

INTRODUCTION

Irish potato (*Solonaumtuberosum* L.*)* is originated from the Lake Titicaca region in Peru and Bolivia of South America [32]. It is a starchy, tuberous crop of the *Solanaceae* family [76]. It is a crop of major economic importance worldwide [25]. Irish potato is also a food for more than three billion people worldwide [25]. It ranks fourth after wheat, rice and maize crops with an estimated cultivated area of 19 million hectares with a production of 332 million metric tons annually [25] and followed by cassava, sweet potato and yam from root and tuber crops [24].In Africa about 1,765,617 ha of potatoes were cultivated with a production of about 17,625,680 t. Studies show that the demand for potatoes will increase over the next two decades in developing countries [121]. It is an important staple and cash crop in Eastern and Central Africa, playing a major role in national food and nutrition securities, poverty alleviation and income generation and employs in the potato production, processing and marketing sub-sectors [41].

The potato was first introduced to Ethiopia in 1858 by the German Botanist, Schemper [59]. Ethiopia has possibly the greatest potential for potato production; seventy percent of its arable land mainly in highland areas, above 1500 m.a.s.l, are believed to be suitable for potatoes[32]. Since the highlands are also home to almost over half of the Ethiopian population, the potato could play a key role in ensuring national food security [25].

Mineral fertilizers are used to supplement the natural soil nutrient supply in order to satisfy the demand for crops with a high yield potential and compensate for the nutrients lost by the removal of plant products and by leaching. Mineral fertilizers have the merit of being readily soluble in soil solution, less bulky and easy to manipulate but their constitution in most cases does not include the much-needed essential minor elements as compared to cattle manures which meet this requirement [8].

In Ethiopia, potato ranks first among the major tuber crop in the volume of production and consumption followed by enset, sweet potato, yam and taro [55]. About 1,571,806 farmers are engaged in potato growing with an area of 74, 935 ha per season with an annual production of 8.6 M. quintal[14]. It is identified as hunger breaking crop during a period when cereal crops are not ready for harvest in the highland. Potato is grown in diverse soil types ranging from vertisol to nitosols in the highlands of Ethiopia. The national average yield stands at 11.8 tha^{-1}[13]. which is low compared to the world's average productivity of 16.4 t ha^{-1}[25].One of the contributing factors to the low yield and yield components of potatoes is substandard agronomic practices including suboptimum fertilizer amount application, use of substandard quality tubers and shortage of improved and adaptable cultivars [64].Potato is a heavy feeder requiring large quantities of fertilizers to produce the highest marketable tuber yield and total tuber yield.

Low soil fertility is one of the limiting factors to sustaining potato production and productivity in Ethiopia [55]. Ethiopian soilis very diverse in terms of inherent and dynamic soil [19]. Fertilizer recommendations made based on preliminary studies vary across diverse agro-ecologies in the country. Economically feasible fertilizer amount varies with soil type, fertility status, moisture amount, climatic variables, variety, crop rotation and crop management practices [9]. In fact, the Ethiopianagricultural Institution(EIAR) generally recommends to farmers the blanket rates of 195 kg DAP ha^{-1} and 165 kg Urea ha^{-1} regardless of cultivar and location or soil type, which together sums up to account for 111 kg N ha^{-1} and 90 kg P_2O_5 ha^{-1}[19]. However, [28] reported that potato farmers in the central highlands of Ethiopia applied on average only 3.0 t manure, 30.6 kg N and 33.4 kg P/ha. This shows that farmers apply sub-optimum levels of nutrients to the potato crop. A participatory rural appraisal in the study area indicated that farmers use smaller rates of DAP and Urea that amount only to 100 kg each, which is equivalent to 46 kg P_2O_5 and 64 kg N ha^{-1}[17].

According to Ethiopia soil data base majority of soils in South western Ethiopia are deficient inmacronutrients (N, P and S) and micronutrients (Cu, B and Zn)because of long years frequent cultivations of staple crops (Ethio SIS, 2014), thus the majority of potato growers depend on P in the form Di-ammonium phosphate (DAP) and N in the form of urea [23].Recently ministry of agriculture (MoA) introduced a new brand of NPS blended fertilizer having the proportion of 19% N, 38% P_2O_5 and 7% S, substituting DAP for adoption by farmers. Besides the application of mineral fertilizers to potatoes, the importance of cattle manure is being recognized because of the increased cost of mineral fertilizers from time to time vis-à-vis the price of potato products on the market and their long-term effects on soil chemical properties [53]. It is also useful in improving the efficiency of fertilizer recovery thereby resulting in higher crop yield and quality.Cattle manure is a potential source of organic fertilizer in Ethiopia, as the country has the highest livestock number in Africa [83].

Cattle manure seems to act directly in increasing crop growth and yields either by accelerating respiratory process with increasing cell permeability and hormonal growth action or by the combination of all of these processes which supply N, P and S in the available form to the plants via biological decomposition and improves physical properties of soil such as aggregation, permeability and water holding capacity [63]. Cattle manure, contains large amounts of nutrients and influences plant growth and production via improving chemical, physical and biological fertility [50]. However, the use of cattle manure alone may not be enough to maintain crop production because of its limited availability and relatively high application rates, high labor requirements [58].Therefore, the combined

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application of mineral NPS and cattle manure is essential to sustain high yields, better tuber quality and more profit and to improve soil physico-chemical properties [22] in one study the highest total tuber yield was observed with the combined application of 10 t FYM ha^{-1} and 75% recommended N and P [15]. Application of two-third of the recommended mineral NP fertilizers combined with 20-30 t FYM $ha^{-1}$was suggested for vertisol and nitisol in West Shewa Zone [5]. According to [16], maximum tuber yield (36.8 t ha^{-1}) was obtained using 20 t ha^{-1}cattle manure +150 kg N ha^{-1}.The application of cattle manure positively influenced potato vegetative growth characters, whereas plant height, stem number $plant^{-1}$ and whole plant dry weight were increased with increasing cattle manure levels up to 20 t ha^{-1}[4].The application of compost in combination with mineral-blended NPS to soils increased onion bulb diameter [27].

Potato growers in DaboGhibeKebele, SekaWerada of Jimma Zone usually use cattle manure and household leftover empirically for growing potatoes, maize, and others in their homestead without scientific information. Amin *et al.* (2007) observed that the application of 100 kg N, 80 kg P, and 30 kg S ha^{-1} along with 50 kg K ha^{-1}significantly increased yield components of onion over the lower rates and the check. Application of abalanced amount of mineral N, P and S has a cumulative positive effect on crop growth because N improved the vegetative growth and accelerated the photosynthates in storage organs of bulbs via an increased diameter and weight of the bulb [98].Furthermore, if cattle manure is supplemented with mineral NP fertilizers could enhancethe yield and nutrient uptake of potatoes[7].However, information on the effect of the application of cattle manure along with mineral NPS blended fertilizers is not available on the growth, yield components and quality of potatoes at Dabo Gibe Kebele in Jimma zone, Southwestern Ethiopia. Therefore, it is imperative to develop recommendation/database on the use of mineral NPS blended fertilizers along with cattle manure for the optimum production of potatoes.

Thus, the study was carried out with the following objectives:

- To assess the combined effect of mineral NPS blended fertilizers and cattle manure on yield and yield components of potatoes at Dabo Ghibekebele.
- To determine theoptimum rate of mineral NPS blended fertilizer and cattle manure for potato production at Dabo Ghibekebele.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted on a farmer's field in SekaWereda of Jimma zone of the Oromia Regional State from December to March during the irrigation cropping season of 2016.Sekawereda is located at a distance of 375 km, south -West of Addis Abeba and 18 km from Jimmatown. Dabo Ghibekeble is 15 km from Jimma City. Sekawereda shares a boundary with Gomma and Manna districts in the North, Gera wereda in the South, Dedowereda and Jimmatown in the East and Shabe Sombowereda in the West. The geographical coordinates of the research site is 7.67^{0}'N latitude and 36.83^{0}'E longitude having an altitude of 1780 meters above sea level (from GPS reading, 2016). The experimental area is characterized by a mono-modal pattern of rainfall. The total annual rainfall is 1553 mm. The peak rainy months are July, August and September.

The mean annual maximum and minimum temperatures are 28.8°C and 8.9°C, respectively. The coldest months are October-January whereas February to April is the hottest month. The soil type of the site is nitisol, which is typically formed from highly basic rocks such as basalt in climates that are seasonally humid or subject to erratic, droughts and floods, or impede drainage (Sekawereda Agriculture and Rural development Office, 2009, Annual Report Unpublish).

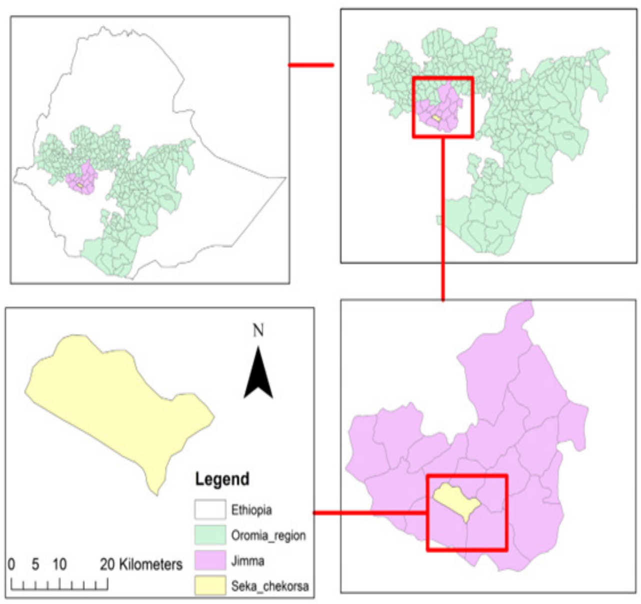

Figure1: Map of the Study Area

Experimental Materials

Potato cultivar "Gudane" which was obtained from the Jaldu farmer's cooperative union via Holetta Agricultural Research center was used for the study in 2016. Gudane is adapted to areas located 1600-2800 meters above sea level and receives an annual rainfall of 750-1000mm [30].

Treatments and Experimental Design

The treatments were two factors namely four level of NPS blended fertilizer application rates (0, 50, 100 and 150kg ha^{-1}) based on the agricultural transformation agency tentative fertilizer recommendation rate on the study area (100kg ha^{-1} NPS blended fertilizer was a tentative recommendation) and four level of cattle manure rates (0, 10, 20 and 30t ha^{-1}) and (30t ha^{-1} CM used as a base). The experiment was laid out as a randomized complete block design (RCBD) in a factorial arrangement and replicated three times. There were sixteen treatment combinations, which were assigned to each plot randomly.

Table 1: Description of treatment combination

Treatment	Description
T1	Control (0 NPS + 0 CM)kg/t ha^{-1}
T2	50 kg ha^{-1} NPS blended fertilizers + 0 t ha^{-1} cattle manure
T3	100 kg ha^{-1} NPS blended fertilizers + 0 t ha^{-1} cattle manure
T4	150 kg ha^{-1} NPS blended fertilizers + 0 t ha^{-1} cattle manure
T5	10 t ha^{-1} cattle manure
T6	10 t ha^{-1} Cattle manure + 50kg ha^{-1} NPS blended fertilizers
T7	10 t ha^{-1}Cattle manure + 100kg ha^{-1} NPS blended fertilizers
T8	10 t ha^{-1}Cattle manure + 150kg ha^{-1} NPS blended fertilizers
T9	20 t ha^{-1} cattle manure
T10	20 t ha^{-1} Cattle manure + 50kg ha^{-1} NPS blended fertilizers
T11	20 t ha^{-1} Cattle manure + 100kg ha^{-1} NPS blended fertilizers
T12	20 t ha^{-1} Cattle manure + 150kg ha^{-1} NPS blended fertilizers
T13	30 t ha^{-1} Cattle manure
T14	30 t ha^{-1} Cattle manure + 50kg ha^{-1} NPS blended fertilizers
T15	30 t ha^{-1} Cattle manure + 100kg ha^{-1} NPS blended fertilizers
T16	30 t ha^{-1} Cattle manure + 150 kg ha^{-1}NPS blended fertilizers

Experimental Procedure and crop management

The experimental field was ploughed using oxen and plots were leveled manually. Sowing was done on December, 4, 2016 at Seka district Dabo Gibe kebele farmers' field site. The experimental site measuring 57m by 12m was cleared and ploughed to a depth of about 25 - 30 cm. There were 48 plot each measuring 3x3 m ($9m^2$) and was separated by a buffer of 0.5 m.The distance between blocks was 1 meter. The seed tubers were planted at the depth of 5 cm in the soil [43] at a spacing of 75 cm between rows and 30 cm between seed tubers. The two outer rows were considered borders. NPS was used as a source of mineral nutrients and full doses which varied depending on treatments were applied as side banding at planting time decomposed cattle manure was also used as source of nutrients and full doses which varied depending on treatments was applied as two weeks before planting the potato tubers and homogeneously applied and distributed into desired plots, then incorporated into the soil at the depth of 20 cm. Uniform and well sprouted, two and more than two sprouted potato tubers were planted at 5-7cm depth of planting and soon after planting, a ridge was done to cover the potato tubers by excavating the soil from both sides.

The experiment was carried out using furrow irrigation starting fromthe planting date to the harvesting date at seven-day irrigation intervals based on the weather condition of the area. Plots were irrigated until the soil was saturated. Other agronomic practices were kept uniform for all treatments as recommended and adopted for the location.

Soil and Cattle Manure Sampling and Analysis

Before planting, the physical and chemical properties of the experimental field soil were determined. Therefore, representative soil samples were collected from the experimental field randomly in a zigzag pattern at depth of 0-30 cm before planting using an auger. The soil samples were composited and a one kg sample was taken as a working sample. Crumbs of soil were broken into pieces and sieved. The collected composite samples were air-dried on paper trays, ground, and sieved to pass through a 2 mm sieve for chemical analysis.

The soil analysis included the determination of total nitrogen, available phosphorus, textural analysis (sand, silt and clay), soil pH, Cation exchangeable

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Table 2: Initial physico- chemical properties of soil and cattle manure

No	Parameter	Soil			Cattle manure
		Values	Rating	Reference	Values rating
1	pH	6.5	Slightly acid	[33]	7.5
2	%OC	2.5	Medium	[33]	5.4
3	%TN	0.22	Medium	Bruce &Rayment (1982)	0.469
4	av.P(ppm)	11.34	medium	Bray II (1954)	20.19
5	CEC(cmol)	19.26	Medium	[49]	ND
6	Soil Texture	-			
	Sand	12.67			
	Clay	42			
	Silt	45.33			
	Textural classes	Silt clay			

Where Cmol = Cent mole, pH = hydrogen power, % OC = percent of organic carbon, %TN = Percent of total nitrogen, Av.p.ppm = available phosphorus in parts per million, CEC = Cation exchange capacity, ND = Not determined and CM = Cattle manure.

capacity and organic carbon. Cattle manure was also analyzed for selected chemical compositions such as total nitrogen, soil pH, organic carbon and available phosphorus using the appropriate laboratory procedures. Soil texture analysis was performed by theBouyoucous hydrometer method (Day, 1965). Total nitrogen was determined using the Kjeldhal method [18].The pH of the soil was measured in water at the soil-to-water ratio of 1:2.5 potentiometric pH meters with glass electrode[33], and determination of cation exchange capacity (CEC) was done using 1N ammonium acetate (NH_4-AOC) method as described by [12]. The available phosphorus content of the soil was determined by theBray II method[56].

Data Collection

Data on different growth and yield components were recorded on sample plants and plot basis. The detailed methodologies adopted for thecollection of different data are described below.

Phenological data

Days to 50 percent flowering: It was recorded as thenumber of days from emergence to the time when 50 percent of the plant stand in each experimental plot yielded flowers

Days to maturity: The number of days from emergence to physiological maturity was registered when 75 % of the plants per plot were ready for harvest as observed by the senescence of the haulms or plants leaves turned yellowish.

Growth parameters

Plant height (cm): Plant height was measured in cm from the soil surface to the tipof stem aboveground growth point at 75% physiological maturity. The plant height was measured from 10 randomly selected plants in each plot and the mean was recorded from the plot.

Main stems number per hill: the actual number of main stems per hill was recorded as the average stem count of 10 hills per plot at 50% flowering. Only stems that emerged independently above the soil as single stems were considered as main stems (Stems arising from the mother tuber were considered as main stems). Stems branching from other stems above the soil were not considered main stems.

Yield and yield components

Marketable Tuber Number per hill: Number of tubers harvested from randomly selected five plants per plot which were counted as marketable after sorting tubers that had greater or equal to 25 g weight free from disease and insect [41].

Unmarketable Tuber Number per hill: The tubers that are sorted as diseased, insect attacked and small-sized (< 25 g) from randomly selected five plants per plot as indicated above was recorded as unmarketable tuber number. The average number of unmarketable tubers was counted and registered from the plot[41].

Total Tuber Number hill^{-1}: The total tuber number per hill was obtained by counting and adding up the number of marketable and unmarketable tubers [82].

Marketable Tuber Yield(t ha^{-1}): The tubers that were sorted and counted from randomly selected plants as marketable were weighted and converted to marketable tuber yield in tons per hectare from thenet plot [82].

Unmarketable Tuber Yield (t ha^{-1}): The average weight of tubers that were unhealthy, injured by insect pests, with defects and less than 25g weight category from net plots tubers were recorded and calculated to t ha^{-1}.

Total Tuber Yield (t ha^{-1}): The total tuber yield per plot was recorded by adding up the weights of marketable and unmarketable tuber and later extrapolated to per hectare [82].

Dry Matter Content of Tuber (%): Five potato tubers were randomly selected from each plot, chopped into small 1-2 cm, mixed thoroughly, and two sub-samples each weighing 200 g were weighed. The exact weight of each sub-sample was determined and recorded as fresh weight. Each sub-sample was placed in a paper bag and put in an oven at 70^{o}C until a constant dry weight was attained. The sample was immediately weighed and recorded as dry weight. Percent dry matter content was calculated based on the formula described by [13].

Specific Gravity of Tubers (gcm^{-3}): Tubers of all size categories weighing about five kilogram was randomly taken from each plot and washed with water. Following this step, the sample was first weighed in air and then re-weighed suspended in water. Specific gravity was finally determined as described by [37]. g cm^{-3}

Statistical analyses

Data were subjected to analysis of variance (ANOVA) using SAS version 9.3 (SAS Institute Inc., 2012). The difference between treatments means was compared usingthe Least Significant Difference (LSD) at 5% level of significance. Pearson correlation analysis was done between themajor growth and yield component of potatoes.

Post-harvest soil sampling and analysis

The soil sample was taken after harvesting from each treatment of the experimental site and soil chemical properties were determined. The soil samples were analyzed for selected chemical properties mainly for soil pH, total nitrogen, available phosphorus and organic carbon using the appropriate laboratory procedures.

Economic analysis

The economic analysis was done using the partial budget analysis described by [11].The net return (Birr ha^{-1}) and costbenefit ratio were calculated by considering the saleprices of potatoes andthe cost of fertilizers and labor for all field activities done. Thus, theeconomic gains of the different treatments were calculated to estimate the net returns and thecost of cultivation, after considering the cost of fertilizer NPS, cattle manure , labor andthe income from total potato tubers for economic analysis. Hence, following theCIMMYT partial budget analysis methodology, total variable costs (TC), gross benefits(GB) and net benefits (NB) were calculated [11]. For each pair of treatments, amarginal rate of return [MRR (%)] was calculated as the ratio of the difference in ahigher net benefit to lower benefit over the difference in higher total costs that vary to lower costs and expressed in percent. Thus, the treatment which was non-dominated and had a MRR of greater or equal to 50% with the highest net benefit was taken to be economically profitable.

RESULTS AND DISCUSSION

Selected Physico-chemical Properties of the Soil of the Experimental Site

The result of cattle manure (CM) treated plots analysis showed that the organic C and/or organic matter is high, implying that this organic fertilizer can be a good source of plant nutrients. Therefore, the application of inorganic NPS fertilizers along with well-decomposed cattle manure with very high nutrient content is justified to produce good yield of potato at the study site.

The change in total N,P,S after harvest (Appendix table 4) relative that the incorporation of cattle manure and mineral N,P,S fertilizers could improve the fertility status of the soil. Improvement in the soil nutrient contents with the application of cattle manure might be a result of buildup in the organic carbon [66], solubilization of different organic nitrogenous compounds into a simple and available

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Table 3: Selected physic-chemical properties of soil after harvesting

Treatment	NPS kg ha-^{1} Fertilizer	Cm t ha^{-1}	pH-H_2O	EC(dS/m)	%OC	%OM	%TN	av.P(ppm)
1	0	0	5.69	0.078	1.51	2.051	0.103	10.227
2	50	0	5.53	0.099	2.18	3.144	0.157	11.341
3	100	0	5.61	0.147	2.15	3.752	0.188	11.508
4	150	0	5.52	0.109	2.09	3.446	0.272	11.551
5	0	10	6.75	0.098	2.63	4.538	0.227	11.389
6	50	10	5.79	0.106	2.11	3.631	0.282	12.051
7	100	10	5.65	0.186	2.16	5.446	0.292	12.518
8	150	10	5.52	0.104	1.93	3.328	0.256	12.696
9	0	20	6.78	0.12	2.67	4.899	0.123	12.647
10	50	20	5.78	0.214	2.15	3.631	0.182	12.066
11	100	20	5.71	0.114	2.81	4.641	0.242	12.364
12	150	20	5.43	0.132	2.63	4.238	0.297	12.784
13	0	30	6.98	0.099	2.46	4.936	0.212	12.073
14	50	30	5.78	0.107	2.18	4.562	0.248	12.862
15	100	30	5.69	0.109	3.77	4.278	0.299	12.885
16	150	30	5.69	0.105	2.95	4.273	0.294	12.922

Where; CM=cattle manure,TN=Total nitrogen,Av.p= Available phosphors,PH= hydrogen power,OC=organic carbon,EC=electric conductivity and OM=organic matters

form, conversion of unavailable P into available form at the time of decomposition of manure [21]. The application of organic or inorganic fertilizers is widely known to ameliorate soil N or P status [54]. This explains why plots that received CM or NPS+CM had higher N and P contents after harvesting.

This was probably due to the released of organic manure (Cattle Manure). Nitrogen and phosphorus availability recorded after harvesting revealed that the highest Nitrogen (0.299%) was found in 100kg NPS+30t CM ha^{-1} and the lowest was 0.103% observed in the control. Similarly, the amount of available phosphorus ranged from 10.227ppm in the control to 12.922ppm in 150kgha^{-1}NPS+30tCMha^{-1}.

Soil analysis results before planting showed that the soil is Silty clay in texture and it was found to be moderately acid with a pH of 6.5. Sole application of CM led to a slight decrease in pH levelafter harvesting from 6.75 to 6.68 which was not different from the initial soil sample pH (7.5). These trends of results were in agreement with those obtained by [47]. Furthermore, [36] reported that the application of organic manure over many years had an average surface soil pH of 6.3 compared to fields receiving only chemical fertilizers (pH 5.8).The pH of the soil is moderately acidic with values ranging between 5.69 – 6.98, which facilitated nutrient uptake by the plants. Soil pH was observed to reduce with the application of organic or inorganic fertilizer compared to the initial soil condition before planting (Table 2). The reduction was more pronounced with plots that received inorganic fertilizer particularly NPS.It is therefore advisable to apply chemical fertilizer to the experimental site to reduce the pH level.

Organic carbon before planting was 2.5% (Table 2). After harvesting, it ranged from 1.51 to 3.77% having the highest value in 100kgNPSha^{-1}+30tha^{-1}CM ha^{-1}followed by 2.95% in 150kg NPS+30tha^{-1} CM and by 2.81% in 100kgha^{-1}NPS+20tha^{-1}Cm. After harvesting, the soil organic carbon was reduced to 1.51 % in the control. However, the organic carbon was in the range 2.11 to 3.77% in the NPS + CM treated plots. The total organic carbon results were in similar trends to those obtained by [47]. Singh *et al.,* 1999 reported a drastic reduction in organic carbon concentration on the continuous application of chemical fertilizer, whereas the addition of 5t/ha Farm Yard manure in combination with N fertilizer helped in maintaining the original organic matter status of the soil. According to Landon. (1991), the cation exchange capacity (CEC) of the soil before planting is medium 19.26 cmol (+) kg^{-1} of soil.

Effect of NPS Blended Fertilizer and Cattle Manure on Growth and PhenologyParameters of Potatoes

Plant height

The main effects of NPS blended fertilizer and cattle

Table 4: Interaction effect of NPS blended fertilizer and Cattle manure on growth and phenological variables

Treatments		Growth	Phenological variables	
NPS blended fertilizer (kgha^{-1})	Cattle Manure (t ha^{-1})	Plant height(cm)	Days to 50% flowering	Days to Physiological Maturity
0	0	46.5^{g}	48.7^{j}	89.0^{i}
	10	56.7^{f}	51.0^{hi}	90.0^{hi}
	20	68.2^{cd}	53.7^{f}	90.7^{hg}
	30	68.6^{cd}	55.3^{e}	91.0^{fgh}
50	0	47.8^{g}	50.7^{i}	89.7^{hi}
	10	57.6^{f}	51.7^{h}	91.0^{fgh}
	20	72.7^{c}	55.7^{e}	92.0^{efg}
	30	78.6^{b}	57.00^{d}	94.0^{cd}
100	0	61.2^{ef}	51.3^{hi}	92.3^{ef}
	10	83.9^{ab}	57.3^{d}	94.3^{cd}
	20	85.5^{a}	59.3^{c}	97.0^{b}
	30	85.8^{a}	60.3^{b}	98.7^{a}
150	0	63.8^{ed}	52.7^{g}	93.0^{de}
	10	84.1^{a}	57.3^{d}	94.7^{cd}
	20	85.6^{a}	61.0^{ab}	98.3^{ab}
	30	86.7^{a}	61.7^{a}	99.7^{a}
LSD(0.05)		5.33	0.86	1.51
CV (%)		4.51	2.11	1.16

LSD = least significant difference; CV = coefficient of variation. Means in a column followed by the same letters are not significantly different at ($P \leq 0.05$)

manure (CM) rates and their interaction effects have shown highly significant ($P<0.01$) differences on plant height (Appendix 1 table 3).The highest plant height of (86.7 cm) was recorded witha treatment combination of 150 kg NPS ha^{-1} + 30t CM ha^{-1} which increased 1.86 times the control (0kgha^{-1} NPS + 0tha^{-1}CM) which was also statistically in parity with the plant height obtained with 150 kg NPS ha^{-1}+ 20 t CM ha^{-1}, 150 kg NPS ha^{-1} + 10t CM ha^{-1}, 100kg ha^{-1}NPS +30 tha^{-1}CM and 100kg ha^{-1}NPS blended fertilizer +20t ha^{-1} CM. Increasing the different rates of NPS blended fertilizers from zero to 150kg ha^{-1} increased mean plant height (Table 3). In a like manner increasing the different rates of CM from zero to 30 t ha^{-1}also enhanced the plant height.

The finding is in agreement with [72] who demonstrated that the highest values of plant height, stem diameter, and leaf size were high for plots fertilized with cow dung at the rate of 20tha^{-1}and NPK (20: 10: 10) kgha^{-1} compared with sole application of cow dung or NPK mineral fertilizer. Application of CM in combination with NP fertilizers might be attributed to theprovision of sufficient micro and macro nutrients, which most likely have helped in enhancing the metabolic activity in the early growth phase which in turn probably encouraged the overall growth (Najm*et al.*, 2013).The findings are also in conformity with the work of [29] who reported that organic manure and inorganic fertilizer supplied most of the essential nutrients during thegrowth stage resulting in the increase of growth variables including plant height. Similar to our result, Bwembya and Yerokun (2001) reported that plants applied with N and P fertilizer and CM were significantly taller than those in the control plots.

Main stem numbers

Understanding the number of main stems per hill or plant provides insight on the morphology and physiology of the potato plant. Each stems produces a single eye can be regarded as an independent production unit. Therefore, a sufficient number of stems should develop per seed tuber [67] since every single main stem is regarded as a production unit, and tuber yield is most likely to vary with an increase in tuber number [31]. The analysis of variance showed highly significant differences in main stem number due to the main effects of NPS blended fertilizer and CM ($P<0.05$) but not for the interaction effect (Appendix table 1).Potato grown with the highest rate of NPS blended fertilizer (150 kg ha^{-1}) recorded highermain stem number of 8.5, which is statistically in parity with 100kg ha^{-1} NPS blended fertilizer (7.9). On the other hand, the lowest main stem number (6.5) was obtained from the control treatment [Figure 3(A)].This result was consistent with that of

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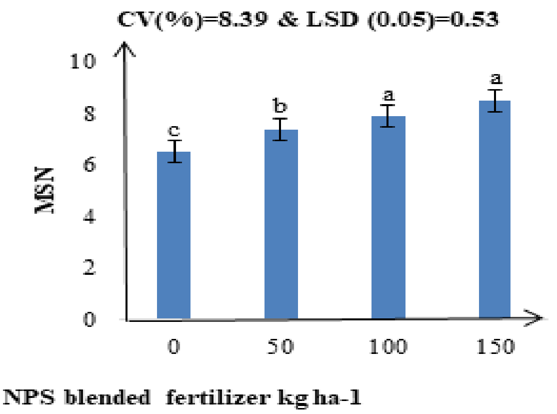
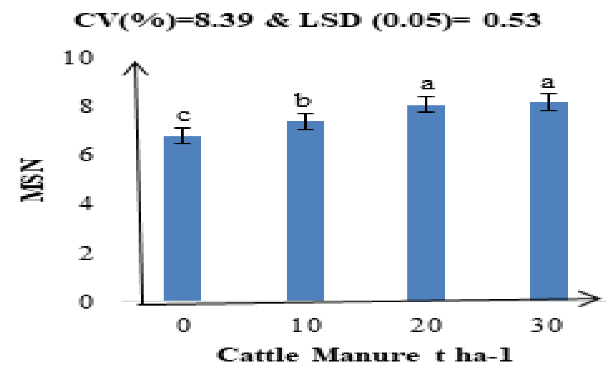
[44] who reported that increasing NP level from nil up to 80 kg N ha^{-1} led to significantly increased potato stem numbers by about 99%.

Similar with NPS blended fertilizer, highest main stem number of 8.2 was recorded with rate of 30 t CM ha^{-1}, which is also statistically at par with 20t CM ha^{-1}with the result of (8.1) [Figure 3(B)]. Conversely, the lowest main stem number of 6.8was recorded with the control treatment. The results revealed that increasing the rate of CM increased the number of main stems produced per plant. However, the increase in the number of the stem in response to increasing CM did show a significant difference among rates from 0 to 30 t ha^{-1}. This work is similar to the result obtained by [82]who reported that the rate of application of CM was increased from 0 to 30 t ha^{-1} the number of main stems increased significantly by 23%.

Contradicting to our findings other researchers reported that stem number is not influenced by mineral fertilizers but by other factors such as thephysiological age of the seed tuber [4], storage condition of tubers, number of viable sprouts at planting, sprout damage at the time of planting and growing conditions [26], variety and tuber size [60].



(A)



(B)

Figure 2: Main effects of NPS blended fertilizer and CM on main stem number of potatoes (A= NPS blended fertilizer and B= Cattle Manure (CM). Means followed by the same letter within a treatment is not significantly different at 5% significant.

Days to 50 % flowering

Highly significant ($P < 0.001$) differences in days to 50% flowering was due to the main effect of NPS blended fertilizers and cattle manure (CM) as well as their interaction effects (Appendix table 1). The earliest days to 50% flowering (48.7days) were recorded with a treatment combination of zero NPS and zero CM. Application of 50/0, 0/10, 100/0 and 50/10 kgha^{-1} NPS/t ha^{-1}CM recorded days to 50% flowering by 50.7, 51.0, 51.3 and 51.7 in the same order whereas, application of 150/20 and 150/30 kgha^{-1} NPS/t ha^{-1}CM delayed days to 50% flowering by12.3and 13.0 respectively compared to the check (Table 3). Increasing the different rates of NPS blended fertilizers from zero to 150kg ha^{-1}delayed mean days to 50% flowering from 52.7 to 58.2 (Same Table 3). Increasing the different rates of CM from zero to 30 t ha^{-1} extended the number of days to 50% flowering. Similarly, the combined application of 150 kg NPS blended fertilizer ha^{-1} +30 t CM ha^{-1} delayed days to 50% flowering (61.67) by 13 days compared to 0/0 NPS/CM (Table 3).

The results of this study in agreement with the finding of [80]who reported that the earliness in flowering due to combinations of lower rates of inorganic NP and CM as well as the control treatments could be attributed to the enhancement of vegetative growth and storing of sufficient reserved food materials for differentiation of buds into flower buds. On the other hand, the delayed flowering in response to the interaction effect of themaximum amount of mineral and organic fertilizer could be due to extended vegetative phase of the plant owing to the availability of nutrients in cattle manure [49] and could also be due to enhanced soil moisture holding capacity as a result of integrated mineralfertilizer and organic manure application [70].The number of days required for flowering is one of the important parameter for potato farmers due to the fact that it enables the grower to forecast its harvesting scheme as well as the marketing plan [35].

Days to physiological maturity

Days to physiological maturity for potatoes defined asa number of days from emergence to maturity when

Table 5: Interaction effect of NPS blended fertilizer and CM rates on marketable tuber yield (MTY), total tuber yields (TTY), marketable tuber number (MTN) and total tuber number (TTN) of potato.

Treatment		**Tuber yield (t ha^{-1})**		Tuber number		
NPS blended fertilizers (kg ha^{-1})	**CM**(t ha^{-1})	MTY	TTY	MTN	TTN	SG(gcm^{-3})
0	0	9.59^{k}	11.12^{k}	3.94^{i}	6.59^{g}	1.056^{j}
	10	12.22^{j}	13.25^{j}	6.42^{h}	7.61^{fg}	1.059^{ij}
	20	21.69^{h}	22.66^{h}	7.15^{fgh}	8.26^{f}	1.062^{hi}
	30	21.79^{h}	23.04^{h}	7.47^{fgh}	8.57^{ef}	1.063^{h}
50	0	15.01^{i}	16.41^{i}	6.17^{h}	7.79^{fg}	1.075^{g}
	10	26.97^{g}	28.48^{f}	7.13^{fgh}	7.56^{fg}	1.080^{ef}
	20	30.62^{f}	31.79^{e}	7.67^{efg}	8.24^{f}	1.082^{de}
	30	32.08^{ef}	33.09^{de}	7.87^{ef}	8.33^{f}	1.084^{d}
100	0	25.10^{g}	25.97^{g}	8.46^{ef}	8.58^{ef}	1.075^{g}
	10	33.73^{ed}	34.19^{d}	8.01^{ef}	9.58^{ed}	1.090^{c}
	20	37.08^{bc}	37.91^{bc}	14.25^{b}	15.44^{b}	1.092^{c}
	30	37.95^{ab}	38.90^{ab}	16.07^{a}	17.32^{a}	1.096^{ab}
150	0	26.02^{g}	26.56^{g}	8.83^{de}	10.17^{d}	1.078^{fg}
	10	35.67^{cd}	36.94^{c}	9.85^{d}	10.24^{d}	1.090^{c}
	20	37.96^{ab}	39.30^{ab}	13.03^{bc}	13.43^{c}	1.093^{bc}
	30	39.79^{a}	40.23^{a}	12.36^{c}	12.89^{c}	1.098^{a}
LSD(0.05)		2.04	1.95	1.26	1.05	0.003
CV (%)		4.35	4.0	8.92	7.63	0.53

Means sharing the same letter are not significantlydifferentat $P \leq 0.05$ CV= Coefficient of variance, LSD= Least significant different.

75% of the plants of different treatments were reached harvest accompanied with senescence of the haulms. A highly significant ($P < 0.05$) difference between the interaction effects of NPS blended fertilizer and CM was recorded for days to physiological maturity (Appendix table 1).The early physiological maturity date was recorded from the control treatment. Treatment combinations of 50/0, 0/10 and 100/0 kgha^{-1} NPS/t ha^{-1}CM recorded earlier days to physiological maturity which is statistically at par with the check (Table 3), because of probably cattle manure activates many species of living organisms, which release phytohormones and may stimulate the plant growth and absorption of nutrients.

This may be a plausible reason that the use of organic manure with inorganic fertilizer leads to an increase in the leaf area which increases the amount of solar radiation intercepted thereby increasing days to flowering, physiological maturity, plant height and dry matter accumulation [57]. Plots that received 150kg ha^{-1}NPS blended fertilizer +30t ha^{-1}cattle manure delayed maturity, which was statistically in parity with those plots fertilized with 150kgha^{-1}NPS blended fertilizer +20t ha^{-1} cattle manure and 100kgha^{-1}NPS blended fertilizer + 30t ha^{-1}cattle manure (Table 3).

The findings of this study are in agreement with the work of [81] who reported that the application of N and P fertilizers delayed flowering and prolonged days required to attainthe physiological maturity of potato. Moreover, [52] reported that the application of N resulted in significantly delayed physiological maturity. EARO (2004) also stated that the days to maturity of potato varieties varied from 90 to 120 days and the variation is accounted for by variety, growing environment and cultural practices. The presence of N in excess promotes the development of the above-ground organs, Synthesis of proteins and formation of new tissues are stimulated, resulting in vigorous vegetative growth. This increases the days of physiological maturity [40].

Effect of NPS Blended Fertilizer and Cattle Manure on Yield Variables

Total tubers number per plant

The total tuber number per plant^{-1} was increased with thecombined application of organic and inorganic fertilizers compared tothe sole application of NPS blended fertilizers or CM.This might be due to its higher nutrient composition and capacity to increase theavailability of native soil nutrients through higher

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biological activity .The main effect of NPS blended fertilizer and CM rates and their interaction showed highly significant (P<0.01) differences on the total number per plant (Appendix table 2).Maximum total tuber number per plant (17.32) was recorded with100 kg NPS ha^{-1} + 30t CM ha^{-1}followed by 100 kg NPS ha^{-1} +20t CM $ha^{-1}$and 150 kg NPS ha^{-1} +20 t CM $ha^{-1}$with total tuber number of 15.44 and 13.43 respectively (Table 4).

The lowest total tuber number per plant (6.59) was recorded with the control which was statically in parity with thetotal tuber number per plant obtained with treatment combinations of 50 kg NPS ha^{-1} + 10 t CM ha^{-1}, zero NPS and 10t CM $ha^{-1}$and 50kg NPS + zero t CM ha^{-1}respectively with 7.56, 7.61 and 7.79 per plant in the same order. The result of this study is in conformity with the finding of [3] who stated that the increase in total tuber number per plant is in response to the increased application of the combined NP fertilizers and CM might be due to the increased photosynthetic activity and translocation of photosynthetic to the root, which is probably helped in the initiation of more stolon in potato. Taheri*et al*. (2010) also found the highest ratio (13.07%) of a number of large tubers as a result of the application of 20 t compost $ha^{-1}$of combined with 225 kg P ha^{-1} and 50 kg zinc ha^{-1}. Sparrow *et al.* (1992) and Lynch and Rowberry (1997) reported a significant tuber number per plant increment in response to increasing N rates. At any given level of P the total tuber number $plant^{-1}$, increased with an increase in cattle manure application. Thus, tuber number increased with an increase in P and FYM application [62].In the contrary to our result, tuber number is also determined by the number of stems produced which in turn depends on the tuber size and variety as reported by [20].

Marketable tuber number

The marketable tuber number $plant^{-1}$increased with an increasing CM application rate because the CM applied to soil resulted in an increase in carbon mineralization in the soil due to available carbon for microbial respiration and provision of nitrogen. The main effects of NPS blended fertilizer and CM rates and their interaction revealed a highly significant differences (P<0.01) on marketable tuber number $plant^{-1}$(Appendix Table 2). Higher marketable tuber number $plant^{-1}$(16.07) recorded with100kg NPS ha^{-1} + 30t CM ha^{-1}followed by 100 kg NPS ha^{-1} +20 t CM ha^{-1} and 150 kg NPS ha^{-1} +20 t CM $ha^{-1}$with marketable tuber number of 14.25 and 13.03 respectively (Table 4). However, the lowest marketable tubers number $plant^{-1}$ (3.94) was obtained with the control plots.

The possible reasons for the maximum marketable number of tuber per hill observed from the higher combined application of NPS blended fertilizer and cattle manure could be due to the presence of an adequate amount of nitrogen which resulted in better vegetative growth, greater photo assimilates for the production of marketable tuber numbers. The high total and marketable tuber yields obtained due to the combined use of mineral and organic fertilizers could be attributed to the synergetic effect of mineral NP and Cattle Manure [583]. Similarly, the number of marketable tubers increased significantly as the rate of sulfur increased, probably due to Sulfur's role in the synthesis of sulfur-containing amino acids, proteins, energy transformation, activation of enzymes which in turn enhances carbohydrate metabolism, and photosynthetic activity of plant with increased chlorophyll synthesis [33].This was important for photosynthesis and net assimilation processes and no re-absorption evidently took place from the tubers, leading to increased tuber size and weight so the tuber could be marketable [10].

Un marketable tuber number

The analysis of variance revealed that there was no significant difference (P>0.05) due to theinteraction effect of NPS blended fertilizer and Cattle manure rates on unmarketable tuber numbers of potatoes. Similarly, the main effects of NPS blended fertilizer and cattle manure rates remained non-significant difference (Appendix Table 2).

Total tuber yield

Variations in the rate of application of organic manure and inorganic fertilizers could influence the yield of potatoes[47]. The main effects of NPS blended fertilizer and CM rates and their interaction hada highly significant (P<0.001) effect on the total tuber yield (t ha^{-1}) of potatoes (Appendix Table 2). The total tuber yield ha^{-1} increased with the combined application of NPS blended fertilizer and CM compared to the sole application of either NPS blended fertilizer or CM. The highest total tuber yield (40.23 t ha^{-1}) wasobtained with combined application of 150 kg NPS blended fertilizer ha^{-1} + 30 t CM ha^{-1} followed by 150 kg NPS blended fertilizer ha^{-1} + 20 t CM $ha^{-1}$and 100 kg NPS blended fertilizer ha^{-1} + 30 t CM $ha^{-1}$with total tuber yield of 39.30 and 38.90t ha^{-1}respectively, which were also statistically in parity with this optimal total tuber yield (Table 4).On the other hand the lowest total tuber yield (11.12 t ha^{-1}) was obtained from the control treatment. The combined application of 150 kg NPS blended fertilizer ha^{-1} + 30 t CM ha^{-1} increased total tuber yield by 38.31% over the control treatment. In the present study it was observed that total tuber yield had highly significant and positive Correlated with total tuber number (r= 0.734**), marketable tuber number (r=0.811**), plant height (r=0.944**) and main stem number (r=0.781).The possible reasons for the existence of this relation among the parameters are as the plant height increased the plants produce higher photosynthesis and as a result the total tuber yield was higher. This result is consistent with that of [31] who reported that an increase in stem numbers markedly increased tuber numbers and total tuber yield per unit area of land and also plant height and total tuber yield indicating the existence of a positive association between the two parameters which corroborated the findings of [79].

Mohammadi*et al*. (2013) reported that the presence of nutrients in manure and balanced supplement of nitrogen and phosphorus through mineral fertilizers might have contributed to increased cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and regulation of water intake into the cells, resulting in the enhancement of yield parameters. Probably because CM supply and promote the uptake of nitrogen, the tuberous root bulking might have enhanced due to the catalytic role CM plays in enhancing the dissolution and uptake of other nutrients from the soil. Similarly in onion, the application of compost and combinations of N, P, and S to soils somehow increased the bulb diameter [27]. Our finding is also similar to the works of [5] who reported that application of 20 or 30 t ha^{-1} FYM + 66.6% of the recommended inorganic NP fertilizers significantly increased total tubers yield. Nasreen*et al*. (2007) obtained the highest onion yield in response to the combined application of 120 kg N + 40 kg S ha^{-1} with a blanket dose of 40 kg P, 75 kg K, 5 kg Zn ha^{-1} and 5 t ha^{-1} of cow dung.[16]reported that the maximum tuber yield (36.8 t ha^{-1}) was obtained by using 150 kg N ha^{-1} + 20 t CM ha^{-1}. [72]observed also that tuber yield was increased by the combined use of cow dung and NPK (20: 10: 10) compared to sole application of cow dung or NPK.

Marketable tuber yield

The main effect of NPS blended fertilizer and CM rates and their interaction showed a significant (P< 0.001) effect on the marketable tuber yield of potatoes (Table 4 and Appendix Table 2).The highest marketable tuber yield (39.79 t ha^{-1}) was recorded withthe application of 150 kg NPS blended fertilizer ha^{-1} + 30 t CM ha^{-1}followed by 150 kg NPS blended fertilizer ha^{-1} + 20 t CM ha^{-1} and 100 kg NPS blended fertilizer ha^{-1} + 30 t ha^{-1} CM with marketable tuber yield of 37.98 and 37.95 t ha^{-1}respectively, which are also statistically at par with this highest marketable tuber yield (Table 4). However, the lowest marketable tuber yield (9.59 t ha^{-1}) was recorded with the control treatment, which is less by 33.82% compared with the highest value obtained with150 kg NPS blended fertilizer ha^{-1} + 30 t CM ha^{-1}. The control plot produced the lowest values for marketable tuber yield of potato, due to the absence of adequate nutrient levels needed for proper growth, development and yield. Combining mineral fertilizers with cattle manure prolonged the release and added more macro and micro nutrients thereby promoting better crop growth and marketable tuber yield of potato [77].

The possible reasons for the maximum marketable tuber yield per ha observed with the higher combined application of NPS blended fertilizer and CM could be due to a function of total biomass production, the percentage of biomass that is partitioned to the tubers, the moisture content of the tubers and the proportion of tubers that are acceptable to the market, in terms of size and lack of defects; and great opportunities exist to increase potato yield and quality by improving nutrient management. Abayand Tesfaye, (2011) reported that supplementation of 10 t ha^{-1} compost with 73.4 kg N and 59.5 kg P_2O_5 ha^{-1} gave yield advantage of 8.4 t ha^{-1} in southern Ethiopia. Marketable tuber yield was positively and significantly (P < 0.01) correlated with total tuber yield (r = 0.998**) and total tuber number (r=0.739**).This indicates that factors leading to increased marketable tuber yield would also increase total tuber yields and tuber numbers significantly.

Unmarketable tuber yield

The analysis of variance revealed that there was no statistically significant difference (P>0.05) due tothe treatments interaction effect of NPS blended fertilizer and Cattle manure rates on unmarketable tuber yield of potato. Similarly, the main effects of NPS blended

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Table 6: Results of the economic analysis for combination of NPS and CM in potato grown at DaboGhibeKebele in Sekawereda

NPS kg ha^{-1}	CM t ha^{-1}	TC (Birr ha^{-1})	MC (Birr ha^{-1})	AGY(tha^{-1})	GR(Birr ha^{-1})	NR (Birr h^{-1})	MB	MRR (%)	BCR
0	0	50128		11.12	55600	5472	-	-	1.11
50	0	51625	1497	16.41	82050	30425	24953	16.67	1.58
100	0	52898	1273	25.97	129850	76952	46527	36.55	2.45
150	0	54165	1267	26.56	132800	68635	-8317	-	2.41
100	20	55892	1727	37.91	189550	133658	65023	37.65	3.39
100	30	55987	95	38.9	194500	138513	4855	51.1	3.47
150	20	59607	3620	39.3	196500	139893	1380	0.38	3.29
150	30	69757	110150	40.23	201150	131393	-8500	-	2.88

Where: Purchasing costs for fertilizers NPS (Nitrogen, phosphorus, sulfur) were estimated at Birr 16 kg $^{-1}$. The cattle manure were estimated at Birr 25/quintals .The selling price of potato at the local market at the harvest time was estimated at Birr 500/quintal . Purchasing costs for potato seed Birr 9/kg.MC=marginal total cost, MRR = marginal rate of return TC=total production cost per ha, marginal cost, AGY= Adjusted yield, GR=gross return, NR= net return, MB = marginal benefit, BCR= cost benefit ratio.

fertilizer and cattle manure rates remained non-significant difference (Appendix Table 2).

Effect of NPS Blended Fertilizer and Cattle manure (CM) on specific gravity (g cm^3)

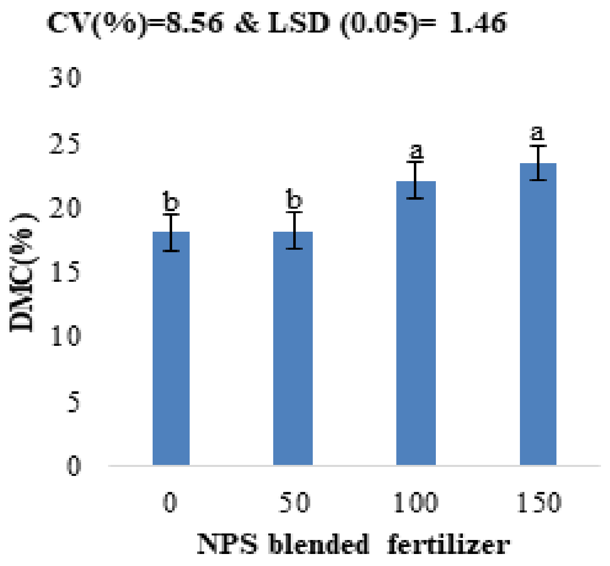
The specific gravity may give an insight into estimation of starch content of potato tuber because it is the major component of the dry matter, usually comprising 65-75 per cent of the total soluble solids [71]. The analysis of variance revealed that there was a significant difference between treatments due to the main effect of NPS blended fertilizer and CM and their interaction (Table 4 and Appendix Table 3). In the present study, the application of NPS blended fertilizer and CM highly significantly ($p< 0.001$) increased tuber-specific gravity (Table 4). The highest tuber-specific gravity (1.098 g cm^{-3}) was obtained with the combination of NPS blended fertilizer rate of 150 kg ha^{-1} + 30 t ha^{-1} CM followed by a treatment combination of 100 kg NPS ha^{-1} + 30 t CM ha$^{-1.}$ Application of NPS blended fertilizer rate of 150 kg ha^{-1} + 30 t ha^{-1} CM registered higher specific gravity which is at par value with the treatment combination of100 kg NPS ha^{-1} + 30 t CM ha^{-1}(Table 4).The lowest tuber specific gravity (1.056 g cm^{-3}) was also recorded from the control treatment which was also statistically in parity with the specific gravity (1.059 gcm^{-3}) of potato tuber obtained with zero NPS and 10 t CM ha^{-1}. This explained that significant increase in specific gravity with the increase in the combined application of mineral NPS and CM might be attributed to release of macro and micronutrients from CM.

Increasing CM rate from zero to 30 t ha^{-1} increased specific gravity (Table 4) However, an increase in tuber specific gravity by increasing N rates, cattle and chicken manure was also reported by (Abou-Hussein *et al*., 2003), and combined application of chicken manure and NPK [45].In this study integrating100 to 150 kg NPS blended fertilizer with 20 to 30 t CMha^{-1} seemed to improve tubers specific gravity (Table 4) similar to [79] works who reported that potato growth and quality were affected by the combination of both sources of fertilizers.

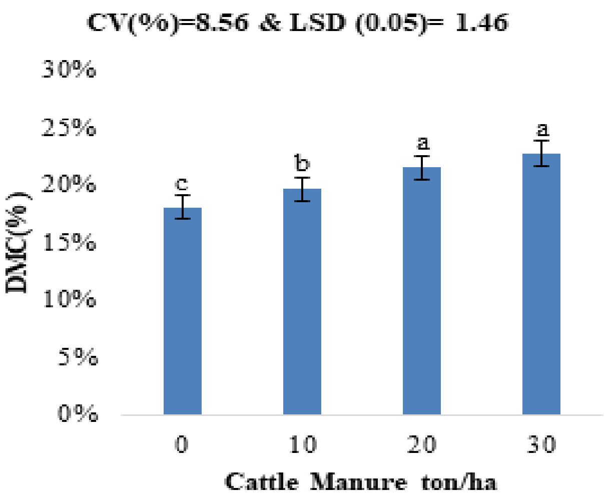
Pervez et al.(2000) reported that combined application of 5 t FYM ha^{-1}along with 200 kg K_2O ha^{-1}recorded higher specific gravity (1.091) compared to sole K fertilizer and control. In a similar manner, [34] found improved specific gravity (1.064 g cm^3) with 60% mineral N (238 kg N ha^{-1}) combined with 40% organic chicken manure (158 kg N ha^{-1}). N'Dayegamiye*et al*., (2013) reported also that specific gravity of tubers ranged from 1.070 to 1.073 and was significantly increased with an organic amendment and mineral fertilizer application.

Effect of NPS Blended Fertilizer and CM on Dry matter content (%)

Dry matter content is affected by various factors, among which the most significant are the following ones: tuber maturity, growth character, plant nutrient and water uptake (Haris, 1992).In the present study, dry matter content was determined based on the formula described by [13]. Highly significant ($p<0.05$) differences were noted for dry matter content due to the main effect of NPS blended fertilizer and CM but not for their interaction(Appendix Table 3).Potato



(A)



(B)

Figure 3: Mains effects of NPS blended fertilizer and Cattle Manure on dry matter content of potato tuber (A = NPS blended fertilizer and B = Cattle Manure). Means followed by the same letter within a treatment is not significantly different at 5% significant.

grown with150 kgha^{-1} NPS blended fertilizer recorded 23.5% which is statistically at par 100 kgha^{-1} NPS blended fertilizer (Figure 3A), however, the lowest dry matter content was obtained with the control treatment, which was also statistically in parity with the value obtained with intermediate level (50 kg) NPS blended fertilizer ha^{-1}. This probably is associated with the influence of N on gibberellins biosynthesis and other phyto-hormonal activities which have direct influence on plant growth and dry matter accumulation. This might be attributed to high NPS dose which results in high NPS use efficiency and dry matter accumulation in tuber.

Dry matter content was positively and significantly (P < 0.05) correlated with specific gravity (r = 0.74**) (Table 7). This indicated that the dry matter (total solid) of tubers is a true indicator of the amount of specific gravity of tubers which is similarto the report of [74].Similarly, dry matter content has been used as a criterion of potato quality due to its positive correlation with the specific gravity of tubers. In a like manner highly significant (p<0.05) difference was recorded for dry matter content with CM. the maximum value of dry matter content was observed with 30 t ha^{-1}which is statistically at par with 20 t CM ha^{-1}, whereas the lowest dry matter content was recorded with the control treatment (Figure 3B). The addition of such organic sources might create favorable condition in rhizosphere, increase the uptake of nutrients, the secretion of certain enzymes and auxins and other growth-promoting substances which ultimately improve the quality of potato [73].

This work contradicts Baniumiene and zekaite (2008) findings who reported higher values of starch and dry matter content with potato tubers grown without FYM. The highest dry matter and starch content were accumulated in potatoes tubers fertilized with mineral not organic fertilizers (Stimumar*et al*.,1990).Other study indicated that an increase in NP fertilizer might have enhanced growth components by promoting dry matter accumulation [49]. The increase in plant height with the increased application of S might be due to its role in the growth and physiological functioning of plants, thus improving its quality by increasing the dry matter contents of the tubers [6]. The dry matter content of potato tubers determines suitability for chip processing purposes by influencing the chip yield, texture flavor, final oil content and process efficiency [38].

Economic benefit

The results of the partial budget analyses revealed that the highest net returns of Birr 139,893 was recorded in the treatment that received 20 t ha^{-1} cattle manure in combination with 150kg ha^{-1} of NPS fertilizer followed by 30t/ha cattle manure along with 100kgNPS ha^{-1}.However, the lowest net returns of Birr 5472 were received 0-0 NPS kgha^{-1}and CM t ha^{-1}.The same treatments which give the highest net return also recorded highest benefit: cost ratio of 3.29 and 3.47 respectively (Table 5).Dominance analysis is thus carried out by first listing the treatments in order of increasing costs that vary. Any treatment that has net benefits that are less than or equal to those of treatment with lower costs that vary was

APPENDICES

Appendix 1: Analysis variance showing mean squares for 50% of flowering days, 75% of maturity days, plant height at 60days after emergence and main stem numbers at 50% of flowering days.

Source of variation	DF	DFR	DM	PH	MSN
REP	2	0.33	1.39	18.17**	0.18
CM	3	144.58**	54.75**	1562.91**	5.64**
NPS	3	94.47**	109.25**	1259.77**	9.07**
CM*NPS	9	3.12**	3.39**	49.58**	0.19ns
ERROR	30	0.27	0.82	10.22	0.41
CV(%)		2.11	1.16	4.51	8.39

Where; DF = degrees of freedom, DFR = days to 50% flowering, DM= days to 75% maturity, PH=plant height, main stem number and NS, * and ** implies non-significant, significant and highly significance differences at 5% level of probability, respectively.

Appendix 2: Analysis of variance showing mean squares forunmarketable tuber yield, unmarketable tuber number, marketable tuber yield, marketable tuber number, total tuber number, total tuber yield of potato, as affected by the application of NPS and cattle manure.

Source of Variables	df	Mean quares					
		Tuber yield(t/h			Average tuber number		
		MTY	unMTY	TTY	MTN	UnMTN	TTN
REP	2	0.68	0.0073	0.55	0.46	0.55	0.48
CM	3	461.72**	0.085ns	454.09**	47.35**	0.52ns	37.63**
NPS	3	847.72**	0.67ns	810.94**	90.32**	0.87ns	75.39**
CM*NPS	9	13.52**	0.36ns	14.91**	7.59**	0.54ns	10.05**
ERROR	30	1.49	0.32ns	1.36	0.65	0.36	6.2
CV(%)		4.35	54.77	4.00	8.46	**50.88**	7.63

MTY= marketable tuber yield, unMTY= unmarketable tuber yield, TTN= total tuber numbers, MTN= marketable tubers and unMTN= unmarketable tuber numbers, CM=cattle manure, NPS=Nitrogen, phosphorus and sulfur fertilizerandNS, * and ** implies non-significant, significant and highly significance differences at 5% level of probability, respectively.

Appendix 3: Analysis of variances showing that mean square of dry matter content (%) and specific gravity (gcm^{-3}).

Source of variation	DF	DMC (%)	SG(gcm^{-3})
REP	2	9.001	0.000007
CM	3	50.37**	0.00046**
NPS	3	89.13**	0.0022**
CM*NPS	9	3.28ns	0.000029**
ERROR	30	3.07	0.0000026
CV(%)		8.56	0.15

Where; DMC=dry matter contents, SG= specific gravity and NS, * and ** implies non-significant, significant and highly significance differences at 5% level of probability, respectively considered dominated [11]. The high net return from the foregoing treatments could be attributed to high yield and the low net return was attributed to low yield. However, the maximum marginal rate of return was recorded in the treatment receiving 100 kg NPS kg ha^{-1} +30 t ha^{-1} CM and the minimum marginal rate of return was recorded from the treatments that received 150 kg NPS kg ha^{-1} + 20 t ha^{-1} CM.

From the economic point of view, all the treatment which have a marginal rate of return are advantages; however, it was apparent from the results that treatments receiving 100 NPS kg ha^{-1} + 20 t ha^{-1} CM and 30tha^{-1}CM were more profitable than the rest of treatment combinations.

SUMMARY AND CONCLUSIONS

The field experiment was conducted on NPS blended fertilizer rateand cattle manure on potato at SekaweredaDaboGhibeKebele farmers' site in 2016. The results of this study showed that growth, yield, and qualityparameters of potato such as days to 50% flowering, days to 75% of physiological maturity, marketable tuber yield, marketable tuber number per plant, total tuber yield, total tuber numberper plant, plant height, main stem number, dry matter content and specific gravity ofpotato increased as aresult of the application of NPS blended fertilizer and cattle manure rates.

Results indicated that the main effects of NPS blended fertilizer and cattle manure and their interaction significantly influenced plant height, days to 50% flowering, days to 75% of physiological maturity, total tuber yield, marketable tuber yield, total tuber numberper plant, marketable tuber number per plant andspecific gravity.

The interaction effect of NPS blended fertilizer and cattle manure significantly influenced plant height, days to 50% flowering, days to 75% of physiological maturity, total tuber yield, marketable tuber yield, total tuber numberper plant, marketable tuber number per plant andspecific gravity (1.098) were recorded at application of150kg ha^{-1}NPS blended fertilizer + 30t ha^{-1}cattle manure followed by 150/20,100/30,100/20kg/t ha^{-1}. In general, the highest mean number of plant height,days to 50% flowering,days to 75% of physiological maturity,total tuber yield t ha^{-1},marketable tuber yield,total tuber numberper plant,marketable tuber number per plant and specific gravity (86.7cm,61.7,99.7,40.23 t ha^{-1},39.79 t ha^{-1},12.89, 12.36and1.098gcm^{-3}) were observed when 150kg ha^{-1} NPS blended fertilizer + 30t ha^{-1} cattle manure were applied respectively followed by150/20,100/30 and100/20kg/tha^{-1}. The main effect of NPS blended fertilizers and cattle manuresignificantly influenced main stem number and dry matter content of tuber.The highestmain stem number obtained by application of 150kgha^{-1}NPS (8.5) and 100kgha^{-1}NPS (7.9) and the lowest from control. In the same mannerhighestmain stem number obtained by application of 30tha^{-1} (8.2) and 20tha^{-1}(8.1) cattle manure.The highestdry matter content obtained by application of 150kgha^{-1}NPS (23.5%) and 100kgha^{-1}NPS (22.1%) and the lowest from control. In the same mannerhighestdry matter content was obtained by application of 30tha^{-1} (22.7%) and 20tha^{-1}(21.5%) cattle manure was the lowest from control.Almost all parameters except unmarketable tubernumber and yield had the highest values when the highest application rate of NPS blended fertilizers, cattle manure and their interaction.In this study, it is found that there is a positive and significant association among response variables such as marketable tuber yield, total tuber yield, marketable and total tuber number, plant height, main stem number, dry matter content and specific gravity.

Generally, the present study indicated that the combined application of NPS blended fertilizer and CM improved the growth, yield, and quality of potatoes. Accordingly, optimum tuber yield was obtained from the combined application of 150 kg ha^{-1} NPS blended fertilizer and 20- 30t ha^{-1} CM. In terms of an economic point of view, the combined application of 100 kg NPS kg ha^{-1} blended fertilizers and 20-30tha^{-1}CM found high net benefit with a high marginal rate of return and economically feasible and recommended for potato growing areas of Dabo Gibe kebele in Sekawereda. However,a sound recommendation cannot be drawn from this study since the research work was conducted only for one season in a single location. Therefore, we suggest that NPS blended fertilizer levels combined with CM study be carried out in more than one seasons with multi-locations having diverse ecologies, for optimum potato productivity which would help to draw sound conclusions and recommendations.

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