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Research Article
NPSZnB Fertilizer and Cattle Manure Effect on Potato (*Solanum tuberosum* L.) Yield and Yield Components in Awi Zone, Ethiopia

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Abstract

Background and Objective: Potato (*Solanum tuberosum* L.) is one of an important food and cash generating crop in the northwestern parts of Ethiopia and particularly of Awi zone where it is grown three times per annum. However, its productivity is very low since, separate use of fertilizer, absence of balanced fertilizer and no recommendation on integrated use of organic and inorganic fertilizers for the area. The aim of study was to investigate the best combination of blended NPSZnB fertilizer and cattle manure for the better production of potato. **Materials and Methods:** For this purpose, an experiment was conducted at Banja district, Awi Zone during rainy season of 2017. Four different levels of blended NPSZnB fertilizer (0, 65.7, 133 and 199 t ha^{-1}) and four levels of cattle manure (0, 10, 20 and 30 t ha^{-1}) were factorially combined and tested for effect on the yield and yield component of potato in a randomized complete block design (RCBD). **Results:** Results of analysis of variance revealed that significant effect of treatments on marketable and total tuber yield and total dry biomass yield. The combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure significantly affected the indicated parameters. However, marketable tuber number and total tuber number were significantly affected by blended NPSZnB fertilizer (199 kg ha^{-1}) alone, Harvest index (%) and total dry biomass were significantly affected by cattle manure (30 t ha^{-1}) alone, while average tuber weight was significantly affected by blended NPSZnB fertilizer (199 kg ha^{-1}) alone and cattle (30 t ha^{-1}) manure alone but not interaction. **Conclusion:** Application of 199 kg ha^{-1} blended NPSZnB fertilizer level with 30 t ha^{-1} cattle manure should be used for better yield and yield component performance of dagim potato variety at study area.

Key words: Blended fertilizer, cattle manure, potato, yield, yield component

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family of Solanaceae and genus *Solanum*[1]. It is the most important vegetable crop, constituting the fourth most important food crop in the world following wheat, maize and rice and first among root and tuber crops followed by cassava, sweet potato and yam[2]. It has been cultivated in many parts of Ethiopia for over 150 years; Ethiopia is endowed with suitable climatic and edaphic conditions for potato production. It is grown at different times of the year, viz., main rainy season (June-October), small rainy season (Belg from February/March to May) and irrigation (December/January to April). Over these periods potato has shown a sharp increase in both area coverage and volume of production. During the year 2015 alone over 3.67 million t of potato was harvested from close to 0.3 million ha of land[3]. Despite such sharp rise in both area and volume of production, the productivity of this crop in the country is very low (13.8 t ha^{-1}) compared to the world's average yield of 19 t ha^{-1} (CSA)[3] and the possible yield that could be obtained (30 t ha^{-1}) at farmers field condition if all appropriate technologies are used. Various reasons could be attributed for the observed yield gap between actual and potential yield. Among these factors, poor soil fertility and application of sub-optimal fertilizer rates are most determining factors[4].

Potatoes demand high levels of soil nutrients due to a relatively poorly developed, coarse and shallow root system[5]. Besides, the crop produces much more dry matter in a shorter cycle that results in the removal of large amounts of nutrients per unit time, which generally most of the soils are not able to supply[6]. Review of earlier research works done and recommendations made in the area by Adet Agricultural Research Center found to be old in one hand and considered only N and P nutrients sources alone. Moreover, it did not considered readily available organic sources that are economical and could improve the efficiency of inorganic sources of fertilizer (Banja District Agriculture Office, 2017). The present study was therefore initiated to assess the influence of integrated use of cattle manure and blended (NPSZnB) fertilizer on yield and yield components of potato under most areas of Banja district, Awi zone and increase the productivity of potato through improved soil fertility management technology. According to Ethio-SIS map the soils of study area is deficit in nitrogen, phosphorus, sulfur, zinc and boron nutrients.

MATERIALS AND METHODS

Experimental site: The experiment was conducted at Banja district of Awi Zone, Chewusa kebele farmers training center in 2017 under rain fed condition. Banja district is geographically located at 454 km northwest of Addis Ababa at an elevation of 2560 masl and situated at latitude 10°57'N and longitude 36°56' E. The experimental site received an average annual rainfall of 1700 mm with minimum and maximum temperatures of 5 and 25°C, respectively. The soil of the experimental site was reddish brown clay classified as nitisol[7].

Treatments and experimental design: Sixteen treatments were obtained by a factorial combination of four levels (0, 65.7, 133 and 199 t ha^{-1}) of blended NPSZnB inorganic nutrient sources and four levels (0, 10, 20 and 30 t ha^{-1}) of organic nutrient sources (CM). The different levels of blended inorganic fertilizer (NPSZnB) and different levels of cattle manure (CM) were laid out in randomized complete block design (RCBD) with three replications.

Experimental procedures: The land was prepared in accordance with the standard practice used by farmers by plowing at a depth of 15-20 cm. Plots were leveled and ridges prepared using hand tools to provide a medium fine soil for the growth the crop. Each plot consisted of five rows that were spaced 75 cm apart and planted with tubers that are placed in a row at 30 cm to each other (EIAR)[8]. The space between plots within a block was 1 m while that between blocks was 1.5 m.

Then medium sized and well sprouted seed tubers were planted by manually placing 30 cm at a depth[9] of 5 cm in prepared ridges during the main cropping season after the rain commenced and the soil became moist enough to support emergence. The cattle manure which was used as an organic nutrient source was applied 2 weeks before sowing and incorporated into the soil at a depth 15 cm. The NPSZnB blended fertilizer used as inorganic mineral nutrient source was applied at sowing time depending on the specified or selected levels. The experiment was done under rain-fed condition and agronomic practices were kept uniform for all treatments as recommended and adopted for the location.

Data collected: Data on total and marketable tuber number, average tuber weight total fresh weight of tubers , total tuber yield and marketable tuber yield, fresh weight of plant biomass and harvest index were recorded. The total tuber

number was taken by counting tubers of 10 plants, marketable tuber number by selecting and counting tubers that were not under sized, diseased and green color. Average tuber weight was determined by dividing the total fresh tuber weight to the respective total tuber number and harvest index is recorded as percent of total fresh weight of tubers to total fresh weight of plant biomass. Also total dry biomass was recorded by adding the weight of dried above ground and below ground biomass yield in an oven following the standard over drying protocol of constant weight method. The total tuber yield and marketable tuber yield was taken from the central net plot by weighing each category of yields.

Statistical analysis: All data were subjected to analysis of variance using SAS version[10] 9.3 and effect of blended fertilizer and cattle manure on each parameter of potato has been checked. The difference between treatments means were compared using Least Significant Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Marketable and total tuber numbers: Blended NPSZnB fertilizer levels had highly significant ($p<0.01$) effect on marketable tuber numbers and total tuber numbers. However, cattle manure alone and its interaction with blended NPSZnB fertilizer did not show significant effect on marketable tuber numbers and total tuber numbers. The highest marketable tuber number and total tuber number were recorded at 199 kg ha^{-1} blended NPSZnB fertilizer levels which were also statistically in par with the marketable tuber number and total tuber number obtained from 133 and 65.7 kg ha^{-1} levels respectively. On the other hand, the lowest total marketable tuber number and total tuber number were recorded from control treatment (Table 1). Increasing blended NPSZnB fertilizer rate from 0-199 kg ha^{-1} resulted in increased marketable tuber numbers from 4.16-5.89/hill without and increased total tuber number from 5-7.3/hill.

The trend depicted that marketable tuber number and total tuber number increased with increased nitrogen rate. This increase in marketable tuber number and total tuber number could be probably due to the fact that nitrogen can trigger vegetative growth and development. Sulfur, Zinc and Boron may increase tuber size by facilitating nitrogen and phosphorus absorption, cell division, chlorophyll synthesis and photosynthesis. Cattle manure in addition to source of nutrient, improves soil structure which was important for nutrient and water absorption that subsequently helped in tuberization and tuber size increment[11]. This result was in agreement with the findings of Zewide *et al.*[12], Yourtchi *et al.*[13] and Getie *et al.*[14], who reported that application of nitrogen and phosphorus significantly increased both marketable and total tuber number. Zelalem *et al.*[15] had also reported that nitrogen and phosphorus fertilization improved both marketable and total tuber number of potato.

Table 1: Mean results of effects of blended NPSZnB and cattle manure fertilizer rates on MTN, TTN of potato at Banja district, 2017

NPSZnB (kg ha^{-1})	MTN (number)	TTN (number)
0	4.16^{b}	5.00^{b}
65.7	4.59^{ab}	5.46^{ab}
133	5.46^{ab}	6.54^{ab}
199	5.89^{a}	7.30^{a}
LSD (5%)	1.62	2.03
CV (%)	18.17	17.67

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0.05): Least significant difference at 5% level and CV (%): Coefficient of variation (%)

Marketable yield (MY): Marketable yield was highly significant ($p<0.01$) influenced by the levels of blended NPSZnB fertilizer, cattle manure (CM) and their interaction. The highest marketable tuber yield (31.7 t ha^{-1}) was obtained from combined application of 199 kg ha^{-1} of blended NPSZnB fertilizer level and 30 t ha^{-1} cattle manure. On other hand, the lowest yield (9.81 t ha^{-1}) was recorded for the control treatment (Table 2).

Increasing rate of blended NPSZnB fertilizer and cattle manure alone also positively influenced marketable tuber weight. The possible reasons for the highest marketable yield observed from the combined application of inorganic and organic fertilizer could be related with the increase in the soil nutrients that resulted in better vegetative growth which in turn enable the crops to produce greater photoassimilate. Increase in marketable tuber yield with increasing rates of NPSZnB fertilizer was due to the positive effect of both nitrogen and phosphorus on marketable tuber weight[12] through enhanced vegetative growth of the aerial parts and translocation of photosynthetic assimilate into the storage organ or tuber[14]. Getie *et al.*[14] and Yourtchi *et al.*[13] had similarly reported the significant influence of nitrogen fertilization on the marketable tuber yield of potato. In the same way Zelalem *et al.*[15] and Zewide *et al.*[12] reported that N and P fertilization significantly influenced the marketable and total tuber yields productivity of potato.

Total tuber yield (TTY): Total tuber yield was highly significant ($p<0.01$) influenced by the application of blended NPSZnB fertilizer and cattle manure (CM) and significantly ($p<0.05$)

Table 2: Mean square values of potato yield variables (MY, TY, TDBMY)

Factors		Variables (t ha^{-1})		
NPSZnB (kg ha^{-1})	Cattle manure	MY	TY	TDBMY
0	0	9.81^{i}	12.29^{k}	110.90^{e}
	10	13.79^{h}	17.66^{j}	132.83^{cde}
	20	13.89^{h}	18.04^{j}	138.30^{cde}
	30	14.45^{h}	18.50^{ij}	142.70^{bcde}
65.7	0	13.61^{h}	17.20^{j}	115.87^{e}
	10	15.14^{gh}	21.72^{gh}	144.38^{bcde}
	20	17.77^{gf}	21.73^{gh}	146.43^{abcde}
	30	18.61^{f}	23.00^{gh}	156.50^{abcd}
133	0	18.17^{f}	21.00^{hi}	120.30^{de}
	10	21.63^{de}	26.23^{ef}	146.43^{abcde}
	20	22.35^{d}	26.70^{de}	156.40^{abcd}
	30	25.97^{bc}	29.07^{cd}	162.20^{abc}
199	0	19.47^{ef}	23.63^{fg}	144.03^{bcde}
	10	24.05^{cd}	29.83^{bc}	165.97^{abc}
	20	27.85^{b}	31.82^{ab}	178.75^{ab}
	30	31.70^{a}	34.10^{a}	185.35^{a}
LSD (5%)		2.78	2.62	39.14
CV (%)		8.31	6.45	11.74

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0.05): Least significant difference at 5% level and CV (%): Coefficient of variation (%)

affected by interaction of these two sources of nutrient sources. The highest total tuber yield (34.1 t ha^{-1}) was obtained from combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure. This result was also statistically similar with combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 20 t ha^{-1} cattle manure. On other hand, the lowest total tuber yield (12.29 t ha^{-1}) was recorded from the control treatment (Table 2).

Increasing rate of blended NPSZnB fertilizer and cattle manure alone also influenced total tuber yield positively. The possible probable reasons for the highest total tuber yield observed from the combined application of blended NPSZnB fertilizer and cattle manure was related with increase in the soil nutrients and modification of soil environment that resulted in better vegetative growth which in turn enabled the crop to produce greater photoassimilate. The observed increased total tuber yield with increasing rates of NPSZnB fertilizer was due to the positive effect of both nitrogen and phosphorus on total tuber weight[12]. This may be attributable to the fact that in such conditions vegetative growth of the aerial parts can be enhanced and hence, translocation of photosynthetic matters into the storage parts[14].

Similarly, total tuber yield and marketable yield 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. Zinc exerts a great influence on basic plant life processes, such as: Nitrogen metabolism and uptake of nitrogen and protein quality; photosynthesis and chlorophyll synthesis[16] which results in high marketable and total yield. Boron application also significantly increased tuber yield in this study probably due to its role in regulation of carbohydrate metabolism and its transport within the plant besides the synthesis of amino acids and proteins[17]. This result was in agreement with the findings of Getie *et al.*[14] and Yourtchi *et al.*[13], who reported that application of nitrogen significantly increased both total and marketable tuber yield. Firew[18] and Zewide *et al.*[12] had also reported the significant effect of nitrogen and phosphorus application on total tuber of potato.

Total dry biomass yield (TDMY): Total dry biomass yield was significantly ($p<0.01$) influenced by interaction of blended NPSZnB fertilizer and cattle manure (CM) application. However, blended NPSZnB fertilizer and cattle manure (CM) application alone did not significantly ($p>0.05$) influenced total dry bimass yield in the present study. The highest total dry biomass yield (185.35 g plant^{-1}) was obtained from combined application of 199 kg ha^{-1} blended NPSZnB fertilizer level and 30 t ha^{-1} cattle manure. This result was also statistically similar with combined application of 199 kg ha^{-1} blended NPSZnB fertilizer level with 10 and 20 t ha^{-1} cattle manure, 133 kg ha^{-1} blended NPSZnB fertilizer level combined with 10, 20 and 30 t ha^{-1} cattle manure, 65.7 kg ha^{-1} blended NPSZnB fertilizer level combined with 20 and 30 t ha^{-1} cattle manure, respectively.

Table 3: Mean square values of potato yield component variables (ATW, HI)

NPSZnB	ATW (g)	HI
0	60.47[b]	77.33[a]
65.7	72.65[ab]	79.53[a]
133	73.15[ab]	81.00[a]
199	88.47[a]	81.93[a]
Cattle manure		
0	60.47[b]	77.33[b]
10	72.6[ab]	78.04[b]
20	77.00[ab]	80.7[ab]
30	86.67[a]	84.49[a]
LSD (5%)	25.71	6.43
CV (%)	17.99	3.62

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0.05): Least significant difference at 5% level and CV (%): Coefficient of variation (%)

(It is to mean that highest total dry biomass yield (185.35 g plant^{-1}) was statistically similar with total dry biomass yield values obtained from combined application of 199 kg ha^{-1} NPSZnB fertilizer level with 10 cattle manure, 199 kg ha^{-1} NPSZnB fertilizer level with 20 cattle manure, 133 kg ha^{-1} NPSZnB fertilizer level with 10 cattle manure, 133 kg ha^{-1} NPSZnB fertilizer level with 20 cattle manure, 133 kg ha^{-1} NPSZnB fertilizer level with 30 cattle manure, 65.7 kg ha^{-1} NPSZnB fertilizer level with 20 cattle manure and 65.7 kg ha^{-1} NPSZnB fertilizer level with 30 cattle manure.) On other hand, the lowest total dry biomass yield (110.9 g plant^{-1}) was recorded from the control treatment (Table 2).

The possible reasons for the observed highest total dry biomass yield from the combined application of blended NPSZnB fertilizer and cattle manure fertilizer could be related to the increased nutrients in the soil. Nutrients in soil and the additional fertilizer applied may have been efficiently used since cattle manure improved the soil chemical and physical property. Increased total dry biomass yield with increasing rates of NPSZnB fertilizer might also be attributed to the positive effect of nitrogen and phosphorus on shoot dry and root dry biomass[12]. Sulfur, boron and zinc may also increased total dry biomass by facilitating physiological processes of potato that resulted in the translocation of photosynthetic assimilates from the source into the sinks. Firew[18] and Zewide *et al.*[12] had reported similar result through the increased total tuber yield t ha^{-1} due to nitrogen and phosphorus fertilization.

Average tuber weight (ATW): Main effects of blended NPSZnB fertilizer and cattle manure had shown highly significant ($p<0.01$) effect on average tuber weight. However, non significant ($p>0.05$) interaction effect was observed between blended NPSZnB fertilizer and cattle manure. Potato plants that received the highest rate of blended NPSZnB fertilizer level (199 kg ha^{-1}) produced the highest average tuber weight of 88.47 g, which was also statistically in par with 65.7 and 133 kg ha^{-1} levels. On the other hand, the lowest average tuber weight of 60.47 g was recorded from the control treatment (Table 3). The increase in average tuber weight in response to the increased supply of blended NPSZnB fertilizer could be due to its effect on fast growth, more foliage and leaf area development and subsequently higher partitioning and supply of photosynthate to developing tubers that in higher average tuber weight.

The present study result was in agreement with the findings of Zewide *et al.*[12] and Masrie *et al.*[11], who reported significantly higher average tuber number and yield from application of nitrogen and phosphorus. Potato plants that received the highest rate of cattle manure (30 t ha^{-1}) also gave the highest average tuber weight (86.67 g), which was statistically in par with 20 and 10 t ha^{-1} application. On the other hand, the lowest average tuber weight (60.47 g) was recorded from the control treatment (Table 3). The increase in average tuber weight in response to the increased supply of cattle manure could be attributed to improved soil structure and relatively better nutrient supply which resulted in fast plant growth, more leaf area and higher supply of photosynthate to the growing tubers that resulted in higher average tuber weight. Balemi[19] and Masrie *et al.*[11] had also reported similar result of significant effect of increased average tuber number and tuber yield in potato from cattle manure application.

Harvest index (%): The analysis of variance of harvest index (HI) in the present study showed highly significant ($p<0.01$) differences due to the main effect of cattle manure. However, there was no statistically detectable effect from the interaction of cattle manure and blended NPSZnB fertilizer levels tested. Application of 30 t ha^{-1} cattle manure resulted in the highest HI (84.49%) which was statistically not different from the application of 20 t ha^{-1} that resulted in HI of 80.7%. On other hand, the lowest value (77.33%) of HI was recorded from the control treatment. The HI recorded from the control treatment level was statistically similar with the application of 10 t ha^{-1} (Table 3).

The significant increase in harvest index due to application of cattle manure may be due to improvement in the soil physical and chemical properties that helped to enhancing nutrients use efficiency and increased tuber size and number than above ground part. In addition nitrogen and phosphorus in soil and cattle manure could be attributed for the increased total tuber yield, which could be reflected by improved allocation of photosynthate to the tubers[20].

Table 4: Results of the economic analysis for combined use of NPSZnB blended fertilizer and cattle manure in potato grown at Banja district, Awi zone

Treatments									
NPSZnB fertilizer (kg ha^{-1})	Cattle manure (t ha^{-1})	TY (t ha^{-1})	ATY (t ha^{-1})	GFB (EB ha^{-1})	FC (EB ha^{-1})	HTC (EB ha^{-1})	TVC (EB ha^{-1})	NB (EB ha^{-1})	MRR (%)
0	0	12.29	11.07	55325.7	0.0	3540.84	3540.84	51784.83	
	10	17.29	15.56	77812.6	5270.0	4980.01	10250.01	67562.61	235.17
	20	21.00	18.90	94500.0	10540.0	6048.00	16588.00	77912.00	163.29
	30	23.63	21.27	106350.0	15810.0	6806.40	22616.40	83733.60	96.57
65.7	0	17.66	15.90	79487.0	914.1	5087.17	6001.27	73485.72	61.68
	10	21.73	19.56	97800.0	6184.1	6259.20	12443.30	85356.70	184.27
	20	26.70	24.03	120150.0	11454.1	7689.60	19143.70	101006.30	233.56
	30	29.83	26.85	134250.0	16724.1	8592.00	25316.10	108933.90	128.44
133	0	18.04	16.24	81182.0	1768.2	5195.65	6963.85	74218.14	189.16
	10	21.73	19.56	97775.8	7038.2	6257.65	13295.85	84479.92	162.06
	20	26.23	23.61	118050.0	12308.2	7555.20	19863.40	98186.60	208.70
	30	31.82	28.64	143175.0	17578.2	9163.21	26741.41	116433.82	265.30
199	0	18.50	16.65	83250.0	2622.3	5328.00	7950.30	75299.70	218.90
	10	23.00	20.70	103500.0	7892.3	6624.00	14516.30	88983.70	208.41
	20	29.07	26.16	130800.0	13162.3	8371.20	21533.50	109266.50	289.04
	30	34.10	30.69	153450.0	18432.3	9820.80	28253.10	125196.90	237.07

TY: Tuber yield, ATY (10%): Adjusted tuber yield, GFB: Gross field benefit, FC: Fertilizer cost (which includes transport and application cost), HTC: Harvesting and transport cost, TC: Total variable cost, NB: Net benefit, MRR: Marginal rate of return (%), EB: Ethiopian birr

Application of blended NPSZnB fertilizer alone may not have significant effect due to soil acidity and poor soil structure in the study area. Monirul Islam *et al.*[6] also reported that application of cattle manure alone resulted in significant increase of average tuber number and yield of potato and harvest index.

Economic analysis: The results of the economic analysis revealed that maximum net benefit of birr 125,196.90 ha^{-1} with an acceptable marginal rate of returns (MRR) 237.07% was recorded in the treatment that received 199 kg ha^{-1} NPSZnB blended fertilizer combined with 30 t CM ha^{-1} (Table 4). This combination generated birr 73, 412.07 ha^{-1} more compared to the control treatment and 41, 463.3 birr ha^{-1} more compared to 30 t CM ha^{-1} without NPSZnB blended fertilizer. On the other hand, the next maximum net benefit of birr 116, 433.82 ha^{-1} with an acceptable MRR of 265.3% was recorded in treatment that received 133 kg ha^{-1} NPSZnB blended fertilizer combined with 30 t CM ha^{-1} (Table 4). This combination generated birr 64, 648.47 ha^{-1} more compared to control treatment. Hence, the money generated from the combined application of 199 kg ha^{-1} NPSZnB blended fertilizer with 30 t CM ha^{-1} was more about birr 8763.08 ha^{-1} than the money generated from the combined application of 133 kg ha^{-1} NPSZnB blended fertilizer with 30 t CM ha^{-1}.

High net return from the foregoing treatments could be attributed to the high yield whilst the low net returns to low yield. From the economic point of view, it was apparent from the above results that 199 kg ha^{-1} NPSZnB blended fertilizer combined with 30 t CM ha^{-1} is more profitable than the rest of treatment combinations.

CONCLUSION

The ANOVA of the present study indicated statistically significant incremental effect of a combined application of blended NPSZnB fertilizer with cattle manure on marketable tuber yield, total tuber yield and total dry biomass yield.

The interaction of 199 kg ha^{-1} blended NPSZnB fertilizer level combined with 30 t ha^{-1} cattle manure gave maximum marketable yield (31.7 t ha^{-1}) and total tuber yield (34.1 t ha^{-1}) and maximum total dry biomass yield (185.35 g plant^{-1}). In the same manner increasing the rates of blended NPSZnB fertilizer levels alone from zero to 199 kg ha^{-1} resulted statistically significant increase of marketable and total tuber number, marketable and total tuber yield and average tuber weight. Application of cattle manure from zero to 30 t ha^{-1} had also resulted in statistically significant incremental effect in average tuber weight, marketable and total tuber yield and total dry biomass yield. From the economic point of view, 199 kg ha^{-1} NPSZnB blended fertilizer combined with 30 t CM ha^{-1} is more profitable than the rest of treatment combinations.

Generally, this research shows NPSZnB fertilizer in blended form, which is nutritionally balanced applied with cattle manure results high yield and better performance of yield components than applying alone.

SIGNIFICANCE STATEMENT

This research study addressed influence of integrated use of NPSZnB blended fertilizer and cattle manure on tuber yield and yield component of potato that can be beneficial for farmers, researchers, investors and others. This study will help the researcher to uncover the critical areas of soil fertility researches on potato at Awi zone and other areas, which have similar agro ecology that many researchers were not able to explore. Thus a new theory on use of integrated fertilizer for potato production may be arrived at use of 199 kg ha^{-1} blended NPSZnB fertilizer level with 30 t ha^{-1} cattle manure results better yield and yield component of potato at Awi zone.

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REFERENCES

1. Haward, H.W., 1969. Genetics of Potato (*Solanum tuberosum* L.). Logos Press Haward, H.W., 1969. Genetics of Potato (*Solanum tuberosum* L.). Logos Press, Cambridge, England, pp: 1-7.
2. Douches, D.S., 2013. Breeding and genetics for the improvement of potato (*Solanum tuberosum* L.) for yield, quality and pest resistance. http://potatobg.css.msu.edu/program_overview.shtml
3. CSA., 2016. Agricultural sample survey: The federal democratic republic of Ethiopia central statistical agency report on area and production of major crops. Central Statistics Agency, Addis Ababa, Ethiopia.
4. Haverkort, A.J., M.J. van Koesveld, H.T.A.M. Schepers, J.H.M. Wijnands, R. Wustman and X.Y. Zhang, 2012. Potato prospects for Ethiopia: On the road to value addition. Praktijkonderzoek Plant and Omgeving, PPO Publication No. 528, The Netherlands, pp: 1-66.
5. Dechassa, N., M.K. Schenk, N. Claassen and B. Steingrobe, 2003. Phosphorus efficiency of cabbage (*Brassica oleraceae* L. var. capitata), carrot (*Daucus carota* L.) and potato (*Solanum tuberosum* L.). Plant Soil, 250: 215-224.
6. Monirul Islam, M., S. Akhter, N.M. Majid, Jannatul Ferdous and M. Shamshul Alam, 2013. Integrated nutrient management for potato (*Solanum tuberosum*) in grey terrace soil (Aric Albaquipt). Aust. J. Crop Sci., 7: 1235-1241.
7. Shibabaw, A., G. Alemayehu, Y. Desalegn, E. Adgo and Y. Tewodros *et al*., 2014. Exploratory survey on climate change effects, value chain processes and supportive services: Case study from potato based farming system of Awi-Zone, Ethiopia. Int. J. Agric. Innov. Res., 2: 615-621.
8. EIAR., 2004. Ethiopian institute of agricultural research directory of released crop varieties and their recommended cultural practices. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.
9. Tahmorespour, M.A., M.S. Vishkai, P. Sharifi and A. Soleymani, 2013. Effect of plant density, date and depth of cultivation on yield and yield components of potato planting in the Chabahar. Int. J. Agron. Plant Prod., 4: 1890-1897.
10. SAS., 2012. SAS/STAT Statically Software, Version 9.3. SAS Institute Inc., Cary, North Carolina, pp: 25-22.
11. Masrie, B., N. Dechassa, T. Tana, Y. Alemayehu and B. Abebie, 2015. The effects of combined application of cattle manure and NP fertilizers on yield and nutrient uptake of potato in North-Eastern Ethiopia. J. Sci. Sustain. Dev., 3: 1-23.
12. Zewide, I., A. Mohammed and S. Tulu, 2012. Effect of different rates of nitrogen and phosphorus on yield and yield components of potato (*Solanum tuberosum* L.) at Masha District, Southwestern Ethiopia. Int. J. Soil Sci., 7: 146-156.
13. Yourtchi, M.S., M.H.S. Hadi and M.T. Darzi, 2013. Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato (Agria CV.). Int. J. Agric. Crop Sci., 5: 2033-2040.
14. Getie, A.T., N. Dechassa and T. Tana, 2015. Response of potato (*Solanum tuberosum* L.) yield and yield components to nitrogen fertilizer and planting density at Haramaya, Eastern Ethiopia. J. Plant Sci., 3: 320-328.
15. Zelalem, A., T. Tekalign and D. Nigussie, 2009. Response of potato (*Solanum tuberosum* L.) to different rates of nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia. Afr. J. Plant Sci., 3: 16-24.
16. Potarzycki, J. and W. Grzebisz, 2009. Effect of zinc foliar application on grain yield of maize and its yielding components. Plant Soil Environ., 55: 519-527.
17. Brown, P.H. and H. Hu, 1997. Does boron play only a structural role in the growing tissues of higher plants? Plant Soil, 196: 211-215.
18. Firew, G.W., 2014. Response of potato (*Solanum tuberosum* L.) to nitrogen and phosphorus application under irrigation in Dire Dawa, eastern Ethiopia. Graduate Thesis, School of Plant Sciences, Haramaya University, Ethiopia.
19. Balemi, T., 2012. Effect of integrated use of cattle manure and inorganic fertilizers on tuber yield of potato in Ethiopia. J. Soil Sci. Plant Nutr., 12: 257-265.
20. Walter, R. and B.K. Rao, 2015. Biochars influence sweet potato yield and nutrient uptake in tropical Papua New Guinea. J. Plant Nutr. Soil Sci., 178: 393-400.