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Yield and Quality of Potato (*Solanum tuberosum* L.) as Influenced by Combined Application of FYM and NPSB Blended Fertilizer at Gewata District, Southwestern Ethiopia

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ABSTRACT

Background: The experiment was, conducted during the 2019/2020 cropping season to investigate the yield and quality response of potatoes (variety Belete) to combined fertilization of farmyard manure and NPSB fertilizer in the Gewata district.

Methods: Four levels of FYM (0, 5, 10, 15 t ha^{-1}) NPSB (0, 50, 100, 150 kg ha^{-1}) blended fertilizer, was laid out in a 4×4 factorial randomized complete block design with three replications.

Result: The mixed application of FYM with NPSB blended fertilizer significantly influenced (P<0.01) the tuber weight, marketable, unmarketable, total tuber, starch content and significantly (P<0.05) on specific gravity and nutrient use efficiency. The highest average tuber weight (99.33 g), marketable and total tuber yield (37.62 and 37. 9 t ha^{-1}), specific gravity (1.09 g), starch content (17.83%) and the net benefit of Ethiopian Birr 325849.2 were recorded from the mixed, fertilization of 15t ha^{-1} FYM with 150 kg ha^{-1} NPSB blended fertilizer. Therefore, it can be concluded that the yield and quality of potatoes in the Gewata district, could be improved by mixed use of FYM (15 t ha^{-1}) and NPSB blended fertilizer (150 kg ha^{-1}).

Key words: Fertilizer, Fym, Inorganic, Tuber.

INTRODUCTION

Potato (*Solanum tubersum* L.) belongs to the family of Solanaceae and has a chromosome number (2n=4×=48) (Getachew *et al.,* 2018). The center of origin and diversity of potatoes and their wild relatives is eastern America (Haan and Rodriguez, 2016). Potato ranks fourth from food crops, third in consumption (FAO-STATE, 2019) and first in production from root and tuber crops (Getachew *et al.,* 2018).

Potato tubers are a good source of amino acids and are used as raw materials for industry and for producing alcohol and animal feed (Bekele and Hailu, 2019). Despite its importance, production potential is low due to low soil fertility, poor nutrient management and ignorance of the combined use of organic and inorganic nutrients (Mohammed *et al.,* 2018). The sole use of chemical fertilizers and the absence of balanced fertilizers are major problems (Getachew *et al.,* 2018).

Enhancing the soil's fertilizer status (Gedam *et al.,* 2008), by shifting from chemical-intensive agriculture to the combined use of organic inputs such as farmyard manure is important (Chandini *et al.,* 2019). It improves the physicochemical properties of the soil (Balem, 2012). According to Malle *et al.* (2017), FYM supplies major sources of nutrients and maintains soil fertility. The sole application of FYM does not fully satisfy the nutrient demands of potatoes, especially during the year of application, due to its slow mineralization (Koroto, 2019). The combined use of FYM and inorganic fertilizer supplies balanced nutrients to potatoes, reduces soil nutrient deficience, prevents soil degradation, recycles nutrient resources, minimizes environmental damage and restores soil fertility to meet nutrient demands of potato (Mohammed *et al.,* 2018; Koroto, 2019; Alemayehu *et al.,* 2020).

However, smallholder farmers in the Gewata district lack knowledge and have a poor understanding of the combined application of FYM and mineral NPSB fertilizer. Thus, the purpose of this study was to ascertain how the combined application of FYM and blended NPSB fertilizer affects the yield and quality of potatoes in the Gewata District.

Potato is a heavy feeder crop and hence needs heavy doses of fertilizers for its growth and yield. Nutrient management shall be an essential aspect of the management of potato crops. It is the art of managing the amount, form, placement and timing of the application of

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nutrients to plants. However, integrated nutrient management is an essential tool for balanced fertilization and sustainability of crop production on a long-term basis. Potato is a heavy feeder crop and hence needs heavy doses of fertilizers for its growth and yield. Nutrient management shall be an essential aspect of the management of potato crops. It is the art of managing the amount, form, placement and timing of application of nutrients to plants. However, integrated nutrient management is an essential tool for balanced fertilization and sustainability of crop production on a long-term basis.

MATERIALS AND METHODS

The experiment was conducted at the Achiwa Kebele Farmer's Training Center in Gewata Woreda, southwest Ethiopia during the 2019-2020 cropping season. Geographically, the area is located at latitude 7°84′03″N and longitude 36°82′58″E, at an elevation of 1870 above sea level. The experimental area receives 2115 mm of rainfall.

For the experiment, the potato cultivar "Belete" was used. It was released by the Holetta Agricultural Research Centre in 2009 (Bekele and Haile 2019) and is now obtained from those Research Centres.

The experiment consisted of two factors, four application rates of FYM (0, 5, 10 and 15 t ha^{-1}) and blended NPSB fertilizer (0, 50, 100 and 150 kg ha^{-1}). The experiment was laid out as a 4 × 4 factorial, randomized complete block design (RCBD) and replicated three times.

A 734.5 m^2 agricultural plot was selected for the experiment. It was then, ploughed to a depth of 25-30 cm. Each plot was three meters long and wide, with 0.5 and 1 m between each plot and block, respectively.

Well-decomposed FYM was applied two weeks before planting the potato in each plot. Blended NPSB fertilizer was applied at 8 cm depth at the time of panting.

Uniform tubers weighing 42-85 g sprouted well, with two or more eye selected. Planting was performed at a depth of 5-7 cm and spacing of 75 cm and 30 cm between rows and plants respectively, where 40 tubers were planted in each plot.

The yield and quality component data were recorded carefully from the middle two ridges (net area of 3.6 m^2) of the 16 plants. The detailed methodologies adopted for the collection of the different data are presented below.

The observation on marketable, unmarketable and total tuber yield (t ha^{-1}) were recorded from 16th middle potato plants during harvesting time from each plot. Quality attributes the Specific gravity of tubers (g cm^3) and starch contents (%) were estimated by a formula developed by Kleinkopf *et al.* (1987).

Agronomic efficiency (AE)

Was calculated using the formula developed by Dobermann (2007).

Economic analysis

The cost and return were calculated for partial budgeting according to the procedure given by CIMMYT, (1998). The estimated costs were the purchasing, transportation and application costs of FYM and NPSB as well as the preparation cost of FYM calculated by ETB.

All data were checked for normality and subjected to analyses of variance (ANOVA), using SAS (statistical software) version 9.4. Mean comparison and separation were performed by using the least significant difference (LSD) tests at a 5% level of significance. Correlation analysis of the growth and yield variables was performed using Pearson's correlation analysis.

RESULTS AND DISCUSSION

Yield and yield related result

The average tuber weight of the potato was significantly ($P<0.01$) affected by the interaction of FYM and NPSB blended fertilizer. The highest average tuber weight (99.33 g) was recorded from the combined application of 15 t ha^{-1} FYM and 150 kg ha^{-1} NPSB blended fertilizer. The lowest average potato tuber weight (70.33 g) was observed in the control treatment (Table 1). The size and weight of the tubers increased due to nutrient availability, which improved leaf area, vegetative growth, water usage efficiency and physiological processes.

The current findings are in line with Masrie *et al.* (2015), who reported an increase in the average weight of tubers as a result of the application of an increased rate of combined organic and inorganic fertilizer due to a balanced nutrient supply released from those nutrient sources. Integrated nutrient managements are improve soil fertility that improve the growth and yield of crop (Singh and Kumar, 2016).

The interaction of FYM and NPSB blended fertilizer significantly ($P<0.01$) influenced the marketable, Unmarketable and total potato tuber yield (t ha^{-1}). The highest marketable and total (37.62 and 37.88 t ha^{-1}), as well as the lowest unmarketable tuber yield (0.26 t ha^{-1}) were obtained from the combined application of 15 t ha^{-1} FYM and 150 kg ha^{-1} NPSB blended fertilizer. The lowest marketable and total (11.963 and 13.480 t ha^{-1}) and the highest unmarketable potato tuber were recorded in the control treatment (Table 1).

The availability of soil nitrogen, phosphorus, sulfur and boron may have contributed to the production of the high marketable and total potato tuber yield. The current finding is in line with the result of Masrie *et al.* (2015) who reported that the combined application of organic and inorganic soil nutrients increased large and medium-sized marketable tuber yield due to the enhanced metabolic activity of the plants. The positive effects of FYM and inorganic fertilizer on soil texture, aeration, water holding capacity and CEC of the soil resulted in increased potato tuber yields (Getachew *et al.,* 2018).

Quality parameter

The specific gravity (g cm^3) and starch contents (%) of potato tuber were significantly ($P<0.01$) influenced by the

interaction of FYM and NPSB blended fertilizer. A high specific gravity (1.099 g cm^3) and starch content (17.83%) of potato tuber was obtained from the combined application of 15 t ha^{-1} FYM with 150 kg ha^{-1} NPSB blended fertilizer. The lowest specific gravity (1.054 g cm^3) and starch content (6.43%) of potato tuber was obtained from the control treatment (Table 1).

The availability of nitrogen and phosphorus in the soil leads to the development of high specific gravity and starch contents of the potatoes. The current study is in line with those of Zewide *et al.* (2018) and Shubhadip *et al.* (2017), who obtained the maximum specific gravity of potatoes as a result of the application of the highest amount of cattle manure with NP fertilizer. In addition, Zewide *et al.* (2018) reported an increase in the specific gravity of tubers from 1.070 to 1.073 owing to an increase in organic and mineral fertilizer application.

Agronomic efficiency (AE)

The agronomic efficiency of the applied NPSB blended fertilizer was significantly (P<0.01) influenced by the interaction between FYM and NPSB blended fertilizer. The highest AE (231.85 kg kg^{-1}) was noted from the combined application of 15 t FYM and 50 kg ha^{-1} NPSB blended fertilizer. The lowest agronomic efficiency (8.42 kg kg^{-1}) was recorded from the sole application of 150 kg NPSB blended fertilizer (Table 1).

It reflects the direct production impact of an applied fertilizer and relates directly to economic return (Alemu *et al.,* 2018; Aliveni *et al.,* 2025). The present result is in line with Alemu *et al.* (2018) who reported that AE increased owing to the combined application of lower inorganic fertilizer with increased organic fertilizers compared to high inorganic fertilizer application.

Correlation analysis

The total tuber yield was highly significant (P=0.0001) and positively correlated with the average tuber weight, marketable tuber, specific gravity and starch content of tubers. In addition, the unmarketable tuber t ha^{-1} (r= -0.95**) was highly significant and negatively correlated with the total tuber yield of potato tubers (Table 2). This was due to the improved soil fertility, soil aeration and nutrient uptakes

Table 1: Interaction effects of FYM and NPSB blended fertilizer on yield of potato.

Treatments		Atm (g)	Mty (t ha^{-1})	Uty (t ha^{-1})	Tty (t ha^{-1})	Sg (g cm^3)	Stc (%)	AE (%)
FYM (t ha^{-1})	NPSB (kg ha^{-1})							
0	0	70.33^{j}	11.96^{k}	1.52^{a}	13.48^{j}	1.054^{h}	6.430^{l}	
	50	77.33^{gh}	16.07^{ij}	1.29^{bcd}	17.37^{ih}	1.056^{gh}	6.430^{l}	77.77^{c}
	100	78.40^{gh}	19.18^{gh}	1.15^{e}	20.33^{fg}	1.066^{fg}	8.060^{j}	30.29^{d}
	150	83.10^{ef}	20.37^{g}	1.20^{ed}	21.57^{f}	1.066^{fg}	9.500^{i}	8.42^{e}
5	0	71.66^{j}	15.67^{j}	1.38^{b}	17.06^{i}	1.051^{h}	6.700^{k}	
	50	78.00^{gh}	19.46^{g}	1.24^{cde}	20.70^{f}	1.071^{ef}	10.600^{h}	72.81^{c}
	100	80.66^{fg}	20.56^{g}	1.21^{de}	21.77^{f}	1.075^{def}	11.560^{f}	10.92^{e}
	150	83.33^{ef}	25.63^{e}	0.74^{g}	26.38^{e}	1.080^{cde}	12.930^{f}	30.663^{d}
10	0	72.66^{j}	16.09^{ji}	1.35^{bc}	17.44^{hi}	1.05^{gh}	7.00^{k}	
	50	85.00^{ed}	23.80^{f}	0.92^{f}	24.73^{e}	1.08^{bcd}	13.90^{e}	145.7^{b}
	100	87.33^{cd}	24.77^{ef}	0.78^{g}	25.55^{e}	1.08^{bcd}	14.70^{d}	8.59^{e}
	150	89.67^{c}	27.72^{d}	0.72^{g}	28.44^{d}	1.09^{abc}	15.40^{c}	19.25^{ed}
15	0	75.73^{ij}	17.64^{hi}	1.24^{cde}	18.89^{gh}	1.05^{gh}	7.96^{j}	
	50	90.67^{bc}	29.92^{c}	0.55^{h}	30.48^{c}	1.09^{abc}	15.86b^{c}	231.85^{a}
	100	94.07^{b}	32.92^{b}	0.48^{h}	33.40^{b}	1.09^{ab}	15.90^{b}	29.26^{d}
	150	99.33^{a}	37.62^{a}	0.26^{i}	37.88^{a}	1.09^{a}	17.83^{a}	29.87^{d}
LSD (0.05)	3.59	1.65	0.11	1.68	0.011	0.48	12.80	
CV (%)	2.61	4.41	7.00	4.31	0.657	2.58	13.05	

Atm(g) = Average tuber mass, Mty (t ha^{-1}) = Marketable tuber yield, Uty (t ha^{-1}) = Unmarketable tuber, Tty (t ha^{-1}) = Total yield of tuber.

Table 2: Correlation analysis for yield and yield components of potato at gewata during the 2019/20 main cropping season.

	Atm (g)	Mty (t ha^{-1})	Uty (t ha^{-1})	Tty (t ha^{-1})	Sgt (g cm^3)	Stc (%)	NUE
Atm (g)	1	0.95**	-0.92**	0.95**	0.88**	0.88**	0.56**
Mty (t ha^{-1})		1	-0.96**	0.99**	0.90**	0.89**	0.85**
Uty (t ha^{-1})			1	-0.95**	-0.89**	-0.88**	0.80**
Tty (t ha^{-1})				1	0.89**	0.89**	-0.77**
Sgt (gcm^3)					1	0.99**	0.80**
Stc (%)						1	0.99**

Table 3: Partial budget analysis of potatoes at gewata district during the 2019/20 main cropping season.

FYM (t ha^{-1})	NPSB (kg ha^{-1})	TVC (ETB)	GAY (t ha^{-1})	ADY (t ha^{-1})	GFB (ETB)	NB (ETB)	MRR (%)
0	0	0.00	11.90	10.70	107667.00	107666.70	
	50	772.50	16.10	14.40	144667.00	143894.20	4689.60
	100	1545.00	19.20	17.20	172667.00	171121.70	3524.60
	150	2317.50	20.30	18.30	183367.00	181049.20	1285.10
5	0	3500.00	15.60	14.10	141100.00	137600.00D	-
	50	4272.50	19.40	17.50	175133.00	170860.80	4305.60
	100	5045.00	20.50	18.50	185067.00	180021.70	1185.80
	150	5817.50	25.60	23.10	230733.00	224915.80	5811.50
10	0	7000.00	16.10	14.50	144833.00	137833.3.00D	-
	50	7772.50	23.80	21.40	214233.00	206460.80	8883.80
	100	8545.00	24.70	22.30	223000.00	214455.00	1034.80
	150	9317.50	27.70	24.90	249500.00	240182.50	3330.40
15	0	10500.00	17.60	15.80	158833.00	148333.30D	-
	50	11272.50	29.90	26.90	269333.00	258060.80	14204.20
	100	12045.00	32.90	29.60	296333.00	284288.30	3395.10
	150	12817.50	37.60	33.80	338667.00	325849.20	5380.20

TVC(ETB) = Total variable cost, GAY= Growth average yield, ADY= Adjusted yield, GFB (ETB) = Gross field benefits with Ethiopian Birr, NB(ETB) = Net benefits, MRR= Marginal rate of returns.

which enhance the growth and yield. Getachew (2019), reported that total yield positively and significantly correlated with growth parameters and negatively correlated with unmarketable potatoes tubers.

Partial budget analysis

Variable costs, gross incomes, associated net benefits and marginal rate of return of potatoes, as influenced by different rates of NPSB blended fertilizer and FYM, are presented in (Table 3).

The maximum net benefit of Ethiopian Birr (ETB), 325849.20 ha^{-1} with a marginal rate of returns (MRR) of 5380.2% was recorded from the combined application of 15 t ha^{-1} FYM with 150 kg ha^{-1} NPSB blended fertilizer (Table 3). The lowest net benefit of ETB 107666.70 ha^{-1} was observed in the control treatment (Table 3). The high net return was attributed to the high yield and the low net return to the low yield (Mandla and Vaidya., 2025). From an economic point of view, a combination of 15 t ha^{-1} FYM and 150 kg ha^{-1} NPSB blended fertilizer gave the highest net benefit and MRR compared with the minimum fertilization or sole application. Based on this finding, the combined application of 15 t ha^{-1} FYM and 150 kg ha^{-1} NPSB blended fertilizer resulted in the highest adjustable marketable tuber yield of 33.67 t ha^{-1}, which was profitable for farmers in the study area.

CONCLUSION

Potato productivity is limited by low soil fertility and poor nutrient management. Accordingly, the average tuber weight, marketable and total potato tuber yield, specific gravity and starch contents of potato tuber increased with an increase in the application of FYM and NPSB fertilizer. The highest average tuber weight (99.33 g), marketable and total tuber yield (37.62 and 37. 9t ha^{-1}), specific gravity (1.09 g), starch content 17.83% and the net benefit of ETB 325849.2 were recorded from the mixed fertilization of 15t FYM with 150 kg ha^{-1} NPSB fertilizer. Mixed application of FYM with NPSB blended fertilizer has improved the yield and quality of potatoes and gives the highest marginal rate of return in the study area. However, to give sound conclusions, the research will be worth repeating with more varieties and seasons with high rates of FYM and NPSB blended fertilizers to arrive at a conclusive result.

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Disclaimers

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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