American Journal of Agriculture and Forestry
2022; 10(1): 28-32
http://www.sciencepublishinggroup.com/j/ajaf
doi: 10.11648/j.ajaf.20221001.15
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Supplemental Nitrate Composition of Ca and Mg Liquid Fertilizer Application on Potato *(Solanum tuberosum L.)* to Increase Tuber Yield in Tiyo District of Arsi, Ethiopia

Mengistu Chemeda*, Gobana Negasa, Dugasa Gerenfes, Kasu Tadesse, Anbessie Debebe

Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center (EIAR/KARC), Asella, Ethiopia

Email address:
mcfayisa@gmail.com (M. Chemeda)
*Corresponding author

To cite this article:
Mengistu Chemeda, Gobana Negasa, Dugasa Gerenfes, Kasu Tadesse, Anbessie Debebe. Supplemental Nitrate Composition of Ca and Mg Liquid Fertilizer Application on Potato (*Solanum tuberosum* L.) to Increase Tuber Yield in Tiyo District of Arsi, Ethiopia. *American Journal of Agriculture and Forestry*. Vol. 10, No. 1, 2022, pp. 28-32. doi: 10.11648/j.ajaf.20221001.15

Received: December 13, 2021; **Accepted**: January 14, 2022; **Published**: January 25, 2022

Abstract: Field experiments were conducted at Kulumsa station of Tiyo district, southeastern Ethiopia in 2017 and 2018 off-season, to test the effect of fertilizer products on yield and yield components of potato and to evaluate the possibility of incorporating the products into input system for agricultural production. The treatment set up were 1) No input (negative control), 2) recommended rate of fertilizer (RNP) (111, 39 and 16.5 Kg ha^{-1} N. P and S, respectively) from NPS and Urea, 3) RNP + 1.8 L ha^{-1} LF; 4) RNP + 3 L ha^{-1} LF, and 5) RNP + 4.2 L ha^{-1} LF on growth performance and yield. The results showed that treatment effects were significant for potato total and marketable tuber yields. Since the effect of fertilizers on the yield of potato was consistent across seasons in Kulumsa station, combined analysis has been conducted. The highest total (46.1 t ha^{-1}) and marketable (42.2 t ha^{-1}) tuber yields were recorded with the application of recommended fertilizer (RNP) + 1.8 L ha^{-1} LF and (RNP) + 3L ha^{-1} LF. This treatment was even statistically superior to application of RNP alone. Compared to the control and RNP treatments, application of inorganic fertilizers with 1.8 L ha^{-1} LF gave 23.4 and 14.1% more total tuber yield of potato, respectively. Similarly, RNP + 3.0L ha^{-1} LF gave 20.9 and 13.7 % more marketable tuber yield of potato over the control and recommended fertilizer from inorganic sources (NPS and urea) treatments, respectively. The result further showed that application of 1.8 L ha^{-1} LF with RNP fertilizer gave total and marketable potato tuber yields which is statistically at par with yields obtained from NPS plus 3.0 L ha^{-1} LF. The lowest total (35.3 t ha^{-1}) and marketable (33.4 t ha^{-1}) tuber yields of potato were harvested from the plots that received neither inorganic nor fertilizers. Therefore, integrated application of liquid fertilizer along with full dose of inorganic fertilizers has been recommended for increased productivity of potato in the south-eastern highlands of Ethiopia.

Keywords: Calcium, Liquid Fertilizer, Potato, Tiyo, Arsi

1. Introduction

Potato is among other horticultural crops under massive production both in rainfed and irrigated conditions. The national yield of potato in 2014 under main and belge seasons were 11.8 and 7.3 t ha^{-1}, respectively [1]. This is by far lower than the yield that has been obtained from the research managed plot which is usually above 40 t ha^{-1} [2]. Depletion of soil fertility and sub-optimal use of balanced fertilizers are among major constraining factors contributing to the low potato tuber yield [3].

Urea and DAP fertilizers have been used as sources of nitrogen and phosphorus, respectively to produce major crops in Ethiopia for decades. Nitrogen, one of the main nutrients for the production of root crops, is often the most limiting nutrient for crop yields in many regions of the world. The worldwide increase in food production over the past four decades has been associated with a seven-fold increase in the use of N fertilizers [4].

Potato is a great consumer of nitrogen, phosphorus,

potassium, magnesium and calcium, as well as micro elements for forming abundant vegetative mass and high quantity of tubers at the unit area [5]. Among the macronutrients, calcium (Ca) is one of the most important elements in soil and it is also a very important determinant of plant growth and production such as potato [6]. Calcium plays many crucial roles in plant membrane structure and function for forming abundant vegetative mass and high quantity of tubers [7]. It contributes to maintenance of cell membrane stability and cell wall structure [8].

Chemical fertilizers are the major purchased inputs for horticultural crop production in Ethiopia. The response of potato to these inputs varies from place to place, mainly depending on soil types and agro ecologies. The study on the response of potato to fertilizers of different nutritional levels would be very useful in planning and economic decision of agricultural input system to increase productions and productivity of this crop in the country.

In line with this, agreement was made between Ethiopian Institute of Agricultural Research (EIAR) and the VICTUS TRADING PLC in December, 2017 in order EIAR tests the company's product (Calitech fertilizer), namely fertilizer effect on potato growth and yield. is a concentrated solution based on calcium nitrate, specially formulated to prevent and correct the physiological imbalances induced by the deficiency or low assimilation of calcium is also enriched with magnesium (Mg) and chelated trace elements that ideally complement the formula [9]. Hence, Kulumsa Agricultural Research Center (KARC/EIAR) was assigned as one of the implementing centers and took the responsibility of testing this fertilizer on potato in the off-season under irrigated condition. The objective of this trial was, therefore, to test the effect of fertilizer products on yield and yield components of potato and to evaluate the possibility of incorporating the products into input system for agricultural production.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted on Kulumsa Agricultural Research Center (KARC) in Tiyo district of Arsi zone in 2017 and 2018 under irrigation. The experimental sites was geographically located at 08°00'51.4"N, 39°09'148"E, 2194 masl. The soil pH, available phosphorous, total nitrogen and organic carbon content of the soils of the study sites are summarized in table 1 below. The long-term total rainfall between January to May was 316 mm. Whereas the long-term mean maximum and minimum temperature between January to May were 24.42 and 9.95°C.

Table 1. *Mean soil analysis result before planting.*

Experimental station	pH (1:2.5)	Av.P (ppm)	TN (%)	OC (%)
Kulumsa main station	6.63	6.245	0.155	2.34

* Av.P= available phosphorus; TN= total nitrogen, OC= organic carbon.

2.2. Experimental Procedure

The experiment comprised of 5 treatments. They were 1) No input (control), 2) recommended rate of fertilizer (RNP) (111, 39 and 16.5 Kg ha^{-1} N. P and S, respectively) from NPS and Urea, 3) RNP + 1.8 L ha^{-1} fertilizer; 4) RNP + 3 L ha^{-1} fertilizer, and 5) RNP + 4.2 L ha^{-1} fertilizer. The experiment was set in randomized complete block design with four replications. The size of each experimental plot was 15 m^2 (3.75 m by 4 m), which had 5 rows. The spacing between blocks and plots were 1.0 m each, while the spacing between plants and rows were 30 and 75 cm, respectively. Improved variety (cv *Belete*) of potato was used for this study. The central 3 rows from the net plot area of 9 m^2 (2.25 m by 4 m) was harvested for the total and marketable tuber yield determination. The liquid fertilizer tested was (Ca Nitrate + Chelated micronutrient). The composition of is presented below (Table 2). It was applied as foliar fertilizer 3 times per cropping season diluted in 150 L ha^{-1} water every 10 days starting from foliage at 10 cm height prior to row closure in split.

Table 2. *Composition of the fertilizer product to be tested for the study.*

product	N	CaO	MgO	B	Cu	Fe	Mn	Mo	Zn
W/V (%)									
LF	15	22.5	3	0.08	0.06	0.08	0.15 (EDTA)	0.002	0.03 (EDTA)

The recommended rate of N, P and S nutrients from NPS fertilizer was applied as side banding at planting. The remaining nitrogen, which was not fulfilled from NPS fertilizer, was supplemented from urea in two splits, i.e. half at planting and the other half at row closure. Irrigation water was applied according to the farmers' practices at each site. The recommended agronomic practices such as weed, pest and disease controls were applied uniformly for all treatments.

2.3. Data Collection

Composite soil samples were collected for each plot for the analysis of selected soil parameters (pH, available P, OC and total N). The agronomic data collected include plant height, stem thickness, number of main stems per plant, number of tubers per plant, marketable and total tuber yields.

2.4. Data Analysis

The data were subjected to analysis of variance using the general linear model procedure (PROC GLM) of SAS statistical package version 9.3 [10]. The total variability for each trait was quantified using pooled analysis of variance over years and locations using appropriate models. Means for the effects of treatments (n = 5) were compared using the MEANS statement with the least significant difference (LSD) test at 5% level of probability.

3. Results and Discussion

3.1. Soil Chemical Properties

Laboratory analysis results of soil samples after harvest showed inconsistent trends for soil pH, total nitrogen and organic carbon among locations and seasons. Generally, application of inorganic fertilizers with fertilizer resulted in the decrease of soil pH both in 2017 and 2018 compared to the control treatment (no input) (Tables 3 and 4). Considering nitrogen content, almost no change was observed in 2017 in 2018. It was resulted in the increment of nitrogen content in 2018 (Tables 3 and 4). Increased value of organic matter content in 2017 and decreased in 2018 were recorded owing to the applications of inorganic fertilizers with foliar fertilizer. Relatively consistent results were obtained for the plant available phosphorous (Table 3).

3.2. Effect of Liquid Fertilizer (Calitech) on Potato Tuber Yield

Analysis of variance over two seasons showed that treatment effects were significant for potato total and marketable tuber yields (Table 4). Since the effect of fertilizers on the yield of potato was consistent across seasons, combined analysis has been conducted. The highest total (46.1 t ha^{-1}) and marketable (42.2 t ha^{-1}) tuber yields were recorded with the application of recommended fertilizer (RNP) + 1.8 L ha^{-1} LF and (RNP) + 3L ha^{-1} LF. This treatment was even statistically superior to application of RNP alone. Compared to the control and RNP treatments, application of inorganic fertilizers with 1.8 L ha^{-1} LF gave 23.4 and 14.1% more total tuber yield of potato, respectively. Similarly, RNP + 3L ha^{-1} LF gave 20.9 and 13.7 % more marketable tuber yield of potato over the control and recommended fertilizer from inorganic sources (NPS and urea) treatments, respectively. The result further showed that application of 1.8 L ha^{-1} LF with RNP fertilizer gave total and marketable potato tuber yields which is statistically at par with yields obtained from NPS plus 3.0 L ha^{-1} LF. The lowest total (35.3 t ha^{-1}) and marketable (33.4 t ha^{-1}) tuber yields of potato were harvested from the plots that received neither inorganic nor fertilizers. Yield and yield components of potato significantly responded to application of nitrogen and phosphorus fertilizers [11].

Table 3. *Mean values for soil chemical characteristics after harvesting at Kulumsa station.*

Site	Treatments	2017				2018			
		pH (1:2.5)	Av.P (ppm)	TN (%)	OC (%)	pH (1:2.5)	Av.P (ppm)	TN (%)	OC (%)
Kulumsa station	control	5.45	25.81	0.19	2.18	6.13	6.18	0.18	2.72
	RNP	5.41	24.02	0.19	2.40	6.14	8.16	0.18	2.83
	RNP + 1.8L ha^{-1} LF	5.34	24.57	0.2	2.18	6.13	8.94	0.2	2.82
	RNP+ 3L ha^{-1} LF	5.36	28.16	0.19	2.20	6.01	11.42	0.2	2.56
	RNP + 4.2L ha^{-1} LF	5.48	28.37	0.18	2.17	6.08	9.96	0.18	2.5

* RNP= recommended rate of fertilizer; LF = Liquid Fertilizer; Av.P= available phosphorus; TN= total nitrogen; OC= organic carbon.

Table 4. *Average potato tuber yield as affected by fertilizer treatments combined over years.*

Factors	Total yield (t ha^{-1})	Marketable yield (t ha^{-1})
Year		
2017	44.0a	42.0
2018	39.2b	35.2
LSD (0.05)	2.7	2.7
Fertilizer rate		
control	35.3c	33.4c
RNP	39.6bc	36.4bc
RNP + 1.8L ha^{-1} LF	46.1a	42.0a
RNP+ 3L ha^{-1} LF	45.0a	42.2a
RNP + 4.2L ha^{-1} LF	42.2ab	39.0ab
LSD (0.05)	4.3	4.2
CV (%)	10.1	10.7

Note: RNP = Recommended rate of nitrogen and phosphorus; LF = Liquid fertilizer.

The result also revealed that total and marketable tuber yield of potato were superior in 2017 than 2018. The greater yield in 2017 compared to 2018 could be attributed to the relatively higher maximum temperature (25.4 and 24.6°C in 2017 and 2018, respectively) and lower rainfall (194 and 296 mm in 2017 and 2018, respectively). The relatively lower rainfall induced frequent irrigations and provided sufficient water for the crop's physiological activities. In contrast, the result indicated that there was no statistically significant difference in both total and marketable yield across the two locations (Table 4).

3.3. Effect of Liquid Fertilizer (Calitech) on Growth and Yield Components of Potato

The analysis of variance over two years revealed that the treatments significantly ($p<0.01$) affected plant height, plant thickness, tuber number per plant and number of stem per plant of potato. Application of the liquid fertilizer (Calitech) at different levels significantly ($p<0.01$) influenced plant height, tuber number per plant and number of main stem per plant; and not significantly ($p<0.05$) affected plant thickness of potato. The highest (~86cm and 13) plant height and tuber number per plant were recorded at the application rate of 4.2L ha^{-1} LF + recommended NPS and 3.0 L ha^{-1} LF + recommended NPS fertilizer rate (Figures 1 and 2). Similarly the maximum (~3.8) number of main stem per plant was recorded at the application rate of recommended NPS fertilizer rate (Figure 4).

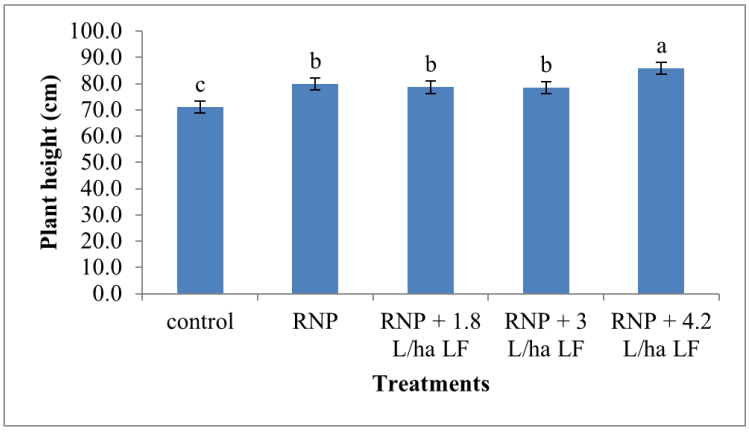

Figure 1. *Effect of liquid fertilizer on plant height of potato.*

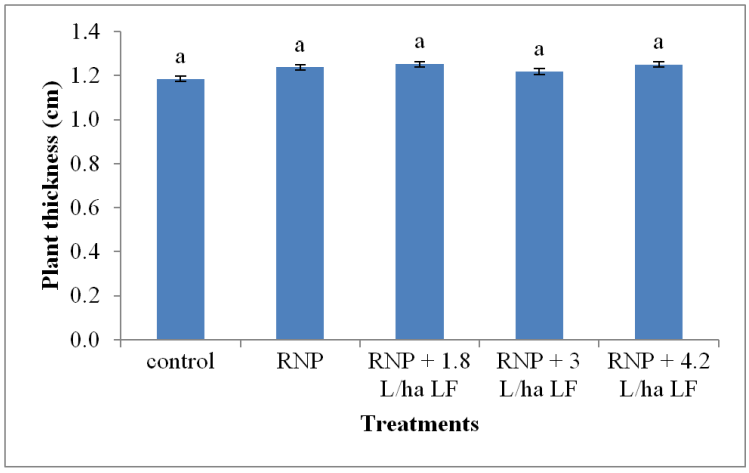

Figure 2. *Effect of liquid fertilizer on plant thickness of potato.*

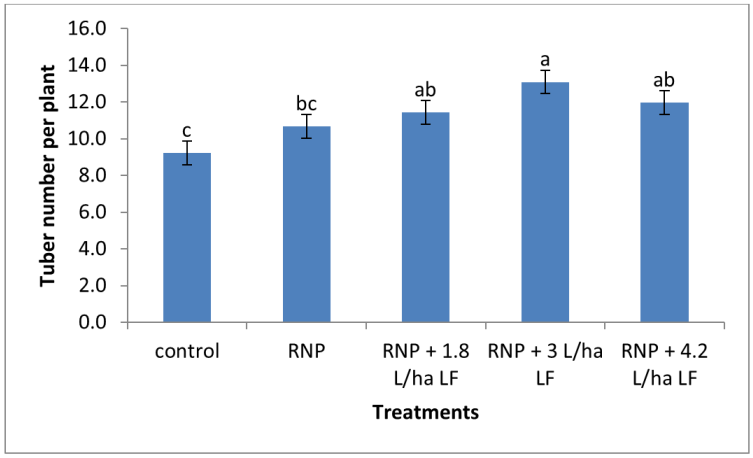

Figure 3. *Effect of liquid fertilizer on tuber number per plant of potato.*

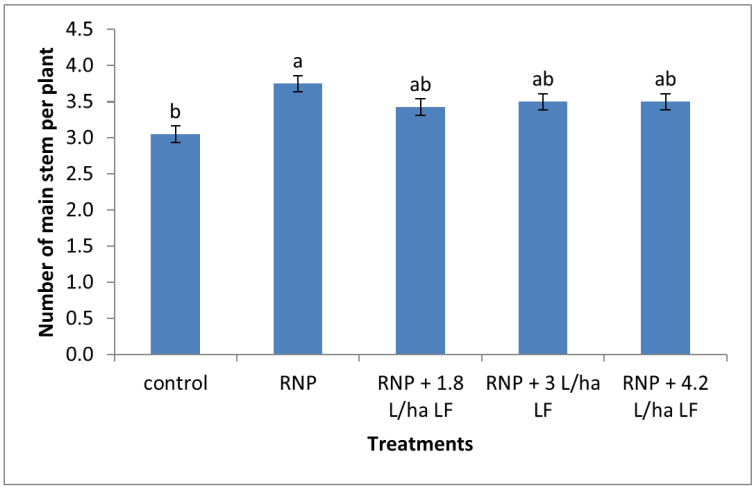

Figure 4. *Effect of liquid fertilizer on main stem of potato.*

4. Conclusions

Field experiment were conducted on Kulumsa station in Tiyo district of Arsi zone in the southeastern highlands of Ethiopia in 2017 and 2018 off-seasons to see the response of potato to the integrated application of liquid with inorganic fertilizers. Integrated application of liquid fertilizer with inorganic fertilizer resulted in significant tuber yield increment of potato. The highest total (46.1 t ha^{-1}) and marketable (42.2 t ha^{-1}) tuber yields were recorded with the application of recommended fertilizer (RNP) + 1.8 L ha^{-1} LF and (RNP) + 3L ha^{-1} LF. This treatment was even statistically superior to application of RNP alone. Compared to the control and RNP treatments, application of inorganic fertilizers with 1.8 L ha^{-1} LF gave 23.4 and 14.1% more total tuber yield of potato, respectively. Similarly, RNP + 3L ha^{-1} LF gave 20.9 and 13.7% more marketable tuber yield of potato over the control and recommended fertilizer from inorganic sources (NPS and urea) treatments, respectively. Therefore, integrated application of this liquid fertilizer along with full dose of inorganic fertilizers has been recommended for increased productivity of potato in the southeastern highlands of Ethiopia.

References

[1] CSA (Central statistical agency). 2014. Agricultural sample survey. Volume V. Report on area, production and farm management practices of Belge season crops for private peasant holdings. Addis Ababa. Statistical bulletin 532.

[2] Alemayehu, M. and Jemberie, M., 2018. Optimum rates of NPS fertilizer application for economically profitable production of potato varieties at Koga Irrigation Scheme, Northwestern Ethiopia. *Cogent Food & Agriculture*, *4* (1), p. 1439663.

[3] Koch, M., Naumann, M., Pawelzik, E., Gransee, A. and Thiel, H., 2020. The importance of nutrient management for potato production Part I: Plant nutrition and yield. *Potato Research*, *63* (1), pp. 97-119.

[4] Hirel, B., Le Gouis, J., Ney, B. and Gallais, A., 2007. The challenge of improving nitrogen use efficiency in crop plants: towards a more central role for genetic variability and quantitative genetics within integrated approaches. Journal of experimental botany, 58 (9), pp. 2369-2387.

[5] Fit, E. M. and Hangan, M. C., 2010. The effect of differential fertilization upon desirée and ostara potatos production on districambosol soil. Research Journal of Agricultural Science, 42 (3), pp. 137-142.

[6] Kleinhenz, M. D. and Palta, J. P., 2002. Root zone calcium modulates the response of potato plants to heat stress. Physiologia plantarum, 115 (1), pp. 111-118.

[7] El-Beltagy, M. S., Abou-Hadid, A. F., El-Abd, S. O., Singer, S. M. and Abdel-Naby, A., 2000, October. Response of fall season potato crop to different calcium levels. In II Balkan Symposium on Vegetables and Potatoes 579 (pp. 289-293).

[8] Ozgen, S., Ozgen, M. and Palta, J. P., 1999. 556 Influence of Supplemental Calcium Fertilization on Potato Tuber Size and Tuber Number. HortScience, 34 (3), pp. 542B-542.

[9] Tradecorpnutri-performance. 2019. http://tradecorp.com.es/en/products/foliar-fertilizers/. Accessed on 14 November 2019.

[10] SAS Institute, Inc, 2011. SAS software, version 9.3 of the SAS system for Windows. Cary, NC.

[11] Zelalem, A., Tekalign, T. and Nigussie, D., 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. *African Journal of Plant Science*, *3* (2), pp. 016-024.