Open Access Library Journal
2018, Volume 5, e4386
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Study of Efficacy of Various Split Applications of Inorganic Nitrogen on Potato Crop

Choudhary Muhammad Ayyub[1], Shoaib Ur Reman[1], Rashad Waseem Khan Qadri[1*], Muhammad Azam[1*], Kareem Yar Abbasi[1], Zia Ullah Khan[2], Muhammad Rashid Shaheen[1], Muhammad Ali[1], Mujahid Hussain Leghari[3], Tehmina Asghar[1]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan
[2]Department of Agriculture, Abdul Wali Khan University, Mardan, Pakistan
[3]Sindh Agriculture University, Hyderabad, Pakistan
Email: *waseemrana_83pk@yahoo.com, *azam32jb@yahoo.com

How to cite this paper: Ayyub, C.M., Reman, S.U., Qadri, R.W.K., Azam, M., Abbasi, K.Y., Khan, Z.U., Shaheen, M.R., Ali, M., Leghari, M.H. and Asghar, T. (2018) Study of Efficacy of Various Split Applications of Inorganic Nitrogen on Potato Crop. *Open Access Library Journal*, **5**: e4386.
https://doi.org/10.4236/oalib.1104386

Received: January 30, 2018
Accepted: March 11, 2018
Published: March 14, 2018

Abstract

Series of experiments have been conducted to find the optimized dose and efficacy of nitrogen to fulfill the requirements of plant at each level by making split doses. Being most important macro nutrient, afield trial was conducted to study the effect of without applying nitrogen (control) single nitrogen (N) application at planting time on yield and nitrogen uptake of potato in comparison to various split applications. Data were collected about plants vegetative growth, total yield and qualitative factors (TSS, nitrogen, phosphorus, potassium and protein percentage in tuber). Experimental design used was Randomized Complete Block Design (RCBD) having seven treatments with three replications. Data were analyzed by using standard statistical techniques. Overall, qualitative characters of tubers and yield enhanced with split nitrogen application as compared to all nitrogen applied once at planting time whereas, there was no significant difference between tuber nitrogen, potassium, phosphorus and protein contents.

Subject Areas

Agricultural Science, Plant Science

Keywords

Potato, Vegetative Growth, Nitrogen, Potassium, Phosphorus, Macronutrients

1. Introduction

Potato (*Solanum tuberosum* L.) is a temperate zone crop which belongs to family solanaceae. Nearly 4300 varieties of native potatoes have been found, which

are available in different colors, shapes and sizes [1]. Out of these 180 are wild species of potato which are not edible because of their poisonous nature [1]. Potato has a great nutritive value; it provides a part of everyday caloric requirements of human. It provides many essential nutrients and vitamins including potassium, phosphorus, manganese, magnesium, folate, vitamin C and vitamin B_6 [2]. Worldwide production of potato is estimated to be 374 million metric tons annually and in many areas of the world it is used as a staple food. Pakistan's annual production is estimated to be 20 metric tons/ha although it varies from year to year but it has an increasing trend. Punjab is the leading potato producing province, followed by NWFP, Baluchistan and Sindh. Pakistan's share in world potato production is less than 1% [1]. Potato crop has strict requirement for a balanced fertilization management, without which growth and development of the crop are poor and both yield and quality of tubers are diminished. It requires proper fertilization including both macro and micronutrients [3].

In macronutrients, nitrogen is an important nutrient since it has a positive effect on the growth of plants. Potatoes have a shallow root system which is a main reason of low uptake efficiency of nitrogen, so proper management is necessary [4]. Nitrogen has a significant effect on chlorophyll concentration, photosynthetic rate, leaf expansion, total number of leaves, plant height, dry matter accumulation and higher yields of potato [5] [6] [7]. In case of nitrogen deficient soils, plant shoot growth is reduced and carbohydrates which are typically used for producing leaf are shifted towards tuber initiation, hence leaf growth is limited [8]. Excess soil N can delay maturity of the tubers, reduce tuber specific gravity and result in poor skin set which harms tuber quality and storage properties [6]. Normally nitrogen is applied at the rate of 250 kg/ha in the form of urea in three splits. Nitrogen fertilizer management is critical since potatoes have low uptake efficiency of nitrogen which is due to shallow root system and nitrate leaching [9]. The nitrogen requirement of the potato crop is influenced by climatic conditions, soil type, soil fertility, preceding crop, variety and practices of crop management especially irrigation [10] [11].

It is important, for two reasons, to know the nitrogen demand in potato crop. The first one is excessive use of nitrogen increases economical cost and the second one is negative effect on the environmental associated with leaching and runoff [12]. The timing of nitrogen application is very important because it determines three things. First of all it stimulates the physiological responses for growth. Secondly nitrogen applied at a time must be sufficient for crop needs till the next dose is applied. Third most important point is that it will reduce nitrogen losses and ultimately cost of production too [13] [14]. Pakistan has always remained deficient and heterogeneous in application of nitrogen [15]. So, keeping in view the importance of nitrogen, its management is need of the day for getting high yield of better quality. This experiment was conducted to observe the effect of split nitrogen application on potato cultivar.

2. Material and Methods

The experiment was conducted in Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Effect of split application of nitrogen fertilizer on potato was studied. An area of 901.90 m^2 was used under this research trial. Field was well prepared before sowing. Total 42 ridges were made each having 30.5 cm width and 457 cm length with plant to plant distance of 22.9 cm and row to row 91.5 cm distance. Two ridges were taken as single experimental unit, each having 20 tubers so each treatment consisted of 40 tubers. Plant material used for this experiment was potato cv. SH-704. Urea fertilizer was used as a source of nitrogen whereas, sulfate of potash (SOP) as potassium and single super phosphate (SSP) for phosphorus were used.

Potato tubers of variety SH-704 were planted. Phosphorus and potassium were applied at 125 kg/ha all at the time of planting. Nitrogen rate used was 250 kg/ha applied in splits; 0 split (all at planting time as basal dose), 2 splits (half at planting and half after 30 days), 3 splits (at planting, after 30 days and 40 days), 4 splits (at planting, after 30 days, 40 days and 50 days), 5 splits (at planting, after 30 days, 40 days, 50 days and 60 days) with one control no nitrogen treatment. Data were observed regarding growth parameters including days to emergence, emergence percentage (%), mortality percentage (%), number of stems per plant, number of leaves per plant, height of plant (cm) and reproductive parameters including number of tubers per plant, number of tubers per plot, fresh weight of tubers per plant (g), tuber yield/ha, tuber dry weight per plant, tuber moisture percentage. Tubers N, P, K, protein and TSS were determined in the laboratory. Harvested tubers were weighed on electrical balance for yield determination and analyzed for quality by using quantitative methods. Nitrogen, potassium and phosphorus were determined by to the method described by [16]. The experiment was laid according to Randomized Complete Block Design (RCBD) having 7 treatments with 3 replications.

3. Results

Days to emergence means showed significant differences among various treatment, maximum days to emerge (11.66) were observed in control and at 250-6 splits while minimum were found (10.00) in 250-3 splits nitrogen and 250-4 splits nitrogen but there was slight difference between treatments. Emergence percentage showed significant results and highest germination percentage (94.17) was observed in 250-5 splits nitrogen application while it was minimum percentage (76) at control. When data pertaining to mortality percentage was subjected to statistical analysis it showed significant results with uppermost mortality percentage (24%) at control and lowermost (5.83%) was at 250-6 splits nitrogen applications. Number of stems per plant was maximum (4.86) in 250-2 splits nitrogen application and minimum (2.33) at control (**Table 1**).

When plant height was observed after 30 days there was no prominent difference among various treatments but after 60 days maximum height (63.89 cm)

was observed in 250-2 split nitrogen application and minimum height (52.66 cm) at control (Table 2).

Among all treatments highest number of tuber per plant (10.06) were in two split nitrogen application (Table 2) which means maximum yield (8.21 tons/ha) produced (Table 3) whereas minimum number of tubers per plant (4.86) (Table 2) and lowest yield (4.01 tons/ha) was in control treatment (Table 3).

Among all treatments tuber yield per ha (8.21) of tubers in two split nitrogen application. Observation regarding tuber fresh weight was highest (508.33 g) at 250-2 splits and minimum (284.33 g) at control whereas there were non-significant results for dry weight of tubers and for moisture percentage among different treatments (Table 3).

In general, it was visualized that this qualitative aspect of study was improved by time of application of nitrogen or split application of nitrogen. This also demonstrates that best TSS of potato tubers was maximum (4.40˚Bx) with 250-2 splits of nitrogen while further splits reduced while minimum (3.00˚Bx) was found with no nitrogen application (Table 4).

Table 1. Effect of various split nitrogen application in comparison to single and no nitrogen dose on vegetative characteristics of potato.

Treatments	Days to emergence	Emergence %	Mortality %	No. of stems/plant
Control	11.66 a	76.00 b	24.00 a	2.33 c
250-1 split	10.33 ab	92.50 a	07.50 b	3.06 bc
250-2 splits	10.66 ab	90.00 a	10.00 b	4.86 a
250-3 splits	10.00 ab	91.67 a	08.33 b	3.06 bc
250-4 splits	10.00 b	93.33 a	06.67 b	3.73 ab
250-5 splits	10.33 b	94.17 a	05.83 b	3.33 bc
250-6 splits	11.66 a	90.83 a	09.17 b	3.60 bc
LSD Value	1.44	8.70	0.09	1.17

Figures sharing same letters do not differ from each other at $P = 0.05$ according to LSD test.

Table 2. Effect of split nitrogen application in comparison to single and no nitrogen dose on yield and quality of potato tubers.

Treatments	No. of leaves/plant	Height after 30 days (cm)	Height after 60 days (cm)	No. of tubers/plant
Control	22.13 b	28.71 a	52.66 d	4.86 c
250-1 splits	37.73 a	31.76 a	60.70 ab	6.80 b
250-2 splits	39.73 a	34.41 a	63.89 a	10.06 a
250-3 splits	35.86 a	31.56 a	60.48 abc	7.93 b
250-4 splits	35.53 a	33.49 a	59.05 bc	6.66 bc
250-5 splits	35.80 a	30.42 a	56.65 bcd	7.86 b
250-6 splits	36.60 a	33.05 a	55.75 cd	7.46 b
LSD Value	8.60	5.83	4.76	1.17

Figures sharing same letters do not differ from each other at $P = 0.05$ according to LSD test.

Table 3. Effect of split nitrogen application in comparison to single and no nitrogen dose on yield and quality of potato tubers.

Treatments	Tuber yield/ha (ton/ha)	Tuber fresh weight/plant (g)	Tuber dry weight (g)	Tuber moisture %
Control	4.01 b	284.33 c	18.73 a	81.27 a
250-1 splits	7.51 a	440.6 b	18.843 a	81.15 a
250-2 splits	8.21 a	508.33 a	18.44 a	81.55 a
250-3 splits	8.18 a	476.67 ab	19.85 a	80.14 a
250-4 splits	7.37 a	424.00 b	20.47 a	79.52 a
250-5 splits	7.43 a	424.33 ab	17.69 a	82.30 a
250-6 splits	6.79 a	401.67 b	18.02 a	81.97 a
LSD Value	2.15	110.86	3.62	3.62

Figures sharing same letters do not differ from each other at $P = 0.05$ according to LSD test.

Table 4. Effect of split nitrogen application in comparison to single and no nitrogen dose on qualitative factors of potato tubers.

Treatments	TSS (˚Bx)	K %	P %	N %	Protein %
Control	3.00 d	1.250 a	0.181 a	1.16 c	7.29 c
250-1 split	3.93 abc	1.257 a	0.250 a	1.40 bc	8.75 bc
250-2 splits	4.40 a	1.267 a	0.253 a	1.86 a	11.66 a
250-3 splits	3.93 abc	1.250 a	0.257 a	1.40 bc	8.75 bc
250-4 splits	3.40 bcd	1.250 a	0.250 a	1.74 ab	10.93 ab
250-5 splits	4.00 ab	1.217 a	0.250 a	1.63 ab	10.20 ab
250-6 splits	3.20 cd	1.200 a	0.240 a	1.63 ab	10.21 ab
LSD Value	0.80	0.084	0.094	0.46	2.90

Figures sharing same letters do not differ from each other at $P = 0.05$ according to LSD.

When tubers qualitative parameters including phosphorus and potassium contents in tubers were analyzed in laboratory they show no significant difference among the various treatments. Nitrogen contents and protein contents were found with slight difference in treatments. There were maximum nitrogen contents (1.86%) with 250-2 splits and minimum (1.16%) at control. Maximum protein contents (11.66%) were found at 250-2 splits nitrogen with minimum value (7.29%) at control. While maximum TSS was observed in two split nitrogen application and minimum were found at control. When results of these parameters studied they showed that highly nutritive best quality product was from split nitrogen application in contrast to single and no nitrogen application (Table 4).

4. Discussion

Days taken to emerge were not affected by nitrogen splits as emergence is basically dependent on internal food reserves of seed and microclimate whereas,

material of same variety must be homogenous so it had almost same external circumstances to fulfill (**Table 1**). Splitting effect positively emergence percentage as highest emergence was 94.17% while in control lowest emergence percentage observed (**Table 1**). These results are in conformity to [17] that nitrogen plays vital role in potato's emergence. Mortality rate was greater in no nitrogen treatment that was 24%. Maximum number of leaves was 39.73 and number of stems was 4.86 in treatment with 2 split nitrogen doses half at planting and other half after 30 days (**Table 2**).

When number of stems was more it ultimately had more photosynthetic factories. These results also showed that soil nutrients only were not sufficient for stem development that's why minimum stems were produced when no nitrogen was applied. Overall we can argue that splitting nitrogen doses were more useful than applying all at sowing. These results are strengthening by [18] who reported that split application of nitrogen increased the number of stems per plant. From above results it could be concluded that two splits of nitrogen fulfilled better nutritional needs of the plant than further splitting up the nitrogen doses. In no nitrogen treatment due to poor nutritional status number of leaves was reduced. These results are in line to findings of [18] who reported that splitting of nitrogen enhanced number of leaves.

Height of plant when measured after 30 days show no significant difference among treatments but after 60 days of planting it had significant results (**Table 2**). This may be due to nutrient reserves of soil which were used by plants while after 60 days splitting nitrogen effect appeared. Height of plant is a vegetative factor, more the number of leaves, more food is produced as in case 2 splits and height improved but further nitrogen splits did not had any positive effect. These results are in agreement to [14] that any further application of nitrogen after 50 - 70 days did not enhance the growth.

Number of tubers was positively affected by two splits of nitrogen which was 10.067 tubers per plant (**Table 2**). Yield of tubers were affected by 2 splits of nitrogen while further splitting did not create any difference. Basal and no nitrogen dose had low yields due to nutrient deficiency. These results have great similarity with [14] who reported that nitrogen application was more useful when given between 50 days of growth. These finding were showing slight difference with the finding of [19] that three (3) split applications had the potential to increase the yield compared to the other treatments this might be due to difference in environmental conditions of Faisalabad and Ireland. Tuber fresh weight show positive response to 2 splits of nitrogen application (**Table 2**). These results are supported by [20] who reported that when half nitrogen was applied at planting and other half after 30 days enhanced the yield (**Table 2**). Split dose of nitrogen had no significant impact on tuber dry weight but significant for moisture percentage (**Table 3**). Our results showed that there was no effect of nitrogen splitting on moisture percentage (**Table 3**). These results are in line with results of [20] that no specific relationship was found between nitrogen application and dry matter concentration and ultimately moisture percentage because nitrogen

amended dry matter by delaying maturity.

Moreover, there was non-significant relationship for potassium % and phosphorus % while nitrogen % and protein content showed just slight difference in treatments (Table 4). But there highest percentage was in two split nitrogen application and lowest in no nitrogen treatment which means splitting nitrogen doses improve the quality of produced as supported by [21] who found that nitrogen improved the quality of produce.

5. Conclusion

It could be concluded from above results that in Faisalabad conditions split application of nitrogen was better than one basal application. Overall plant growth and yield was superior in two splits of nitrogen while further splits reduced the yield. Splitting of nitrogen doses also improved the qualitative characters of tubers especially nutritional composition of tubers.

References

[1] Asghar, T., Ayyub, C.M. and Shaheen, M.R. (2015) Boosting the Production of Potato. Use of Inorganic Nitrogen. LAP Lambert Academic Publishing, Saarbrücken.

[2] Haynes, K., Yencho, G., Clough, M., Henninger, M. and Sterrett, S. (2012) Genetic Variation for Potato Tuber Micronutrient Content and Implications for Biofortification of Potatoes to Reduce Micronutrient Malnutrition. *American Journal of Potato Research*, **89**, 192-198. https://doi.org/10.1007/s12230-012-9242-7

[3] Osaki, M., Sagara, K. and Tanaka, A. (1992) Effect of Nitrogen Application on Growth of Various Organs of Potato plant (*Solanum tuberosum*). *Japanese Journal of Soil Science and Plant Nutrition*, **63**, 46-52.

[4] Mugo, J., Ouma, A. and Schulte-Geldermann, E. (2013) Critical Shoot Nitrogen Curve for Potato Varieties Asante and Tigoni in Kenya. Master's Theses, Jomo Kenyatta University of Agriculture and Technology, Juja.

[5] Zewide, I., Mohammed, A. and Tulu, S. (2012) Effect of Different Rates of Nitrogen and Phosphorus on Yield and yield components of Potato (*Solanum tuberosum* L.) at Masha District, Southwestern Ethiopia. *International Journal of Soil Science*, **7**, 146. https://doi.org/10.3923/ijss.2012.146.156

[6] Yassen, A., Safia, M., Sahar, M. and Zaghloul, M. (2011) Impact of Nitrogen Fertilizer and Foliar Spray of Selenium on Growth, Yield and Chemical Constituents of Potato Plants. *Australian Journal of Basic and Applied Sciences*, **5**, 1296-1303.

[7] Gathungu, G., Shibairo, S., Githiri, S., Mburu, M., Ojiambo, P. and Kidanemariam, H. (2000) Effect of Source, Time and Method of Nitrogen Application on Growth and Yield Components of Potato in Kenya. *African Crop Science Journal*, **8**, 387. https://doi.org/10.4314/acsj.v8i4.27679

[8] Ivins, J. and Bremner, P. (1965) Growth, Development and Yield in the Potato. *Outlook on Agriculture*, **4**, 211-217. https://doi.org/10.1177/003072706500400503

[9] Olivier, M., Goffart, J.-P. and Ledent, J.-F. (2006) Threshold Value for Chlorophyll Meter as Decision Tool for Nitrogen Management of Potato. *Agronomy Journal*, **98**, 496-506. https://doi.org/10.2134/agronj2005.0108

[10] Ojala, J., Stark, J. and Kleinkopf, G. (1990) Influence of Irrigation and Nitrogen Management on Potato Yield and Quality. *American Potato Journal*, **67**, 29-43. https://doi.org/10.1007/BF02986910

[11] Patel, J. and Patel, B. (2001) Response of Potato to Nitrogen under Drip and Furrow Methods of Irrigation. *Journal of the Indian Potato Association*, **28**, 293-295.

[12] Majić, A., Poljak, M., Sabljo, A. and Knezović, Z. (2007) Nitrogen Nutrition Impact on Quantitative Traits of Early Potato (*Solanum tuberosum* L.). *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca*, **64**, 246-250.

[13] Watkins, K.B., Lu, Y.-C. and Huang, W.-Y. (1998) Economic and Environmental Feasibility of Variable Rate Nitrogen Fertilizer Application with Carry-Over Effects. *Journal of Agricultural and Resource Economics*, **23**, 401-426.

[14] Zotarelli, L., Rens, L.R., Cantliffe, D.J., Stoffella, P.J., Gergela, D. and Fourman, D. (2014) Nitrogen Fertilizer Rate and Application Timing for Chipping Potato Cultivar Atlantic. *Agronomy Journal*, **106**, 2215-2226. https://doi.org/10.2134/agronj14.0193

[15] Mukhtar, T., Arif, M., Hussain, S., Tariq, M. and Mehmood, K. (2011) Effect of Different Rates of Nitrogen and Phosphorus Fertilizers on Growth and Yield of Maize. *Journal of Agricultural Research*, **49**, 333-339.

[16] Chapman, D. and Parker, F. (1961) Determination of NPK. *Methods of Analysis for Soils*, *Plants and Water*, **93**, 150-179.

[17] Nelson, K. (2017) Management of Nitrogen and Nitrification Inhibitors for Corn and Wheat Production on Claypan Soils. Master's Thesis, University of Missouri, Columbia.

[18] Roberts, S., Weaver, W. and Phelps, J. (1982) Effect of Rate and Time of Fertilization on Nitrogen and Yield of Russet Burbank Potatoes under Center Pivot Irrigation. *American Potato Journal*, **59**, 77-86. https://doi.org/10.1007/BF02866399

[19] Peter, M., Katsaruware, R.D. and Svotwa, E. (2015) Effect of Split Nitrogen Application and Fertilizer Rate on Yield of Irish Potatoes (*Solanum tuberosum*) in a Smallholder Farming Sector of Zimbabwe. *International Journal of Innovative Science*, *Engineering and Technology*, **2**, 112-123.

[20] Sun, L., Gu, L., Peng, X., Liu, Y., Li, X. and Yan, X. (2012) Effects of Nitrogen Fertilizer Application Time on Dry Matter Accumulation and Yield of Chinese Potato Variety KX 13. *Potato Research*, **55**, 303-313. https://doi.org/10.1007/s11540-012-9220-y

[21] Symanowicz, B. and Kalembasa, S. (1998) The Influence of Limining Cereal Forecrop and Nitrogen Fertilization on the Chemical Properties of Soil and Chemical Composition of Potatoes Tubers. *Zeszyty Problemowe Postepow Nauk Rolniczych-Polska Akademia Nauk*, **456**, 453-458.