**Study of Nitrogen Use Efficiency in Potato (*Solanum tuberosum* L.)**


## ABSTRACT

Study was conducted under All India Coordinated Research project on potato at Research cum Instructional form, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *Rabi* season 2021-22, in split plot design with three replications, for this research the experimental material consisting of twenty potato genotypes including two check variety Kufri Khyati and Kufri Chipsona-1.With three Nitrogen levels (0, 180 and 250 kg N/ ha), to find out the N requirement and Nitrogen use efficiency of Potato genotypes. Results of present experiment reveal that, all the genotypes are showing genotypic variability for NUE, there is sufficient variation for NUE. The genotypes used in the experiment are showing response to nitrogen and performing different the same genotype in three different nitrogen level, among the twenty genotypes P-73 recorded maximum Nitrogen Use efficiency at all the levels of nitrogen followed by Kufri Mohan and Kufri Lalima. Genotype P-73 proved to possess high tolerance to N stress and was the most nitrogen efficient variety followed by Kufri Mohan and Kufri Neelkanth. This experiment can be concluded as, the variety responding same at 180 and 250 Kg Nitrogen can be recommended to apply only 180 kg Nitrogen, the knowledge of NUE can save the money and land of farmer by minimal use of Nitrogen.



**Keyword:** Nitrogen use efficiency, nitrogen, potato, yield, varieties.


## Introduction

Nitrogen in form of urea is perhaps the single most important plant nutrient, which revolutionized the potato production throughout potato growing countries in the world. But hardly 30% of total nitrogen applied to the soil in form of urea is taken up by the plants rest 70% is lost through leaching down in the form of nitrate ($NO_3^-$) and also evaporate in the gaseous form ($NO_2^-$) to the atmosphere through denitrification. Loss of such a huge amount of nitrogen applied to the soil is the greatest loss to the nation in general and farmers in particular.

Second, the prices of fertilizers in general and nitrogen as particular is rising day by day as a result it would be difficult even for rich farmers to apply ever recommended dose of nitrogen to potato crop which may affect the total potato production in the country. Under such a situation the farmers may switch to grow other crops in place of potato which will affect adversely potato production in the country.

Keeping in mind, to minimize the loss of most valuable plant nutrient i.e. "Nitrogen" through leaching down in the lower layer of soil and in gaseous form through denitrification on one hand and rising prices of nitrogen fertilizer like urea on the other, it is quite essential to evolve "Nitrogen Use Efficient" wheat varieties which will not only reduce the loss of nitrogen as stated above but also economize the cost of production by enhancing the yield per unit of nitrogen application.

Since yield is conserve form of solar energy which is equivalent to photosynthesis – respiration - photorespiration = yield.

$$6CO_2 + 6H_2O + \text{Light} \longrightarrow C_6H_{12}O_6 \text{ (carbohydrate)} + 6O_2$$

Where nitrogen helps in the growth of plant to acquire an optimum biomass (source) to trap the solar energy and convert into dry matter. Nitrogen also helps in initiation and proper development of sink as well as prolongs the photosynthesis activity by prolonging the green plant (over maturity period).

Nitrogen (N) is well known as a key factor in plant production because of its important role in the biological process of assimilation and especially in crop growth. With the discovery of the Haber- Bosch process in 1909. To improve NUE of crops including potato is of great importance for sustainable agriculture and food security not only now but also so in the future. NUE is defined by different authors in different ways depending on the objective of the study and the crop under study.

Improving N balance in the production system could be achieved by optimizing crop management strategies. Another option to increase the N efficiency is to improve NUE on the basis of a genetic change in physiology of the crop plant itself. Good *et al*. (2004) mentioned the need of combining traditional breeding, marker assisted selection and even genetic modification designed to improve specific aspects of NUE. Breeding plants with increased NUE at reduced fertilizer input is currently one of the key goals of research on plant nutrition as well as for sustainable agriculture (Hirel *et al.* 2007; Hirel *et al*. 2011).

Potato is a very sensitive crop to nitrogen fertilization. Excess nitrogen may prolong the vegetative phase and thus, interfere with the initiation of tuberization, decreasing yield and dry matter accumulation in the tubers. On the other hand, a low nitrogen application rate may produce premature senescence in the plants due to early translocation of nitrogen from the leaves to the tubers (Saluzzo *et al*., 1999; Kleinkopf *et al.*, 1981).

Central Potato Research Institute, Shimla (India) has developed a number of potato varieties for different agro-climatic conditions which vary in their response to nitrogen. Therefore, identification of nitrogen efficient varieties which produce higher yields per unit of nitrogen was required. Keeping this in view, the present study was undertaken to find out nitrogen requirement of the promising potato varieties and to work out their nitrogen use efficiency (NUE).

**Material and methods**

An experiment was conducted at research cum instructional farm All India Coordinated Research project on potato at Research cum Instructional form, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *Rabi* season 2021-22. The soil of the experimental field was sandy loam in texture with low organic carbon (0.21%), pH (7.70), available N (0, 180, 250 kg/ ha). Treatments included combinations of twenty varieties (P-45, P-46, P-53, P-73, P-21, K. Surya, Kufri Jyoti, Kufri Sinduri, Kufri Mohan, Kufri Lalit, Kufri Neelkanth, Kufri Chipsona-3, Kufri Himalini, Kufri Ashoka, Kufri Garima, Kufri Arun, Kufri Lalima, Kufri Lima, Kufri Khyati and Kufri Chipsona-1) and three N levels (0, 180 and 250 kg/ ha), replicated in split plot design. Surface soil samples taken before planting of potato crop were analyzed for their physico-chemical properties employing standard procedures. Well sprouted seed tubers were planted in the 2nd week of November during Rabi season. Half of the N was applied as planting time while the remaining N was applied through urea at 30 days after planting *i.e*. at the time of earthing up.

Recommended package of practices were followed for raising the crop, haulms were cut at 100 days after planting and harvesting was done 15 days later. Nitrogen use efficiency (NUE) measures the amount of tuber yield produced per unit of nutrient supplied (Fageria *et al.*, 2008). Nutrient use efficiency *viz*. N efficiency was computed using following formula (Moll *et al*., 1982).

NUE= (Tuber Weight / Nitrogen Supplied)

## Results and discussion

**Analysis of Variance for Nitrogen Use Efficiency**

Analysis of variance for NUE reveal that, all the varieties and nitrogen level are showing significant difference as well as the interaction of Nitrogen with Variety found significant, it means there is sufficient level of variation for Nitrogen dose and among the potato varieties.

**Yield and Yield Response of Nitrogen**

Tuber yield was significantly influenced by levels of N and potato varieties Table 1. Maximum tuber yield, which was significantly higher over other varieties, was obtained from P-73 (18.36 kg/plot) followed by K. Mohan (17.08 kg/plot), K. Lalima (16.24 kg/plot), K. Garima (15.92 kg/plot), K. Neelkanth (15.88 kg/plot), P-45 (15.21 kg/plot) and K. Lalit (14.52 kg/plot), while minimum yield was observed in P-21 (5.83 kg/plot) followed by P-46 (6.77 kg/plot), K. Sinduri (6.89 kg/plot), K. Chipsona-3 (7.56 kg/plot), P-53 (7.76 kg/plot), K. Himalini (8.84 kg/plot), K. Jyoti (9.59 kg/plot) and K. Lima (9.90 kg/plot) irrespective of N levels. The interaction between N levels and varieties was found significant. P-73 produced the highest tuber yield at all the levels of N as compared to other varieties. Perusal of data indicated that response of all the cultivars to fertilizer N reduced markedly as the dose of N rate increased. However, the response to N application rate increased significantly in all varieties up to the highest levels of N (250 kg/ ha), except in Kufri Lima, which responded only up to 180 kg N/ ha.

The yield response of nitrogen, among twenty potato genotypes included in the experiment on the basis of mean performance of individual genotypes for total tuber yield at different nitrogen level, same set of seven genotypes P-73 followed by K. Mohan, K. Lalima, K. Garima, K. Neelkanth, P-45 and K. Lalit have shown higher total tuber yield at $N_{0,}$ $N_{180}$ and $N_{250}$ levels. It was also observed that all the varieties have shown increase in plant emergence with increase in nitrogen level and highest total tuber yield was observed at $N_{250}$ level, which was followed, by $N_{180}$ and $N_0$. This indicates that total tuber yield increases with increase in nitrogen level. The poor performance was recorded on P-21 followed by P-46, K. Sinduri, K. Chipsona-3, P-53, K. Himalini, K. Jyoti and K. Lima at $N_0$, $N_{180}$ and $N_{250}$ level. Genotypes P-73 and Kufri Mohan were observed significant superior over the best standard checks at In general, total tuber yield is significantly higher at $N_{250}$, $N_{180}$ than $N_0$ level.

Potato cultivars differ in their growth and yield potential; hence there is a differential response to nitrogen and bulking rate even if they belong to same maturity group. Duynisveld *et al.*, (1988) and Sharifi *et al.*, (2007) have also reported that different cultivars behave differently in terms of yield and bulking rate, to the applied nitrogen.

**Nitrogen use efficiency**

Nitrogen use efficiency (NUE) of nitrogen by various potato varieties calculated as kg tuber produced per kg N supply showed considerable variation Table 2. P-73 at 0, 180 and 250 kg N/ ha gave higher nitrogen use efficiency (0, 15.17 and 11.49 kg tubers/ kg N) followed by Kufri Mohan (0, 14.53 and 10.57 kg tubers/ kg N), K. Neelkanth (0, 12.24 and 10.38 kg tubers/ kg N) and K. Garima (0, 11.89 and 10.56 kg tubers/ kg N). Whereas, P-21 gave lowest NUE of 0, 4.97 and 4.06 kg tubers/ kg N and P-46 at 0, 180 and 250 kg N/ ha, respectively. Other varieties had nitrogen use efficiency ranging from 9.95 to 11.21 at different levels of N.

As regards performance of individual variety for NUE at different nitrogen level, same set of six genotypes have shown higher NUE at $N_{180}$ and $N_{250}$ level but it is interesting to note that in general, the genotypes have shown decline in NUE beyond $N_{180}$. However, the varieties showing highest NUE at $N_{180}$ have shown relatively less decline in NUE at $N_{250}$ level. This indicates that NUE declines with increase in nitrogen level beyond $N_{180}$ in potato. Genotypes P-73 and Kufri Mohan were observed significant superior over the best standard checks at $N_{180}$ and $N_{250}$ level. In general, NUE is significantly better at $N_{180}$ level than $N_{250}$.

The efficient cultivars gave higher tuber yield under nutrient stress (*i.e.* with less dose of N) than less efficient cultivars. The main reason for higher nitrogen efficiency in the presence or absence of N was the capacity of a genotype to use/ absorb more N per unit. Similar reported by (Jatav *et al.*, 2013) and (Trehan, 2009) in Potato.

**Conclusion**

On the basis of present investigation, it is concluded that significant genetic variability was found for Nitrogen Use Efficiency on yield and yield component, along with high heritability. Therefore this physiological traits have good scope to be utilized as selection parameter to bread Nitrogen Use Efficient (NUE) potato verities. Potato cultivar P-73 was the highest yielder and most N efficient variety followed by Kufri Mohan and Kufri Lalima. This variety utilizes for applied N better than the other most common varieties of the Chhattisgarh region.

Therefore integration of these NUE as selection criteria with conventional breeding methods is very much logical and excepted to advance yield per unit area and time without raising input level to economize the cost of production as well as better utilization of nitrogen applied to the crop.

**References**


Duynisveld, W.H.M., Strebel, O. and Bottcher, J. 1988. Are nitrate leaching from arable land and nitrate pollution of ground water avoidable. Ecol Bull 39: 116-125.

Fageria N.K., Baligar, V.C. and Li, Y.C. 2008. The role of nutrient efficient plants in improving crop yields in the twenty first century. J. Plant. Nutr, 31: 1121-1157.

Good, A.G., Shrawat, A.K. and Muench, D.G. 2004. Can less yield more, is reducing nutrient input into the environment compatible with maintaining crop production. Trends in Plant Science, 9 (12): 597-605.

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): 2369-2387.

Hirel, B., Tétu, T., Lea, P.J. and Dubois, F. 2011. Improving nitrogen use efficiency in crops for sustainable agriculture. Sustainability, 3(9): 1452-1485.

Jatavl, M.K., Kumar, M., Trehan, S.P., Dua, V.K. and Kumar, S. 2013. Effect of nitrogen and varieties of potato on yield and agronomic n use efficiency in north western plains of India. Potato J, 40(1): 55-59.

Kleinkopf, G., Westermann, D.T. and Dwelle, R.B. 1981. Dry matter production and nitrogen utilization by six potato cultivars. Agron. J, 73: 799-802.

Moll, R.H., Kamprath, E.J., Jackson, W. 1982. Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. Agronomy Journal, 74(3): 562-564.

Saluzzo, J.A., Echeverr, H.E., Andrade, F.H. and Huarte, M. 1999. Nitrogen nutrition of potato cultivars differing in maturity. J. Agron. Crop. Sci, 183(3): 157–65.

Sharifi, M., Bernie, J.Z. and Coleman, W. 2007. Screening for nitrogen-use efficiency in potato with a recirculating hydroponic system. Commun. Soil. Sci. Plant. 38: 359-70.

Trehan, S.P. 2009. Improving nutrient use efficiency by exploiting genetic diversity of potato. Potato J, 36(3-4): 121-35.

Woolfe, J. 1987. The potato in the human diet. Cambridge University Press, Cambridge, (7): 218-222.

**Table No. 1. Analysis of Variance for Nitrogen Use Efficiency**

| Source of Variations | DF | Mean Squares |
|---|---|---|
| Replicates | 2 | 0.97011 |
| Nitrogen | 2 | 9530.12438 |
| Error A | 4 | 2.63975 |
| Variety | 19 | 59.45861 |
| Nitro X Var | 38 | 37.03929 |

| | | |
|---|---|---|
| **Error B** | 114 | 4.97631 |
| **Total** | 179 | 123.89528 |

**Table No 2. Effect of deferent level of nitrogen on total tuber yield (Kg/Plot)**

| SN | Varieties | Nitrogen level (Kg/Plot) | | | |
|---|---|---|---|---|---|
| | | **$N_0$** | **$N_{180}$** | **$N_{250}$** | **MEAN** |
| 1 | P-45 | 13.25 | 14.46 | 17.91 | **15.21** |
| 2 | P-46 | 4.71 | 7.13 | 8.47 | **6.77** |
| 3 | P-53 | 5.51 | 8.33 | 9.43 | **7.76** |
| 4 | P-73 | 14.82 | 19.57 | 20.68 | **18.36** |
| 5 | P-21 | 3.76 | 6.41 | 7.32 | **5.83** |
| 6 | K. Surya | 10.04 | 14.18 | 15.50 | **13.24** |
| 7 | Kufri Jyoti | 7.46 | 9.51 | 11.79 | **9.59** |
| 8 | Kufri Sinduri | 4.56 | 7.83 | 8.28 | **6.89** |
| 9 | Kufri Mohan | 13.45 | 18.74 | 19.03 | **17.08** |
| 10 | Kufri Lalit | 12.20 | 12.61 | 18.76 | **14.52** |
| 11 | Kufri Neelkanth | 13.16 | 15.79 | 18.68 | **15.88** |
| 12 | Kufri Chipsona-3 | 5.55 | 7.65 | 9.48 | **7.56** |
| 13 | Kufri Himalini | 6.44 | 9.23 | 10.55 | **8.74** |
| 14 | Kufri Ashoka | 7.43 | 10.59 | 11.75 | **9.92** |
| 15 | Kufri Garima | 13.43 | 15.33 | 19.00 | **15.92** |
| 16 | Kufri Arun | 10.75 | 14.16 | 15.76 | **13.56** |
| 17 | Kufri Lalima | 13.73 | 15.63 | 19.37 | **16.24** |
| 18 | Kufri Lima | 7.48 | 10.39 | 11.82 | **9.90** |
| 19 | Kufri Khyati | 9.79 | 13.73 | 14.00 | **12.51** |
| 20 | Kufri Chipsona-1 | 11.66 | 15.62 | 15.86 | **14.38** |
| | MEAN | **9.46** | **12.34** | **14.17** | **11.99** |
| | | | | CD 5% | 5.46 |
| | | | | CV | 11.42 |

**Table No 3. Response of Nitrogen Use Efficiency by deferent potato cultivars.**

| SN | Varieties | Nitrogen use efficiency(Kg tuber produced/Kg N supply) | | | |
|---|---|---|---|---|---|
| | | Nitrogen level (Kg/Plot) | | | |
| | | **0** | **180** | **250** | **MEAN** |
| 1 | P-45 | 0.00 | 11.21 | 9.95 | **10.58** |
| 2 | P-46 | 0.00 | 5.53 | 4.70 | **5.12** |
| 3 | P-53 | 0.00 | 6.46 | 5.24 | **5.85** |
| 4 | P-73 | 0.00 | 15.17 | 11.49 | **13.33** |
| 5 | P-21 | 0.00 | 4.97 | 4.06 | **4.52** |
| 6 | K. Surya | 0.00 | 10.99 | 8.61 | **9.80** |
| 7 | Kufri Jyoti | 0.00 | 7.37 | 6.55 | **6.96** |
| 8 | Kufri Sinduri | 0.00 | 6.07 | 4.60 | **5.34** |
| 9 | Kufri Mohan | 0.00 | 14.53 | 10.57 | **12.55** |
| 10 | Kufri Lalit | 0.00 | 9.77 | 10.42 | **10.10** |
| 11 | Kufri Neelkanth | 0.00 | 12.24 | 10.38 | **11.31** |
| 12 | Kufri Chipsona-3 | 0.00 | 5.93 | 5.26 | **5.60** |
| 13 | Kufri Himalini | 0.00 | 7.16 | 5.86 | **6.51** |
| 14 | Kufri Ashoka | 0.00 | 8.21 | 6.53 | **7.37** |
| 15 | Kufri Garima | 0.00 | 11.89 | 10.56 | **11.22** |
| 16 | Kufri Arun | 0.00 | 10.98 | 8.76 | **9.87** |
| 17 | Kufri Lalima | 0.00 | 12.12 | 10.76 | **11.44** |
| 18 | Kufri Lima | 0.00 | 8.05 | 6.56 | **7.31** |
| 19 | Kufri Khyati | 0.00 | 10.65 | 7.78 | **9.21** |
| 20 | Kufri Chipsona-1 | 0.00 | 12.29 | 8.68 | **10.49** |
| | MEAN | 0.00 | **11.21** | **9.95** | **10.58** |
| | | | | CD 5% | 2.08 |
| | | | | CV | 10.68 |