**Effect of planting dates and nitrogen levels on tuber quality of potato cv. Kufri Lima**

Naveen Kumar1\*, V.P.S. Panghal1, Yugvinder1, Amit Kumar1, Sunil Kumar Gola1

1Department of Vegetable Science, CCS Haryana Agricultural University,

Hisar 125004, India

\*Corresponding author’s email- *sprajapatkhirbi@gmail.com*

 **ABSTRACT**

The experiment was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter season of 2020-21. The treatments comprising of three planting dates (25th September, 10th October and 25th October) and four levels of nitrogen (0, 75, 100 and 125% of RDN) were laid out in a randomized block design (factorial) with three replications.

Potato tuber quality parameters like dry matter of tubers and haulms, reducing, non reducing and total sugar were recorded maximum under 10th October planted crop, whereas, ascorbic acid and specific gravity of tubers were found non significant. While, among the different nitrogen levels, 125% of RDN application recorded significant maximum values for reducing, non reducing and total sugar, while ascorbic acid, dry matter content of tuber as well haulms increased with increase in nitrogen levels upto 100% of RDN. Specific gravity of tubers was found maximum where no nitrogen was applied.

The highest values for nitrogen, phosphorus and potassium uptake in haulms and tubers were registered with 10th October planting, whereas, nitrogen uptake in haulms, phosphorus uptake of tubers also found at par with 25th October planting. Among the nitrogen levels, maximum NPK uptake in haulms and tubers were recorded with 125% of RDN application, whereas, phosphorus and potassium uptake by haulms was increased significantly with increasing nitrogen levels upto 100% of RDN application. The leftover NPK in soil after harvest was noted maximum with earlier planting (25th September), while among the different nitrogen levels, leftover nitrogen in soil was increased with increasing levels of nitrogen upto 100% of RDN, while, phosphorus and potassium availability was recorded in reverse trends.

**KEY WORDS:** Potato, tuber, nitrogen, planting dates, NPK

**1. INTRODUCTION**

 Potato (*Solanum tuberosum* L.), a perennial herbaceous plant that belongs to the family (Solanaceae) and species *Solanum tuberosum* L. (2n=4x=48). Protein of potato is more superior to that of cereals due to presence of “lysine” (Pandey, 2001). It can also help to fight against malnutrition and hunger due to high production potential and high nutritional value. Besides reducing malnutrition it has medicinal values like the juice of potato reduces gastrogenic problems and also provides relief and heels burned skin wounds.

 Potato is a temperate region crop but can also be grown under subtropical climatic conditions. Potato is a long day plant but it is cultivated as short day plant for tuber, it is raised in India when maximum day temperature is below 35°C and the maximum night temperature is below 20°C. Temperature about 16-22°C is observed to be best for its tuber formation which is adversely affected when the temperature rises above 30°C. Among the several factors which are responsible for determining the production and productivity and quality parameters of the crop, fertilizer dose and planting time are the most important ones.

 Nitrogen is the most vital and responsible for the synthesis of amino acids, protein, coenzymes and nucleic acid formation, which are accountable for cell division and elongation which ultimately results in higher vegetative growth. Potato is a sensitive crop to application management of nitrogen, which is one of the top management priorities for potato growing systems (Stark *et al*., 2004). It determines the quantity and structure of potato yield, its chemical composition and tuber quality (Kolodziejczyk, 2014). It primarily influences tuber size, dry matter and sugar contents. Excessive application of nitrogen translocates the photosynthates from tops to tubers which directly affects the yield. Specific gravity will vary within a range for a given cultivar because it is strongly influenced by climate, soil and cultural factors. Nitrogen fluctuation during the growing season influence different tuber characteristic including tuber weight, specific gravity and enogenous nitrogen concentration.

 Proper fertilization with inorganic sources plays an important role in increasing quantity and quality of produce (Seghatoleslami *et al*., 2013). Moreover, selection of high yielding variety is very important as different varieties respond differently to various nutrients levels. Excess soil nitrogen levels during tuberization can delay growth of tuber, yield and also lessen the specific gravity. This delay in tuber maturation can adversely affect the storage and quality of the potatoes.

 Potato is a weather sensitive crop. Planting dates is considered very important to take the full advantage of the short growing period. Earlier planting is not possible due to unfavourable weather conditions. Tuberization rate in potato declines above a temperature of 17°C, increasing temperature may lead to reduced yields in potato. Early planted potatoes are high in starch content (White and Sanderson, 1983) and low in glucose and fructose (Nelson and Shaw, 1976) whereas, delayed planting results in reduced dry matter and starch content and increased reducing sugar (Lisinska and Leszczynski, 1987) of the tubers. Kufri Lima (CP4054) is an early season high yielding variety suitable for planting in North-Indian plains, having tolerance to hopper and mite burn, good keeping and culinary quality.

**MATERIAL AND METHODS**

**Description of the Study Area and Climatic conditions**

The present study entitled was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *Rabi* season of 2020-21. Hisar is situated at latitude of 290 10’ N, longitude of 750 46’E and height of 215.2 meters above mean sea level and falls in semi-arid and sub-tropical region with dry and hot summer and severe cold in winter. The total rainfall (approx. 400 mm) and its distribution in this region are subjected to large variation. About 80 to 90% of the total rainfall is received through southwest monsoon during July to September with few showers during winter and spring seasons. The average minmum and maximum temperature as well as relative humidity during the crop period was between 8 to 25°C and 54 to 94.1 %, respectively. Before conducting the investigation, the composite sample (500 g) of soil were taken from the experimental field up to a depth of 15 cm and subjected to mechanical analysis to know the chemical composition of the experimental field.

Table 1: Physico-chemical characteristics of soil of experimental field before experimentation

|  |  |  |
| --- | --- | --- |
| **Component** | **Values** | **Method** |
| Clay (%) | 10.05 | International pipette method (Piper, 1966) |
| Silt (%) | 16.50 |
| Sand (%) | 79.85 |
| pH (1:2) | 7.95 | pH meter having glass electrode (Walkley and Black, 1934) |
| EC (dSm-1 at 25° C) | 0.27 | Walkley and Black (1934) |
| Organic carbon (%) | 0.47 | Walkley and Black (1934) |
| Available nitrogen (kg ha-1) | 122.4 | Alkaline Permanganate method (Subbaih and Asija, 1956) |
| Available phosphorus (kg ha-1) | 22.1 | Sodium bicarbonate soluble P method (Olsen *et al*., 1954) |
| Available potassium (kg ha-1) | 210 | Ammonium acetate method (Jackson,1973) |

**Treatment and Experimental Details**

 The experiment was laid out in a randomized block design (factorial) with three replications, keeping three planting dates, viz., 25th September, 10th October and 25th October and four nitrogen levels, viz., nitrogen 0 kg/ha, i.e. control, 75% RDN, 100% RDN and 125% RDN. The seed material (tubers) of potato varieties Kufri Lima used for the present investigation was procured from the Department of Vegetable Science, CCS Haryana Agricultural University. The recommended dose of phosphorus (50 kg/ha) and potassium (100 kg/ha) for the crop and nitrogen was applied in two split doses as per treatments. The remaining half of the nitrogen was applied at the time of earthing up (35 DAP). Recommended dose of nitrogen by university is 150kg/ha for this crop. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. The statistical method described by **Panse and Sukhatme (1967)** was followed for the analysis of variance and interpretation of experimental results. For this, OPSTAT statistical software was used, developed by Chaudhry Charan Singh Haryana Agricultural University, Hisar, Haryana, India. All the tests of significance were made at 5% level of the significance. Critical difference was computed to test the significance of difference between means of two treatments.

**Crop raising and data recording**

 The experimental field was prepared by four harrowings each followed by planking to prepare a suitable planting bed. The potato tuber was planted according to treatment in the net plot of 3.0 m × 3.0 m with plant spacing of 60 cm × 20 cm. The recommended package of practices was followed for raising the crop successfully. Haulm cutting of potato crop was done at 90 days after planting of crop as per treatments, harvested after 10-15 days of haulm cutting. The thin slices of tuber and haulms (washed) weight of 200 g from each plot was taken and then dried separately first in polyhouse for 5-7 days and then in hot air oven at 60°C temperature until a constant weight was achieved. The dry matter content of haulms and tuber was worked out by using the following formula:

 Oven dried haulms/tuber weight (g)

 Dry matter (%) = –––––––––––––––––––––––––––––––– × 100

 Fresh haulms/tuber weight (g)

 The weight of sample unit in air divided by weight of sample unit in water is one of the commonly used methods to determine the specific gravity. Specific sample units were first weighed in air and then the same units were re-weighed after suspending in water.

 For NPK estimation in potato tuber and haulm, samples were collected just after harvesting washed and dried in hot air oven at 65°C for three days. The dried samples were ground in stainless steel Wiley mill, passed through sieve of 40-mesh size and thus analyzed as per standard procedures for NPK content.

List 1 : List of method used for the study

|  |  |  |
| --- | --- | --- |
| **Nutrient** | **Method used** | **Reference** |
| N | Nessler’s reagent method | Lindner (1944) |
| P | Ammonium Vanademolybdo-Phosphoric acid yellow colour method | Koening and Johnson (1942) |
| K | Flame photometric method | Jackson (1973) |

 To analyze N, P and K content of tubers and haulm, the prepared samples were digested in diacid mixture of H2SO4 and HClO4 (4:1). The final volume of the digested samples was made 50 ml by using distilled water, followed by filtration and storage for further assessment. The NPK contents were analyzed by the methods mentioned above.

Sugars are estimated by the method of Hulme and Narain (1931) and the ascorbic acid content was determined by the standard method (A.O.A.C., 1980).

**3. RESULTS AND DISCUSSION**

**Total Yield**

 The data demonstrated that different planting dates and nitrogen levels significantly affected the total (kg/m2) was recorded maximum with 10th October planting as compared to early and late planting dates. As the temperature is one of the most dominating factors in yield contribution in potato crop temperatures during vegetative as well as reproductive growth phase might have suitable towards getting better vegetative growth and higher yield in this planting date. The present results are similar to the finding of Thongam *et al*. (2017), recorded the highest tubers yield with 10th October planting as compared to delayed planting.

Among the different nitrogen levels, weight of tubers (kg/m2) were recorded in the range 1.98 to 2.94 kg/m2, which were observed significantly highest for the 125% of RDN application, it was at par with 100% of RDN. Inadequate supply of nitrogen fertilizer to potato crop leads to poor growth and yield, while excessive application of nitrogen, especially as mineral fertilizer, leads to luxury consumption for plant growth, occasionally a reduction in yield and quality of tubers, delayed maturity and leaching of excessive nitrate in soil (Arriaga *et al*., 2009; Cerny *et al*., 2010).

**Quality parameters**

 Dry matter of tubers and haulm influenced significantly with different planting dates and maximum was recorded with 10th October planting. It may be due to that 10th October planting is the optimum date of planting of potato var. Kufri Lima. Begum *et al.*, (2015) also reported that optimum date of planting showed highest dry matter content as compared to delayed plating. The dry matter content of tubers and haulms (%) for different nitrogen levels was recorded in the range of 15.9 to 18.6% and 8.6 to 10.9%, respectively and noted significantly highest dry matter content of tubers (18.6%) and haulms (10.9%) with 125% of RDN application closely followed with 100% of RDN. Zinada *et al*. (2009) observed that nitrogen increment significantly increased tuber dry matter percentage, probably due to an increase in new leaf formation and extended activity of older leaves. The stimulatory effect of nitrogen application in increasing dry matter of potato tubers might be explained that nitrogen is an indispensable elementary constituent of numerous organic compounds of general importance, *i.e.*, cytoplasm, chlorophyll, amino acids, proteins, nucleic acids and many other important compounds, which might have improved the dry matter content of tubers. As the nitrogen level increased, fresh and dry weight of plant were also increased and found significantly maximum with the application of nitrogen 200 kg /ha (Sriom *et al.*,2017) and with 187.5 kg/ha (Chopra *et al.*, 2006).

 The data on specific gravity of potato tubers revealed that different planting date had non-significant and nitrogen levels had significant influence on specific gravity of tuber. Specific gravity for different nitrogen levels was fluctuated in the range of 1.047 to 1.078 and significantly maximum (1.078) was noticed in control plots (without nitrogen application) and lowest specific gravity (1.047) was recorded with 125% of RDN. It is clear from the results that specific gravity of tubers decreased with increasing nitrogen levels. Nitrogen fertilization increased the tuber nitrogen and NO3-N concentrations, and decreased specific gravity in Atlantic Canada variety of potato (Belanger *et al.,* 2002). Yassen *et al.* (2011) observed the highest specific gravity (1.071) was recorded with 200 kg N/ha and lowest at 250 kg N/ha.

 The reducing, non-reducing and total sugar content (mg/100 g) in tubers was observed significantly maximum with 10th October planting. Among the different nitrogen levels, reducing, non reducing and total sugar content in tubers was increased with increase in nitrogen levels and it was significantly highest (249.2, 171.6, 429.8 mg/100) for the 125% of RDN application. Reducing sugar of potato tubers increased with increasing rates of nitrogen up to 187.7 kg/ha and decreased thereafter (Chopra *et al*., 2006). Banu *et al.* (2007) noted that reducing sugars and crude protein content were increased with increase in nitrogen levels andmaximum (190 mg/100g) was recorded at 240 kg N/ha application, while Sandhu *et al.* (2010) found maximum up to 200 kg N/ha. The interaction effect of planting dates and nitrogen levels was significant for total sugar content of tubers and recorded in the range of 334.0 to 440.4 mg/100 g. The maximum total sugar content (440.4 mg/100 g) was recorded with 10th October planting along with application of 125% of RDN which was considerably higher than all other interactions, whereas the minimum was recorded in the plot with planting on 25th September without application of nitrogen fertilizer.

 The data on ascorbic acid (mg/100g) content in tubers revealed that different nitrogen levels significantly influenced the ascorbic acid (mg/100g) content of tubers but planting dates was found statistically non-significant. In context of different nitrogen treatments, ascorbic acid fluctuated in the range of 19.3 to 22.0 mg/100 g and significantly maximum was noticed with 125% of RDN, it was at par with 100% of RDN (21.4 mg/100 g) application. Mondy *et al*. (1979) concluded that there was significant relation between ascorbic acid content and nitrogen levels, as nitrogen level increased there was significant increase in ascorbic acid of tuber.

 Nitrogen, phosphorus and potassium uptake (kg/ha) in haulms was found significantly affected with different planting dates and nitrogen levels. Among the planting dates, significantly maximum nitrogen, phosphorus and potassium in haulms (35.9, 9.5, 99.7 kg/ha, respectively) was found with 10th October planting. This may be due to that plant got favourable environmental condition planting on this date, which resulted vigorous plant growth and maximum uptake of nutrients from the soil. Among the different nitrogen levels, nitrogen, phosphorus and potassium uptake by the haulms was observed in the scale of 23.9-39.2, 4.4-10.8, 60.4-114 kg/ha, respectively and significantly maximum was observed with 125% of RDN closely followed with 100% of RDN. The increased accumulation of nitrogen, phosphorus and potash in haulms might be due to more absorption of these elements from the soil caused by better growth and development of root and aerial portion with successive increase in fertility levels. Kumar and Trehan (2012) reported that increase in nitrogen levels from 0 to 240 kg/ha significantly increased the uptake of nitrogen by haulm from 10.73 to 29.07 kg N/ha.

 Nitrogen, phosphorus and potassium uptake by the tuber was significantly differed with different planting date and nitrogen levels. Among the planting dates, nitrogen, phosphorus and potassium uptake were recorded significantly maximum (62.3, 14.9, 135.3 kg/ha, respectively) with 10th October planting, whereas, phosphorus was at par with 20th October planting. As the temperature is one of the most dominating factors for potato crop, the required temperatures during vegetative as well as reproductive growth phase might have suitable towards getting better vegetative growth and higher nutrient uptake by tubers in this planting date. Sandhu *et al*. (2014) also found the maximum uptake of NPK in potato tuber with optimum planting time.

 Among the different nitrogen levels, nitrogen, phosphorus and potassium uptake by the tubers was observed in the range of 43.7-67.0, 8.7-16.7, 95.9-153.6 kg/ha, respectively and significantly maximum nitrogen, phosphorus and potasium uptake by the tubers was recorded with application of 125% of RDN, while, phosphorus uptake by tuber was at par with 100% of RDN application. The increased content of nitrogen, phosphorus and potash in tubers might be due to more uptakes of these elements from the soil with successive increase in fertility levels and their slow utilization under low temperature conditions in the field. Kumar and Trehan (2012) also noticed significantly increase in nitrogen uptake by tubers with increasing nitrogen levels from 0 to 240 kg/ha. Similarly, with increasing levels of nitrogen, tuber nitrogen content (Kumar *et al*., 2008) and potassium content (Mahmoodi and Hakimian, 2005) also increased significantly.

 For potassium uptake in tubers, the effect of interaction between planting dates and nitrogen levels was found significant; moreover considerably maximum (161.1 kg/ha) uptake of potassium in tubers was observed when crop was planted on 25th October with 125% of RDN application, it was at par with 100% of RDN on same date of planting and 125% of RDN application with 10th October planting.

Available nitrogen, phosphorus and potassium in soil after harvesting of potato crop was observed significantly difference among the different planting dates and nitrogen levels and 25th September planted crop recorded maximum leftover NPK (160.8, 22.5, 237 kg/ha, respectively) in soil after crop harvest. The higher leftover values for nitrogen, phosphorus and potassium in soil on early planting date (25th September) might be due to less utilization of these elements because of poor plant growth and tuber yield.

 Among the different nitrogen levels, available nitrogen in soil after harvesting crop was increased with increase in nitrogen levels, whereas, phosphorus and potassium was recorded in reverse trends. The significantly highest leftover nitrogen in soil after harvesting of crop was recorded with 125% of RDN application, which was at par with 100% of RDN, while phosphorus was recorded with the treatment where no nitrogen was applied, closely followed with 75 % of RDN application and for potassium availability, significantly highest was recorded with treatment where no nitrogen was applied.

 The maximum leftover value for nitrogen in soil where its highest dose was applied might be due to its excessive application than the crop requirement, while the higher leftover values for phosphorus and potassium in soil where no nitrogen was given might be due to less utilization of these elements because of poor plant growth and tuber yield. The respective increase in total nitrogen, phosphorus and potassium uptake was recorded when they were applied at the rate of 150, 150 and 100 kg/ha in the presence of farmyard manure 15 t/ha (Datt *et al*., 2002). The highest nitrogen and potassium was available in soil at all stages of potato growth when nitrogen and potassium each was applied 180 kg/ha (Lakshmi *et al*., 2012).

**4. CONCLUSION**

 Based on one year study, carried out during winter season of 2020-21 at research farm of Department of Vegetable Science, CCS HAU, Hisar, it is concluded that the potato variety Kufri Lima planting on 10th October with application of 100% of RDN provided with high quality potato tuber.

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Table 2. **Effect of planting dates and nitrogen levels on quality parameters of potato tubers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Dry matters %** | **Specific gravity** | **Sugar (mg/100g)** | **Ascorbic acid (mg/100g)** |
| **Leaves**  | **Tubers**  | Reducing  | Non reducing  | Total  |
| **Planting dates** |
| **25th sept.** | 8.7 | 17.1 | 1.06 | 214.9 | 152.3 | 375.2 | 20.5 |
| **10th oct.** | 10.9 | 17.9 | 1.06 | 224.8 | 160.6 | 393.9 | 20.8 |
| **25th oct** | 9.9 | 17.0 | 1.07 | 219.4 | 157.1 | 384.8 | 20.7 |
| **SE(M)** | 0.2 | 0.2 | 0.002 | 1.3 | 1.0 | 1.2 | 0.5 |
| **CD** | 0.7 | 0.7 | N.S. | 3.8 | 3.0 | 3.5 | N.S. |
| **Nitrogen levels** |
| **N0** | 8.6 | 15.9 | 1.078 | 189.7 | 140.9 | 338.1 | 19.3 |
| **N75** | 9.5 | 16.8 | 1.068 | 209.4 | 151.5 | 368.8 | 19.8 |
| **N100** | 10.3 | 18.0 | 1.054 | 230.5 | 162.7 | 401.8 | 21.4 |
| **N125** | 10.9 | 18.6 | 1.047 | 249.2 | 171.6 | 429.8 | 22.0 |
| **SE(M)** | 0.3 | 0.3 | 0.002 | 1.5 | 1.2 | 1.4 | 0.5 |
| **CD** | 0.8 | 0.9 | 0.007 | 4.4 | 3.4 | 4.1 | 1.6 |

Table 3: Effect of Planting Dates and Nitrogen Levels on Nutrient Uptake and Post-Harvest Soil Status

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Uptake by Haulm (%)** |  **Uptake by Tubers (%)** |  **Soil status after harvest (%)** |
| **N** | **P** | **K** | **N** | **P** | **K** | **N** | **P** | **K** |
| **PLANTING DATES** |
| **25th sept.** | 29.4 | 6.4 | 89.4 | 52.0 | 10.0 | 119.0 | 160.8 | 22.5 | 237.0 |
| **10th oct.** | 35.9 | 9.5 | 99.7 | 62.3 | 14.9 | 135.3 | 149.2 | 18.2 | 230.2 |
| **25th oct** | 34.3 | 8.5 | 96.4 | 59.0 | 12.9 | 130.2 | 153.1 | 20.6 | 233.4 |
| **SE(M)** | 0.6 | 0.2 | 0.8 | 0.8 | 0.6 | 1.2 | 2.0 | 0.5 | 1.0 |
| **CD** | 1.7 | 0.6 | 2.3 | 2.3 | 1.8 | 3.5 | 5.8 | 1.6 | 3.0 |
| **NITROGEN LEVELS** |
| **N0** | 23.9 | 4.4 | 60.4 | 43.7 | 8.7 | 95.9 | 117.3 | 22.3 | 243.0 |
| **N75** | 32.4 | 7.1 | 94.5 | 56.7 | 9.9 | 115.6 | 143.4 | 20.8 | 239.4 |
| **N100** | 37.1 | 10.3 | 111.8 | 63.7 | 15.1 | 147.6 | 175.6 | 20.0 | 230.2 |
| **N125** | 39.2 | 10.8 | 114.0 | 67.0 | 16.7 | 153.6 | 181.4 | 18.7 | 221.6 |
| **SE(M)** | 0.6 | 0.2 | 0.9 | 0.9 | 0.7 | 1.4 | 2.3 | 0.6 | 1.2 |
| **CD** | 1.9 | 0.7 | 2.7 | 2.7 | 2.1 | 4.0 | 6.7 | 1.9 | 3.5 |

**Table 4 : Interaction effect of planting dates and nitrogen levels on different parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Interaction** | **Total yield (kg/m2)** | **Total sugar in tuber (mg/100g)**  | **K uptake by tuber** |
| **D1N0** | 0.76 | 334.0 | 84.8 |
| **D1N75** | 1.04 | 361.1 | 114.6 |
| **D1N100** | 1.21 | 387.7 | 135.0 |
| **D1N125** | 1.26 | 418.1 | 141.6 |
| **D2N0** | 2.89 | 344.9 | 99.2 |
| **D2N75** | 3.27 | 377.1 | 131.5 |
| **D2N100** | 4.20 | 413.0 | 152.3 |
| **D2N125** | 4.20 | 440.4 | 158.0 |
| **D3N0** | 2.28 | 335.3 | 103.8 |
| **D3N75** | 2.95 | 368.2 | 100.5 |
| **D3N100** | 3.35 | 404.6 | 155.3 |
| **D3N125** | 3.35 | 431.1 | 161.1 |
| **SE (m)** | 0.14 | 2.4 | 2.4 |
| **CD** | 0.42 | 7.0 | 7.1 |