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# Time and method of nitrogen application for chipping potato variety Kufri Chipsona-3 for higher productivity, profitability and processing quality during long term storage

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**Abstract**

Field trial was conducted at Modipuram (India) with potato cultivar Kufri Chipsona-3 with four treatments of time and method of N application (2 split, 3 split, 3 split + 1 foliar spray, and 2 split + 2 foliar spray) in randomized block design. Time and method of N application did not influence shoot number, plant height and leaf number also different time and method of N application did not bring any marked changes in processing grade and total tuber number. Tuber yield (processing grade, small and total) did not vary significantly with different time and method of N application. Similar net income and benefit cost ratio was realized with 2 N splits, 3 N splits and 3 N splits + one foliar spray. Tuber specific gravity and dry matter content were found maximum when N was applied in 2 splits in the soil. At the time of harvest chip colour score and glucose concentration in tubers did not vary due to N time and method of application and were observed within the acceptable limits of the chipping industry. Chip colour remained acceptable upto 150 days of storage, where N was applied in 2 splits. In case of foliar N, chip colour score was acceptable only upto 60 days of storage. Therefore, it was concluded that recommended dose of 270 kg N/ha should be applied in two equal splits in soil at planting and earthing up for higher tuber yield and good processing quality at harvest and during long term storage for Kufri Chipsona-3.

**Key words** : Potato, Kufri Chipsona-3, time of N application, tuber yield, net income, processing quality, long term storage.

Processing of potatoes into chips requires certain minimum quality attributes that include round to oblong tubers (> 45 mm) with shallow eyes and low peeling losses for higher recovery of chip yield. The tubers need to have >20% dry matter with glucose content as low as possible (preferably below 35 mg/ 100 g fresh tuber weight) to yield crisp and light colored chips (Gould, 1999, Kumar *et al*., 2013). Indian chipping variety Kufri Chipsona-3 is widely grown and used at large scale by processing industries in India for making chips, flakes and French fries. Fertilizer dose (270 kg N + 80 kg $P_2O_5$ + 150 kg $K_2O$/ha) have been optimized for realizing higher processing grade tuber yield with better processing quality for Kufri Chipsona-3 (Kumar *et al*., 2012). There was continuous feedback from the growers as well as from the industries that in certain parts of Punjab and Uttar Pradesh cv. Kufri Chipsona-3 results in low processing grade yield and also matures earlier than the normal duration (110 days). The feedback indicated

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towards inappropriate nitrogen management during various phases of crop growth and development. It is well known that N management especially rate and time of application affect the tuber size distribution as well as influence the crop duration (Morena *et al*., 1994). Since potato is a seasonal crop and a perishable commodity, therefore to run the chipping/processing industry round the year, long term storage is inevitable. For this purpose storage at elevated temperature (10-12°C) with sprout suppressant (isopropyl-chlorocarbamate) treatment is done extensively to avoid the low temperature sweetening (Kumar *et al*., 2013). Therefore, any agronomic intervention done to increase the processing grade, should not affect the processing quality at harvest as well as during storage. Therefore, the present investigation was undertaken with different time of N application including foliar spray of urea with objective to standardize the time and method of N application for cv. Kufri Chipsona-3 for getting maximum proportion of processing grade tubers, higher net returns and its impact on processing quality parameters at harvest and during long term storage.

## Materials and Methods

The field experiment was conducted for two consecutive seasons during 2008-2010 at Central Potato Research Institute Campus, Modipuram (29°4' N, 77° 46' E, 237 m above mean sea level) in randomized block design. The treatments consisted of four N method and application time (2 split, 3 split, 3 split + 1 foliar spray of urea, and 2 split + 2 foliar spray of urea) with five replications. Soil of the experimental site was sandy loam (Typic Ustochrept) in texture. Chemical analysis of the soil (0-15 cm) showed neutral pH (7.05), low organic carbon content (0.35%) and low alkaline $KMnO_4$-N (167.4 kg/ha), high Olsen's (0.5 M $NaHCO_3$ extractable) P (52.6 kg/ha) and medium 1N ammonium acetate extractable K (146.8 kg/ha). Uniform dose of P (35.0 kg/ha) and K (124.5 kg/ha) were applied at the time of planting. Whereas, uniform N (270 kg/ha) was applied as per the treatments. At planting all the fertilizer including N was placed in bands below the seed tuber, however, at earthing up (about 25 days after planting) N was side dressed, and at 60 days after planting (DAP) N was top dressed through urea as per the treatments. Top dressing was done near noon time in the moist field. For foliar spray 2% urea solution was used as per treatments. The source of N was calcium ammonium nitrate at planting and urea afterwards. Phosphorus and potash were given through diammonium phosphate and muriate of potash, respectively. The experimental crop was planted on 18 and 21 October during 2008 and 2009, respectively. Well-sprouted seed tubers (50-60 g seed weight, about 40-45 mm seed size) were planted with 67.5 × 20 cm crop geometry in plots of 4.05 × 6 m and the crop was raised under assured furrow irrigation method. Dehaulming was done manually at 110 days after planting as per the treatments and harvesting was done two weeks later after skin suberization.

Growth parameters (plant height, stem number and compound leaf number) were recorded from five randomly selected potato plants from each plot at 50 DAP. Processing grade (> 45 mm diameter) and small (< 45 mm) tuber number and yield were recorded at harvest from the whole produce of the plot. Tuber specific gravity was measured by the hydrometer method on 3.632 kg of processing grade tubers from each plot (Gould, 1999). Ten processing grade tubers were selected randomly from each plot and used for determining the processing quality attributes *viz*. chips colour score, glucose content and dry matter percentage. Potato chips were prepared at laboratory scale which involved peeling of tubers in abrasive peeler, 1.75 mm thick slicing with an automatic slicer, washing and drying on paper towel. Dried slices were then fried in refined soybean oil in a thermostatically controlled deep fat fryer at 180°C till bubbling stopped. Fried chips were evaluated for chip colour on a scale of 1-10, subjectively with the help of colour cards where, 1 denotes a highly acceptable colour and10 denotes a dark brown unacceptable colour, while chips with colour range of up to 3.0 were considered acceptable (Kumar *et al*., 2011). The glucose content in potato tubers was quantified using YSI Biochemistry analyzer as described by Sowokinos (1978). For

tuber dry matter estimation, three tubers were fine chopped and mixed, 50 g sample was oven dried at 80°C till constant weight was achieved. To calculate the cost of cultivation, the price of seed potato was considered at Rs 10000/t, which was the rate for certified seed in those years. The price of the processing-grade and small potato tubers were taken as Rs 5000/t (price paid by the processors to their contract growers during those years) and Rs 3000/t (the prevailing market price for that quality of potato tubers), respectively, for calculating the economics. The produce of the experiment was kept for storage studies after 15-20 days of curing in heaps after the harvest. Sample of thirty processing grade tubers from each plot was stored at 10-12°C with two isopropyl-chlorocarbamate (CIPC, a sprout suppressant) foggings for six months to investigate the effect of N method and application time on chip colour score and glucose content during long term storage. Data of each character collected from the experiments were statistically analyzed using standard procedures of variance analysis with the help of statistical software CROPSTAT 7.2 (IRRI, 2009). Critical difference (CD) values at P=0.05 were used to determine the significance of differences between means.

## Results and Discussion

### *Growth, graded tuber number and tuber yield*

The crop growth traits such as stem number, plant height and number of compound leaf did not significantly affected due to time and method of N application treatments (Table 1). Different time and method of N application also did not bring any marked changes in processing grade and total tuber number. This indicated that N status of the root zone was not a limiting factor for the tuber setting in all the treatments of N application. Tuber yield (processing grade, small and total) did not vary significantly with different time and method of N application (Table 1). In North America, Canada and Europe where potatoes meant for processing purposes are grown on large scale, whole of the N is being applied before planting, especially on heavy soils where nitrate leaching is not a problem (Love *et al*., 2005). However, on light soils splitting of the total N application into two equal splits between planting and tuber initiation showed increase in tuber yield (Joern and Vitosh, 1995). Similar results for growth, tuber number and yield were reported by Kumar *et al*. (2011) for processing cultivar Kufri Chipsona-1.

**Table 1. Effect of time of N application on growth parameters, graded tuber number, yield and economics of potato cv Kufri Chipsona-3 (two-year pooled data).**

| *Time of N application* | Stem/ plant | Plant height (cm) | Leaf/ plant | Tuber number (× $10^3$/ ha) | | | Tuber yield (t/ha) | | | Net income (× $10^3$ Rs./ha) | B : C ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | PG > 45 mm | Small < 45 mm | Total | PG | Small | Total | | |
| $T_1$ = $N_{135}$ (P) + $N_{135}$ (E) | 4.82 | 54.8 | 52.7 | 342.4 | 245.4 | 587.8 | 32.92 | 5.49 | 38.41 | 99.1 | 2.21 |
| $T_2$ = $N_{135}$ (P) + $N_{67.5}$ (E) + $N_{67.5}$ (60 DAP) | 4.79 | 55.1 | 50.4 | 374.6 | 227.2 | 601.9 | 32.56 | 5.38 | 37.94 | 96.6 | 2.17 |
| $T_3$ = $N_{135}$ (P)+ $N_{67.5}$ (E)+$N_{58.5}$ (60 DAP)+ 1 urea spray (2%) at 80 DAP | 4.80 | 54.9 | 47.5 | 332.2 | 236.1 | 568.3 | 33.48 | 5.68 | 39.15 | 101.8 | 2.23 |
| $T_4$ = $N_{126}$ (P) + $N_{126}$ (E) + 2 urea spray (2% ) at 60 and 80 DAP | 5.07 | 56.9 | 51.0 | 359.0 | 206.1 | 565.1 | 32.11 | 4.74 | 36.85 | 92.2 | 2.12 |
| SEm+ | 0.25 | 0.78 | 2.55 | 12.3 | 23.4 | 20.2 | 0.47 | 0.54 | 0.77 | 2.5 | 0.02 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | 8.7 | 0.08 |

P = Planting; E = Earthing up; DAP = days after planting; PG= Processing or chipping grade.

### *Economics*

Statistically similar net income and benefit cost ratio (Table 1) was realized with $T_1$ (2 splits), $T_2$ (3 splits) and $T_3$ (3 splits + one foliar spray), however the lowest values of both the economic variables was estimated with treatment $T_4$ (2 splits+2 foliar spray). Love *et al*. (2005) and Kumar *et al*. (2011) also reported that timing of N applications made very little difference in the final value of the crop.

### *Processing quality at harvest and during long term storage*

Chipping quality traits tuber specific gravity and dry matter content were found maximum when N was applied in 2 splits in soil (Table 2). The decline in both the variables was significant when N was applied through foliar application ($T_3$ and $T_4$). This can be ascribed to the fact that high N availability during the entire growing season, particularly late tuber bulking often delays tuber maturity and lowers specific gravity levels (Laboski and Kelling, 2007). Higher values of above stated processing quality traits is desirable for higher recovery of the chips with low oil absorption and better crispiness in taste (Kumar *et al*., 2012). At the time of harvest chip colour score and glucose concentration in tubers did not vary due to N time and method of application and were observed within the acceptable limits of the chipping industry. In long term storage study, chip colour score improved up to 60 days of storage in all the treatments of time and method of N application (Table 2). Chip colour remained acceptable upto 150 days of storage in $T_1$ where only 2 splits of N was given in soil, however, in case of 3 N splits ($T_2$) the acceptable chip colour score was observed only up to 120 days of storage. In case of foliar N applied treatments ($T_3$ and $T_4$), chip colour score was acceptable only upto 60 days. Correlation was also estimated between chip colour score and glucose content (r=0.458), though it was positive but not very strong. It is documented that glucose has important role in determining chip colour, but it cannot always be directly correlated, since besides glucose other compositional factors like fructose, sucrose and free amino acids are also involved in determining non-enzymatic colour development in fried potato products (Kumar *et al*., 2004). Our study indicated that for realizing higher tuber yield with good processing quality at harvest and during long-term storage, more than 2 N splits or foliar spray of urea in late season is not desirable for variety Kufri Chipsona-3. Therefore, it was concluded that recommended dose of 270 kg N/ha for potato processing cv. Kufri Chipsona-3 should be applied in two equal splits in soil at planting and earthing up.

**Table 2. Effect of time of N application on processing quality parameters of chipping variety Kufri Chipsona-3 at harvest and during storage at 10-12°C with CIPC (two year pooled data)**

| *Time of N application* | Specific gravity | Tuber dry matter (%) | Glucose content | Chip colour score (days after storage) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 30 | 60 | 90 | 120 | 150 | 180 |
| $T_1 = N_{135}$ (P) + $N_{135}$ (E) | 1.088 | 24.24 | 5.91 | 2.59 | 1.50 | 1.67 | 2.98 | 2.03 | 2.93 | 4.72 |
| $T_2 = N_{135}$ (P) + $N_{67.5}$ (E) + $N_{67.5}$ (60 DAP) | 1.086 | 23.32 | 7.62 | 2.97 | 1.37 | 1.63 | 3.00 | 2.40 | 4.16 | 5.54 |
| $T_3 = N_{135}$ (P)+ $N_{67.5}$ (E)+ $N_{58.5}$ (60 DAP)+ 1 urea spray (2%) at 80 DAP | 1.086 | 21.21 | 6.79 | 2.96 | 1.50 | 1.70 | 3.33 | 3.10 | 4.36 | 6.72 |
| $T_4 = N_{126}$ (P) + $N_{126}$ (E) + 2 urea spray (2% ) at 60 and 80 DAP | 1.086 | 21.38 | 3.12 | 2.93 | 1.53 | 1.37 | 3.50 | 3.03 | 4.10 | 6.32 |
| SEm+ | 0.0005 | 0.55 | 2.76 | 0.23 | 0.23 | 0.13 | 0.13 | 0.05 | 0.14 | 0.20 |
| CD (P=0.05) | 0.0016 | 1.92 | NS | NS | NS | NS | 0.46 | 0.18 | 0.48 | 0.70 |

P = Planting; E = Earthing up; DAP = days after planting; [a] mg/100g fresh tuber weight; [b] on 1-10 scale, where < 3 is considered acceptable

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