



Effect of varying levels of nitrogen and plant density on the production behaviour of undersize seed tubers of potato (*Solanum tuberosum*) in north-western hills of India

ASHWANI KUMAR SHARMA¹ and VINOD KUMAR²

Central Potato Research Station, Kufri, Shimla, Himachal Pradesh 171 012

Received: 20 June 2012; Revised accepted: 17 February 2014

Key words: Ground cover, Nitrogen, Plant density, Potato, Tubers, Yield

Seed is a major and important input in potato (*Solanum tuberosum* L.) cultivation. On account of vegetative propagation through tubers, the requirement of seed potatoes is voluminous and alone accounts for 40-50% of the total production cost depending upon the size of seed tubers (Singh 2003). This cost may still be higher in the high hills, where, generally a major proportion of the potato produce comes in large grade on account of long crop season coupled with long day conditions (Raj *et al.* 1997). To reduce the seed costs, small seed tubers are most preferred by the farmers over larger ones (Horton 1987) as such tubers reduce the seed requirement by about 50% and consequently decline the cost of cultivation by 25% (Arsenault *et al.* 2001). Moreover, successful cultivation of undersize seed tubers of potato in hills has already been reported by Sharma and Singh (2010). However, no information regarding the optimum dose of nitrogen in relation to plant density for such small seed tubers is available till now.

Keeping this in view, a field study was conducted at Central Potato Research Station – Kufri (Fagu Unit), Shimla, HP, India, 2700 m above mean sea level during the *kharif* seasons of 2007 and 2008, in randomized complete block design with three replications. Small (15g) seed tubers of potato variety Kufri Giriraj collected from last season (September harvest) were planted at three plant densities, viz. 83333 (D1); 111111 (D2) and 166666 (D3) plants/ ha, representing the intra-row spacing 20, 15 and 10 cm, respectively. Row to row spacing was kept uniform at 60 cm. Four doses of nitrogen, viz. 80 kg (N1), 120 kg (N2), 160 kg (N3) and 200 kg (N4) per hectare were applied, whereas, phosphorous and potassium were applied @ 100 kg/ha, respectively. Planting was done on 29 April in 3 × 3 m plots during both the years. Full doses of P as single super phosphate, K as muriate of potash and 80% N as calcium ammonium nitrate (CAN) were applied at the time of planting. Remaining dose of 20% N was applied as CAN

at the time of earthing up after 50 days of planting. Haulms were cut after 120 days of planting. Data were collected on height (cm), number of shoots and compound leaves per plant after 75 days of planting. Ground cover (%) was estimated after 40 and 100 days of planting with the help of a 50 × 50 cm grid with 100 equal compartments at two locations in each plot as described by Burstall and Harris (1983). At harvest, data were recorded on the number and yield of total and seed size (20-80g) tubers. The average of two years data was analyzed statistically by applying the technique of analysis of variance (ANOVA) as described by Gomez and Gomez (1984).

Plant height was affected significantly by the varying plant densities and nitrogen doses (Table 1). Increasing plant density and doses of nitrogen (up to 160 kg/ha) resulted in a gradual increase in the height of plants. Significant increase in plant height with the increasing plant population can be attributed to increased competition between stems for light and space as already observed by earlier workers (Singh *et al.* 1993, Singh *et al.* 1997). Similarly, increase in plant height with increasing doses of nitrogen is in conformity with the findings of Kushwah (1989) and Malik *et al.* (1999) and can be attributed to the more availability of nutrients (nitrogen) at higher doses.

Number of stems and compound leaves per plant showed a gradual and significant decrease with the increasing plant density but were not affected by the varying levels of nitrogen (Table 1 and 2). Reduction in number of leaves and stems per plant with increasing plant population can be attributed to the availability of limited space for the proper development of plant (Lal *et al.* 1981, Khurana and Pandita 1982). Poor response of increasing doses of nitrogen in the development of plant vigour (stems and leaves) may also be due to lack of space on account of increasing plant population and thus posing a barrier for plant development (Singh *et al.* 1997, Kushwah 1989).

Increasing plant density from D1 (83 333 plants/ha) to D2 (111 111 plant/ha) resulted in a significant decrease in the weight of haulms/plant which was not affected with

¹ Senior Scientist (Hort.) (e mail: ashwanicpri@gmail.com),

² Head (e mail: vinodkapoorcpr@gmail.com)

Table 1 Effect of plant density and nitrogen doses on height and number of stems/plant in potato cv Kufri Giriraj

Plant density	Height/plant (cm)					Number of stems/plant				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
D1	49.7	48.4	48.7	47.5	48.6	2.9	2.3	2.2	2.1	2.4
D2	42.5	49.1	55.6	53.6	50.2	1.8	2.0	2.0	1.9	1.9
D3	51.3	51.4	52.4	49.9	51.3	1.8	1.9	2.0	1.9	1.9
Mean	47.9	49.6	52.2	50.3		2.2	2.1	2.1	1.9	
CD (P=0.05)										
Density (D)			1.4					0.27		
Nitrogen (N)			1.5					NS		
D × N			2.8					NS		

Table 2 Effect of plant density and nitrogen doses on the number of compound leaves/plant and days taken to foliage maturity in potato cv Kufri Giriraj

Plant density	Number of compound leaves/plant					Haulms weight/plant (g)				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
D1	41.2	46.1	54.6	50.9	48.2	19.1	33.9	41.3	48.1	35.6
D2	43.4	43.4	34.9	34.9	39.2	16.1	16.2	20.5	26.5	19.8
D3	29.0	30.0	32.6	31.8	30.9	8.3	16.9	28.2	26.1	19.8
Mean	37.9	39.8	40.7	39.2		14.5	22.3	30.0	33.6	
CD (P=0.05)										
Density (D)			6.3					6.3		
Nitrogen (N)			NS					7.3		
D × N			NS					NS		

further increase in plant density (Table 2). Increasing the dose of nitrogen from 80 kg (N1) to 120 kg (N2) resulted in a significant increase in the weight of haulms, however, further increases to 160 kg/ha and 200 kg/ha, though resulted in an improvement in weight of haulms but the differences were statistically at par between N2 (120 kg/ha) and N3 (160 kg/ha) as well as between N3 (160 kg/ha) and N4 (200 kg/ha). Significant reduction in weight of haulms with increase in plant population has also been reported earlier (Zamil *et al.* 2010) and can be attributed to the increasing competition between plants, whereas, increasing haulms weight with increasing doses of nitrogen in spite of non-significant increases in number of stems and leaves per plant further supports the fact that space is the major limitation in the development of plant under high plant densities even at high doses of nitrogen.

Per cent ground cover after 40 and 100 days of planting was affected significantly by the plant density as well as nitrogen. Increasing plant density resulted in a gradual increase in the ground cover though the differences were statistically at par between D1 (83 333 plants/ha) and D2 (111 111 plants/ha). At 40 days after planting, ground cover was maximum with 120 kg N/ha (N2) only. At 100 days crop age, per cent ground cover showed an increasing trend with the increasing levels of nitrogen as well as plant densities and was maximum with 160 kg N/ha (N3) at the maximum plant density (Fig 1).

Increase in ground cover with increasing plant

population may be due to more number of plants per unit area as already reported by Midmore (1988), Singh *et al.* (1997) and Zamil *et al.* (2010), whereas, increasing ground cover with increasing doses of nitrogen can be attributed to the well known effects of nitrogen fertilizer in cell division and cell expansion which ultimately results in the better plant development with long life.

Doubling the plant density from 83 333 plants/ha to 166 666 plants/ha resulted in a significant increase in the number of total and seed size tubers (Table 3). Increasing dose of nitrogen up to 120 kg/ha resulted in a significant increase in the number of tubers. With further increase in dose of nitrogen, number of total and seed size tubers was not affected significantly. Among the various treatment combinations, the number of total and seed size tubers was found to be maximum (579 000 and 364 000 tubers/ha, respectively) at maximum plant density (166 666 plants/ha, D3) with 160 kg nitrogen/ha (N3). The non-responsiveness of further higher doses of nitrogen (200 kg/ha, N4) with respect to the number of tubers may be due to limited capacity of the genotype to utilize the greater amounts of nitrogen beyond a certain optimum (Malik *et al.* 1999).

Increase in number of tubers per unit area with increasing plant population may be due to more number of plants or stems per unit area as tuber number is known to be directly related to stem number (Lal *et al.* 1981, Khurana and Pandita 1982, Kushwah and Singh 2008, Malik *et al.* 1999 and Zamil *et al.* 2010). Getting the maximum number

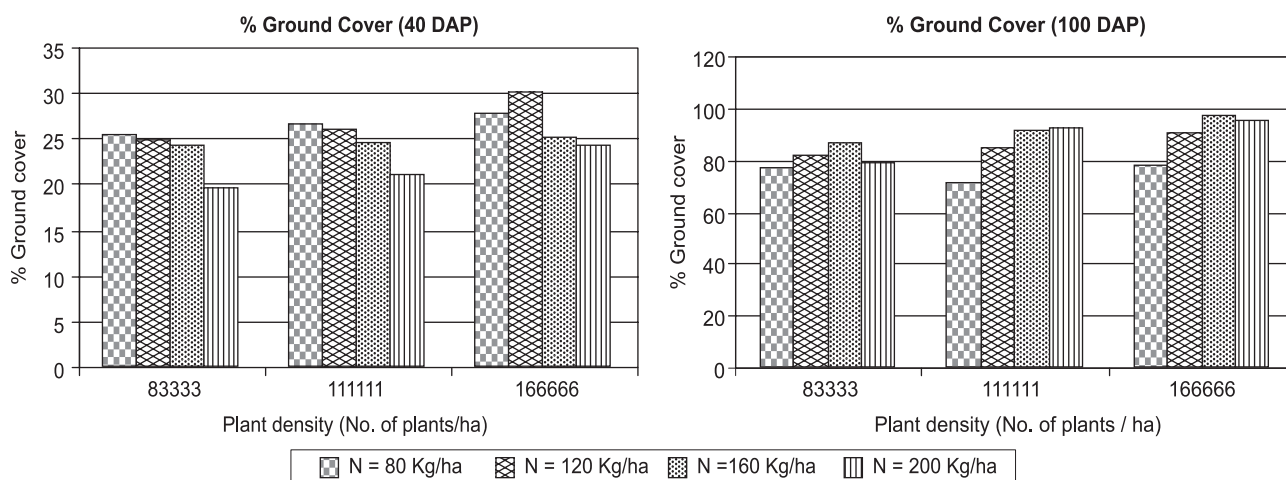


Fig 1 Per cent ground cover at varying plant densities and nitrogen doses in potato cv. Kufri Giriraj

Table 3 Production behaviour of potato cv Kufri Giriraj at varying plant densities and nitrogen doses in relation to number of total and seed size (20-80g) tubers

Plant density	Number of total tubers ('000/ha)					Number of 20-80g tubers ('000/ha)				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
D1	314	378	363	333	347	158	206	182	157	176
D2	410	450	426	436	431	249	281	247	236	253
D3	477	566	579	537	540	288	342	364	336	333
Mean	400	465	456	435		232	276	265	243	
CD (P=0.05)										
Density (D)				26				23		
Nitrogen (N)				30				27		
D × N				NS				NS		

of total and seed size tubers at a plant density of 166 666 plants/ha (D3) with 160 kg nitrogen /ha can also be related to the higher plant height as well as ground cover at 100 days after planting. Kumar *et al.* (2004) and Zamil *et al.* (2010) have also reported that potato yields are related to growth vigour of plants in response to varying fertility levels.

Like number, total and seed size tuber yields were also significantly affected with the varying plant density and nitrogen doses (Table 4). Increasing plant density, in general, resulted in a significant increase in the yields of seed size

tubers, whereas, total yields were higher only with doubling of plant density (Table 4). Higher tuber yield of potato at high plant density can be attributed to more number of stems per unit area (Singh and Chhabria 1980, Kushwah 1989, Malik *et al.* 1999 and Kushwah and Singh 2008).

Almost similar total tuber yields at two plant densities (D1 and D2) in spite of significant differences in number of tubers may be due to small size of the tubers obtained with D2 over D1. A reduction in oversize tubers and an increase in the number of undersize tubers with increase in plant density was also reported by Guarda and Giulliarri (1983),

Table 4 Effect of varying plant density and nitrogen doses on total and seed size (20-80g) tuber yields in potato cv Kufri Giriraj

Plant density	Total yield (q/ha)					Seed size tuber yield (q/ha)				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
D1	239.7	305.4	311.4	292.5	287.3	81.6	96.3	93.4	74.8	86.5
D2	275.8	274.7	301.8	294.7	286.8	125.9	138.3	120.6	113.8	124.6
D3	237.1	304.7	354.1	326.7	305.7	128.3	161.9	174.9	160.5	156.4
Mean	250.9	294.9	322.4	304.7		112.0	132.2	129.6	116.4	
CD (P=0.05)										
Density (D)				16.6				9.2		
Nitrogen (N)				19.2				10.6		
D × N				33.3				18.4		

Kumar *et al.* (2001) and Kushwah and Singh (2008) and the possible reason for the same was ascribed to be the reduced availability of assimilates for individual tubers to grow on account of reduced per plant number of stems and leaves at higher plant density by Wurr *et al.* (1992).

Irrespective of plant density, increasing doses of nitrogen (up to 160 kg/ha) also resulted in a significant increase in the total yields, whereas, the seed size tuber yields were maximum with 120 kg N/ha (N2). Poor response of further higher doses of nitrogen may be due to the limited capacity of this cultivar to utilize it beyond a certain level. The significant interaction effects between the plant density and nitrogen doses indicate that the every combination of nitrogen dose and plant density influenced the total and seed size tuber yields significantly. The maximum plant density (166 666 plants/ha, D3) with 160 kg nitrogen (N3) resulted in maximum total (354.1 q/ha) and seed size tuber yields (174.9 q/ha).

SUMMARY

Production potentiality of undersize (15g) seed tubers of potato (*Solanum tuberosum* L.) variety Kufri Giriraj was evaluated at three plant densities, viz. 83 333; 111 111 and 166 666 plants /ha and four doses of nitrogen in high hills of north –western India. Both, plant density as well as nitrogen doses had a significant effect on the number as well as yields of total and seed size tubers. A plant density of 166 666 plants/ha with 160 kg nitrogen/ha resulted in maximum number of total and seed size tubers as well as yields. Thus, in the hills, under size (15 g) seed tubers of potato should be planted at a plant density of 166 666 plants/ha by following 60 cm × 10 cm spacing along with a nitrogen dose of 160 kg/ha for getting the maximum number as well as yields of total and seed size (20-80g) tubers.

REFERENCES

- Arsenault W J, LeBlanc D A, Tai George C C and Boswall P. 2001. Effects of nitrogen application and seed-piece spacing on yield and tuber-size distribution in eight potato cultivars. *American Journal of Potato Research* **78**: 301–9.
- Burstall L and Harris P M. 1983. The estimation of percentage light interception from leaf area index and percentage ground cover in potatoes. *Journal of Agricultural Science*. Cambridge **100**: 241–4.
- Gomez K A. and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley & Sons, New York.
- Guarda and Giulliarri S. 1983. Effect of plant density on seed tuber yield of potato varieties. *Sementi-Ellette* **29**: 23–8.
- Horton D. 1987. *Potatoes: Production, Marketing and Programs for Developing Countries*. Westview press, Colarado, USA.
- Khurana S C and Pandita M L. 1982. Effect of spacing and seed size on growth and yield of total and seed size tubers in potato. *Journal of Indian Potato Association* **9**: 74–84.
- Kumar P, Pandey S K, Singh B P, Rawal S, Singh S V and Kumar D. 2004. Fertilizer requirements of chipping potato (*Solanum tuberosum* L.) cultivars in west-central plains. *Potato Journal* **31** (3-4): 177–81.
- Kumar P, Sharma R C, Upadhyay N C and Rawal S. 2001. Effect of spacing, farmyard manure and dehauling on production of seed sized tubers of potato (*Solanum tuberosum*). *Indian Journal of Agricultural Sciences* **71**(10): 658–60.
- Kushwah V S. 1989. Effect of different levels of nitrogen and planting density on production of seed potato (*Solanum tuberosum*). *Indian Journal of Agricultural Sciences* **59**(9): 561–5.
- Kushwah V S and Singh S P. 2008. Effect of intra-row spacing and date of haulm cutting on production of small size tubers. *Potato Journal* **35**(1-2): 88–90.
- Lal S S, Sahota T S and Grewal J S. 1981. Studies on seed size and spacing in potato for optimum tuber yield. *Journal of Indian Potato Association* **8**: 74–80.
- Malik Y S, Bhatia A K, Singh N, Nehra B K and Khurana S C. 1999. Effect of nitrogen, seed size and spacing on seed potato production in cv. Kufri Sutlej. (In) *Potato, Global Research and Development*, Vol II, pp 861–65. Paul Khurana S M, Shekhawat G S, Pandey S K, and Singh B P. Indian Potato Association, Shimla.
- Midmore D J. 1988. Potato in hot tropics. VI Plant population effects on soil moisture, plant development and tuber yield. *Field Crop Research* **19**: 183–200.
- Raj D, Garg V K and Singh S. 1997. Effect of date of planting and haulms killing on total and seed-size tubers in potato cv. Kufri Jyoti. *Journal of Indian Potato Association* **24** (1-2): 71–3.
- Sharma, A K and Singh S. 2010. Production behaviour of undersize seed tubers of potato under varying plant densities in north-western hills of India. *Potato Journal* **37**(3-4): 131–7.
- Singh A, Nehra B K, Khurana S C and Singh N. 1997. Influence of plant density and geometry on growth and yield in seed crop of potato. *Journal of Indian Potato Association* **24** (1-2): 24–30.
- Singh B N and Chhabria G T. 1980. Yield dynamics of seed potato in relation to seed size and spacing. *Journal of Indian Potato Association* **7**: 27–31.
- Singh J, Singh M, Saimbhi M S and Kooner K S. 1993. Growth and yield of potato cultivars as affected by plant density and potassium levels. *Journal of Indian Potato Association* **20**: 279–82.
- Singh Sarjeet. 2003. Potato Propagation: Nucleus and Breeder Seed. (In) *The Potato—Production and Utilization in Sub-tropics*, pp 347–55. Paul Khurana S M, Minhas J S and Pandey S K (Eds). Mehta Publishers, New Delhi, India.
- Wurr D C E, Fellow S J R and Allen E J. 1992. Determination of optimum tuber planting density in potato varieties Pentland Squira, Cara, Estima, Maris Piper and King Edward. *Journal of Agricultural Science* **119**: 35–44.
- Zamil M F, Rahman M M, Rabbani M G and Khatun T. 2010. Combined effect of nitrogen and plant spacing on the growth and yield of potato with economic performance. *Bangladesh Research Publication Journal* **3**(3): 1 062–70.