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Efficient Use of Water and Fertilizer Through Drip Fertigation in Potato (*Solanum tuberosum* L.) Cv. KufriBahar in Haryana

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The present investigation was carried out at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter season of 2014-15.The experiment comprising of three fertigation frequency (Fertigaton at every 3rd (F_1), 6th (F_2) and 9th (F_3) day) and four nitrogen levels (Nitrogen @ 90 (N_1), 120 (N_2), 150 (N_3) and 180 (N_4) kg/ha) was laid out in a Randomized Block Design with three replication. The removal of nitrogen, phosphorus and potassium, nitrogen use efficiency and water use efficiency were significantly higher when fertigation applied at every 3rd day (F_1). However, black scurf incidence was maximum with F_3. Nitrogen levels exhibited significant difference for growth and yield. The maximum value for removal of nitrogen, phosphorus and potassium, nitrogen use efficiency and water use efficiency were maximum with the application of nitrogen @120 kg/ha (N_2). However, black scurf incidences were maximum with N_4. Interaction effect of fertigation frequency and nitrogen levels showed remarkable variation. The maximum nutrient use efficiency and water use efficiency with F_1N_2. When fertigation applied at every 3rd day with the application of nitrogen @120 kg/ha was found significantly superior to all other treatments combination.

Key words: Drip irrigation, Fertigation frequency, Nitrogen, NUE, WUE

Potato is the third most important food crop after rice and wheat is being grown and consumed in all over the world[4,8] . Its production in many part of the world is highly dependent on inputs of irrigation water and N fertilizer to achieve optimum yield and quality. These inputs must be carefully managed to ensure optimum profits and minimal environmental impacts. Escalating fertilizer costs and declining water availability are causing growers to adopt production practices which allow them to significantly improve water and N use efficiency and decrease labor costs. Frequent application of water and nutrients ensure that the root systems well supplied with nutrient solution and prevents the formation of depletion zone resulted from uptake of nutrient between successive fertigation. N rate and fertigation frequency resulted in significant differences in total N uptake, N recovery and apparent N use efficiency. Total N uptake was appreciable higher with increasing N rate and with more frequent than with less frequent fertigation[2]. As critical as irrigation management, both the timing and amount of N applied to the crop must be managed in a way that supplies sufficient N for crop yield without leaching N of the groundwater. This greatly improves the potential for excellent N use efficiency due to decreased amount of applied N and leaching losses. Drip irrigation also provides application of soluble fertilizers and other chemicals along with irrigation water. Among modern irrigation techniques, drip irrigation has been shown to be a more water efficient alternative than furrow irrigation for potato[13]. In fertigation Nutrient use efficiency could be as high as 90% compared to 40 - 60% in conventional methods. The amount of fertilizer lost

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through leaching can be as low as 10% in fertigation where as it is 50% in the traditional system. Adoption of micro-irrigation systems may help to increase the irrigated area, productivity of crops and water use efficiency. Inadequate N fertilization leads to poorer potato growth and yield, while excessive N application leads to delayed maturity, poor tuber quality, and occasionally a reduction in tuber yield[3].With rising environmental concerns for N fertilizer management practices, efficient Nuse is important for the economic sustainability of cropping systems[7]. The balanced use of nutrients could be the most accepted treatment to obtain maximum benefit from the potato[9]. Irrigation through T_1 (Drip each row) (146.25 kg/ha-mm) and T_2 (Drip each pair) (140.26 kg/ha-mm) achieved the highest water use efficiency compare to other irrigation treatment in this zone[5].

MATERIAL AND METHODS

The field experiment was carried out at Vegetable Research Farm CCSHAU, Hisar during Rabi-season 2014-15. Hisar is situated at latitude of 29º10' N, longitude of 75º 46' E and height of 215.2 metres above mean sea level and falls in semi-arid and sub-tropical region with hot and dry summer and sever cold in winter. The soil was sandy loam in available organic carbon (0.66%), available nitrogen (105 kg/ha), available phosphorus (8.0 kg/ha) and available potash (225 kg/ha) with pH of 8.3. The air temperature (ºC), relative humidity (%) and sum of precipitation (mm) during the potato vegetation period at the experimental field are summarized in Figure 1. The experiment was laid out in randomized block design. The net plot size was two rows of eight-meter length each (8.0 x 1.2 m). Farm yard manure (FYM) @ 50 t/ha was applied prior to field preparation and full dose of phosphorus and potash were applied as basal dose. Potato tubers of *cv*. Kufri Bahar were planted at 60×20 cm spacing in the last week of October. Immediately after planting a common irrigation was applied in all the treatments through conventional furrow method for uniform and rapid germination. The differential drip fertigation treatments were started two week of planting.

The crop was subjected to four levels of nitrogen i.e. N_1: 90 kg/ha, N_2: 120 kg/ha, N_3: 150 kg/ha and N_4: 180 kg/ha. Each nitrogen level was coupled with three fertigation frequencies *viz* every 3rd day in 30 split doses (F_1), every 6th day in 12 split doses (F_2) and every 9th day in 8 split doses (F_3). Hence, twelve treatment combinations were used for conducting present study. The irrigation was applied at every 3rd day though drip. The NPK removal, nutrient use efficiency, water use efficiency and black scurf incidence was recorded.

Nutrients uptake by potato haulam

Nutrient uptake was calculated by multiply the nutrient contents in leaf sample with dry weight of haulm and dividing by hundred and then expressed as kg per ha.

Nutrients uptake by haulm (kg/ha) = [Nutrient contents in haulm (%) ×Dry Weight of haulm (kg/ha)] / 100

Nutrients uptake by tuber

Nutrient uptake by tuber was calculated by multiply the nutrient contents in leaf sample with oven dry weight of tuber and dividing by hundred and expressed as kg per ha. Similarly, nutrient uptake by potato tuber was derived with same formula.

Nutrients uptake by tuber (kg/ha) = [Nutrient contents in tubers (%) ×Dry weight of tuber (kg/ha)] / 100

Total nutrient removal

Total nutrient uptake by potato crop was the sum of nutrients uptake by potato haulm and tuber.

Total nutrient uptake = Nutrients uptake by haulm + Nutrients uptake by tuber

Nutrient use efficiency (kg/kg)

Nutrient use efficiency was calculated with 'Partial Factor Production' method of nutrient use efficiency. NUE was calculated with dry weight of tuber dividing by the dose of nutrient applied in potato crop.

Nutrients use efficiency (kg/kg) = Dry weight of tuber (kg/ha) / Dose of nutrients (kg/ha)

Water use efficiency (q/ha/cm)

The water use efficiency was worked out with the following formula:

Wateruse efficiency (q/ha/cm) = Marketable tuber yield (q/ha)/ Water applied to each treatment (cm)

Black scurf incidence

Fifty tubers were randomly selected from each plot to determine black scurf incidence using formula.

Black scurf incidence (%) = [No. of tubers infected× 100] / Total Tubers Observed

RESULTS AND DISCUSSION

Nutrient removal (NPK) removal

The perusal of data with respect to uptake of N, P and K by potato crop indicated significant differences due to fertigation frequency and nitrogen levels, while pair-wise interaction between treatments did not show significant differences. The data obtained from present study indicated that the uptake of N, P and K by potato crop was significantly higher in F_1 (fertigation frequency at every 3rd day) and N_2 (nitrogen 120 kg/ha). Among the fertigation frequency, F_1 had significantly maximum nitrogen removal (138.02 kg/ha), which was followed by the F_2 (134.19 kg /ha), whereas, the minimum nitrogen removal was found with F_3 (127.39 kg/ha). Among the nitrogen levels, application of N_2 removed maximum nitrogen (145.39 kg/ha), which was closely followed by N_3 (140.43 kg/ha) (Table 1). The higher values of nitrogen uptake with drip irrigation methods might

Table 1. Effect of fertigation frequency and nitrogen levels on nitrogen removal by potato crop (kg/ha) *cv.* Kufri Bahar

Fertigation frequency	Nitrogen levels (kg/ha)				
	N_1 (90)	N_2 (120)	N_3 (150)	N_4 (180)	Mean
Every 3rd day(F_1)	136.68	150.71	146.63	135.24	142.32
Every 6th day(F_2)	125.29	146.06	141.33	124.06	134.19
Every 9th day(F_3)	121.48	139.40	133.34	115.35	127.39
Mean	127.82	145.39	140.43	124.88	

C.D. at5%Frequency : 3.01; Nitrogen : 3.47; Frequency × Nitrogen : NS
*NS = Non-significant, CD= Critical difference

Table 2. Effect of fertigation frequency and nitrogen levels on phosphorus removal by potato crop (kg/ha) *cv*. Kufri Bahar

Fertigation frequency	Nitrogen levels (kg/ha)				
	N_1 (90)	N_2 (120)	N_3 (150)	N_4 (180)	Mean
Every 3rd day(F_1)	37.84	41.24	40.84	35.12	38.76
Every 6th day(F_2)	35.37	39.27	37.49	33.39	36.38
Every 9th day(F_3)	33.90	36.44	33.90	32.52	34.19
Mean	35.70	38.99	37.41	33.67	

C.D. at5%Frequency : 1.46; Nitrogen : 1.69; Frequency × Nitrogen : NS
*NS = Non-significant, CD= Critical difference

Table 3. Effect of fertigation frequency and nitrogen levels on potassium removal by potato crop (kg/ha) *cv.* Kufri Bahar

Fertigation frequency	Nitrogen levels (kg/ha)				
	N_1 (90)	N_2 (120)	N_3 (150)	N_4 (180)	Mean
Every 3rd day(F_1)	242.31	254.16	245.22	230.36	243.01
Every 6th day(F_2)	225.88	233.70	228.17	213.58	225.33
Every 9th day(F_3)	206.73	224.12	212.24	205.24	212.08
Mean	224.97	237.33	228.54	216.39	

C.D. at5%Frequency : 4.78; Nitrogen : 5.52; Frequency × Nitrogen : NS
*NS = Non-significant, CD= Critical difference

be due to increase in solubility of nutrients with increasing water content in soil. Similar to these findings reported that both nitrogen rate and fertigation frequency at shorter durations (daily, alternate and weekly) intended to stimulate the pattern of potato N uptake more than longest duration. The total nitrogen uptake was significantly higher with daily fertigation (180 kg N/ha) than with weekly (165 kg N/ha) and biweekly fertigation (139 kg N/ha)[2]. The lowest N uptake in the longest duration was mostly likely due to a lack of NO_3-N in the root zone when plant demand was high. This may be because of a better synchrony between N supply and demand. The significantly maximum phosphorus removal (38.76 kg/ha) was observed by F_1 followed by F_2 (36.38 kg/ha) and minimum phosphorus removal was recorded with F_3 (34.19 kg/ha). Among the various nitrogen levels, N_2 was maximum phosphorus removed (38.99 kg/ha), which was statistically at par with N_3 (37.41 kg/ha). However, the minimum phosphorus removal (33.67 kg/ha) was observed with N_4 (Table 2). The higher uptake of phosphorus under drip irrigation might be due to sound root-soil relation, which provides rapid diffusion of ions by reducing the path length of ion movement on

Table 4. Effect of fertigation frequency and nitrogen levels on black scurf incidence (%) in Potato *cv*. Kufri Bahar

Fertigation frequency	Nitrogen levels (kg/ha)				
	N_1 (90)	N_2 (120)	N_3 (150)	N_4 (180)	Mean
Every 3rd day(F_1)	30.67	27.33	32.33	31.33	30.42
Every 6th day(F_2)	31.33	30.00	30.67	32.67	31.17
Every 9th day(F_3)	36.00	34.00	34.67	36.67	35.33
Mean	32.67	30.44	32.56	33.56	

C.D. at5%Frequency : 1.41; Nitrogen : 1.63; Frequency × Nitrogen : NS
*NS = Non-significant, CD= Critical difference

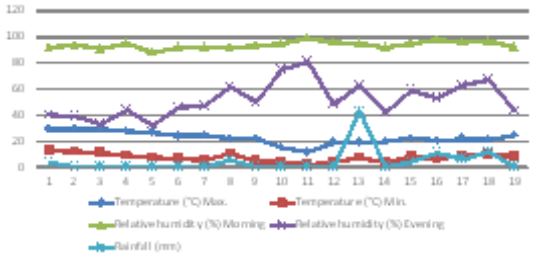

Fig. 1. The air temperature (°C), relative humidity (%) and sum of precipitation (mm) during the potato vegetation period at the experimental field

one hand and other hand increase in elongation, turgidity and number of root hairs, which ultimately boost the uptake. Among the fertigation frequency, F_1 removed maximum potassium removal (243.01 kg/ha) which was followed by F_2 (225.33 kg /ha), whereas, the minimum potassium removal was found with F_3 (212.08 kg/ha). Similarly, nitrogen levels also differed significantly with respect to potassium removal by potato crop. Nitrogen 120

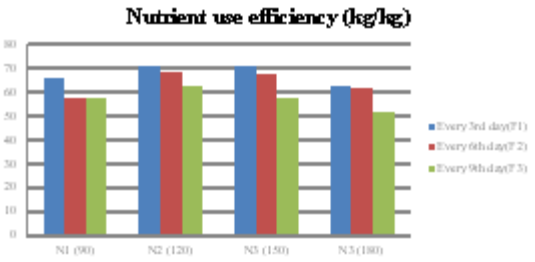

Fig. 2. Effect of fertigation frequency and nitrogen levels on nutrient use efficiency (kg/kg) in Potato *cv*. Kufri Bahar

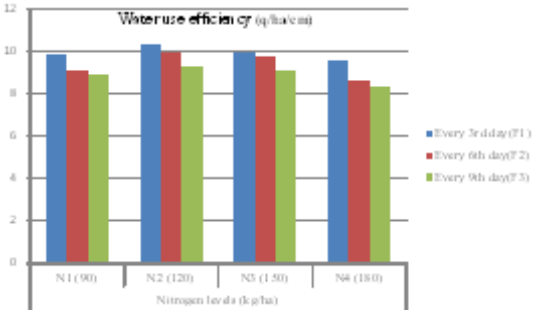

Fig. 3. Effect of fertigation frequency and nitrogen levels on water use efficiency (q/ha/cm) in Potato cv. Kufri Bahar

kg/ha (N_2) was found maximum potassium removal (237.33 kg/ha), which was closely followed by N_3 (228.54 kg/ha) and minimum potassium removal (216.39 kg/ha) was observed with N_4 (Table 3).

Nutrient use efficiency

There were significant differences among the fertigation frequency, nitrogen levels and interaction between the treatments with respect to nutrient use efficiency. The maximum nutrient use efficiency (70.70 kg/kg) was recorded with F_1N_2, which was statistically at par with F_1N_3 (70.67 kg/kg) and minimum nutrient use efficiency (51.48 kg/kg) was recorded with F_3N_4 (Figure 2). According to the method of fertilizer application was very important in obtaining optimal use of fertilizers[12]. They recommended that the fertilizer should be applied regularly and timely in small amounts. This will increase the amount of fertilizer use by the plant and reduce the amount lost by leaching. The N rate and fertigation frequency caused significant differences in nitrogen use efficiency. It was significantly higher at low nitrogen rate as compared with the high N rate. The NUE was 151 and 142 kg yield/kg/N with applied 200 and 300 kg/ha, respectively[2]. Nitrogen use efficiency as high as 90% compared to 40-60% in conventional method and the amount of fertilizer lost through leaching was as low as 10% in fertigation whereas, it was 50% in the traditional system[10]. Similarly the nutrient use efficiency was higher with lower rate of nutrient application fertigation level F_3 (N 93: P_2O_5 32: K_2O 63 kg/ha) recorded higher nutrient use efficiency followed by F_2 (141:47:93 kg/ha) and F_1 (fertigation levels N 187: P_2O_5 63:K_2O 125 kg/ha)[6].

Water use efficiency

In the present investigation, significant differences for water use efficiency among fertigation frequency, nitrogen levels and interaction between treatments were observed. F_1N_2 showed significantly highest water use efficiency (10.33 q/ha/cm) followed by F_1N_3 (9.98 q/ha/cm). However, least water use efficiency (8.35 q/ha/cm) was recorded with F_3N_4 (Figure 3). Also, reported that the use of drip irrigation was the best system for increasing yield, maximizing water and nitrogen use efficiency and thereby minimizing nitrate leaching[1]. These also results are in conformity with those reported that under drip irrigation water use efficiency increased compared with conventional irrigation method[11].

Black scurf incidence (%)

The results for black scurf incidence showed significant variation at different fertigation frequency and nitrogen levels. The maximum black scurf incidence was noticed with fertigation at every 9th day (F_3), while lowest black scurf incidence (30.42%) was recorded with fertigation on every 3rd day. Among various nitrogen levels, N_4 (nitrogen 180 kg/ha) resulted maximum black scurf incidence (33.56%), while the minimum black scurf incidence (30.44%) was observed with N_2 (Table 4).

CONCLUSION

Based on the findings of one season study it may be concluded that when nitrogen @ 120 kg/ha was applied through drip irrigation every 3rd day gave highest nutrient and water use efficiency and lowest value was recorded with F_3N_4. In case of fertigation frequency and nitrogen levels, fertigation at every 3rd day and nitrogen 120 kg/ha showed significant effect on nutrients removal, nutrient use efficiency, water use efficiency and black scurf incidence.

REFERENCES

1. Al-Omran, A.M., Sheta, A.S., Falatah, A.M. and Al-Harbi, A.R. Effect of drip irrigation on squash (*Cucurbita pepo*) yield and water-use efficiency in sandy calcareous soils amended with clay deposits. *Agricultural Water Management*, 2005; **73**: 43-55
2. Badr, M.A., Taalab, A.S. and El-Tohamy, W.A. Nitrogen application rate and fertigation frequency for drip-irrigated potato (*Solanum tuberosum*).*Australian Journnal of Basic and Applied Sciences*, 2011; **5**(7): 817-825.
3. Cerny J, Balk J, Kulhnek Kulhanek M, Casova K, Nedved V Mineral and organic fertilization efficiency in long-term stationary experiments. *Plant Soil Env*. 2010; **56**:28–36.
4. FAO statistical databases FAOSTAT. http://faostat3.fao.org/ Accessed (8 Jun 2014) Gildemacher P, Schulte-Geldermann E, Borus D, Demo P, Kinyae P, Mundia P, Struik PC (2011) Seed potato quality improvement through positive selection by smallholder farmers in Kenya. Potato Res. 2014; **54**: 253–266.
5. Kapadiya H.N, K. B. Gohil, S. A. Trivedi Potato Crop Performance and Economics Under Various

Irrigation Systems. *Indian Journal of Research*. 2013; **3:** 103-104.

6. Kumar, S., Mandal, G., Asrey, R. and Singh, R. Influence of irrigation and fertigation on yield, production efficiency and economic returns of drip irrigated potato under semi-arid environment. *Potato Journal*, 2006; **33**(3-4): 126-130.
7. Shrestha RK, Cooperb LR, MacGuidwin AE Strategies to reduce nitrate leaching into groundwater in potato grown in sandy soils: case study from North Central USA. *Am J Pot Res*.2010; **87**:229–244.
8. Singh, H.P. Policies and strategies conducive to Potato development in Asia and the Pacific region. In: *Proceedings of the Workshop to Commemorate the International Year of Potato*-2008 held on 6 May 2008 at Bangkok, Thailand, 2008; 18-29.
9. Singh, V., Singh, S. and Singh, H. Effect of balanced fertilization on nutrient uptake, yield and profits with potato in partially reclaimed sodic soil. *Annals of Plant and Soil Researc*. 2010; **12(2)**: 83–85.
10. Sivanappan, R.K. and Padmakumari, O. Susutainable micro-irrigation management for trees and vines.*Research advances in sustainable micro-irrigation,* Tamil Nadu Agricultural University, Coimbatore, 1980; **3**: 79-94.
11. Sood, M.C. and Singh, N. Effect of N fertigation and planting methods on potato growth and yield in Shimla hills.*Journal of Indian Potato Association*, 2003; **30**: 65-66.
12. Thompson, T.L., White, S.A., Walworth, J. and Sower, G.J. (2003). Fertigation frequency for subsurface drip irrigated broccoli. *Soil Science Society American Journal*, **67**: 910-918.
13. Wang FX, WU XX, Shock CC, Chu LY, GU XX, Xue, X. Eûects of drip irrigation regimes on potato tuber yield and quality under plastic mulch in arid northwestern China. Field Crops Research. 2011; **122**:78–84.