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Effect of drip irrigation and fertigation levels on soil moisture content, relative leaf water content and water use efficiency of potato

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Abstract

Drip irrigation and fertigation offers a vast potential for efficient use of water and nutrients in sustainable agricultural management. The study was conducted at experimental farm of CSK HPKV, Palampur. Ten treatments comprised three drip irrigation levels viz., 0.4 PE, 0.6 PE and 0.8 PE corresponding to 40, 60 and 80 per cent of cumulative pan evaporation, respectively, three fertigation levels viz., 50 % RDF, 75 % RDF and 100% RDF equivalent to 50, 75 and 100 per cent of recommended dose of NPK, respectively and RP i.e. recommended practice (recommended dose of fertilizers was applied through conventional methods and 6 flood irrigations of 50 mm each). The results revealed that soil moisture and relative leaf water contents (RLWC) were higher at 0.8 PE in comparison to 0.4 PE whereas water use efficiency (WUE) was highest at irrigation level of 0.4 PE followed by 0.6 PE and minimum at irrigation level of 0.8 PE. Irrigation water use efficiency (IWUE) decreased with increase in irrigation levels whereas fertigation levels increased it. The IWUE was significantly lower under the recommended practice (about 82 per cent lower in comparison to overall mean of the other treatments).

Keywords: Potato, drip irrigation and fertigation, RLWC, WUE, soil moisture content

Introduction

Potato popularly known as 'the King of Vegetables', has emerged as fourth most important crop in India after rice, wheat and maize. Potato also plays a vital role in the economy of Himachal Pradesh. However, the productivity of potato in Himachal Pradesh is low in comparison to the national average. It is an herbaceous plant with sparse and shallow rooting system and requires light and frequent irrigations throughout period of crop growth. The water requirement of potato is quite high and depends upon soil type/texture, atmospheric conditions, duration of variety, length of growing period, cropping pattern and management practices. Drought at any stage can prove detrimental, however, the excess water is also equally harmful as it creates aeration problem and favours certain diseases and pests. The crop productivity and quality of the produce largely depend upon proper balance between soil air and soil water in the plant root zone.

In the present day context, due to increasing water scarcity and recurring drought in many parts of the country, the use of drip and sprinkler irrigation methods have become extremely important. These methods not only improve efficiency of irrigation water and fertilizer nutrients, but also the hydro-thermal regimes and physical conditions of the soil by maintaining proper balance between soil air and soil water in the plant's root zone for better root growth and tuber development. The use of drip irrigation considerably decreases the amount of water used and maintains adequate moisture content in soil. In Himachal Pradesh, potato is mostly grown by applying flood irrigation at critical stages, leading to significant water as well as nutrient losses. Moreover, 80 per cent of the cultivated area in this state is rainfed where drip irrigation system may be used by making use of the harvested rain water. Recent emphasis on efficient utilization of water (per drop more crop) necessitates systematic studies for standardizing the frequency and amount of water to be used for growing potato through drip irrigation system.

The other most important aspect is proper nutrient management. Application of right amount of nutrients at right time and right place is the key for sustainable cultivation of any crop. For this we can make use of already installed drip irrigation system to deliver nutrients in timely and efficient manner in the root zone (fertigation). Fertigation is an attractive technology in modern agriculture where we can maintain optimal nutrient and moisture levels according to the specific needs of the crop in a particular soil type for enhancing nutrient use efficiency and productivity of the crops. However, this requires standardization of nutrient doses and fertigation schedule.

Material and Methods

A field experiment was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental farm is situated at 32º 6' N latitude and 76º 3' E longitude at an altitude of about 1290 m above mean sea level. The site lies in the Palam valley of Kangra district representing mid hill wet temperate zone (Zone 2.2) of Himachal Pradesh. Taxonomically, the soils of study area fall under order Alfisol and sub-group Typic Hapludalf. These soils have originated from rocks like slates, phyllites, quartzites, schists and gneisses.

The field experiment on potato (cv. Kufri Jyoti) was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The field experiment on potato was laid out in randomized block design (RBD) with ten treatments, each replicated three times. Ten treatments comprised three drip irrigation levels viz., 0.4 PE, 0.6 PE and 0.8 PE corresponding to 40, 60 and 80 per cent of cumulative pan evaporation, respectively, three fertigation levels viz., 50 % RDF, 75 % RDF and 100% RDF equivalent to 50, 75 and 100 per cent of recommended dose of NPK, respectively and RP i.e. recommended practice (recommended dose of fertilizers was applied through conventional methods and 6 flood irrigations of 50 mm each). The recommended dose of fertilizers (RDF) for potato was N, P_2O_5 and K_2O were 120, 80 and 60 kg ha^{-1}, respectively. The irrigations were applied through online drip system on alternate days for each treatment. Fertigation was done as per treatments using urea and water soluble fertilizers 17:44:00 and 00:00:50 in calculated proportions. Fertigation was started after complete emergence of the crop. Fertigation with 17:44:00 and 00:00:50 was completed in 5 splits whereas, urea was applied in 10 splits. In the last treatment i.e. RP, recommended dose of fertilizers was applied through urea, single super phosphate and muriate of potash. Half of the nitrogen dose (60 kg N ha^{-1}) and full dose of phosphorus and potassium was applied in the RP treatment at the time of sowing. The remaining dose of nitrogen in this treatment was applied at the time of earthing up. Six irrigations @ 50 mm water per irrigation were applied during the crop period. Soil samples were collected periodically at an interval of 15 days after the start of drip irrigation from each plot from a depth of 0-0.15 m and 0.15-0.30 m for determination of moisture content in soil.

Relative leaf water content

The relative leaf water content (RLWC) was determined at tuber initiation and bulking stages at 7:00 am and 12:00 noon. It was computed from the fresh weight, turgid weight and oven dry weight according to the method given by Weatherly (1950) as

$$\text{RLWC} = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Fully turgid weight} - \text{Oven dry weight}} \times 100$$

Water use efficiency

The tuber yield obtained for each treatment was divided by the quantity of water used (irrigation water + rainfall) for the respective treatments by this method. Water use efficiency was worked out and expressed in kg ha- mm^{-1} of water used.

$$\text{WUE} = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Total water use (ha} - \text{mm)}}$$

Likewise, irrigation water use efficiency was worked out as:

$$\text{IWUE} = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Irrigation water use (ha} - \text{mm)}}$$

Results and Discussion

Soil moisture studies during crop growth

The soil moisture contents determined at 15 days interval throughout the growth period are presented in Fig. a and b. The soil moisture contents determined on dry weight basis at first sampling after initiation of the crop on 17-2-2016 were 22.6 and 23.9 per cent in 0.4 PE, 22.7 and 23.5 per cent in 0.6 PE and 22.5 and 23.8 per cent in 0.8 PE at 0-0.15 and 0.15-0.30 m depths, respectively. The soil water contents were almost similar under all the irrigation levels. Since no irrigation was applied. The contents in the sub surface layer were found to be higher in comparison to the top layer.

The moisture contents determined after 15 days of first sampling that is on 3-3-2016 were higher in comparison to previous sampling owing to the effect of drip irrigations. The highest moisture content of 25.6 per cent was recorded with irrigation level of 0.8 PE whereas, minimum (23.8 %) was found in 0.4 PE followed by 0.6 PE (24.8 %) in 0-0.15 m depth. Like the previous sampling, the soil moisture contents in 0.15-0.30 m depth were higher in comparison to the top soil and varied between 26.3 per cent (0.4 PE) to 27.2 per cent (0.8 PE).

The moisture content recorded on 19-3-2016 did not show much difference among various levels as it varied from 28.5 per cent at 0.4 PE to 28.9 per cent at 0.8 PE. Almost similar contents were recorded in the sub surface layer of 0.15-0.30 m depth also as these varied from 28.0 per cent in 0.4 PE to 29.1 per cent in 0.8 PE. This was probably due to the significant amount of water received during the preceding week through rainfall which might have neutralized the effect of irrigation levels.

The moisture contents in samples collected on 2-4-2016 varied from 21.6 per cent at 0.4 PE to 24.6 per cent at 0.8 PE in surface soil whereas, in the 0.15-0.30 m soil depth these varied from 24.5 per cent in 0.4 PE to 25.3 per cent in 0.8 PE. The moisture content at the next sampling on 17-4-2016 varied from 22.5 per cent at 0.4 PE to 23.8 per cent at 0.8 PE. Little higher moisture contents were recorded in the sub surface layer of 0.15-0.3 m depth also as these varied from 23.5 per cent in 0.4 PE to 24.7 per cent in 0.8 PE.

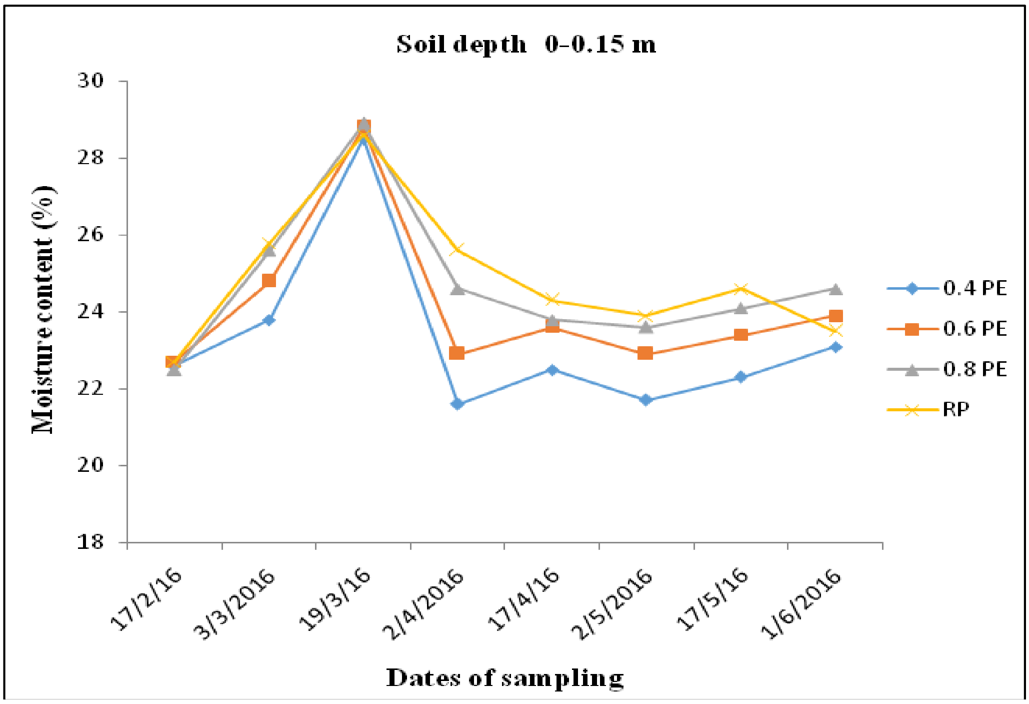

Fig a: Effect of irrigation levels on soil water content during crop growth at 15 days interval in 0-0.15 m soil depth

The moisture contents in top soil (0-0.15 m) recorded on 2-5-2016 varied from 21.7 per cent at 0.4 PE to 23.6 per cent at 0.8 PE and from 22.3 per cent at 0.4 PE to 24.1 per cent at 0.8 PE in samples collected on 17-5-2016. Likewise, the moisture contents in 0.15-0.30 m soil depth on 2-5-2016 and 17-5-2016 varied between 24.6 and 23.8 per cent, respectively at 0.4 PE to 25.4 and 24.7 per cent, respectively at 0.8 PE. The moisture contents at the last sampling on 1-6-2016 were comparatively higher in comparison to the previous sampling and similar trend was observed with respect to the drip irrigation levels.

The moisture contents in the recommended practice involving 6 flood irrigations of 50 mm water each at crucial stages were 22.7, 25.8, 28.6, 25.6, 24.3, 23.9 and 24.6 per cent in 0-0.15 m and 23.8, 27.7, 29.3, 25.7, 25.3, 26.4 and 25.3 per cent in 0.15-0.30 m depth at specified dates mentioned earlier. Here too, the moisture contents in the lower layer were higher in comparison to the surface layer.

Soil moisture contents under recommended practice were almost equal or higher than recorded under 0.8 PE at all the sampling stages except the last where these were lower in both the soil depths.

In general, higher moisture contents were observed at irrigation level of 0.8 PE in comparison to the other levels due to higher amount of water applied in this treatment. The soil water content changed more under the influence of irrigation levels in the upper soil layer than in the lower layer. Similar results have been reported by Kaseem (2008) [5], Mokh *et al*. (2014) [6] and Kapoor (2016) [4].

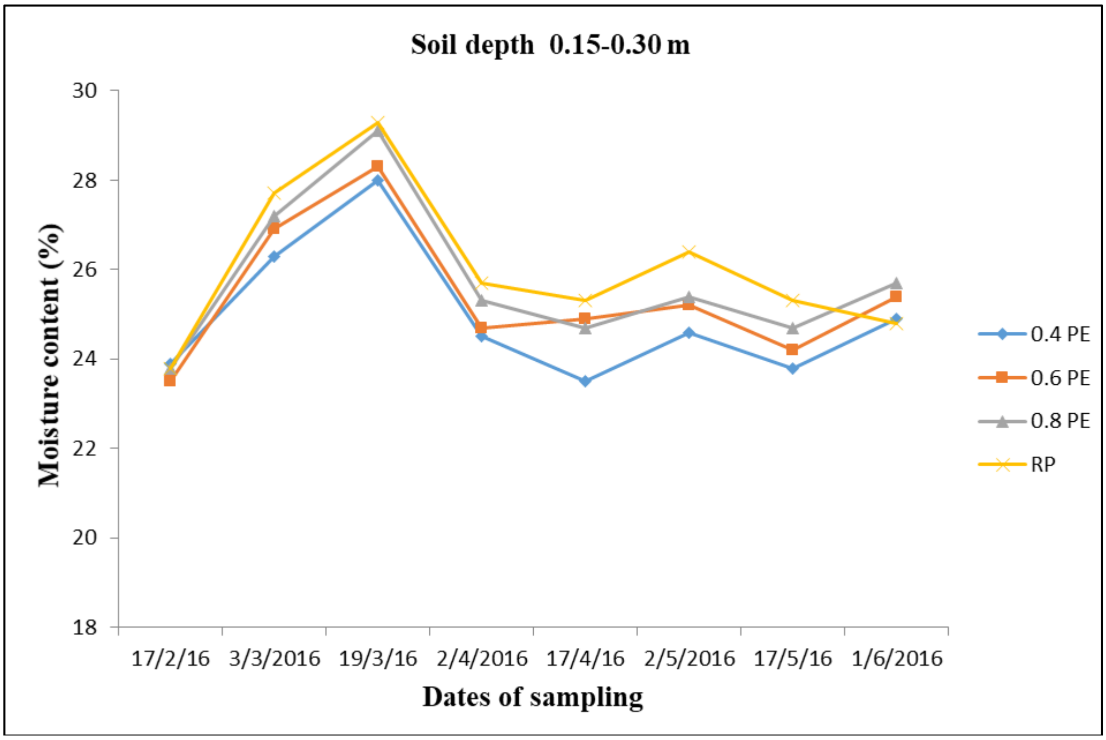

Fig b: Effect of irrigation levels on soil water content during crop growth at 15 days interval in 0.15-0.30 m soil depth

Relative leaf water content (RLWC)

Effect of drip irrigation and fertigation levels on relative leaf water content (RLWC) during crop growth

Tuber initiation stage

Data on the relative leaf water content (RLWC) determined during tuber initiation stage are given in Table 1.

Table 1: Effect of drip irrigation and fertigation levels on relative leaf water content (RLWC) at tuber initiation stage

Treatment	RLWC (%)	
	7 am	**12 pm**
Irrigation level		
0.4 PE	80.2	70.5
0.6 PE	81.2	72.4
0.8 PE	81.7	74.4
CD (P=0.05)	1.2	2.7
Fertigation level		
50 % RDF	80.8	71.8
75 % RDF	81.1	72.2
100 % RDF	81.2	73.3
CD (P=0.05)	NS	NS
Recommended practices (RP) vs others		
RP	82.6	76.1
Others	81.0	72.4
CD (P=0.05)	1.5	3.5

Application of different levels of irrigation water influenced the relative leaf water contents significantly at this stage. Application of water @ 0.8 PE recorded significantly higher RLWC at tuber initiation stage (81.7 % and 74.4 %, at 7 am and 12 pm, respectively) in comparison to 0.4 PE (80.2 % and 70.5 %, at 7 am and 12 pm, respectively). However, no significant differences were observed in RLWC between irrigation levels of 0.4 PE and 0.6 PE. Likewise, RLWC at 0.6 PE was statistically at par with that observed at 0.8 PE. The higher relative leaf water content under irrigation level of 0.8 PE in comparison to 0.4 PE might be due to considerably higher amount of water applied under this level in comparison to later. Almost similar findings in different crops have been reported by Xu and Leskover (2014) [12] and Thakur (2015) [9].
As regards the comparison of recommended practice vs others, RLWC under recommended practice was significantly higher (82.6 per cent and 76.1 per cent, at 7 am and 12 pm, respectively) in comparison to overall mean of others (81.0 per cent and 72.4 per cent, at 7 am and 12 pm, respectively) probably due to higher amount of water applied under recommended practice. Fertigation levels did not influence the relative leaf water content of potato plants significantly. Also the interaction between irrigation and fertigation was not significant.

Bulking stage

Data on the relative leaf water content (RLWC) determined during bulking stage are given in Table 2. Application of different levels of irrigation water influenced the relative leaf water contents significantly at bulking stage also. Similar trends with respect to the effect of irrigation and fertigation levels were observed in the RLWC at this stage as were observed during the tuber initiation stage. The RLWC contents of plants under drip irrigation levels of 0.4, 0.6 and 0.8 PE were 80.6, 81.5 and 82 per cent, respectively at 7.00 am and 71.5, 72.7 and 74.7 per cent, respectively at 12.00 pm. The higher RLWC values at 0.8 PE during bulking stage too might be ascribed to more availability of water to plants due to higher amount of irrigation water applied.
The RLWC under recommended practice was statistically at par with overall mean of others at 7.00 am, though at 12 PM on same day, recommended practice recorded significantly higher RLWC (76.8 %) in comparison to overall mean of others (73 %). Fertigation levels did not influence the relative leaf water content of potato plants significantly. Also the interaction between irrigation and fertigation was not significant.
Irrespective of irrigation or fertigation levels, during both the growth stages, RLWC contents recorded at 7.00 am were higher than recorded at 12.00 pm. However, no water stress was observed at any level of irrigation even at 12.00 pm as RLWC was more than 70 percent even at lower level of irrigation.

Table 2: Effect of drip irrigation and fertigation levels on relative leaf water content (at bulking stage)

Treatments	RLWC (%)	
	7 am	**12 pm**
Irrigation level		
0.4 PE	80.6	71.5
0.6 PE	81.5	72.7
0.8 PE	82.0	74.7
CD (P=0.05)	1.0	2.4
Fertigation level		
50 % RDF	81.2	72.5
75 % RDF	81.4	72.5
100 % RDF	81.5	73.9
CD (P=0.05)	NS	NS
Recommended practices (RP) vs others		
RP	82.5	76.8
Others	81.4	73.0
CD (P=0.05)	NS	3.1

Water use efficiency (WUE)

The data with respect to water use efficiency (WUE) based on total water applied in each plot plus the rainfall received during the crop period have been presented in Table 3. Water use efficiency at irrigation level of 0.4 PE was highest (38.4 kg ha-mm^{-1}) followed by 0.6 PE (37.2 kg ha-mm^{-1}) and minimum at irrigation level of 0.8 PE (33.5 kg ha-mm^{-1}). However, the difference in WUE was significant only between 0.4 PE and 0.8 PE.
As regards the effect of fertigation levels, data revealed that WUE was significantly higher in 75 per cent recommended dose of fertilizers (39.3 kg ha-mm^{-1}) in comparison to fertigation level of 50 per cent recommended dose of NPK (32.2 kg ha-mm^{-1}) by about 22 per cent. However, 75 per cent recommended dose of fertilizer was statistically at par with 100 per cent recommended dose of fertilizers which recorded WUE of 37.6 kg ha-mm^{-1}. Similar results reported by Onder *et al*. (2005) [8], Nagaz *et al*. (2008) [7], Bakeer *et al*. (2009) [1], Mokh *et al*. (2014) [6] and Ghiyal *et al*. (2016) [3].
In ‘Recommended practice’ vs. ‘others’, WUE under others (36.4 kg ha-mm^{-1}) was significantly higher by about 37 per cent in comparison to the recommended practice (26.5 kg ha-mm^{-1}).

Table 3: Effect of drip irrigation and fertigation levels on irrigation water use efficiency (WUE)

Treatment	WUE (kg ha-mm^{-1})
Irrigation level	
0.4 PE	38.4
0.6 PE	37.2
0.8 PE	33.5
CD (P=0.05)	4.0
Fertigation level	
50 % RDF	32.2
75 % RDF	39.3
100 % RDF	37.6
CD (P=0.05)	4.0
Recommended practice (RP) vs others	
RP	26.5
Others	36.4
CD (P=0.05)	5.2

Irrigation water use efficiency (IWUE)

The data with respect to irrigation water use efficiency (IWUE) have been presented in Table 4. An examination of the data revealed that IWUE was significantly higher in 0.4 PE (137.6 kg ha-mm^{-1}) in comparison to 0.6 PE (101.4 kg ha-mm^{-1}) and 0.8 PE (76.8 kg ha-mm^{-1}). Among different fertigation levels, the IWUE was highest in 75 per cent recommended dose of fertilizers (113.5 kg ha-mm^{-1}) which was about 21.9 per cent higher than that obtained with 50 per cent recommended dose of fertilizers (93.1 kg ha-mm^{-1}). Increase in the fertigation level to 100 per cent of recommended fertilizers recorded IWUE of 109.2 kg ha^{-}mm^{-1}, however, it was statistically at par with 75 per cent recommended dose of fertilizers. Similar results were reported by Yuan *et al*. (2003) [13], Erdem *et al*. (2006) [2], Wang *et al*. (2007) [10], and Mokh *et al*. (2014) [6].

As regards the comparison of 'Recommended practice (RP)' vs. 'others', IWUE under overall mean of others (105.2 kg ha-mm^{-1}) had significantly higher irrigation water use efficiency in comparison to recommended practice (57.9 kg ha-mm^{-1}), the magnitude of difference being 47.3 kg ha-mm^{-1} (an increase of about 81.7 % over RP). This may be due to more water applied through flood irrigation coupled with comparatively lower yield obtained in recommended practice.

Table 4: Effect of drip irrigation and fertigation levels on irrigation water use efficiency (IWUE)

Treatments	IWUE (kg ha^{-}mm^{-1})
Irrigation level	
0.4 PE	137.6
0.6 PE	101.4
0.8 PE	76.8
CD (P=0.05)	12.9
Fertigation level	
50 % RDF	93.1
75 % RDF	113.5
100 % RDF	109.3
CD (P=0.05)	12.9
Recommended practices (RP) vs others	
RP	57.9
Others	105.3
CD (P=0.05)	16.7

Summary and Conclusions

The soil water content determined at 15 days interval throughout the growth period indicated that in 0-0.15 and 0.15-0.30 m soil layers, the gravimetric moisture content varied in soil as per irrigation levels and comparatively higher moisture contents were observed in the subsurface samples. The moisture contents under all the irrigation levels were close to the field capacity during the crop season.

The relative leaf water contents at tuber initiation and bulking stages were significantly higher in 0.8 PE in comparison to 0.4 PE. However, there was no significant difference between 0.6 PE and 0.8 PE. Similarly, the relative leaf water contents under various fertigation levels were statistically at par. As regards the comparison of recommended practice vs others, RLWC under recommended practice was significantly higher in comparison to overall mean of others.

The water use efficiency (WUE) was highest at irrigation level of 0.4 PE and minimum at irrigation level of 0.8 PE. Among fertigation levels, the highest WUE was obtained with 75 per cent recommended dose of fertilizers and minimum was in case of 50 per cent recommended dose of NPK. In 'recommended practice' vs. 'others', WUE under others (36.4 kg ha-mm^{-1}) was significantly higher by about 37 per cent in comparison to the recommended practice (26.5 kg ha-mm^{-1}).

Irrigation water use efficiency (IWUE) was significantly higher in 0.4 PE in comparison to 0.6 PE and 0.8 PE. Among different fertigation levels, the IWUE was highest in 75 per cent recommended dose of fertilizers (113.5 kg ha^{-}mm^{-1}) which was about 21.9 per cent higher than that obtained with 50 per cent recommended dose of NPK (93.1 kg ha^{-}mm^{-1}). Further increase in the fertigation level to 100 per cent of recommended NPK did not increase the IWUE significantly over 75 per cent recommended dose of NPK. In 'recommended practice (RP)' vs. 'others', IWUE under overall mean of others recorded an increase of about 81.7 per cent over recommended practice. Irrigation water use efficiency (IWUE) decreased with increase in irrigation levels whereas fertigation levels increased it. However, no significant differences were observed between 75 and 100 per cent recommended dose of NPK. The IWUE was significantly lower under the recommended practice (about 82 per cent lower in comparison to overall mean of the other treatments).

References

1. Bakeer GAA, Ebabi FGE, Saidi MTE, Abdelghany ARE. Effect of pulse drip irrigation on yield and water use efficiency of potato crop under organic agriculture in sandy soils. Misr J Ag. Eng. 2009; 26(2):736- 765.
2. Erdem T, Erdem Y, Orta H, Okursoy H. Water-yield relationships of potato under different irrigation methods and regimens. Sci. Agric. 2006; 63(3):226-231.
3. Ghiyal V, Bhatia AK, Maan DS. Efficient use of water and fertilizer through drip fertigation in potato (*Solanum tuberosum* L.) in Haryana. Biosciences Biotechnology Research Asia. 2016; 13(4):2025-2030.
4. Kapoor R. Effect of drip irrigation on soil-plant water dynamics, nutrient use and productivity of capsicum and broccoli under varying NPK fertigation in an acid alfisol. Ph.D. Thesis, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, 2016, 197.
5. Kassem MA. Effect of drip irrigation frequency on soil moisture distribution and water use efficiency for spring potato planted under drip irrigation in a sandy soil. Misr Journal of Agricultural Engineering. 2008; 25(4):1256-1278.
6. Mokh FE, Nagaz K, Masmoudi MM, Mechlia NB. Effects of surface and subsurface drip irrigation regimes with saline water on yield and water use efficiency of potato in arid conditions of Tunisia. Journal of Agriculture and Environment for International Development. 2014; 108(2):227-246.

7. Nagaz K, Toumi I, Masmoudi MM, Mechlia NB. Comparative effects of drip and furrow irrigation with saline water on the yield and water use efficiency of potato in arid condition of Tunisia. Australian Journal. 2008; 3(4):272-277.
8. Onder S, Caliskan ME, Onder D, Caliskan S. Different irrigation methods and water stress effects on potato yield and yield components. Agricultural water management. 2005; 73:73-86.
9. Thakur M. Standardization of drip based irrigation and fertigation schedule in cucumber grown under protected condition. M.Sc. Thesis, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India Palampur, 2015, 82.
10. Wang FX, Kang Y, Liu SP, Hou XY. Effect of soil matric potential on potato growth under drip irrigation in the north china plain. Agricultural Water Management. 2007; 88:34-42.
11. Weatherley PE. Studies in the relations of the cotton plants. I. The field measurement of water deficits in leaves. New Phytology. 1950; 49:36-51.
12. Xu C, Leskovar DI. Growth, physiology and yield responses of cabbage to deficit irrigation. Horticulture Science. 2014; 41(3):138-146.
13. Yuan BZ, Nishiyama S, Kang Y. Effects of different irrigation regimes on the growth and yield of drip-irrigated potato. Agricultural Water Management. 2003; 63:153-167.