



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(3): 258-262

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Received: 16-03-2020

Accepted: 18-04-2020

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Effect of micro-irrigation and nutrient management on quality parameters and economics of potato

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i3d.9237>

Abstract

The present study was conducted at experimental farm of CSK HPKV, Palampur, with the objective of evaluating the effects of micro-irrigation and nutrient management on quality and economics of drip based irrigation and fertigation. 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). Fertigation level of 75% RDF was statistically at par with 100% RDF but significantly better than 50% RDF with respect to quality parameters. Drip irrigation and fertigation was better than the recommended practice as combination of irrigation level of 0.6 PE and 75% RDF recorded better quality parameters. Also, the highest gross return (Rs. 285200 ha⁻¹), net return (Rs. 153949 ha⁻¹) and B:C ratio (2.17) were obtained by applying drip irrigation @ 60 per cent of cumulative pan evaporation (0.6 PE) and 75 per cent recommended dose of NPK (75% RDF).

Keywords: Drip irrigation and fertigation, potato quality, economics

Introduction

Potato (*Solanum tuberosum* L.) originates from the Andean region where it has been grown for over 7000 years as a staple food crop. Potato produces more dry matter (47.6 kg ha⁻¹day⁻¹) and edible proteins (3 kg ha⁻¹day⁻¹) than the major cereal food crops and therefore, requires higher amount of nutrients on per day basis. Freshly harvested potato tubers contain about 80 per cent water and 20 per cent dry matter of which 70 per cent is starch. On the dry weight basis, the protein content of potato is similar to that of cereals and is very high in comparison with other root and tuber crops. In addition, the potato is low in fat (0.1 per cent) and energy (80 k cal. per 100g edible portion) and is rich in vitamins, especially vitamin C (17 mg per 100 g edible portion) and minerals (Ca, P and Fe). Dietary antioxidants and fibre in potato tubers take part in preventing diseases related to ageing and benefit health. It 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. The use of drip and sprinkler irrigation methods have become extremely important due to increasing water scarcity and recurring drought in many parts of the country. 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. 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. 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

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zone (fertigation). Fertigation is an effective 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 quality and productivity of the crops.

Material and Methods

The field experiment on potato (cv. Kufri Jyoti) was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental farm is situated at 32° 6' N latitude and 76° 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 climate of the region is characterized as wet temperate with mild summers (March to June) and cool winters. The average rainfall of the area is about 2500 mm. A major portion of the rainfall *i.e.* about 75 per cent is received during monsoon period from June to September. The relative humidity in the region varies from 46 to 84 per cent. The mean maximum weekly temperature varied from 14.39 °C in 51st standard week to 32.74°C in 20th standard week. Likewise, mean minimum weekly temperature varied from 1.79°C in 3rd standard week to 19.43°C in 20th standard week while mean weekly rainfall varied from 0 in 52nd, 1st, 3rd, 4th, 7th, 9th, 13th, 20th standard week to 83 mm in 11th standard week. The total rainfall received during the study period for 25 weeks was 353.8 mm. Mean weekly relative humidity varied from 38 per cent in 17th standard week to 85.57 per cent in 51st standard week.

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). The recommended dose of fertilizers (RDF) for potato was N, P₂O₅ and K₂O 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. Fertigation was started after complete emergence of the crop.

Quality Parameters

To assess the effect of different treatments on quality of potato tubers, fresh potato tuber samples were analysed for total soluble solids (TSS) whereas, sugar, starch and crude protein contents were determined in dried samples following standard methods as given below:

Total soluble solids (TSS)

Total soluble solids were determined by hand refractometer. Hand refractometer is based on the principle of total refraction. The refractometer was first checked for accuracy before use. This was done by placing a few drops of distilled water on the prism in the specimen chamber of the refractometer with the help of a glass rod after folding the

cover. By looking through the eye piece with the projection inlet facing towards the light, the point on the scale was noted when the boundary line of the shaded area intersected with the unshaded area. The distilled water reading was set zero with the scale correction knob. The specimen chamber was then cleaned with the muslin cloth (A.O.A.C. 1990) [1]. For determining the TSS, a drop of sample juice was placed on the prism and the percentage of dry substance in it was read directly.

Total Sugars

Total sugar was estimated by following the method of Dubois *et al.* (1956) [4] as given below

Reagents used

- 5% Phenol
- 95.5% Sulphuric acid
- 80% Ethanol
- Saturated lead acetate solution
- Sodium oxalate powder
- Standard Glucose Solution: Stock solution- 100 mg glucose was dissolved in 100 ml distilled water. Working standard- 10 ml of stock solution diluted to 100 ml with distilled water.

Extraction: 0.5 g of sample (dried) was macerated in 50 ml of ethanol (80 per cent) and transferred to a conical flask. The contents of the flask were then boiled on boiling water bath up to half of the volume (25 ml). The contents were filtered and filtrate was made up to 98 ml with distilled water. 1 ml of saturated lead acetate solution was added to it. To remove the lead ions, a pinch of sodium oxalate crystals was added and the volume was made up to 100 ml with distilled water.

Procedure: 0.2 ml aliquot was taken in the test tube and 1 ml of 5 per cent phenol (freshly prepared) and 5 ml of 95.5 per cent of concentrated sulphuric acid was added from the top, not from the side of test tube in ice cold solution. The intensity of pink colour was read at 490 nm. The amount of sugars present in the extract was then calculated using a standard curve from glucose (0.1 mg ml⁻¹).

Starch content

Extraction: 0.2 g of sugar free residue was taken for starch determination. 6.5 ml of 52 per cent per-chloric acid was added. Then the contents were stirred continuously for 5 minutes on a stirrer and then intermittently for next 15 minutes. 20 ml of distilled water was added to each centrifuge tube and the contents were centrifuged at 3000 rpm for 10 minutes. The supernatant was poured into 100 ml volumetric flask and the extraction is repeated two times in the same manner. After the final extraction volume of each flask was raised to 100 ml with distilled water, after the addition of 1 ml lead acetate, pinch of sodium oxalate and the contents were filtered through Whatman No. 1 filter paper.

Procedure: 0.2 ml aliquot was taken in the test tube and 1 ml of 5 per cent phenol (freshly prepared) and 5 ml of 95.5 per cent of concentrated sulphuric acid was added from the top, not from the side of test tube in ice cold solution. The intensity of pink colour was read at 490 nm. The amount of starch content present in the extract was then calculated using a standard curve from glucose (0.1 mg ml⁻¹).

Calculations: Starch content was calculated from the standard curve using the following equation:

$$\text{Starch content} = \frac{\text{Standard conc. (g)} \times \text{Volume made (ml)} \times \text{OD of sample}}{\text{Standard OD} \times \text{Aliquot of sample taken (ml)} \times \text{Weight of sample (g)}}$$

Finally starch percentage was obtained by multiplying with 0.9 as 0.9 g of starch yields approximately 1 g of glucose on hydrolysis.

Crude Protein content

Crude Protein content was determined by multiplying nitrogen content in tubers (dry matter) by 6.25 factor.

Results and Discussions

Total Soluble Sugars (TSS)

The data pertaining to TSS as affected by different treatments have been presented in Table 1. There was no significant effect of irrigation levels on total soluble solids. However, among different fertigation levels, the TSS content was significantly higher in 100% RDF (5.5 ° brix) in comparison to 50% RDF (5.2 ° brix). There was no significant difference between 75% RDF (5.4° brix) and 100% RDF (5.5° brix). Similar results were reported by Jeyakumar *et al.* (2010) [5]. Overall mean of fertigation and irrigation levels (others) exhibited significantly higher TSS content (5.4° brix) in comparison to that recorded under the recommended practice (5.1 ° brix).

Table 1: Effect of drip irrigation and fertigation levels on total soluble solids (TSS)

Treatments	TSS (° brix)
Irrigation level	
0.4 PE	5.3
0.6 PE	5.3
0.8 PE	5.4
CD (P=0.05)	NS
Fertigation level	
50% RDF	5.2
75% RDF	5.4
100% RDF	5.5
CD (P=0.05)	0.2
Recommended practices (RP) vs others	
RP	5.1
Others	5.4
CD (P=0.05)	0.3

Sugar and starch content

The data pertaining to sugar and starch content as affected by different treatments have been presented in Table 2. Among different irrigation levels, sugar and starch content was significantly higher in 0.8 PE (0.880 mg g⁻¹ and 63.4%, respectively) in comparison to 0.4 PE (0.811 mg g⁻¹ and 61.0%, respectively). There was no significant difference between irrigation levels 0.6 PE and 0.8 PE.

Table 2: Effect of drip irrigation and fertigation levels on sugar content and starch content

Treatments	Sugar content (mg g ⁻¹)	Starch content (%)
Irrigation level		
0.4 PE	0.811	61.0
0.6 PE	0.853	62.4
0.8 PE	0.880	63.4
CD (P=0.05)	0.031	1.8
Fertigation level		
50% RDF	0.829	60.5
75% RDF	0.846	62.4
100% RDF	0.869	63.8
CD (P=0.05)	0.031	1.8
Recommended practices (RP) vs others		
RP	0.850	62.2
Others	0.848	62.2
CD (P=0.05)	NS	NS

Among different fertigation levels, sugar and starch content was significantly higher in 100% RDF (0.869 mg g⁻¹ and 63.8%, respectively) in comparison to 50% RDF (0.829 mg g⁻¹ and 60.5%, respectively). However, 75% RDF (0.846 mg g⁻¹ and 62.4%, respectively) was significantly at par with 100% RDF (0.869 mg g⁻¹ and 63.8%, respectively). Potassium which was applied along with nitrogen played a greater role in translocation of sugars from leaves to tubers and synthesis of starch. Similar results were also reported by Sujata and Krishnappa (1995) [17]. Similar results were also reported by Chadchan *et al.* (1990) [3] and Singh and Singh (1996) [15]. The amount of starch accumulated is a function of the rate of photosynthesis, translocation of photosynthates from leaves to tubers and subsequent conversion to starch (Praveen *et al.*, 2008) [9]. There was no significant effect of overall mean of fertigation and irrigation levels (others) and recommended practices on sugar and starch content of potato.

3. Crude protein content

Table 3 contains the data with respect to the crude protein content as influenced by different treatments. There was no

significant effect of irrigation levels on crude protein content. However, among different fertigation levels, crude protein content was significantly higher under 100% RDF (10.93%) in comparison to 50% RDF (9.94%).

Table 3: Effect of drip irrigation and fertigation levels on crude protein content

Treatment	Crude protein content (%)
Irrigation level	
0.4 PE	10.38
0.6 PE	10.56
0.8 PE	10.67
CD (P=0.05)	NS
Fertigation level	
50% RDF	9.94
75% RDF	10.75
100% RDF	10.93
CD (P=0.05)	0.35
Recommended practice (RP) vs others	
RP	10.00
Others	10.54
CD (P=0.05)	0.46

There was no significant difference between 75% RDF (10.75%) and 100% RDF (10.93%). The increase in protein content due to the synergetic effect of N and K in absorption and their role in protein synthesis, translocation of amino acids and their polymerization. Similar findings have also been documented by Chadchan *et al.* (1990) [3], Sharma and Ezekiel (1993) [12], Sujatha and Krishnappa (1995) [17], Singh and Singh (1996) [15], Sharma and Dubey (1998) [11] and Kanwar and Paliyal (2005) [6]. The comparison of overall mean of fertigation and irrigation combinations (others) with recommended practice (RP) revealed that crude protein content was significantly higher in others (10.54%) in comparison to the RP (10.00%).

Effect of drip irrigation and fertigation levels on economics of potato

For assessing the effect of any intervention, economic analysis with respect to costs and the returns is must for its practical feasibility. The B:C ratio was calculated on the basis of gross returns per unit rupee invested. The data with respect to the effect of drip irrigation and fertigation levels on economics of potato have been given in Table 4.

Table 4: Effect of drip irrigation and fertigation levels on economics of potato

Treatment	Yield (q ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	B:C ratio
I ₄₀ F ₅₀	167.7	201200	75053	1.59
I ₄₀ F ₇₅	198.7	238400	107149	1.82
I ₄₀ F ₁₀₀	201.5	241800	105445	1.77
I ₆₀ F ₅₀	180.8	217000	90853	1.72
I ₆₀ F ₇₅	237.7	285200	153949	2.17
I ₆₀ F ₁₀₀	209.3	251200	114845	1.84
I ₈₀ F ₅₀	191.7	230000	103853	1.82
I ₈₀ F ₇₅	222.7	267200	135949	2.04
I ₈₀ F ₁₀₀	219.7	263600	127245	1.93
RP	173.7	208400	87235	1.72

The data revealed that highest gross return, net return and B: C ratio (285200 Rs ha⁻¹, 153949 Rs ha⁻¹ and 2.17) were obtained with irrigation depth of 0.6 PE and fertigation level of 75 per cent recommended dose of NPK whereas, lowest gross return, net return and B: C ratio (201200 Rs ha⁻¹, 75053 and 1.59) were observed under the combination of 0.4 PE and 50 percent recommended dose of NPK. Combination of 0.8 PE irrigation and fertigation levels of 75 per cent of recommended dose emerged as the second most remunerative combination giving gross return of 267200 Rs ha⁻¹, net return of 135949 Rs ha⁻¹ and benefit to cost ration of 2.04. The gross return, net return and B:C ratio under recommended practice (RP) were 208400 Rs ha⁻¹, 87235 Rs ha⁻¹ and 1.72, respectively. Similar findings were also reported by Kumar *et al.* (2006) [7], Singh *et al.* (2010) [14], Patel *et al.* (2011) [8], Bisht *et al.* (2012) [2], Sharma *et al.* (2012) [13] and Sadawarti *et al.* (2013) [10] for various irrigation and fertigation combinations.

Summary and Conclusions

There was no significant effect of irrigation levels on the total soluble solids (TSS). Among fertigation levels, TSS content was significantly higher in 100 per cent recommended dose of NPK in comparison to 50 per cent of recommended dose of NPK. However, 75 per cent recommended dose of NPK was significantly at par with 100 per cent recommended dose of

NPK. In 'recommended practice' vs. 'others', the TSS content was significantly higher in 'others'.

Sugar and starch contents were significantly higher in 0.8 PE in comparison to 0.4 PE but statistically at par with 0.6 PE. Among different fertigation levels, sugar and starch contents were significantly higher in 100 per cent recommended dose of NPK in comparison to 50 per cent recommended dose of NPK but statistically at par with 100 per cent recommended dose of NPK. In 'recommended practice' vs. 'others', no significant differences were observed in sugar and starch contents of potato.

There was no significant effect of irrigation levels on crude protein content. However, among different fertigation levels, crude protein content was significantly higher under 100% RDF (10.93%) in comparison to 50% RDF (9.94%). There was no significant difference between 75% RDF (10.75%) and 100% RDF (10.93%). The crude protein content was significantly higher under overall mean of fertigation and irrigation combinations (10.54%) in comparison to the recommended practice (10.00%).

The highest gross return, net return and B: C ratio (Rs 285200 ha⁻¹, Rs. 153949 ha⁻¹ and 2.17) were obtained with irrigation depth of 0.6 PE and fertigation level of 75 per cent recommended dose of NPK whereas, lowest gross return, net return and B: C ratio (Rs. 201200 ha⁻¹, Rs.. 75053 ha⁻¹ and 1.59) were observed under the combination of 0.4 PE and 50 percent recommended dose of NPK. The gross return, net return and B: C ratio under recommended practice (RP) were Rs. 208400 ha⁻¹, Rs. 87235 ha⁻¹ and 1.72, respectively.

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