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EFFECT OF OPERATING PRESSURE ON WATER SAVING IN DRIP IRRIGATED POTATO

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ABSTRACT

The field experiment was conducted for potato var. Kufari Ashoka during Rabi season of 2012-13 at the research farm of Rajendra Agricultural University, Pusa (Samastipur), Bihar. Irrigation was scheduled at different operating pressure viz; 0.4 kg/cm² (I_1), 0.6 kg/cm² (I_2), 0.8 kg/cm² (I_3), 1.0 kg/cm² (I_4), 1.2 kg/cm² (I_5) and control furrow irrigation (I_6) to find out the saving of water in drip irrigated potato. Results revealed that the Yield (312.22 q/ha), water use efficiency (329.12 kg/ha-mm) saving of water (47.29%), and hydraulic performance of system was maximum when drip system is operated at 1.20kg/cm². Based on the result it can be concluded that the operation of drip irrigation system at 1.2 kg/cm² pressure head, gives the maximum yield and saving of water.

KEY WORDS
Drip irrigation
Operating pressure
Water saving
Emission uniformity

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is the fourth most important food crop after wheat, rice and corn in terms of global production (Fabeiro *et al.,* 2001). Potato is conventionally grown through vegetative reproduction of its tuber (Kashyap and Panda, 2003). Previous research shows that the yield and quality of potatoes improved through drip irrigation (Yuan *et al.,* 2003; Onder *et al.*, 2005; Kaur *et al.,* 2005). The potato crop evapotranspiration vary from 30.0 to 70.0 cm, depending on the environment and crop growth stages (Shock and Feibert, 2000). Expected potato yield of 79% and relative water use efficiency of 1.06 was obtained when 25% deficit of evapotranspiration was prevailed for the whole season of potato (Kirda, 1982).

The hydraulic performance of drip irrigation system is indicated by water distribution uniformity, which is measured by uniformity coefficient (BIS, 1991; Wu and Gitlin, 1983), emission uniformity (BIS, 1991), coefficient of variation (BIS, 1991; Wu, 1997) and coefficient of manufacturing variation (Solomon, 1979; Wu and Gitlin, 1983).The uniformity coefficient and emission uniformity increased while coefficient of variation decreased as the operating pressure head increased for all emission devices (Sandeep and Pratap 2007). The different measures for hydraulic performance of drip irrigation system are very useful for effective design and operation of the system.

Hence drip irrigation can be a great aid to the efficient use of water. Well designed drip irrigation will lose practically no water to runoff, deep percolation or evaporation. Irrigation and fertigation scheduling, can be precisely managed to meet crop demands, holding the promise of increased crop yields and quality.

Keeping all these points in view present investigation was taken up, the objectives of this study were (1) to evaluate the performance of drip system at different operating pressure and (2) to study the effect on water saving and yield of potatoes.

MATERIALS AND METHODS

The field investigation was conducted at Water Management plot of South Pangabri upland adjoining to Rajendra Agricultural University farm during October, 2012 to February, 2013. Pusa is situated on the bank of the *Budhi Gandak* River. It lies at 25.98° N latitude, 85.67° S longitudes and at an altitude of 52.00 meter above the mean sea level. The field has an approximate uniform topography with deep and well drained sandy loam soil, to study the effect of operating pressure on potato under drip irrigation. The treatments consisted of; (i) Irrigation at the operating pressure of 0.4 kg/cm² (I_1), Irrigation at the operating pressure of 0.6 kg/cm² (I_2), Irrigation at the operating pressure of 0.8 kg/cm² (I_3), Irrigation at the operating pressure of 1.0 kg/cm² (I_4), Irrigation at the operating pressure of 1.2 kg/cm² (I_5), Irrigation by the conventional method (I_6 control). The test crop selected for the experimental study was potato (*Solenum tuberosum*) cultivar Kufri Ashoka, a high yielding variety that could be harvested at 95-110 days after sowing. After layout of crop field, potato was sown on October 25, 2012 at a spacing of 50 cm × 15 cm and harvesting of crop was done on February 10, 2013. The seed @ 25q/ha was calculated for the experiment plot. Potato seed having at least 3 eyes were placed at the desired depth after treated by Bavistine @ 2.0 ml/ litre of water. Ridges are made on each line of potato.

Water use efficiency

The water utilized by crop for its development is generally described in terms of water use efficiency, which is defined as the ratio of crop yield to the total depth of water used in the field inclusive of effective rainfall that has occurred during the crop growing period. It is express in terms of q/ha-mm or t/ha-cm.

$$\text{Water use efficiency} = \frac{\text{Tuber yield (q/ha)}}{\text{water applied to each treatment (mm)}}$$

Irrigation scheduling

Drip irrigation system was scheduled at an interval of 2 days. The first irrigation was given after 15 days of sowing.

According to the Ministry of Agriculture, Department of Agriculture and Co-operation, Horticulture Division, New Delhi. The daily water requirement or consumptive use of the plants can be calculated as under.

$V_{WR} = E_P . K_C . K_P . W_P . A$

Net volume of water V_n is expressed as under

$V_n = V_{WR} - R_e . A$

$$\text{The total volume of water applied per day is given by} = \frac{\text{Vn x No. of plants}}{\text{Emission uniformity}}$$

Where

V_{WR} = water requirement of plant, lit/plant/day, V_n = net volume of water, lit, E_p = pan evaporation, mm/day, K_c = crop coefficient, K_p = pan factor pan factor is taken as 0.8, W_p = wetted area factor taken as 0.9, A = spacing of the plant, m^2, Re = effective rainfall, cm.

Emission uniformity

The EU (emission uniformity) during the field test is the ratio expressed as a percentage of the average emitter discharge from the lowest 1/4th of the emitter to the discharge of all the emitters for minimum discharge, as recommended by the United State Soil Conservation Service for field evaluation of irrigation system and is expressed by the equation.

$$EU = \frac{qn}{qa} \times 100$$

Where; EUf = the field test uniformity, percent, q_n = average of the lowest 1/4th of the field data emitter discharge, lph

Pressure-discharge relationship

Pressure discharge relationship was established by using the equation given by Keller (1974). Which is given below:-

q = K x H x

Where

q = Average flow rate through the emitter, K = Multiplying constant specific to the emitter, H = Initial pressure head of lateral, x = Flow component, whose value depends on the flow regime.

RESULTS AND DISCUSSION

Irrigation studies

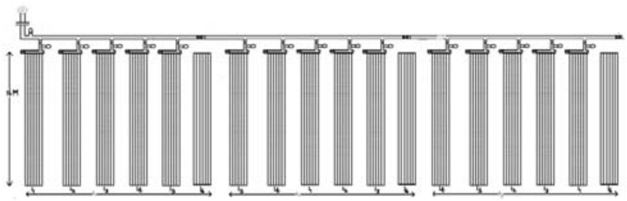
The total pan evaporation during crop season was 150.56 mm. The trend of variation in water requirement with respect to date of is shown in fig 4. The total rainfall receive during the crop season was 12.2 mm. The total amount of water applied from Nov 10, 2012 to Feb 3, 2013 through drip system was 1008913, 972446.3, 938523.8, 917193.8 and 896811.6 liter/ha for I_1, I_2, I_3, I_4 and I_5, difference in volume of water applied maybe caused due to emission uniformity of the drip irrigation treatment because due to low emission uniformity

Table 1: Effect of different treatments on water use efficiency

Treatment	Actual water required (mm)	Total water applied (mm)	WUE (kg/ha-mm)	percent saving of water over SIM
I_1	85.45	106.73	164.799	40.71
I_2	85.45	102.87	202.8774	42.85
I_3	85.45	99.36	267.2605	44.8
I_4	85.45	97.02	293.1767	46.1
I_5	85.45	94.87	329.103	47.1
I_6	85.45	180	118.7611	

Table 3: Effect of different irrigation level on yield and yield attributes

Treatment	Number of tuber per plant	Size of tuber per plant (mm)	Fresh tuber yield Q/ha
I_1	6	37.81	175.89
I_2	8	39.13	208.7
I_3	9	43.35	265.55
I_4	11	45.23	284.44
I_5	14	47.21	312.22
I_6	8	43.29	213.77
CV	17.28	4.47	9.65
CD (P= 0.05%)	1.14	3.47	15.75



Filtration unit
Pressure guage
Valve
Flush valve
Pumping station
In-line laterals

I_1 - Irrigation at the operating pressure of 0.4 kg/cm²
I_2 - Irrigation at the operating pressure of 0.6 kg/cm²
I_3 - Irrigation at the operating pressure of 0.8 kg/cm²
I_4 - Irrigation at the operating pressure of 1.0 kg/cm²
I_5 - Irrigation at the operating pressure of 1.2 kg/cm²
I_6 - Surface method of irrigation

Plot size : 3m × 16.5 m
Plant to plant spacing : 15cm
Row to row spacing : 50cm

Figure 1: Layout of experimental plot

Figure 2: Observation during the initial stage

Table 2: Average discharge (lph) uniformity coefficient (%) at different operating pressure (kg/cm²)

Treatment	Discharge (lph)	Cv	EU
I_1	1.08	0.12	80.55
I_2	1.24	0.13	84.89
I_3	1.46	0.12	86.3
I_4	1.62	0.11	88.88
I_5	1.74	0.09	90.8

more water is applied to meet the crop water requirement. As the emission uniformity increases with respect to operating pressure of the different treatment applied volume of water decreases. In case furrow irrigation the first irrigation was applied on November 10, 2012 and depth of water applied was 60 mm. The total number of irrigation was three amounting to 180 mm. depth of water for the whole growing season.

Water saving

The results pertaining to the total water applied through different level of drip irrigation and furrow irrigation method to potato are presented in Table 1. These results show that during crop season the net amount of water applied through treatments I_1, I_2, I_3, I_4, I_5 and surface method of irrigation were 106.73, 102.87, 99.36, 97.02, 94.87 and 180 mm respectively, with a net water saving of 40.71, 42.85, 44.80, 46.10, 47.29 respectively over surface method of irrigation during the season. Similar result reported by Ahire *et al.* (2000) that the trickle irrigation saved 46% irrigation water compared to surface irrigation. While (Pawar et al 2002) reported 39% of water saving in drip irrigated potato.

Water use efficiency (WUE)

It is clearly indicated from Table 1 that the WUE of 329.10 kg/ha-mm was found in treatment I_5 which is highest as compared to treatment I_1, I_2, I_3, I_4 and I_6 which have the water use efficiency 164.68, 205.17, 267.28, 293.18, and 118.76 kg/ha-mm respectively. Kashyap and Panda (2003), Yuan *et al.* (2003) and Onder *et al.* (2005) also observed the similar findings for potato crop. Lesser amount of applied irrigation water, gives the higher WUE (Faberio *et al.,* 2001).

Performance evaluation of the system

The maximum mean emitter discharge (1.74 lph) was found at 1.2 kg/cm² and minimum mean emitter discharge(1.05 lph) was found at 0.4 kg/cm² the value of k and x were found to be 0.572 and 0.450 respectively by the regression of pressure head and mean emitter discharge. It is clear that emitter discharge increase exponentially with increase in pressure head. It was found that the uniformity coefficient varied from 80.55 per-cents to 90.80 per cent. The maximum uniformity coefficient (90.80%) was found at pressure 1.2 kg/cm². It was found that the coefficient of manufacturing variation varies from 0.09 to 0.13. The maximum coefficient of variation (0.13) was found in treatment I_2 and minimum (0.09) was found in treatment I_5 the uniformity coefficient and emission uniformity increased while coefficient of variation decreased as the operating pressure head increased for all emission devices. The same result of uniformity coefficient, emission uniformity and coefficient of variation was found as in evaluation of hydraulic performance of drip irrigation system by (Kumar and Singh, 2007). The uniformity coefficient and emission uniformity increased while coefficient of variation decreased as operating pressure increased for all emission devices (Popale *et al.,* 2011). The low CV indicated good performance of the system throughout the cropping season. CV estimated by Decroix and Malaval (1985) and Bargel *et al.* (1996) for the in-line labyrinth type drippers was reported to be 0.066. Bargel *et al.* (1996) had concluded that a CV between 0.05 and 0.066 indicated a good performance of the drip system.

Yield and yield attributes

The observations recorded for all irrigation treatment are presented in Table 3. The total yield of potato per plot (49.5 m²) and based on this yield per hectare for different treatments of irrigation are given in Table 3. The yields obtained from an area of 49.5 m² of experimental plots were 87.06, 103.30, 131.44, 140.79, 154.54 and 124.14 kg for I_1, I_2, I_3, I_4, I_5 and I_6 respectively. Yield per hectare for I_1, I_2, I_3, I_4, I_5 and I_6 works out to be 175.89, 208.70, 265.55, 284.44, 312.22 and 213.77 quintals respectively. It may be seen that maximum yield is obtained from I_5 which is significantly superior (at significant level of 0.05) over treatments I_1, I_2, I_3 and I_6 while statistically at par with treatment I_4. The yield of potato decreases in treatments I_1 (29.86%) and I_2 (16.78%), while increases in treatments I_3 (5.88%), I_4 (13.41%) and I_5 (24.49) over treatment I_6. Previous studies have shown that potato yield responds linearly to applied water (Hegney and Hoffman, 1997; Martin *et al.,* 1992). Steyn et al. (1998) had reported significant tuber yield and size

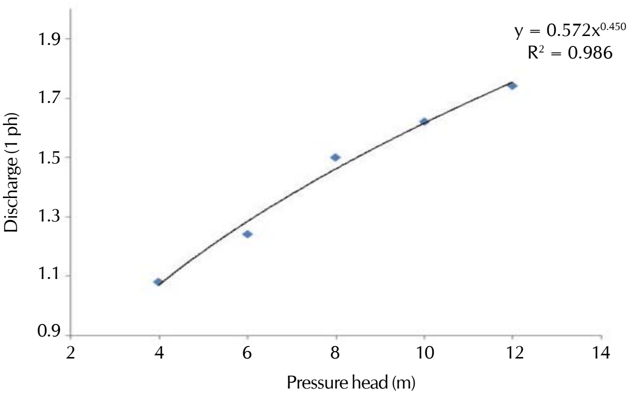


Figure 3: Pressure discharge relationship at different operating pressure

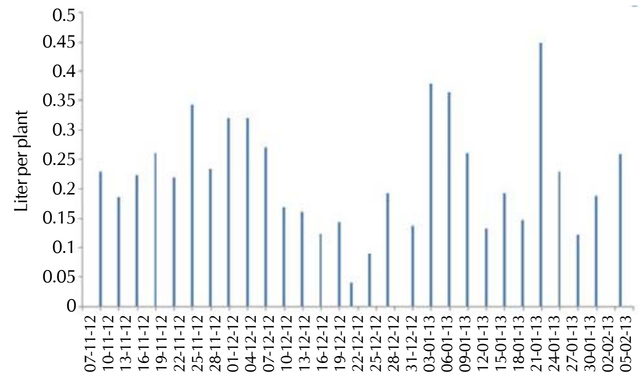


Figure 4: Water requirement of potato crop at different date of irrigation

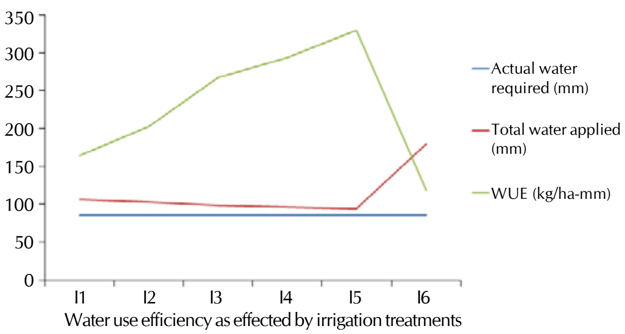


Figure 5: Water use efficiency as effected by treatments

reductions with the reduction of applied water, but they also pointed out significant differences among genotypes in response to water stress. Onder et al. (2005) also had suggested that farmers could not be advised to grow potato under water deficiency of more than 33% of the irrigation water requirement.

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