

Irrigation water productivity and potato (*Solanum tuberoses* L.) yield under different planting methods

Abstract

To investigate the effect of drip irrigated beds (DIB), furrow irrigated beds (FIB) and ridge (R) methods under different irrigation regimes on irrigation water productivity and potato (*Solanum tuberoses* L.) yield, a field experiment was conducted in sandy loam soil at the Research Farm of Department of Soil Science, Punjab Agricultural University, Ludhiana during rabi 2011-12. Three irrigation levels based on IW/PAN-E ratio of 1.2, 1.6 and 2.0 were tested under FIB and R, while 0.3, 0.4, 0.5 were tested under DIB. The potato yield increases with increase in irrigation level for all the methods. The highest mean yield of 26.5 t/ha was recorded in DIB at IW/PAN-E 0.5, followed by FIB (24.2) and R (22.6 t/ha) at equivalent IW/PAN-E ratio 2.0. Potato biomass was also observed to be highest in DIB and least under R method. The irrigation water productivity (IWP) was highest under DIB followed by FIB and least under R method. The IWP decreases with increase in irrigation level. The results revealed that drip irrigation at IW/PAN-E ratio of 0.5 could successfully be used for potato cultivation with water saving and higher productivity.

Key words: Potato, drip, ridge, bed, IW/PAN-E, water productivity.

Introduction:

Potato is one of the most important vegetables in the world. Potatoes are sensitive to water stress. They are generally planted in raised beds and furrow-irrigated. As such, water use efficiency is very low. Drip irrigation is well suited for use with raised bed production cultures (Clark et al.,

1995). Currently, because of water shortages, farmers have been encouraged to adopt drip irrigation. Irrigation frequency is one of the most important factors in drip irrigation scheduling. Due to the differences in soil moisture and wetting pattern, crop yields may be different when the same quantity of water is applied under different irrigation frequencies. High irrigation frequency might provide desirable conditions for water movement in soil and for uptake by roots (Segal et al., 2000). Drip irrigation has a high efficiency for adding water and nutrients to crops. Crop yield can increase through improved water and fertility management and reduced disease and weed pressure. Thus, the main benefits of drip irrigation are that it reduces water use and improves the health of the plant (Lamont, 2002). Kang et al. (2004) carried out a field experiment comparing different irrigation frequencies and soil matric potential thresholds on potato evapotranspiration (ET), yield (Y) and water-use efficiency (WUE) in a loam soil. The implementation of drip irrigation technologies results in net water savings, thereby easing the prevailing water-scarcity problems. The water saving is attained through substantial reduction in losses due to evaporation and inefficient field conveyance and distribution systems. For instance, water application can be reduced by 50 to 100 percent through the drip method of irrigation (Namara et al., 2005). Kumar et al. (2007) evaluated the role of differential drip irrigation regime on the growth in Punjab, India, during 2002-04, yield and postharvest attributes of potato (*Solanum tuberosum*) cv. Kufri Chandramukhi. Irrigation for 0.60, 0.80, 1.00 and 1.20 of Ep was applied when cumulative pan evaporation reached 17.5, 13.1, 10.5 and 8.8 mm, respectively. The highest irrigation water use efficiency was observed with the irrigation regime of 0.80 Ep. Drip irrigation system is completely suitable for potato production under sandy land conditions, where it can provide the exact water requirements to the crops. Fabeiro et al. (2001) reported that the larger potatoes were achieved with the treatments which had not suffered deficit in the ripening

45 period. Yuan et al. (2003) found that plant height, biomass and shoot water content increased,
 46 but the specific leaf weight decreased with increasing amount of irrigation water. The amount of
 47 irrigation water had significant effects on decreasing the canopy temperature. Total fresh tuber
 48 yields and marketable tuber yields (>85 g) increased with increasing amount of irrigation water.
 49 The highest yield was obtained at the 1.25 times regime and the total tuber yield was close to the
 50 theoretical maximum. Onder et al. (2005) reported that water stress significantly affected the
 51 yield and yield parameters of early potato production. Benam and Hassanpanah (2007) showed
 52 that water deficit was an important stress factor in potato cultivation and led to yield decrease.
 53 The results detected that irrigation treatments had significant effects on tuber yield, tuber
 54 number, tuber weight, tuber biomass  than 55 mm, and tuber number (35-55 mm). Water stress led
 55 to decrease in tuber yield, tuber weight and tuber number (> 55 mm). Tuber-setting stage was the
 56 most sensitive stage  and led to the most decrease in yield. Kumar et al. (2007) found that plant
 57 height, biomass and tuber yield increased by the increase in irrigation level. The highest tuber
 58 yield was obtained in the irrigation regime of 1.20 Ep (Pan Evaporation). A preferable grade of
 59 tuber (>28 mm in size) decreased with the decrease in irrigation level from 1.20 to 0.60 Ep.
 60 Specific gravity and starch percentage in tuber increased with the increase in irrigation level.
 61 Therefore, it could be detected that potatoes should be irrigated at 1.20 Ep to obtain higher yield
 62 and better quality. However, if water availability is limited, 0.80 Ep would be most appropriate
 63 for sustainable agriculture. Kumar et al. (2009) compared the effect of micro sprinkler, drip and
 64 furrow irrigation systems on potato production. The highest total tuber yield (31.6 ton/ha) was
 65 obtained with micro sprinkler, then drip (29.8 ton ) and furrow (22.6 ton/ha ) irrigation systems
 66 when irrigation level was 1.20 IW (Irrigation Water): CPE (Cumulative Pan Evaporation). Potato
 67 tuber yield increased with increasing irrigation level from 0.60 to 1.20 IW: CPE, regardless of

irrigation system. However, the highest water use efficiency was recorded by 0.80 IW: CPE under micro sprinkler irrigation. Applying 257 and 261 mm of irrigation water attained the best tuber yield under micro sprinkler and drip irrigation systems, respectively. The purpose of this study was to understand different planting systems and irrigation regimes for establishing optimum irrigation method and level for enhancing potato and irrigation water productivity.

Materials and Methods:

The study was conducted during 2011-12 at the research farm of the Department of Soil Science, PAU, Ludhiana, Punjab, India (30°56'N latitude, 70° 52'E longitude and 247 m above mean sea level). The region experiences semi-arid climate with extremely hot during summers and cold during winter. The annual average temperature is 18.7 °C and annual average total precipitation is 700 mm. The soils in the research field are deep, medium textured and well drained. Basic soil physico-chemical properties are listed in Table 1. In-situ infiltration rate was measured using double ring infiltrometer method and bulk density was measured using core method. Soil was sampled from 0-15 cm depth to determine soil chemical characteristics e.g. $\text{A}^{\text{+}}$, N, P, K, pH, EC and OC etc. All agronomic practices were kept uniform for all treatments. The treatments consisted of three planting methods (drip irrigated beds (DIB), furrow irrigated beds (FIB) and ridge (R)) and three irrigation regimes i.e., IW/PAN-E ratio of 1.2, 1.6 and 2.0 for FIB and R, while the equivalent ratio of 0.3, 0.4 and 0.5 were maintained under DIB. Crop biomass and tuber yield was recorded separately for each treatment plot and converted into t/ha.

90 RESULTS AND DISCUSSION

91 Amount of irrigation applied

92 After sowing, common irrigation was applied to all the plots for proper crop
 93 establishment irrespective of different irrigation treatments. Subsequently, the irrigation water
 94 was delivered through drip irrigation in DIB, through furrows in FIB and between ridges in R
 95 sown plots. Irrespective of irrigation regimes, minimum water was applied in DIB (231 mm)
 96 followed by FIB (273 mm) and highest water was applied under R irrigation method (287 mm).
 97 However, among different irrigation regimes mean maximum water was applied under I3 i.e. 310
 98 mm followed by I2 (260 mm) and I1 (220 mm) treatments. Faberio et al. (2001) found that 597
 99 mm irrigation water was required to reach maximum tuber yield 45.2 t ha^{-1}

100 Potato biomass

101 Potato biomass yield was observed to be significantly affected by planting method and
 102 irrigation levels. Irrespective of irrigation level treatments, minimum biomass yield
 103 observed in R method (6.6 t/ha) followed by FIB (6.9) and highest biomass yield was recorded
 104 under DIB (7.5 t/ha). Under DIB 6.9, 7.4 and 8.1 t/ha of biomass yield was recorded for
 105 IW/PAN-E ratios of 0.3, 0.4 and 0.5, respectively (Table 2). Similarly, 6.3, 7.0 and 7.5 t/ha
 106 was observed under FIB and 6.1, 6.6 and 7.0 t/ha under ridge method at equivalent IW/PAN-E
 107 ratios 0.2, 0.4 and 0.5. However, irrespective of planting method maximum mean potato biomass
 108 yield was observed under I3 treatment i.e. 7.5 t/ha followed by I2 (7.0 t/ha) and least under I1
 109 (6.4 t/ha) treatments.

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111 Tuber yield

112 Tuber yield was observed to be significantly affected by planting methods and irrigation
 113 levels. Irrespective of irrigation level treatments, minimum potato yield was observed in ridge
 114 method (22.6 t/ha) followed by FIB (24.2) and highest potato yield was recorded under DIB
 115 (26.5 t/ha). Under DIB 25.1, 26.8 and 27.7 t/ha of yield was recorded for IW/PAN-E ratios of
 116 0.3, 0.4 and 0.5, respectively (Table 3). Similarly, 22.8, 24.6 and 25.3 t/ha yield was observed
 117 under FIB and 21.4, 22.8 and 23.6 t/ha under ridge method at equivalent IW/PAN-E ratio 1.2,
 118 1.6 and 2.0. However, irrespective of planting method maximum mean potato yield was
 119 observed under I3 treatment i.e. 25.5 t/ha followed by I2 (24.7 t/ha) and least under I1 (23.1 t/ha)
 120 treatments. Many researchers have also reported increased tuber yield with irrigation applications
 121 (Shock et al., 1998; Ferreira & Carr, 2002; Kashyap & Panda, 2003; Yuan et al., 2003; Kang et
 122 al., 2004).

123 Irrigation water productivity

124 Irrigation water productivity (IWP) was observed to be significantly affected both by the
 125 planting method and irrigation levels (Table 4). Irrespective of irrigation levels, IWP was
 126 observed to 1.2, 0.9 and 0.8 t/ha-cm under DIB, FIB and R methods, respectively. Under DIB
 127 1.3, 1.2 and 1.0 t/ha-cm of IWP was recorded for IW/PAN-E ratios of 0.3, 0.4 and 0.5
 128 respectively (Table 4). Similarly, IWP of 1.0, 0.9 and 0.8 was observed under FIB, and 0.9, 0.8
 129 and 0.7 was observed under R method at IW/PAN-E ratio of 1.2, 1.6 and 2.0 respectively.
 130 However, irrespective of planting method maximum mean IWP was observed to be 1.07 (I1)
 131 treatment, followed by I2 (0.97) and I3 (0.80) treatments. Kang et al. (2004) and Onder et al.
 132 (2005) also registered similar WUE values for potato.

133 Conclusion:

134 The planting methods and irrigation levels had significant effect on potato yield and irrigation
 135 water productivity. Drip irrigated beds yielded maximum, while the potato raised on ridges
 136 yielded the minimum. Potato biomass was also observed to be significantly higher under drip
 137 irrigated beds than furrow irrigated beds and ridge method. Irrigation water productivity was
 138 highest under drip irrigated beds followed by furrow irrigated beds and least in ridge method. It
 139 is thus concluded that drip irrigated beds with IW/PAN-E ratio 0.5 should be adopted for higher
 140 production and irrigation water productivity.

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143 **Table 1 :** Physical and chemical properties of the soil collected from experimental site.

Soil depth (cm)	pH	OC (%)	Av. N (kg ha ⁻¹)	Av. P (kg ha ⁻¹)	Av. K (kg ha ⁻¹)	BD (Mg m ⁻¹)	PWP (%)	FC (%)
0-15	7.8	0.42	148.5	53.8	125.8	1.55	8.4	18.6
15-30	7.7	0.31	126.7	42.5	120.2	1.74	8.0	17.8

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145 **Table 2:** Effect of planting methods and irrigation levels on biomass yield (t/ha)

Planting method	Irrigation levels			
	I1	I2	I3	Mean
Drip irrigated beds	6.9	7.4	8.1	7.5
Furrow irrigated beds	6.3	7.0	7.5	6.9
Ridge	6.1	6.6	7.0	6.6
LSD (<0.05)	0.4	0.6	0.7	

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149 Table 3 : Effect of planting methods and irrigation levels on tuber yield (t/ha)

Planting methods	Irrigation levels			
	I1	I2	I3	Mean
Drip irrigated beds	25.1	26.8	27.7	26.5
Furrow irrigated beds	22.8	24.6	25.3	24.2
Ridge	21.4	22.8	23.6	22.6
LSD (<0.05)	1.7	1.8	2.3	

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151 Table 4: Irrigation water productivity (t/ha-cm) under different planting methods and irrigation levels

Planting methods	Irrigation levels			
	I1	I2	I3	Mean
Drip irrigated beds	1.3	1.2	1.0	1.2
Furrow irrigated beds	1.0	0.9	0.8	0.9
Ridge	0.9	0.8	0.7	0.8
LSD (<0.05)	0.2	0.2	0.3	

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