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Effect of different treatments on WUE, Consumptive use and soil moisture extraction pattern

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Abstract
The field trial was conducted during both the seasons (2010-11 and 2011-12) on PGI Farm without changing randomization. The experiment was laid out in *rabi* season. The various components of water expense *viz*. Consumptive use (Cu), Daily Consumptive Use (DCU), Water Use Efficiency (WUE) were measured at an interval of 28 days. Water flow is measured accurately by refrigual instrument. The highest consumptive use was found the crop with mulching and five irrigations. A positive linear correlation existed between the Consumptive use and the dry matter accumulation in the potato. Proportion of dry matter partitioned to tubers increased with plant weight. The data emphasizes the importance of the use of detailed studies on the relationship between Consumptive use and dry matter production in the analysis of relative efficiencies of the different treatments. The approach has been recognized as a more rational means of growth than the traditional growth analysis techniques. In present studies, this point has been amply illustrated by the differences in the calculated production efficiencies of different treatments. Apart from measured water components growth indices such as no. of functional leaves, no. of branches, dry matter accumulation and final yields, a useful index of crop productivity can be obtained by computing the production efficiencies (CU or DCU) as shown by this study. Analysis of the relationship between production and CU or DCU at the various growth stages for the different treatments shows that 1.2 IW/CPE ratio and early planting with mulching treatment proved to be superior to the other treatments not only in yield but also in conservation natural resources due to its complimentary effect in better use of natural resources like soil moisture. CU or DCU related with amount of dry matter produced by crop, as increasing the number of irrigation and early planting with mulching, as the amount of soil moisture consumed by crop and converted into dry matter.

Keywords: Sowing window, consumptive use

Introduction
Potato is one of the most important crops of the world, ranking next to rice and wheat. It assumes greater significance for its ability to provide food security to millions of people across the globe, as it provides more dry matter content, proteins and calories from per unit area of land and time. It is a wholesome food which is rich in carbohydrates, phosphorus, calcium, vitamin C and vitamin A, minerals and is high yielding short duration crop with high protein calorie ratio. Potato is one of the unique crops grown in our country having high productivity and supplementing food needs. (Gupta, 2006) [1]. The non-adoption of improved agro-techniques in a climate change scenario as irrigation scheduling, variable planting dates and use of mulch are the limiting factors for low productivity and poor in creation of favorable microclimatic conditions. Globally this climate change should also be addressed in eco-friendly manner.
With this back ground in view, the present investigation was undertaken to know the water expenses as Influenced by sowing windows in potato.

Materials and Methods
The field trial of Potato (Variety) Kufri Pukhraj was conducted during both the seasons (2009-10 and 2010-11) on PGI Farm without changing randomization. The experiment was laid out Split Plot Design in rabi season with Recommended dose of fertilizer. 120:60:120 NPK Kg ha-1. There were eighteen treatments comprised of nine main plot treatments and two sub-plot treatments:

Treatment details: A. Main plot Treatments (Nine)	
Irrigation levels (I) X Planting dates (D)	
I_1D_1 - (0.8 IW/CPE) X (42 MW)	I_2D_1 - (1.0 IW/CPE) X (42 MW)
I_1D_2 - (0.8 IW/CPE) X (44 MW)	I_2D_2 - (1.0 IW/CPE) X (44 MW)
I_1D_3 - (0.8 IW/CPE) X (46 MW)	I_2D_3 - (1.0 IW/CPE) X (46 MW)
I_3D_1 - (1.2 IW/CPE) X (42 MW)	
I_3D_2 - (1.2 IW/CPE) X (44 MW)	
I_3D_3 - (1.2 IW/CPE) X (46 MW)	
B. Sub-plot Treatments (Two) Mulching (M)	
M1 - With mulch	M2 - Without mulch

Measurement of CU and DCU: The various components of water expenses *viz*.CU, DCU etc. were measured at an interval of 28 days with the help of refrigual instrument.

Cu (mm) = PET (mm) of 48 hours immediately after irrigation + soil moisture depletion (per cent) from the effective root zone (i.e. soil moisture use by the crop from the profile) + effective rainfall (mm). The field consumptive use of water by rabi potato crop in mm, respectively is computed by the formula as given below.

$$Cu\ (mm) = \sum_{i=1}^{n} \frac{FC - M_{1i}}{100} (BD \times D_i)$$

Where,
Cu = Consumptive use of water in mm
n = Number of soil layers in the root zone
i = Time instant of the respective irrigation schedule (1, 2, 3, n)
M1i = Moisture content at the first sampling in the i^{th} layer (per cent)
BD = Bulk density (Mg m^{-3})
D_i = Depth of soil in the i^{th} layer (cm)

Moreover, from the data on consumptive use of water, the daily water use rates (mm day^{-1}) were also computed for respective schedule of irrigation in potato crop.

Water use efficiency

Water use efficiency (WUE) *i.e.* kg of potato tubers produced mm^{-1} of water $hectare^{-1}$ in each irrigation treatment and is worked out by the following formula, as given below (Michael *et al.*, 1977) [2].

$$WUE = \frac{Y}{Cu}$$

where, WUE = Water use efficiency (kg $ha^{-1}mm^{-1}$)
Y = yield (kg ha^{-1})
Cu = Total seasonal consumptive use of water (mm)

Results and Discussion

The important findings of the experiment studies under different irrigation levels, planting dates and mulching are presented in this chapter under appropriate heads.

Effect of treatments on Consumptive use (Cu): The data pertaining to Consumptive use of water by potato as influenced by various treatments at different growth stages are housed in Table 1 (pooled data). Moreover, potato recorded higher mean Cu 198.85 and 191.26 mm in I_3D_1 during 2009 and 2010, respectively. On the basis of pooled analysis, (Table 1), amongst all the applied irrigation levels and planting date highest mean consumptive use (Cu) of water by potato was recorded with 1.2 IW/CPE ratio and planting on 42^{nd} MW followed by 1.0 IW/CPE ratio and planting on 42^{nd} MW, whilst it was lowest with 0.8 IW/CPE ratio and planting on 46^{th}MW. Thus, it indicates that wet regimes with frequent irrigations provided wet surface for longer period resulting in greater loss of soil moisture due to evapotranspiration in these treatments.

Since frequent irrigated crops produced profuse vegetative growth causing more evapotranspiration losses, so required higher consumptive use of water. In the same line, decrease in consumptive water use may be attributed to the greater amount of soil moisture depletion before irrigation and lower amount of available soil moisture maintained in less frequently irrigated plots than in the more frequently irrigated plots. This decrease in soil moisture availability restricted the transpiration rates in frequently irrigated treatments.

Similar observations on higher consumptive water use by potato crop with higher number of irrigations were reported by Choudhury *et al.* (1996) [3].

Effect of treatments on Daily Consumptive Use (DCU)

The investigation of (Table 77), the daily consumptive use of water was also highest with scheduling of irrigation at 1.2 IW/CPE and planting on 42^{nd} MW and 1.0 IW/CPE and planting on 42^{nd} MW, as compared to 0.8 IW/CPE and planting on 46^{th} MW. This might be due to the highest relative evapotranspiration with higher frequency of irrigation and early planting date than the lower and later ones. This result was in accordance with findings of Choudhury *et al.* (1996) [3]. Moreover, potato recorded higher mean daily Cu rates 2.16 and 2.08 mm in I_3D_1 during both years.

Effect of treatments on Water Use Efficiency (WUE)

In potato, the higher water use efficiency (WUE) was recorded only with the irrigation level and planting date *i.e.* at 1.2 IW/CPE and planting on 44^{th} MW (I_3D_2) on pooled investigation (Table 1). As well, the water use efficiency increased with the increase in frequency of irrigations. This was due to the fact that the increased frequency of irrigations increased the consumptive use and the tuber yield proportionately. These results are in conformity with those reported by Choudhury *et al.* (1996) [3] and Ramnik Sharma *et al.* (1999) [4].

While, the lower water use efficiency due to less moisture supply was due to proportionately more increase in the evapo-transpiration than the increase in potato yield. This corroborated with the findings of Subhash Chandra *et al.* (2001) [5] and Yadav *et al.* (2003) [6].

As well, it was observed that with the increase in number of irrigations there was enhance in the WUE or increased WUE can be achieved through increased consumptive use (Cu) of water. Likewise, water requirement increased with an increase in the level of irrigation, however, mean maximum WUE was recorded with more moisture regimes. Moreover, potato recorded higher mean WUE 4.09 and 5.28 in (I_1D_3) during 2009 and 2010, respectively.

Table 1: The yield, consumptive use of water, daily water use and water use efficiency of potato as influenced by different treatments on pooled basis

Treatments	Yield (q ha^{-1})			CU (mm)			Daily water use (mm)			WUE (kg ha^{-1} mm^{-1})		
	M_1 (With mulch)	M_2 (Without mulch)	Mean	M_1 (With mulch)	M_2 (Without mulch)	Mean	M_1 (With mulch)	M_2 (Without mulch)	Mean	M_1 (With mulch)	M_2 (Without mulch)	Mean
I_1D_1 (0.8 IW/CPE x 42 MW)	177.20	151.82	164.51	145.23	153.66	149.44	1.58	1.67	1.62	122.02	98.81	110.41
I_1D_2 (0.8 IW/CPE x 44 MW)	229.51	208.97	219.24	133.69	146.94	140.31	1.45	1.60	1.53	171.68	142.21	156.95
I_1D_3 (0.8 IW/CPE x 46 MW)	179.10	154.54	166.82	132.49	140.99	136.74	1.44	1.53	1.49	135.19	109.61	122.40
I_2D_1 (1.0 IW/CPE x 42 MW)	234.74	203.47	219.10	173.61	197.64	185.62	1.89	2.15	2.02	135.21	102.95	119.08
I_2D_2 (1.0 IW/CPE x 44 MW)	294.24	257.03	275.64	148.69	160.64	154.66	1.62	1.75	1.68	197.89	160.01	178.95
I_2D_3 (1.0 IW/CPE x 46 MW)	225.06	183.37	204.21	145.27	164.77	155.02	1.58	1.79	1.68	154.93	111.29	133.11
I_3D_1 (1.2 IW/CPE x 42 MW)	269.28	238.37	253.82	188.21	201.90	195.06	2.05	2.19	2.12	143.07	118.06	130.57
I_3D_2 (1.2 IW/CPE x 44 MW)	328.98	286.20	307.59	156.55	164.50	160.53	1.70	1.79	1.74	210.14	173.98	192.06
I_3D_3 (1.2 IW/CPE x 46 MW)	263.28	233.19	248.24	159.63	170.98	165.30	1.74	1.86	1.80	164.93	136.39	150.66
Mean	244.60	213.00	228.80	153.71	166.89	160.30	1.67	1.81	1.74	159.45	128.15	143.80

Conclusions

The application of mulching of sugarcane trash @ 5 t ha^{-1} significantly reduced the consumptive use (8.57%) and daily water use (8.38%) and increased the water use efficiency (19.62%) by obtaining the higher tuber yield (244.60 q ha^{-1}) (6% more) over without mulching (231.00 q ha^{-1}) on pooled basis. Irrigation applied at 1.2 IW/CPE ratio (5 irrigations at 18 to 20 days interval) and planting on 44th MW (29th Oct to 04th Nov) with sugarcane trash mulching @ 5 t ha^{-1} significantly obtained the higher tuber yield of 328.98 q ha^{-1}

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