Indian Journal of Agronomy 47 (3) : 443–448 (September 2002)

Effect of mulch and irrigation on tuber size, canopy temperature, water use and yield of potato (*Solonum tuberosum*)

SUBHASH CHANDRA, R.D. SINGH, V.K. BHATNAGAR[1] AND J.K. BISHT

Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR) Almora, Uttranchal 263 601

Received : December 2001

ABSTRACT

A field experiment was conducted during 3 spring seasons (February–June) for 1995–97 on sandy-loam soil, to study the effect of irrigation levels in conjunction with pine needle mulch on potato (*Solanum tuberosum* L.). Pine needle mulch increased the tuber yield by 35% over no mulch. The yield increased significantly up to IW:CPE 1.50, except during 1997, which received a good rainfall (236.3 mm). The mean effect of mulch was equivalent to 1 irrigation (5 cm) in terms of potato yield advantage. Mulch and irrigation treatments produced more large size (>50 mm) tubers compared to no mulch and rainfed treatment respectively. The water-use efficiency (WUE) was more (39.9%) with mulch over no mulch. All irrigation treatments had more WUE than rainfed (678 kg/ha-cm), being the maximum with stolonization stage irrigation treatment (830 kg/ha-cm). The canopy temperature was 25 ± 2.5°C in IW:CPE 1.50, which recorded the highest tuber yield.

Key words : Potato, Mulch, Irrigation, Canopy temperature, WUE, Tuber size

Potato is an important cash crop of hills of India. In mid-hills (900-1,600 m above mean sea-level), it is grown during February–May. This period coincides with high evaporative demand (3.0–5.6 mm/day), making it relatively dry for crop cultivation. Potato, requires 380–450 mm water for better yield (Karim *et al.*, 1982). The crop prefers wet moisture regime not only for adequate moisture supply, but also for maintenance of low soil strength, which are conducive for development and enlargement of tubers (Parihar and Sandhu, 1987). In Uttaranchal hills, only about 10% cultivabie area is irrigated. Mulches conserve soil moisture and maintain soil temperature. Singh *et al.* (1987) reported 26% increase in tuber yield due to mulch. They further reported that under no mulch, irrigation applied at 40 mm CPE was

Present address : [1]Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh

significantly superior to 60 mm CPE, but under mulch both were at par. Pine needle is the most abundant organic material in the region and can be utilized as mulch. Hence the present study was formulated to asses the contribution of mulch in yield enhancement and water saving in relation to irrigation treatment in potato.

MATERIALS AND METHODS

The field experiment was conducted during 1995–97 at experimental Farm, Hawalbagh (29°36' N, 79°40' E, 1,250 m above mean sea-level) of Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR), Almora. The soil was sandy loam (77% sand, 15% silt and 8% clay). The initial characteristics of surface soil (0–15 cm) were : pH 5.2, organic carbon content 0.52%, available soil nitrogen 175 kg/ha, phosphorus 30 kg P/ha and potassium 90 kg K/ha). The available soil water content of the profile was 20.7 cm/m. A buffer channel of 50 cm was kept between plots to avoid the influence of lateral movement of water.

The treatments comprising 2 mulch levels (pine needle @ 6 tonnes/ha and no mulch) and 4 irrigation levels (rainfed, irrigation at stolonization stage only, irrigation at IW:CPE 0.75 and 1.50) were studied in split-plot design having mulch in main and irrigation levels in subplots with 3 replications. Depth of irrigation (5 cm) was common for all the treatments. Pine needle mulch was spread uniformly after planting of the crop. The potato variety 'Kufri Jyoti' was planted at spacing of 50 cm × 25 cm in the first week of March on ridges. Crop was fertilized @ 10 tonnes FYM + 100, 80 and 80 kg N, P_2O_5 and K_2O/ha. Total quantity of phosphorus and potash along with half dose of nitrogen was mixed into the soil before planting. The remaining half dose of nitrogen was top-dressed, before earthing up at 45–50 days after sowing (DAS).

The water-use efficiency (WUE) was worked by dividing tuber yield with seasonal water use. The seasonal water use (ET) was also calculated.

The profile moisture values were deducted in case of recharge and added in case of depletion. The canopy temperature and depression was measured with the help of infra-red thermometer, model 510 B. Canopy temperature depression was calculated by deducting canopy temperature from air temperature. The rainfall received during different seasons was 72.3, 118.5 and 236.3 mm in 1995, 1996 and 1997 respectively.

RESULTS AND DISCUSSION

Germination

Mulch increased the soil temperature (0–10 cm) by 2–4°C in the morning (07 : 00 hours) and lowered it by 3–5°C at noon (14:00 hours). This induced early emergence of the crop. The average germination of mulched plots was higher by 15% and advanced by 4–6 days over no mulched plots. Ram and Singh (1992) also reported significantly more germination of potato due to mulch.

Tuber weight, number and yield

The pooled analysis revealed that mulch increased the yield significantly over no mulch (165.0 q/ha), the extent being 58 q/ha (35%). Singh *et al.* (1987) also reported

26% increase in yield of potato owing to mulch. The tuber number and weight/plant were increased owing to mulching providing congenial environment for tuber development by maintaining soil temperature and conserving soil moisture.

In 1995 and 1996, the tuber yield increased significantly with increase in number of irrigations up to IW : CPE 1.50 (CPE 33 mm). Sharma *et al.* (1993) also obtained the highest potato yield when irrigation was applied at 33 mm CPE. But during these years, the interaction effects were not significant. In 1997, the interaction effect was significant, and the yield increased significantly up to IW:CPE 1.50 (4 irrigations) in case of no mulch, whereas in case of mulch it increased significantly only up to 1 irrigation applied at stolonization stage.

Potato responded differently to mulching over the years and yield response increased with increase in seasonal rainfall, being 16.3% in 1995 (rainfall 72.3 mm), 38.6% in 1996 (rainfall 118.5 mm) and 41.9% in 1997 (rainfall 236.3 mm). This indicates that the beneficial effects of mulch can also be expected in the years having good rainfall as mulch also need some moisture to conserve. The effect of mulch was found to be equivalent to 1 irrigation, as rainfed treatment with mulch produced comparable yield (156.8 q/ha) with 1 irrigation applied at stolonization stage without mulch (154.1 q/ha).

The highest benefit of mulch was noted under rainfed treatment (71.%), and reduced drastically with increase in number of irrigation, being 42, 30 and 20% with

Table 1. Effect of mulch and irrigation levels on tuber weight, number and yield (pooled)

Treatment	Tuber weight (kg/plant)	Tubers/plant (number)
Mulch		
No mulch	0.23	5.4
Pine mulch	0.29	6.5
CD (P=0.05)	0.06	NS
Irrigation		
Rainfed	0.17	4.2
Stolonization	0.26	5.6
IW : CPE 0.75	0.29	6.6
IW : CPE 1.50	0.32	7.3
CD (P=0.05)	0.11	1.0

Table 2. Effect of mulch and irrigation levels on year-wise tuber yield

Treatment	Tuber yield (q/ha)			
	1995	1996	1997	Mean
Mulch				
No mulch	114.0	159.0	222.1	165.0
Pine mulch	132.6	220.3	315.1	222.7
CD (P=0.05)	NS	NS	28.4	28.4
Irrigation				
Rainfed	73.6	103.2	195.7	124.2
Stolonization	93.1	182.2	284.4	186.6
IW : CPE 0.75	140.2	206.2	292.3	213.0
IW : CPE 1.50	186.4	266.5	302.1	251.7
CD (P=0.05)	28.5	28.7	27.8	15.6

stolonization stage, IW:CPE 0.75 and 1.50 treatments respectively. This indicates that mulches can be more beneficial under water constraints.

Tuber size

The quantity of tuber in different categories has been expressed in percentage (Table 3). The tuber enlargement was benefited owing to mulch and irrigation treatments.

Mulch produced 9.4% more large size (> 50 mm) tubers than no mulch (12.5%). The medium size (30–50 mm) tubers were almost similar, but the small size (<30 mm) tubers were more in no mulch. The size of tubers increased with increase in number of irrigations. Sharma *et al.* (1987) reported more large-size tubers with frequent irrigation (6–8 days) over 10 days interval irrigation.

The rainfed treatments recorded the lowest large size tubers (12.3%), while the IW:CPE 1.50 the maximum (23.7%). The percentage of medium-size tubers was more in rainfed (63.1%) and irrigation at stolonization stage (65.1%). The trend was reverse in case of small size than that of the large size. The better development of tubers under irrigated treatments was a result of better moisture availability, which maintained the internal water balance of the plant.

Table 3. Mean tuber size (mm) as influenced by mulch and irrigation levels

Treatment	Tubers (%)		
	<30	30–50	> 50
Mulch			
No mulch	21.5	66.2	12.5
Pine mulch	18.9	59.1	21.9
CD (P=0.05)	NS	0.40	5.8
Irrigation			
Rainfed	24.5	63.1	12.3
Stolonization	20.6	65.1	14.4
IW : CPE 0.75	19.6	62.0	18.5
IW : CPE 1.50	16.3	60.4	23.7
CD (P=0.05)	3.5	NS	2.3

Crop canopy temperature

The canopy temperature was lower in mulch treatment during early phase of the crop growth as compared to no mulch; however, during later phase of the growth the difference was negligible. Irrigation levels greatly reduced the canopy temperature (Fig. 1). Irrigation applied at IW:CPE 1.50 recorded the lowest mean temperature and it remained 25±2.5°C during the course of crop growth. The rainfed treatment invariably recorded the highest temperature at all the stages of temperature measurement.

The temperature depression (canopy–air) has been depicted in Fig. 2. Up to 40 days of sowing, canopy temperature was more in all the treatments as compared to air temperature. But with the imposition of irrigation treatments, it was generally lower in irrigation treatments, depending on the time of irrigation application. The canopy temperature less than air temperature indicates that the crop was not under stress. The lower canopy temperature in irrigation treatments may be credited to better soil moisture, where crop transpired freely. However, reduced transpiration under moisture-stress conditions increased the canopy temperature. Furthermore, water maintained well turgidity of the cells, in turn well functioning of the plants at

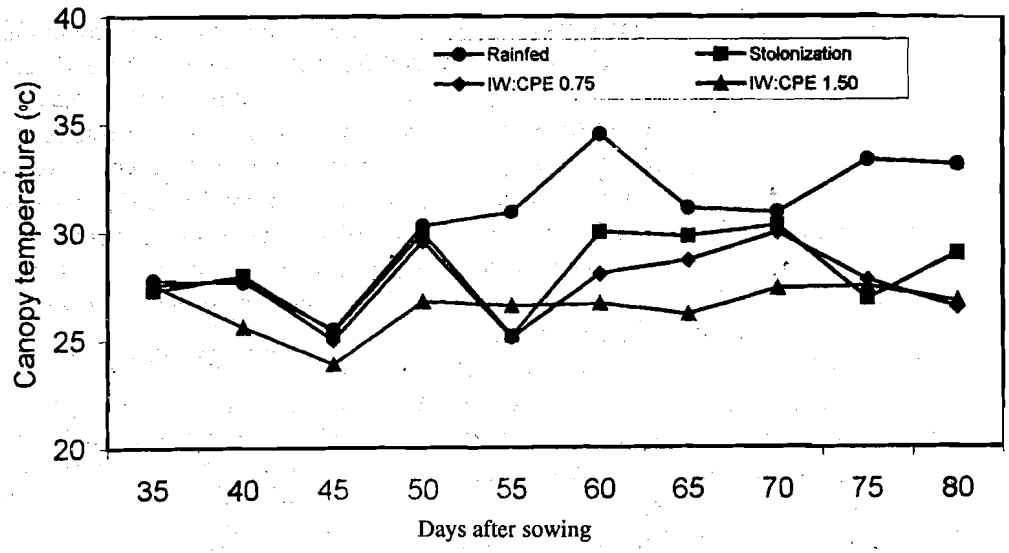

Fig. 1. Canopy temperature as influenced by irrigation levels

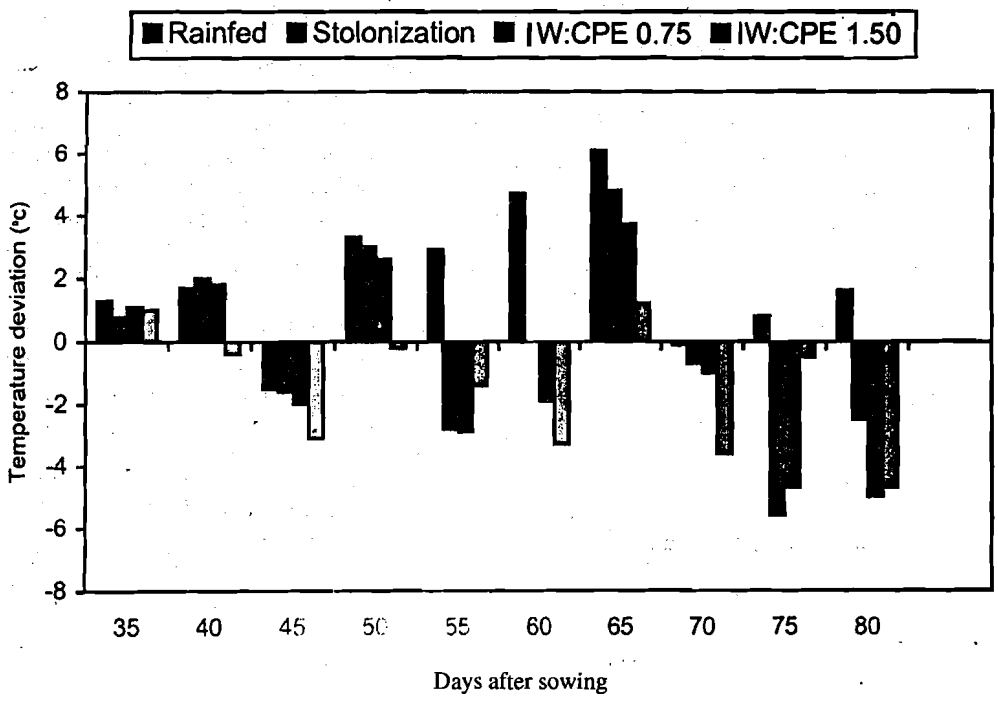

Fig. 2. Canopy temperature depression (canopy–air) under irrigation levels

cellular level, which ultimately resulted in higher tuber number, size and yield.

Water use and water-use efficiency

The water use increased with the increase in number of irrigations (Table 4), being maximum in IW:CPE 1.50 (30.8 cm). In case of mulch, water use was less than no mulch, as under mulched plots the profile moisture recharging was more. Mulch reduced the water loss through evaporation process, by acting as a barrier at surface, which in turn conserved more moisture in the profile. The water-use efficiency followed the trend similar that of yield, as mainly it is function of yield. Mulch recorded 39.9% more WUE than no mulch (647 kg/ha-cm). Singh *et al.* (1987) also recorded 26% higher WUE due to mulch over no mulch.

Table 4. Water use and its efficiency under mulch and irrigation levels

Treatment	Irrigation (Nos.)	Water-use (cm)	Water-use efficiency (kg/ha-cm)
Mulch			
No mulch		25.5	647
Pine mulch		24.6	905
Irrigation			
Rainfed		19:8	628
Stolonization	1	22.5	830
IW : CPE 0.75	2–3	26.6	800
IW : CPE 1.50	4–5	30.8	818

It was concluded that to obtain higher yields, potato should be irrigated at IW:CPE 1.50 (CPE 33 mm). Pine mulch is capable of conserving moisture equivalent to 1 irrigation. Combination of mulch and irrigation is more beneficial under water constraints. The canopy temperature of 25 ± 2.5°C may be considered optimum for potato during the course of growth.

REFERENCES

Karim, Z., Khan, M.S. and Akand, N.A. 1982. Potential evapotranspiration, rainfall probability and irrigation requirement of potato for different agroclimatic regions of Bangladesh. *(In) Proceedings of Fifth Workshop of Potato Research Workers*, Bangladesh, pp. 96–119.

Parihar, S.S. and Sandhu, B.S. 1987. *Irrigation of Field Crops : Principles and Practices,* pp. 128–182. Indian Council of Agricultural Research, New Dehli.

Singh, P.N., Joshi, B.P. and Singh, Gurmel. 1987. Effect of mulch on moisture conservation, irrigation requirement and yield of potato. *Indian Journal of Agronomy* **32** : 452–454.

Sharma, R.C., Upadhayay, N.C. and Sharma, U.C. 1987. Effect of irrigation on the efficiency of N-fertilizers and movement of nitrate in soil. *Annual Scientific Report, CPRI,* Shimla, pp. 53.

Sharma, S.K., Dixit, R.S. and Tripathi, H.P. 1993. Water management in potato (*Solonum tuberosum). Indian Journal of Agronomy* **38** : 68–73.

Ram, B. and Singh, V.P. 1992. Evaluation of mulch materials for potato under hill low valley conditions of U.P. *Vegetable Science* **19** (2) : 126–128.