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Moisture regimes and relay cropping studies in spring potato (*Solanum tuberosum* L.) under mid hill conditions of Himachal Pradesh

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ABSTRACT

A field experiment was conducted for two years during spring season at the research farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to study the influence of different moisture regimes on growth and yield of potato and explore the possibility of growing relay crops in spring potato (*Solanum tuberosum* L.) Mulching with pine needles significantly increased tuber yield, growth and yield attributes. Optimum moisture regime (irrigation at IW / CPE ratio of 1.0) resulted in significantly higher tuber yield, growth and yield attributes. Rajmash was grown successfully as relay crop in spring potato resulting in significantly higher potato equivalent yield and net returns.

Key words : Potato, Moisture regimes, Relay/inter cropping.

INTRODUCTION

Potato occupies an important place in the economy of Himachal Pradesh. Because of favorable environmental conditions, State enjoys natural advantages in respect of potato production. Potato is quite exacting in its input requirements which must be met for the full realization of its potentialities. One such input is water and main reason for low yield of spring potato in Himachal Pradesh is lack of proper scheduling of irrigation and poor water management practices. Sprouting in potato can initiate and progress even in dry soils on account of high water content, but emergence of sprouts above ground is delayed in such conditions. Excess soil moisture is equally harmful as it lowers the soil aeration and may also favour certain diseases and pests. Recently, the climatological approach is considered the most reliable device in which scheduling of irrigation is based on cumulative pan evaporation (Sharma and Dixit, 1992).

The spring crop is also exposed to very low temperature in the early stages before emergence and to high temperatures during tuber development. Mulching have been reported to moderate soil temperature and conserve moisture in the soil, thereby helping in reducing the adverse effects of low and high temperatures and improving the yield (Jaiswal,1995). Spring season is good for short duration pulses and can be beneficial in increasing the income by growing them as intercrop/relay crops in spring potato. Intercropping of Rajmash with potato has been successfully demonstrated by Massod and Kushwaha (1987). Keeping in view these factors the present investigation was carried out to work out suitable moisture regime/irrigation schedule and intercrop/relay crop for spring potato under mid hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The experiment was conducted during the spring seasons for two years at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated 32.6° N and 76.3° E at an elevation of 1291.0 m above mean sea level which falls in the mid-hill zone of the Shiwalik ranges of Himachal Pradesh. The soil of the experimental site was silty clay loam in texture and acidic in reaction (pH 5.8) having 0.64% organic carbon, medium in available nitrogen (385.6 kg/ha), phosphorus (14.1 kg/ha) and potash (228.1 kg/ha).The experiment with ten treatments comprising of one control (without irrigation, mulch and relay crop) and nine combinations of three moisture regimes [M_0 - Rainfed with mulch of pine needles @ 10 t/ha, M_1 - Sub optimum (irrigation at IW / CPE ratio of 0.5), M_2 - Optimum (irrigation at IW / CPE ratio of 1.0)] and three relay crops [C_1 - Rajmash(*Phaseolus vulgaris*), C_2 - Moong (*Vigna radiata*), C_3 - Cowpea(*Vigna unguiculata*)] was laid out in randomized block design with three replications. IW (irrigation water) of 5.0 cm depth at one time was applied by calculating flow of water through regulated surface channel flow against time by furrow method and CPE (cumulative pan evaporation) was recorded with USDA open pan evaporimeter. Mulch was applied immediately after the planting of potato and partially rolled but replaced just after the earthing up and sowing of relay crops. Kufri Jyoti variety of potato was planted on January 2 and 22 during two years of experimentation. Potato was planted

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on ridges 5 cm deep and 20 cm apart. Ridge to ridge distance was kept as 50 cm. The crop was fertilized uniformly with 120 kg N, 80 kg P_2O_5, 60 kg K_2O and 20t FYM/ha. Nitrogen was applied in two splits, half at the time of sowing and half at the time of earthing up. One row of relay crop was sown in between two rows of potato in the first fortnight of April and followed standard package of practices. A rainfall of 261.9 and 413.5mm and evaporation of 731.4 and 724.1 mm from pan evaporimeter was recorded during 1st and 2nd years of experimentation. Mean weekly minimum and maximum temperature ranged from 3.0 to 20.9 ^{0}C and 11.5 to 33.1 ^{0}C during 1st and 3.7 to 22.4 ^{0}C and 12.9 to 32.8 ^{0}C during 2nd year respectively. Digging of potatoes was done in the first fortnight of June and on the very next day general crop of maize was sown in place of potato. Relay crops were harvested in the first week of July. Potatoes were graded as A, B and C on the basis of tuber weight i.e. >75, 50-75 and < 50g respectively.

RESULTS AND DISCUSSION

Growth and yield attributes

Emergence of shoots in mulched treatments was early and took significantly less number of days for emergence of shoots (Table 1). Optimum and sub optimum moisture regimes did not influence emergence of shoots and remained at par with control where no irrigation was applied. Since the crop was planted in the month of January when the temperatures are very low for the start of germination and emergence of potato shoots, the early start of emergence in mulched plots could be attributed to higher soil temperature due to mulching. Similar results have also been reported by Midmore *et al*. (1985). Similarly, other growth and yield attributes like plant height, number of shoots, fresh and dry weight of shoots and number of tubers were observed to be significantly more with application of mulch over control. Mulching proved to be at par with suboptimum moisture regime in respect of shoots/m^2. Such an improvement in growth parameters with mulching may be due to better soil moisture conservation and moderate soil temperature. The results are in conformity with the findings of Singh et al., (1987), Jaiswal (1995) and Khalak and Kumaraswamy (1992). Plant height, number of shoots, fresh and dry weight of shoots and tubers/m^2 recorded a significant increase of 56, 89, 191, 211, 50 percent under optimum and 28, 63, 117, 127 and 25 percent under suboptimum moisture regimes respectively over control. Difference in soil moisture under different moisture regimes influenced growth and yield attributes of potato. The results are in conformity with the findings of Tripathi and Misra (1984). Inter /relay crops did not influence growth and yield contributing characters of potato.

Yield and quality

The tuber yield was significantly higher with application of mulch over control (Table 2). Mulching also improved quality of tubers significantly by producing more percentage of A and B grade tubers than control. Optimum moisture regimes (IW/CPE ratio of 1.0) recorded significantly higher potato yield resulting in 133, 60 and 23 percent increase over control, mulching (M_0) and sub-optimum moisture regimes (M_1). Sub optimum moisture regimes proved to be better over mulching and control with an increase of 90 and 30 percent in tuber yield respectively. Superiority of optimum moisture (M_2) was also observed over control, M_0 and M_1 in respect of quality of tubers with significant increase in large (A-grade) and

Table 1 : Effect of moisture regimes and relay crops on growth and yield contributing characters of potato (Pooled data of 2 years).

Treatments	Days for start of emergence	Plant height (cm)	Number of shoots (m^2)	Fresh weight of shoots (g/m^2)	Dry weight of shoots (g/m^2)	Number of tubers (m^2)
Control	67.3	29.0	27.7	532.9	78.6	68.3
M_0C_1	58.4	32.7	44.3	905.3	136.8	76.1
M_0C_2	58.2	32.4	44.7	918.9	140.3	76.4
M_0C_3	59.1	32.9	45.3	907.8	137.3	75.8
M_1C_1	67.5	37.0	44.3	1159.4	179.3	84.8
M_1C_2	67.4	36.4	45.8	1147.2	176.1	86.2
M_1C_3	67.6	37.6	45.5	1165.4	180.2	85.6
M_2C_1	64.9	45.3	51.5	1544.3	243.1	101.5
M_2C_2	65.2	44.8	52.2	1544.4	242.7	102.4
M_2C_3	65.4	45.7	53.2	1574.2	247.7	102.1
CD (P=0.05)	3.4	2.7	4.8	165.8	9.3	6.7

Table 2 : Effect of moisture regimes and relay crops on potato yield and potato equivalent yield (Pooled data of 2 years).

Treatments	Potato tuber yield (q/ha)	A grade (Large sized) (q/ha)	B grade (Medium sized) (q/ha)	C grade (Small sized) (q/ha)	A grade (%)	B grade (%)	C grade (%)	Yield of relay crops (q/ha)	Potato equivalent yield (q/ha)
Control	89.03	21.59	27.82	39.63	24.3	31.2	44.5	-	89.03
M_0C_1	127.85	34.73	42.07	51.05	27.2	32.9	39.9	4.7	146.06
M_0C_2	131.87	37.83	42.18	51.86	28.7	32.0	39.3	-	131.87
M_0C_3	129.16	35.17	43.53	50.47	27.2	33.7	39.1	-	129.16
M_1C_1	167.59	62.15	56.91	48.53	37.1	34.0	29.0	5.23	187.86
M_1C_2	170.78	63.18	58.90	48.70	37.0	34.5	28.5	-	170.78
M_1C_3	169.44	61.70	57.43	50.32	36.4	33.9	29.7	-	169.44
M_2C_1	207.53	114.66	66.20	26.67	55.2	31.9	12.9	6.71	233.53
M_2C_2	207.68	114.92	64.75	28.02	55.3	31.2	13.5	-	207.68
M_2C_3	208.75	114.95	67.93	25.88	55.1	32.5	12.4	-	208.75
CD (P=0.05)	11.02	4.42	4.50	5.49	2.8	NS	4.2	-	14.67

medium (B-grade) sized potato. Optimum moisture regimes further proved its superiority by producing a significantly higher percentage of A-grade and lower percentage of C-grade tubers. Although tuber yield is directly related to number of tubers per m^2 but size of tubers also largely contributes for tuber yield. More quantity of A grade tubers under optimum moisture regimes could be attributed to better soil moisture at the time tuber development. Percentage of medium sized potato tubers was not influenced by different moisture regimes. Similar results were also reported by Khalak and Kumaraswamy (1992). Effect of relay crops was not observed on yield and quality of potato tubers.

Since the relay crops of moong and cowpea failed after germination, may be due to smothering effect of potato crop or high water requirement of cowpea, yield of Rajmash was recorded under different moisture regimes. Optimum moisture regime resulted in highest yield of Rajmash (6.7 q/hq) which was followed by sub optimum (5.2 q/ha) and Mulching (4.7 q/ha). Masood and Kushwaha (1987) also reported successful cultivation of rajmash with potato. Potato equivalent yield from M_2C_1 (optimum moisture with Rajmash) was significantly higher and proved to be superior among optimum moisture regimes.

Water use and economics

Quantity of water used during crop season (Table 3) was highest under optimum moisture regimes (66 cm) followed by suboptimum (51cm), control (39 cm) and mulching (35cm) treatments. Relay crops did not influence water used by potato crop. These effects could be due to

Table 3 : Effect of moisture regimes and relay crops on water use and economics of potato (Pooled data of 2 years)

Treatments	Water use (cm)	Water use efficiency (kg/ha-cm)	Net returns (Rs/ha)	Benefit: Cost ratio
Control	38.6	22.81	-499	-0.05
M_0C_1	35.2	36.00	6707	0.42
M_0C_2	35.2	37.15	4179	0.26
M_0C_3	35.2	36.39	3835	0.24
M_1C_1	50.5	33.18	13454	0.87
M_1C_2	50.5	33.81	10455	0.67
M_1C_3	50.5	33.54	10316	0.67
M_2C_1	65.8	32.61	20296	1.29
M_2C_2	65.8	32.65	15825	1.01
M_2C_3	65.8	32.80	16047	1.03
CD (P=0.05)			283	0.13

higher availability of water under optimum and suboptimum moisture regimes and less evaporation losses with mulches. However, water use efficiency expressed as yield per hectare per centimeter of water used was highest with the application of mulch. Water use efficiencies of optimum and sub optimum moisture regimes were higher than control, but did not differ much from each other. The differences in water use efficiency are due to yield and water use under different treatments. Similar trend in net returns and benefit cost ratio was observed. Significantly higher net returns of Rs 20296.00 per hectare with a cost benefit ratio of 1.29 were recorded from M_2C_1 (optimum moisture + Rajmash). Sowing crop under rainfed condition resulted in loss of Rs 499 with C: B ratio of -0.05. Net returns decreased significantly with the decrease in moisture regimes

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