Journal of Agrometeorology 5 (1) : 60-67 (June 2003)

Tuber yield of potato as influenced by planting dates and mulches

GOURANGA KAR

Water Technology Centre for Eastern Region (I. C. A. R.), Bhubaneswar-23

ABSTRACT

In coastal Orissa, after *khairf* rice, farmers do not get good potato yield because of prevailing unfavourable thermal environment during sowing and harvesting periods. Feasibility of growing potato late in the season by modifying micro environment with organic mulching was studied. Biomass, crop growth rate, photosynthesis were found to be the highest when sowing was done during last week of October and mulch was applied during first earthing up. Significant difference in biomass, tuber production and water use efficiency was observed between mulch and non mulch plots when sowing was completed within first fortnight of November.

Key words: Potato, Growth dynamics, Mulches, WUE.

In coastal Orissa, December is the coldest month with mean maximum and minimum temperature of 27.5° C and 15.9° C, respectively. In general for *kharif* crop cultivation, in these regions temperature is not a constraint, but under normal conditions, rapid rise of temperature in February is a constraint for many cold sensitive *rabi* crops like potato, wheat, barley, chick pea, Brassica etc. Being a temperate crop, potato growth and yield are highly affected by higher temperature, specially mean temperature above 17°C (Mendoza and Estrada, 1979). Potato is grown in the countries where day length is 13 to 17 hours, average temperatures prevails around 15° to 18°C and rainfall or irrigation provides ample water supply (Ben Khedher and Ewing, 1985). Tuber initiation and bulking of potato are favored by temperature below 20°C (Borah and Milthrope, 1962). In coastal Orissa after kharif rice, farmers do not get good potato yield because of prevailing unfavorable thermal environment during sowing and harvesting period. In early planting (mid October), emergence is affected due to higher temperature and in late planting (December), tuber bulking is restricted because of prevalent high temperature in the later part of the crop growth period. As a result, tuber yield is reduced with the shortening of tuber bulking period and total crop duration is ultimately reduced. Keeping the importance of photo thermal environment for tuber yield production in view, the present study is aimed at examining the feasibility of growing potato by modifying micro environment with organic mulching. Water use efficiency, photosynthesis of the crop were studied in relation to potato tuber production and crop growth dynamics under different photo-thermal environments.

MATERIAL AND METHODS

A field experiment was conducted in

sandy loamy soils of central research farm of Water Technology Centre for Eastern Region, Bhubaneswar (Orissa state) during two *rabi* seasons of 1997-98 and 1998-99. Treatments consisted of mulching 3 (M_0, M_1, M_2) and 3 planting dates (P_1, P_2, P_3). In the first *rabi* season (1997-98), potato variety 'Kufri Jyoti' was first sown (P1) on 31.10.97. while in second *rabi* season (1998-99), sowing was performed on 27.11.98. The second (P_2) and third (P_3) sowing were completed at 14 days interval. In order to modify micro-environment, rice straw mulch was applied @ 8 tons ha^{-1} at first (M_1) and second (M_2) earthing up operations of all the planting dates. The crop was grown with optimum irrigation, recommended fertilizers and others optimum agronomic management practices. The irrigation was applied at 50% of available water depletion. Five irrigations (6 cm depth) were applied to non mulch plots. For mulch plots 3 irrigations with 6 cm and one irrigation with 3 cm depth were applied. The experiment was laid out in randomized block design with 3 replications. The soil properties of the experimental site are given in Table 1.

To study the crop growth dynamics, the phenological observations were recorded on every alternate day. Based on emergence, shoot and tuber development, for our study growth of potato was divided into 5 distinct stages *viz.*, emergence (when 50% of plants in a plot emerged), early vegetative stage (early plant development, initiation of branching and it ends in the tuber initiation phase), tuberization (stage of formation of majority of tuber), tuber bulking (tuber enlargement to near maturity) and maturity. Plant samples from randomly selected 3 plants were collected at weekly interval and above ground biomass were determined using oven dry method. The leaf area was measured using leaf area meter (LI-3100). Crop growth rate and growing degree-days (5°C base temperature) were also determined for the study.

The photosynthesis rate for different planting dates and mulching was measured using portable photosynthesis system (LI-6200) on the first mature leaf of 5 plants and then averaged.

The water use by the crop was computed using the following water balance equation (Uttam and Das, 1983)

$$WU = I + P + 10Dp(m_1 - m_2)$$

Where WU is the seasonal water use (mm); I is the applied irrigation depth (mm), P is the precipitation (mm), D is the depth of soil layer for moisture measurement (m), p is the soil bulk density (mg m^{-3}); and m_1 and m_2 are the soil moisture contents (%) at the sowing and harvesting time, respectively. The soil moisture was computed using gravimetric method. The runoff and deep percolation loss of water were assumed to be zero. Water use efficiency was determined by dividing the tuber yield with seasonal water use. The ambient weather data were collected from automatic weather station of the research farm. Tuber yield of potato per unit area was collected at final harvest. The soil temperature was monitored at regular interval at 0-15 cm and 15-30 cm depth using soil thermometer.

Table 1 : Important physico-chemical properties of the experimental site.

Depth (cm)	Coarse sand (%)	Find sand (%)	Silt (%)	Clay (%)	B.D. (mg m^{-3})	pH	EC (dS m^{-1})	Org.C (%)
0-15	46.0	17.0	16.0	21.0	1.44	5.7	0.25	0.46
15-30	31.2	18.4	37.9	13.0	1.45	6.7	0.50	0.38
30-45	26.3	11.4	32.3	30.0	1.46	6.8	0.43	0.36
45-60	20.2	9.8	40.0	30.0	1.48	6.9	0.33	0.32
60-90	32.7	10.8	30.0	36.5	1.49	6.3	0.25	0.31
90-120	21.9	10.9	27.7	40.0	1.50	6.5	0.38	0.28
120-150	13.3	13.4	33.3	40.0	1.50	8.3	1.23	0.26

Table 2: Photo-thermal environments during different phenological stages of two crop seasons.

Phenological	Maximum temperature(°C)		Minimum temperature(°C)		Solar radiation (Wm^{-2})	
Stages	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
First sowing						
Emergence	29.8-32.1	26.1-27.5	19.5-22.7	17.8-18.5	734-705	534-550
Vegetative	31.1-33.4	26.8-28.8	22.1-22.9	18.8-20/8	605-680	530-650
Tuberization	27.9-30.8	23.3-25.9	19.9-20.2	13.8-14.8	618-672	569-678
Tuber Bulking	24.3-26.5	28.5-29.5	11.7-15.4	16.8-18.3	540-598	680-726
Maturity	29.5-32.4	31.4-32.9	19.8-20.6	18.1-20.5	607-668	720-738
Second sowing						
Emergence	30.1-31.5	25.3-27.2	21.1-21.5	15.8-17.3	572-695	650-660
Vegetative	30.8-32.8	24.4-26.7	19.5-20.2	13.7-15.8	560-575	540-657
Tuberization	26.9-29.6	28.2-30.2	16.3-18.1	14.3-16.9	540-622	592-690
Tuber Bulking	23.4-26.9	29.5-32.7	16.1-22.2	17.1-18.5	638-692	693-732
Maturity	29.9-33.8	31.3-33.8	15.4-18.2	18.1-19.3	660-715	736-750
Third sowing						
Emergence	26.5-29.7	24.9-25.7	18.8-20.6	15.2-15.4	505-545	530-550
Vegetative	25.3-28.1	23.8-25.9	22.8-25.3	18.1-20.2	515-660	536-556
Tuberization	25.8-29.3	27.8-29.3	14.9-17.4	16.9-18.5	540-680	628-660
Tuber Bulking	30.5-32.3	31.2-33.8	18.1-20.2	20.5-20.9	615-695	650-728
Maturity	31.2-33.9	32.8-34.9	18.2-22.8	20.1-21.5	708-720	728-836

Table 3: Duration of phenoogical stages as affected by sowing dates and mulching

		Germination	vegetative	Tuberization	Tuber bulking	Maturity	Total
First Planting:							
M_0	Y1	11	22	16	22	11	82
	Y2	11	21	14	19	11	76
M_1	Y1	10	22	15	34	11	92
	Y2	09	24	15	27	10	85
M_2	Y1	11	21	15	30	12	89
	Y2	10	22	15	24	11	82
Second Planting:							
M_0	Y1	11	17	13	22	10	73
	Y2	09	18	11	23	10	71
M_1	Y1	11	16	13	30	11	81
	Y2	09	19	14	24	10	74
M_2	Y1	11	21	15	29	12	88
	Y2	10	18	12	23	11	74
Third Planting:							
M_0	Y1	12	18	14	21	10	75
	Y2	10	19	12	21	10	72
M_1	Y1	11	17	13	26	10	78
	Y2	10	20	14	22	10	76
M_2	Y1	09	20	14	25	12	80

M_0 = No mulching M_1 = Mulching during first earthing up M_2 = Mulching during second earthing up

RESULTS AND DISCUSSION

Weather and phenological stages

The temperature trend revealed that in the first *rabi* season during early vegetative and tuber initiation phase of the first sown crop , the maximum and minimum ambient temperatures were 3-4°C higher (Table 2) and during tuber bulking stage (after 55 days) crop experienced 4-5°C lower maximum and minimum ambient temperatures than that of second *rabi* season. In second season, tuber bulking stage was mostly affected and duration was shortened by 6-12 days because of 3-4°C higher ambient temperature at this stage than that in the first season. It was also revealed that because of 3-4°C difference of soil temperature between mulch and non-mulch plots, tuber bulking stage was shortened by 10-12 days

Table 4: Soil moisture depletion and water use efficiency of potato as influenced by mulching and sowing dates.

Treat ments	Profile moisture depletion (mm)					Total moisture depletion (mm)	Irriga-tion (mm)	Mean seasonal water use (mm)	Mean tuber yield (kg ha^{-1})	Mean WUE (kg ha^{-1} mm)
	0-15m	15-30m	30-45m	45-60m	60-90m					
M_0P_1	41.6	43.9	42.4	40.1	67.6	235.6	300	535.6	11000.3	20.5
M_0P_2	41.1	40.4	49.3	40.6	66.4	237.8	300	537.8	8000.3	14.8
M_0P_3	41.3	39.3	40.7	40.3	69.4	231.0	300	531.0	5000.2	9.4
M_1P_1	34.1	37.4	39.3	35.6	73.4	219.0	210	429.0	13000.3	30.3
M_1P_2	35.1	36.1	38.4	36.3	67.3	213.2	210	423.2	10000.8	23.6
M_1P_3	36.1	37.1	38.9	40.9	65.3	218.3	210	428.3	8000.9	18.6
M_2P_1	36.3	39.3	40.1	39.3	71.4	226.4	210	436.4	10000.3	22.9
M_2P_2	35.3	36.9	37.3	38.8	58.3	206.0	210	416.0	8000.1	29.2
M_2P_3	39.3	36.3	38.3	38.5	61.9	214.3	210	424.3	6000.9	14.1

(Table 3) in non-mulch plots as compared to mulch plots, when sowing was completed within first fortnight of November. The difference of duration was not significant between mulch and non-mulch plots in third sown plants of first season and all the sowings of second season. Though in mulch plots soil temperature was 3-4°C less than that of non-mulch plots (Fig. 1), but higher ambient temperature during tuber bulking stage of the crop might have affected crop growth duration when sowing was done after first fortnight of November.

Soil moisture depletion and water use efficiency

Study revealed that mean seasonal water use was higher in non-mulch plots for all the sowings (Table 4), ranging form 416 mm in M_2P_3 to 538 mm in M_0P_2. Higher water utilization efficiency (30.3 kg ha^{-1} mm^{-1}) was achieved in case of first sown plants when mulch was applied during first earthing up.

The crop growth rate of potato from pooled data of both the seasons was determined and is presented in Fig. 2. Results revealed that the highest crop growth rate of 10.7 gm^{-2} was observed at 63-70 DAS in the first sown crop when mulch was applied during first earthing up as expected like in the case of leaf area, biomass etc.

Photosynthetic rate

The photosynthetic rate throughout the crop growth period was measured and values at 10 days interval were presented in Table 5. Maximum photosynthetic rate (29.4 µmole m^{-2} s^{-1}) was observed at 70 DAS in first planting of first season when straw

Table 5: Photosynthetic rate (μmol m^{-1} s^{-1}) as influenced by mulching and sowing dates. (Y1 = 1996-97; Y2 = 1997-98)

Treatment		40 DAS	50DAS	60DAS	70DAS	80DAS
First planting:						
M_0	Y1	16.5	18.3	19.4	21.3	20.1
	Y2	12.8	14.7	19.1	19.9	17.1
M_1	Y1	18.4	20.6	22.4	29.4	23.8
	Y2	16.8	17.2	21.5	23.1	21.3
M_2	Y1	17.1	19.2	21.1	26.8	21.5
	Y2	14.8	16.9	20.8	22.8	21.1
Second planting:						
M_0	Y1	14.3	16.5	17.9	19.8	18.1
	Y2	11.8	13.7	18.1	17.8	14.1
M_1	Y1	16.2	18.6	20.4	25.2	19.8
	Y2	14.3	16.2	19.9	19.1	17.2
M_2	Y1	16.1	17.2	19.1	23.8	19.4
	Y2	13.8	15.1	19.8	18.7	16.9
Third planting:						
M_0	Y1	13.9	15.7	17.4	20.4	18.3
	Y2	12.3	14.7	18.3	17.1	13.9
M_1	Y1	17.1	18.4	18.9	22.8	18.8
	Y2	13.9	15.1	18.7	18.1	14.1
M_2	Y1	14.1	16.1	17.1	19.8	16.3
	Y2	13.9	14.8	17.8	18.2	13.7

mulch was applied during first earthing up. There was 32.3 percent reduction of photosynthesis rate in non mulch plots for that sowing as compared to the plots where mulch was applied during first earthing up. The photosynthesis rate gradually decreased as sowing was delayed. Significant reduction in photosynthetic rate was found between mulch and non mulch plots when sowing was completed within first fortnight of November, after that no difference was found as in the case of leaf area index or above ground biomass production.

Tuber yield

In the first season, there were 15-41% and 13-25% increase in tuber yield in different sowings (Table 6) when mulches were applied at the first and second earthing up, respectively over non mulched plots. There was drastic reduction of yield in control plots when potato was sown in last week of November or after that. In second

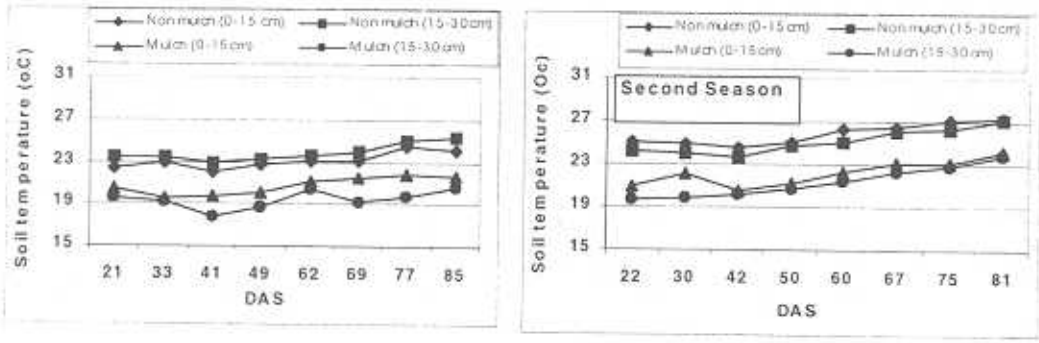

Fig. 1 : Variation of soil temperature at two depths (0-15 & 15-30 cm) in mulch and nonmulch plots.

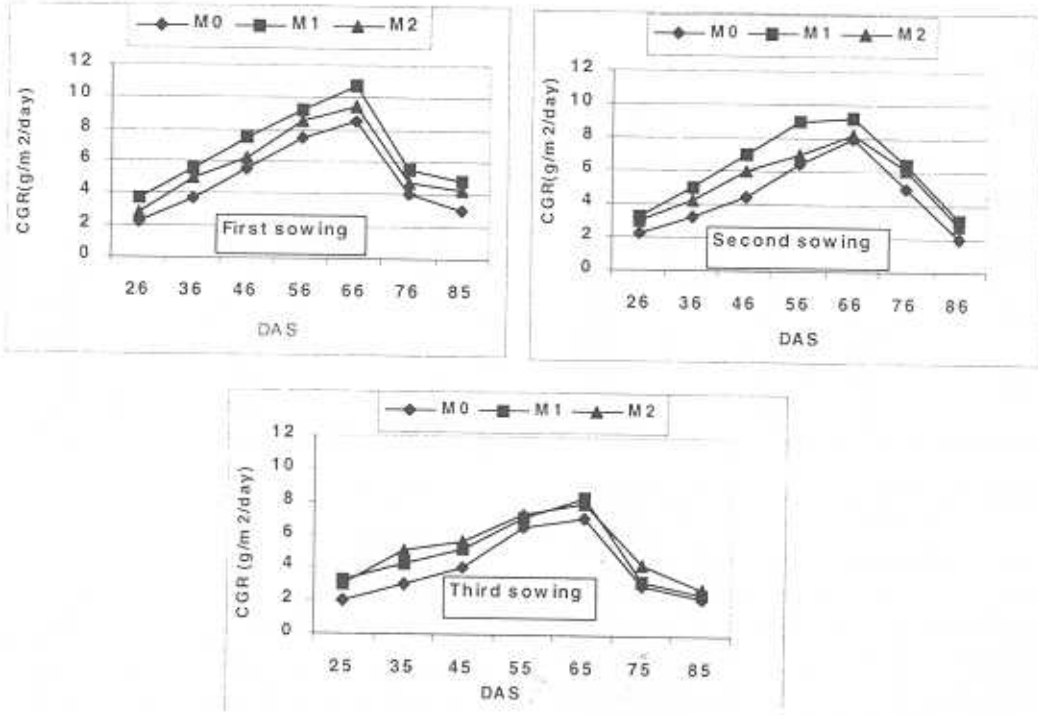

Fig. 2 : Crop growth rate (CGR) of potato as influenced by mulching and sowing dates. (Drawn from pooled data of both years).

Table 6: Tuber yield (t ha^{-1}) production as affected by planting dates and mulching.

Plantings	Season	Mulching		
		Mo	M1	M2
P1:	1997-98	11.3	13.3	10.3
	1998-99	8.5	11.5	10.5
P2:	1997-98	8.3	10.8	8.1
	1998-99	6.5	7.0	7.0
P3:	1997-98	5.2	8.9	6.9
	1998-99	5.5	6.0	5.5
Mean:	1997-98	8.2.	11.0	9.1
	1998-99	6.8	8.1	7.6
S.E.m(±)	1997-98	8.2	11.0	9.1
	1998-99	6.8	8.1	7.6

year, yield was reduced by 23-39% in second sowing over first sowing. It could be due to high day/night temperature during tuber bulking stage of the late sown crop. There was no significant difference in tuber yield production between mulch and non mulch plots when sowing was done after November. In the first planting of second year, yield was increased by 19-26% due to mulching but in second and third sowings, there was no significant difference in tuber yield production between mulch and non mulch plots.

REFERENCES

Borah, M. N. and Milthrope, F. L. 1962. Growth of the potato as influenced by temperature. *Ind. J. Plant Physiol.*, 5: 53-72.

Ben Khedher, M. and Ewing, E. E. 1985. Growth analysis of eleven potato cultivars grown in the greenhouse under long photoperiods with and without that stress. *Am Potato J.*, 62: 537-54.

Marinus, J. and Bodlaender, K. B. A. 1975. Response of some potato of some potato varieties to temperature. Potato Res., 18: 189-204.

Mendoza, H. A and Estrada, R. N. 1979. Breeding potatoes for tolerance to stress: Heat and Frost. In: Mussell, H. and R. C. Staples (Eds.). Stress physiology in crop plants. John Willey and Sons. pp: 227-62.

Uttam, S. K., and Das, S. K. 1983. Moisture use, yield and root development of rainfed wheat in relation to moisture conservation practices in eroded soils of central U. P. *Ind. J. Soil Cons.* 21(1) 7-13.