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Factors associated with reduced yield of delayed planting of potato (*Solanum tuberosum* L.) in middle Gujarat agro-climatic region

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ABSTRACT

Results of three years (1994-95 to 1996-97) field experiments on potato (*Solanum tuberosum* L.) revealed that significantly higher tuber yield was obtained from D_1 (3rd week of November) followed by D_2 (1st week of December) and D_3 (3rd week of December) planting. There was non-significant effect on yield due to cultivar (V_1- Kufri Badshah and V_2- K. Lauvker) and early blight management treatment (S_0-control, S_1-one spray of mancozeb @ 0.2 % and S_2- two sprays of mancozeb @ 0.2 %). Seasonal effects on yield are very large. The relationship between various weather parameters and final tuber yield suggests that D_1 planting would be optimum for potential tuber yield. Weekly evaporation rate in the range of 2 to 5 mm during yield formation (P_3) and ripening phase (P_4), maximum temperature in the range of 25 to 30 °C during vegetative (P_2), P_3 and P_4 phases, minimum temperature in the range of 8 to 14 °C during P_3 and P_4 phase, mean air temperature in the range of 17 to 22 °C during P_3 to P_4 phases and mean relative humidity in the range of 49 to 56 per cent during P_3 phenophase of the crop were found to be optimum and effective for obtaining potential tuber yield in the region.

Key words: Potato, Delayed planting, Weather, Phenophases

Crop production depends on several agronomic factors. Amongst them planting time has its own significance in any crop management. Krishnappa (1991) and Sharma *et al.* (1995) reported that timely planting of potato leads to higher yields and delay in planting results in lower yield. Among all the climatic conditions, temperature has been identified to have a direct bearing on the expression of yield in this crop.

Potato is a temperate zone crop and well adapted to mean temperature of 17 °C as studied by Bushnell (1925). Mendoza and Estrada (1979) stated that high temperatures, like those encountered in the tropics and subtropics, cause severe yield reduction and are considered a major environmental constraint for its production. Ewing (1981) observed that in most of the currently available cultivars, tuber initiation and bulking are favored by temperatures below 20 °C. Temperature in excess of 18-20 °C tend to stimulate haulm growth and depress both tuber initiation and bulking as reported by Ben Khedher and Ewing (1985), Borah and Milthorpe (1962), Bushnell (1925) and Marinus and Bodlaender (1975).

Borah and Milthorpe (1962), Doorenbos and Kassam (1979) observed that tuber initiation is enhanced and number of tubers per plant is higher at low temperatures than at high temperatures. This is especially so for night temperatures of 10-15°C. Marinus and Bodlaender (1975) obtained highest number of tubers at 16 °C. It has long been recog-

nized that the temperature in the range of 15 to 16 °C is optimum for better tuber yield of potato. High night temperatures also seem to decrease the yield more than the high day temperature. In controlled environment Gregory (1956) obtained higher yield at 30/17 °C (day/night) than at 23/23 °C. Murti *et al.* (1976), and Pushkarnath (1976) observed maximum tuberization at mean temperature about 20 °C and inhibited yield at temperature above 29 °C. Borah and Milthorpe (1962) stated that the failure of American varieties to form tubers at temperature of 26-29 °C, is due to higher respiration rates than compared to photosynthesis. This leads to a smaller amount of carbohydrates being available for tuber formation. Ezekiel and Bhargava (1992) reported that under short day condition of sub-tropics of North India, higher tuber yield in optimum planting date (i.e., October 21) was due to higher total dry matter as a result of greater leaf area index (LAI) and crop growth rate(CGR). In delayed planting, LAI and CGR were adversely affected.

In the state of Gujarat in India, potato crop is planted in early rabi season (mid November) and harvested in mid-February or planted in late rabi season (mid-December) and harvested in mid-March. In either case, part of the growing season encounters unfavorable weather conditions. In early plantings, emergence is affected due to high temperatures in early part of the growing season; also due to low temperatures during later part of the growing season crop duration gets prolonged. As against this, in late planting emergence gets inhibited due to low temperatures and because of high temperatures that prevail in the later part of the growing season tuber yield is reduced with shortening of crop duration and the tuber bulking period. Considering the significance the present investigation on potato crop was undertaken in three consecutive years (1994-95 to 1996-97) at Agronomy Farm, B.A. College of Agriculture, Anand (22° 35' N; 72 ° 55' E).

MATERIALS AND METHODS

The investigation was carried out in split plot design with four replications. Main plot comprised of three dates of planting (D_1- 3rd week of November, D_2-1st week of December and D_3-3rd week of December). In sub plot treatment two local grown cultivars (V1-Kufri Badshah and V_2- Kufri Lauvker) with three treatments of early blight management (S_0-No spray, S_1- one spray of recommended fungicide (Mancozeb @ 0.2 %) at the time of appearance of disease symptoms and S_2- first spray at the time of appearance of disease symptoms and second spray on 15th the day of first spraying) in a plot size of 4.00x2.25 m. Planting distance was kept 45x20 cm. Crop was fertilized with 220-110-220 NPK kg ha $^{-1}$ uniformly. The soil at the experimental site was of alluvial in origin having sandy loam texture with bulk density 1.5 g cc^{-1} and pH 8.1. Transplanting was carried out by wet method. Weekly weather data from the Agromet Observatory situated adjacent to the experimental site have been used. Four phenological phases as mentioned by Doorenbos and Kassam (1979) were identified. They are P_1- establishment period, P_2- vegetative phase, P_3- yield formation and P_4-ripening phase. The base temperature employed in this investigation was 4.4 °C as used by Benoit and Grant (1980) and Saeed (1994).

RESULTS AND DISCUSSION

Effects on tuber yield

Results revealed significant yield differences in different planting dates, whereas varieties, as also treatments imposed for early blight

management was non-significant (Table 1).

Significantly higher tuber yield was obtained from D_1 planting (3rd week of November) followed by D_2 (1st week of December) and D_3 (3rd week of December) planting. Nearly 14 and 38 per cent higher tuber yield was recorded in D_1 planting than D_2 and D_3 plantings respectively. Lowest tuber yield was recorded in the year 1995-96. The relationship between planting time and tuber yield established by Krishnappa (1991), Sharma *et al.* (1995) and Ezekiel and Bhargava (1992) were in good agreement with these results. Planting date is one of the important management practices influencing potato yield.

Tuber yield and weather parameters

The phenophase wise average weekly weather parameters and final tuber yield of D_1 planting were correlated (Table 2). Results show that evaporation rate during P_3 and P_4 stage of the crop, is significantly and negatively correlated with final tuber yield. This result suggests that late sown crop (D_3 planting) experienced very high evaporative loss during later stage (P_3 and P_4 stage) of the crop which is reflected in poor tuber yield. Maximum temperature is significantly and negatively correlated in all the phases except in the crop establishment phase (P_1). Lower maximum temperature (25.0 to 30.0 °C) during yield formation phase in D_1 planting might have helped in good tuber formation. Bushnell (1925), Murti *et al.* (1976), and Pushkarnath (1976) also stated that temperatures above 29.0 °C hinder tuber production.

The minimum temperature that prevailed during P_2 to P_4 phase of the crop is significantly and negatively associated with tuber yield. This indicates that magnitude of minimum temperature in the range of 8.0 to 14.0 °C during P_2 to P_4 stage might have helped in good tuber initiation and bulking. Doorenbos and Kassam (1979), Marinus and Bodlaender (1975). The tuber yield from D_2 and D_3 planting might have been adversely affected due to effect of higher minimum temperature compared to D_1 planting.

Mean air temperature that prevailed during P_3 and P_4 stage of the crop, significantly and negatively correlated with tuber yield. This indicates that mean air temperature in the range of 17.0 to 22.0 °C during P_3 and P_4 stage of the crop is optimum for better tuber yield. Mean relative humidity in P_2 phase of the crop is significantly and negatively correlated with yield. This suggests that mean relative humidity in the range of 49 to 56 % during vegetative phase may be beneficial for better tuber yield in D_1 planting, whereas reverse trend was noticed for D_2 and D_3 planting.

Growing degree days (GDD) and yield variation

The results obtained in the present study from the accumulated growing degree days from planting to completion of respective stages of the crop as well as for entire season for individual years for different planting dates are presented in Table 3. Results show that higher growing degree days were accumulated in all the phenological phases and also for entire season in the year 1995-96 in all the dates of planting than compared to rest of the years. This may be the reason for poor tuber yield in the year 1995-96. Late sown planting (D_3) accumulated very low growing degree-days during establishment and vegetative phases while during reproductive phase it recorded very high GDD. This leads to poor yield in D_3 planting. D_1 and D_2 planting experienced totally reverse situation than compared to D_3 planting. The average GDD in D_1, D_2

Table 1: Tuber yield of potato as influenced by planting dates, varieties and number of mancozeb (0.2%) sprays

Treatments	Tuber Yield (t ha^{-1})			
	1994 – 95	1995 – 96	1996 – 97	Pooled
Planting dates (D)				
D_1	30.53	18.50	37.57	28.87
D_2	25.32	15.49	35.02	25.28
D_3	20.15	7.92	26.98	18.35
S. Em.	1.89	0.78	1.29	0.79
CD at 5%	6.53	2.70	4.47	2.36
CV %	36.51	27.59	19.05	27.89
Varieties (V)				
V_1	28.45	15.26	34.39	26.03
V_2	22.22	12.67	31.99	22.30
S. Em.	1.02	0.38	0.46	0.88
CD at 5%	2.91	1.09	1.32	NS
Spraying (S)				
S_0	26.20	12.79	25.50	21.50
S_1	24.72	13.82	35.57	24.71
S_2	25.09	15.28	38.51	26.29
S. Em.	1.25	0.47	0.57	5.13
CD at 5%	NS	1.33	1.61	NS
CV %	24.10	16.52	8.35	16.92

Table 2: Correlation coefficients between tuber yield and weekly weather parameters during different phenological stages of the crop

Weather parameters	Phenological stage			
	P_1	P_2	P_3	P_4
Evaporation	-0.06	0.19	-0.40**	-0.57**
Max. temp.	0.10	-0.70**	-0.28**	-0.40**
Min. temp.	-0.19	-0.44*	-0.42**	-0.62**
Mean temp..	-0.04	-0.25	-0.38**	-0.55**
Mean RH.	-0.11	-0.73**	0.17	0.36

* Significant at 1% level
** Significant at 5%level
P_1: Establishment phase
P_2: Vegetative phase
P_3: Yield formation phase
P_4: Ripening phase

Table 3: Growing degree days (GDD) required to attain various phenophases

Phenophase	Dates of planting									Mean	SD	CV%
	D_1			D_2			D_3					
	94-95	95-96	96-97	94-95	95-96	96-97	94-95	95-96	96-97			
P_1	378	374	355	332	355	336	314	236	235	313	65.3	20.8
P_2	203	242	223	205	236	219	182	232	205	126	19.2	8.8
P_3	730	784	710	749	803	725	793	818	769	765	37.9	4.9
P_4	228	259	232	254	287	288	277	324	306	273	32.4	11.8
Accu. GDD	1539	1659	1520	1540	1681	1568	1466	1610	1515	1566	17.7	4.5

Table 4: Yearly growing degree days (GDD) required to attain various phenophases

Phenophase	Years			SD	CV%
	1994-95	1995-96	1996-97		
P_1	308	322	309	7.8	2.5
P_2	197	237	216	20.0	9.3
P_3	757	802	735	34.1	4.5
P_4	253	290	275	18.6	6.8
Accu. GDD	1515	1651	1535	73.4	4.7

and D_3 were 1573, 1596 and 1530 respectively with the CV as 2.14% indicating that the accumulated GDD utilized by the crop was constant irrespective of dates of planting.

The year-wise accumulated GDD for different phenophases are presented Table 4. Prevalence of GDD in different phases and for entire season recorded were high in 1995-96 than in 1994-95 and 1996-97, with an overall CV of 4.68%. The results indicate that higher minimum and mean air temperature during tuber formation and maturity phases of the crop are unsuitable and may adversely affect the final tuber yield.

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