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Effect of Sowing Windows on Growth Functions and Dry Matter Accumulation

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Abstract: *The field trial was conducted during both the seasons (2009-10 and 2010-11) on PGI Farm without changing randomization. The experiment was laid out in* rabi *season. The various components of growth functions viz. absolute growth rate, crop growth rate, relative growth rate, net assimilation rate, leaf area index, leaf area duration were calculated at an interval of 28 days on the basis of dry matter accumulation. The highest AGR and CGR was found near the crop with mulching and five irrigations. A positive linear correlation existed between the AGR and CGR 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 AGR and CGR 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 growth indices such as LAI and final yields, a useful index of crop productivity can be obtained by computing the growth functions as shown by this study. Analysis of the relationship between dry matter production and AGR and CGR 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 accumulation of dry matter but also conversion of this into AGR and CGR due to its complimentary effect in better use of natural resources like light, soil moisture. AGR and CGR related with amount of dry matter produced by crop, as increasing the number of irrigation and early planting with mulching, as the amount of dry matter produced by crop and converted into AGR and CGR.*

Key words: *sowing window, dry matter, AGR and CGR*

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 crop grown in our country having high productivity and supplementing food needs. (Gupta, 2006). 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 AGR and CGR as Influenced by sowing windows in potato.

MATERIAL 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

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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

Determination of Absolute Growth Rate (g day^{-1}): The rate of increase in growth variable *i.e.* weight of dry matter (W) at the time (t) is called as absolute growth rate (AGR) for total dry matter (TDM) accumulation plant^{-1}. It is measured as differential coefficient with respect to time. It is the total gain in weight by a plant within a specific time interval and expressed as g day^{-1} for TDM accumulation plant^{-1} and is calculated by the formula given by Richards (1969).

$$AGR\,(g\,day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the total dry matter weight (g) at time t_2 and t_1, respectively.

Determination of Crop Growth Rate (g m^{-2} day^{-1}) : Crop Growth Rate (CGR) is a widely used characteristic of production efficiency of plant stand, which enables the comparison to be made between the plant stand and communities of different types in different habitat. (Hunt, 1978). Moreover, CGR is the accumulation of total dry matter per unit of land area per unit of time, (Watson, 1952). The CGR is expressed in g m^{-2} day^{-1} and calculated by the formula, as given below.

$$CGR\,(g\,m^{-2}\,day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times Number\ of\ plants\ per\ m^2$$

where, W_2 and W_1 are the total dry matter weight (g) plant^{-1}at time t_2 and t_1, respectively.

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 Absolute Growth Rate (g day^{-1}): The data pertaining to AGR, on the basis of pooled analysis study in potato (Table 1 to 2) revealed that all the growth functions *viz.,* mean AGR, and CGR plant^{-1} were conspicuously increased from initial stage up to 56 DAP of crop. Moreover, numerically mean maximum values of all the growth functions were observed during grand growth and tuber development phase of crop. Irrigation scheduled at 1.2 IW/CPE and planting on 44th MW (I_3D_2) recorded numerically highest mean values of all these growth functions, whereas Irrigation scheduled at 0.8 IW/CPE and planting on at 46th MW (I_1D_3) treatment exhibited numerically lowest mean values of them throughout the stages of crop growth during both seasons. It might be due to sufficiently available soil moisture from initial growth stage up to maturity phase with high frequency irrigation level and planting on 44th MW. This might be due to the favourable climatic condition available during crop growth period that improved the leaf area and total dry matter of potato crop, which led to record maximum values of these growth functions under higher moisture regimes.

It is observed from the data presented in Table 1 that on pooled basis, planting on 44th MW, the irrigation scheduled at 1.2 IW/CPE (I_3D_2) was comparable with 1.0 IW/CPE (I_2D_2) and exhibited and produced significantly higher mean values of the gradewise yield of tubers, total fresh tuber yield and haulm yield (q ha^{-1}) than rest of the treatments.

The tuber production which reduced by the effect of water stress on stem growth and reduction in number of branches, as well to a limited extent it effect on the tubers themselves. In potato, increased tuber production was more phenomenal with adequate irrigation, since the percentage of bigger tubers was more in irrigated plants than in un-irrigated plants. The maximum tuber yield was recorded in 44th MW, which was decreased as delayed in planting, this might due to the favourable climatic conditions during the crop growth period of early planting during 56 to 84 days the minimum temperature was 8.7-9.7°C. The beneficial effect of early planting might be associated with the prevalence of low temperature during the tuber development stage. The results corroborate the findings of Ghosh and Gupta (1973), Birhman and Verma (1980), and Sharma and Verma (1987). Shiri-*e*-Janagard *et al.* (2009).

Water deficit affects crop growth depending on the stage of growth and the degree or intensity of water stress. Dry matter production is known to be affected significantly by soil moisture stress. Patel *et al.* (2000) noticed significant increase in CGR with successive increase in number of irrigations. Likewise, the beneficial effects of increased irrigation frequency on the improvement of all the growth functions in potato crop were also reported by many research workers at different locations along with favourable climatic condition available during crop growth period. The results corroborate the findings of Gronowicz *et al.* (1992) and Shiri-*e*-Janagard *et al.* (2009).

It is observed from the data presented in Table 1 to 2 that during both the years of experimentation, of crop growth in respect of total dry matter accumulation plant-1, while at all the days of observation regarding fresh tuber weight plant-1, planting on 44th MW, the irrigation scheduled at 1.2 IW/CPE (I3D2) was comparable with 1.0 IW/CPE (I2D2) and produced significantly higher mean values of these attributes than rest of the treatments.

Whereas, during the same period, irrigation scheduled at 0.8 IW/CPE and planting on 46th MW (I1D3) treatment recorded significantly the lowest mean total dry matter accumulation and fresh tuber weight plant-1 compared to other treatments. Thus, the taller but sturdy plants with higher spread and dry matter accumulation at higher soil moisture regimes produced more number of total dry matter

Table 1
Mean absolute growth rate (gm day-1) as influenced by various treatments.

Treatments	*Pooled*											
	28 DAP			*56 DAP*			*84 DAP*			*AT harvest*		
	M_1	M_2	*mean*	M_1	M_2	*mean*	M_1	M_2	*mean*	M_1	M_2	*mean*
I_1D_1	1.36	0.98	0.78	1.21	1.02	0.74	0.45	0.43	0.30	0.07	0.05	0.04
I_1D_2	1.59	1.37	0.99	1.62	1.32	0.98	0.57	0.56	0.38	0.11	0.06	0.06
I_1D_3	0.71	0.63	0.45	0.85	0.73	0.53	0.37	0.30	0.22	0.04	0.02	0.02
I_2D_1	1.45	1.03	0.83	1.35	1.17	0.84	0.50	0.49	0.33	0.07	0.05	0.04
I_2D_2	1.96	1.49	1.15	1.98	1.34	1.11	0.63	0.57	0.40	0.12	0.09	0.07
I_2D_3	1.01	0.84	0.62	0.99	0.83	0.60	0.39	0.34	0.24	0.05	0.03	0.03
I_3D_1	1.56	1.27	0.94	1.46	1.18	0.88	0.56	0.50	0.35	0.07	0.06	0.05
I_3D_2	2.83	1.69	1.51	4.42	2.92	2.45	1.21	0.58	0.60	0.12	0.10	0.07
I_3D_3	1.27	0.87	0.71	1.21	0.95	0.72	0.43	0.39	0.28	0.06	0.04	0.03
mean	1.53	0.57	1.05	1.68	0.64	1.16	0.57	0.23	0.40	0.08	0.03	0.05

	S.Em±	*CD at 5%*	*S.Em±*	*CD at 5%*	*S.Em±*	*CD at 5%*	*S.Em±*	*CD at 5%*
Main plot (I X D)	0.07	0.20	0.11	0.32	0.03	0.10	0.00	0.01
Sub plot (M)	0.03	0.09	0.04	0.12	0.01	0.04	0.00	0.01
Interactions								
I X M	0.06	NS	0.07	NS	0.02	NS	0.00	NS
D X M	0.06	NS	0.07	NS	0.02	NS	0.00	NS
(I X D) X M	0.10	0.28	0.13	0.37	0.04	0.11	0.01	0.02

Note- I_1-(0.8 IW/CPE), I_2-(1.0 IW/CPE), I_3-(1.2 IW/CPE), D_1-(42 MW), D_2-(44 MW), D_3-(46 MW), M_1- (with mulch), M_2- (without mulch)

Table 2
Mean crop growth rate (gm m-2 day-1) as influenced by various treatments

Treatments	*Pooled*								
	28 DAP			*56 DAP*			*84 DAP*		
	M_1	M_2	*mean*	M_1	M_2	*mean*	M_1	M_2	*mean*
I_1D_1	3.0	2.8	1.9	0.03	0.03	0.03	2.4	2.0	2.2
I_1D_2	4.2	3.6	3.9	0.05	0.04	0.04	3.0	2.5	2.8
I_1D_3	2.3	1.6	1.9	0.02	0.02	0.01	1.9	0.9	0.9
I_2D_1	3.1	2.9	2.0	0.04	0.03	0.02	2.5	2.0	1.5
I_2D_2	4.6	4.0	2.8	0.05	0.04	0.03	3.6	2.8	2.1
I_2D_3	2.5	2.4	1.6	0.03	0.03	0.02	2.1	1.4	1.1
I_3D_1	3.3	3.1	2.1	0.04	0.04	0.03	2.9	2.3	2.6
I_3D_2	9.5	4.4	6.9	0.10	0.05	0.07	6.8	3.4	5.1
I_3D_3	2.8	2.6	1.8	0.03	0.03	0.02	2.2	1.9	1.4
mean	3.9	1.8	2.9	0.04	0.02	0.03	3.0	1.4	2.2

	S.Em±	*CD at 5%*	*S.Em±*	*CD at 5%*	*S.Em±*	*CD at 5%*
Main plot (I X D)	0.30	0.90	0.00	0.01	0.32	0.95
Sub plot (M)	0.10	0.29	0.00	0.00	0.07	0.21
Interactions						
I X M	0.17	NS	0.00	NS	0.12	NS
D X M	0.17	NS	0.00	NS	0.12	NS
(I X D) X M	0.29	0.87	0.00	0.01	0.21	0.62

Note- I_1-(0.8 IW/CPE), I_2-(1.0 IW/CPE), I_3-(1.2 IW/CPE), D_1-(42 MW), D_2-(44 MW), D_3-(46 MW), M_1- (with mulch), M_2- (without mulch)

Table 3
Mean dry matter accumulation (g) plant-1 as influenced periodically by various treatments

Treatments	*Pooled*											
	28 DAP			*56 DAP*			*84 DAP*			*AT harvest*		
	M_1	M_2	*mean*	M_1	M_2	*mean*	M_1	M_2	*mean*	M_1	M_2	*mean*
I_1D_1	40.43	39.14	26.52	72.92	68.78	47.23	39.92	39.02	26.31	2.68	1.88	1.52
I_1D_2	43.79	40.66	28.15	78.91	73.11	50.67	43.78	40.91	28.23	3.76	2.83	2.20
I_1D_3	34.00	32.51	22.17	68.78	60.85	43.21	34.42	32.51	22.31	2.03	0.85	0.96
I_2D_1	41.07	39.55	26.87	74.97	71.40	48.79	40.57	39.67	26.75	2.94	2.18	1.71
I_2D_2	45.34	41.96	29.10	82.11	73.75	51.95	45.21	42.06	29.09	3.93	3.35	2.43
I_2D_3	36.26	34.87	23.71	72.04	65.18	45.74	37.01	34.74	23.92	2.14	1.10	1.08
I_3D_1	41.89	40.03	27.31	76.11	72.48	49.53	42.30	40.53	27.61	3.09	2.58	1.89
I_3D_2	64.19	52.22	38.80	115.20	97.06	70.75	64.19	52.74	38.98	4.02	3.79	2.60
I_3D_3	39.00	38.26	25.75	72.67	66.71	46.46	38.12	37.76	25.29	2.51	1.42	1.31
mean	42.88	19.96	31.42	79.30	36.07	57.69	42.83	20.00	31.42	3.01	1.11	2.06

	S.Em±	*CD at 5%*	*S.Em±*	*CD at 5%*	*S.Em±*	*CD at 5%*	*S.Em±*	*CD at 5%*
Main plot (I X D)	1.75	5.26	3.47	10.42	1.64	4.93	0.10	0.31
Sub plot (M)	0.79	2.35	1.64	4.88	0.83	2.47	0.07	0.21
Interactions								
I X M	1.37	NS	2.85	NS	1.44	NS	0.12	NS
D X M	1.37	NS	2.85	NS	1.44	NS	0.12	NS
(I X D) X M	2.37	7.05	4.93	14.64	2.49	7.40	0.22	0.64

Note- I_1-(0.8 IW/CPE), I_2-(1.0 IW/CPE), I_3-(1.2 IW/CPE), D_1-(42 MW), D_2-(44 MW), D_3-(46 MW), M_1- (with mulch), M_2- (without mulch) accumulation plant-1 with higher fresh tuber weight resulting into higher yield. Similar trend was observed at 28, 56, 84 DAP and at harvest. Lowest total dry matter was recorded in 46 MW at all the days after planting. These results are corroborated with the findings of Shiri-e-Janagard *et al*. (2009) reported that moisture-stress will reduce the leaf area which results in reducing the photosynthesizing surface which will ultimately reduce the dry matter accumulation in potato crop under stressed treatments. The early planting recorded maximum dry matter than late once. The similar results were recorded by Gronowicz *et al.* (1992). This might be due to the favourable climatic condition available during crop growth period.

CONCLUSION

Growth attributes study in respect of mean AGR, CGR, RGR, NAR, LAI, LAD revealed that during both the seasons at all the growth stages of potato, numerically higher mean values of each growth function were recorded with application of irrigation at 1.2 IW/CPE ratio and early planting on D_2 (44th MW), whereas numerically lower mean values of said parameters were recorded at application of irrigation at 0.8 IW/CPE ratio and late planting on D_3 (46th MW).

More water stress imposed due to irrigation scheduling at 0.8 IW/CPE ratio (58.3 mm CPE) and late planting on 46th MW (I_1D_3) affecting the early tuber initiation stage, tuber bulking stages and tuber development stage recorded significantly less values as compared to other treatments.

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