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EFFECT OF TRANSPLANTING DATES AND PLANT POPULATION ON GROWTH PARAMETERS OF POTATO *(SOLANUM TUBEROSUM* L.*)* RAISED FROM TRUE POTATO SEED (TPS)

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ABSTRACT. A field experiment was conducted during the rabi season of 2007-2008 and 2008-2009 at Paschim Medinipore, West Bengal to study the effect of transplanting dates and plant population on growth parameters of potato raised from TPS. Dry matter accumulation per plant was more in early transplanted (December 3) and sparsely populated (60 cm x 15 cm) crop. The highest leaf area index was observed in early transplanted crop with closer spacing (40 cm x 10 cm) at 60 days after transplanting. The highest crop growth rate, tuber bulking rate and tuber growth rate values were also recorded in early and closely transplanted TPS crop between 45-60 days after transplanting during both the years under investigation.

Key words: Growth attributes; Dry matter accumulation; Leaf area index; Crop growth rate; Tuber growth rate.

INTRODUCTION

Potato (*Solanum tuberosum* L.) bears a significant role in food and nutritional security of India. But cultivation of the crop is very much cost intensive, of which major part is shared by the planting material alone. In this context, the true potato seed (TPS), a unique disease and pest free planting material, will open up a great possibility in reducing the seed cost and in increasing the availability of superior quality planting materials.

Productivity of a crop largely depends on various growth attributes, which is a factor of agrotechnology applied (Sen *et al.,* 2010). Hence, the present investigation was carried out to find out the impact of dates of transplanting and plant population on

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various growth attributes such as dry matter accumulation, leaf area index (LAI), crop growth rate (CGR), tuber bulking rate (TBR) and tuber growth rate (TGR) of potato crop raised from TPS.

MATERIALS AND METHODS

A field experiment was conducted during the rabi season of 2007-'08 and 2008-'09 at Paschim Medinipore, West Bengal to study the effect of transplanting dates and plant population on growth parameters of potato raised from TPS.

The experimental plot was well drained and leveled and it had sandy loam soil, which belongs to *alfisol*. The chemical analysis of top thirty centimeter soil showed that it was slightly acidic in reaction (pH=6.7), medium in available phosphorus (46 kg P_2O_5 ha^{-1}) and low in both total nitrogen (0.04 %) and available potassium (99 kg K_2O ha^{-1}).

The zone falls under sub-tropical humid climate in lower gangetic plain, where both summer and winter are short and mild. Total rainfall during the crop growth period (November to March) was meager for both the year under study (*Figs. 1a and 1b*). Average relative humidity, during this period, was ranged from 41 to 88%. During the experimental period, the maximum mean weekly temperature was 37.1°C and 33.8°C in 2007-'08 and 2008-'09, respectively, while, the minimum mean weekly temperature was 9.5°C and 6.3°C, during the two consecutive years.

The experiment was laid out in 'split plot design', with three dates of transplanting as main-plot treatments and six plant population/ spacing as sub-plot treatments. Size of each sub-plot was 6.0 m x 3.0 m. The experimental data were statistically analysed through calculation of variance by the standard statistical method (Cochran and Cox, 1977) and the significance of different treatments was tested by error mean square by Fisher and Snedecor's 'F' test at 0.05 probability level. For determination of critical difference (CD) at 5% level of significance, Fisher and Yate's tables were consulted.

The test crop variety was HPS I/13. During the experimentation, all the necessary agronomic measures were taken routinely and different growth attributes such as dry matter accumulation, leaf area index, crop growth rate, tuber bulking rate and tuber growth rate were studied.

Dry matter accumulation. The dry matter accumulated per unit area was determined at 30, 45, 60 and 75 days after transplanting; five plants uprooted by destructive sampling from each plot were oven dried to determine dry matter accumulation in $g.m^{-2}$.

Leaf area index (LAI). Ten compound leaves were detached randomly from each plot at 30, 45, 60 and 75 days after transplanting to compute the LAI of the crop using the following formula:

$$LAI = \frac{\text{Total leaf area of the crop}}{\text{Total ground area under the crop}}$$

Crop growth rate (CGR). The crop growth rate between 30 and 45 days after transplanting, 45 and 60 days after transplanting and 60 and 75 days after transplanting were determined with the following formula:

$$CGR = \frac{w_2 - w_1}{t_2 - t_1} \quad (g.m^{-2}.day^{-1})$$

where w_1 and w_2 are plant dry weights at time t_1 and t_2, respectively.

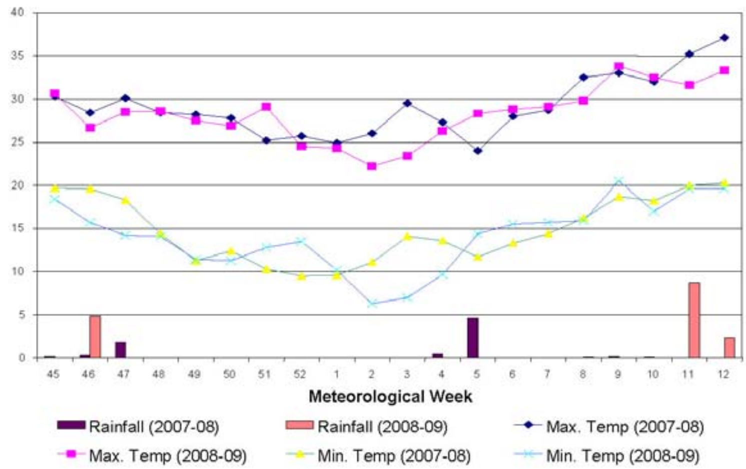

Figure 1a - Temperature and rainfall at the experimental station during two potato growing season (2007-2008 and 2008-2009)

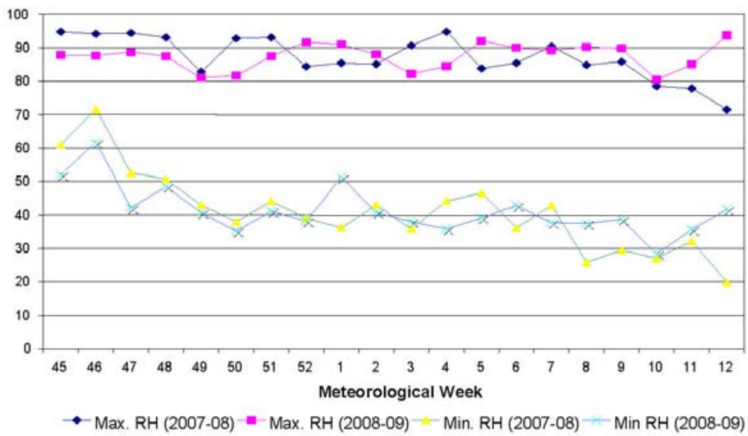

Figure 1b - Relative humidity at the experimental station during two potato growing season (2007-2008 and 2008-2009)

Tuber bulking rate (TBR). It indicates the growth rate of tuber in potato. It is expressed as fresh weight of tubers produced per unit of land area in a day and is calculated as:

$$TBR = \frac{W_2 - W_1}{t_2 - t_1} \quad (g.m^{-2}.day^{-1})$$

where W_1 and W_2 are fresh weights of tuber at time t_1 and t_2, respectively.

Tuber growth rate (TGR) It indicates the growth rate of tuber on dry weight basis. It is expressed as dry weight of tubers produced per m^2 of land area in a day and assessed as:

$$TGR = \frac{w_2 - w_1}{t_2 - t_1} \quad (g.m^{-2}.day^{-1})$$

where w_1 and w_2 are dry weights of tuber at time t_1 and t_2, respectively.

RESULTS AND DISCUSSION

Dry matter accumulation per plant increased consistently till 75 days after transplanting irrespective of the date of transplanting and spacing combination during both the years (*Fig. 2*). Early transplanted crop recorded significantly greater dry matter accumulation over those of intermediate and late transplanted crop at all the stages during both years under this study (*Table 1*). This might be due to vigorous growth in the early transplanted crop. This is in conformity with the findings of Malik (2000).

Table 1 - Effect of date of establishment and crop geometry on dry matter accumulation (g. plant-1) at different stages

Particulars	2007-2008				2008-2009			
	30 DAT*	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Date								
December 3	3.11	7.98	15.96	18.19	3.79	8.71	17.69	19.97
December 11	2.78	6.79	13.83	15.59	3.03	7.33	14.88	16.88
December 19	2.19	5.38	11.98	13.26	2.26	5.62	12.71	14.19
CD (P=0.05)	0.31	0.28	0.55	1.14	0.24	0.47	0.31	0.43
Spacing								
40 cm X 10 cm	2.77	6.77	12.63	14.30	3.03	7.44	14.03	15.86
40 cm X 15 cm	2.68	6.77	13.87	15.80	3.06	7.44	15.04	16.88
50 cm X 10 cm	2.67	6.66	13.19	14.78	2.99	7.14	14.68	16.50
50 cm X 15 cm	2.69	6.72	14.65	16.41	2.99	7.18	15.64	17.58
60 cm X 10 cm	2.68	6.74	13.96	15.57	2.93	7.09	14.92	16.84
60 cm X 15 cm	2.69	6.66	15.24	17.21	3.16	7.36	16.24	18.41
CD (P=0.05)	NS	NS	0.46	0.58	NS	NS	0.52	0.55

* Days after transplanting

Crop geometry also registered significant effect on dry matter accumulation in potato plant. However, during the initial stages (30 and 45 days after transplanting), crop geometry did not show any significant difference on dry matter accumulation per plant (*Table 1*). But later on, when plant to plant competition for light, water and space became evident, the highest dry matter accumulation per plant was recorded in widely spaced crop (60 cm x 15 cm), which was significantly higher than any other spacing combination under this study, in both the years. The crop spaced at 50 cm x 15 cm also recorded significantly greater dry matter yield per plant than other spacing at 60 and 75 days after transplanting, during both years. Similar findings were also reported by Veerana *et al.* (1997). Wadhwa *et al.* (2000), on the other hand, computed the dry matter accumulation per unit area and found that close spacing gave higher dry matter accumulation, due to more number of plants per unit area.

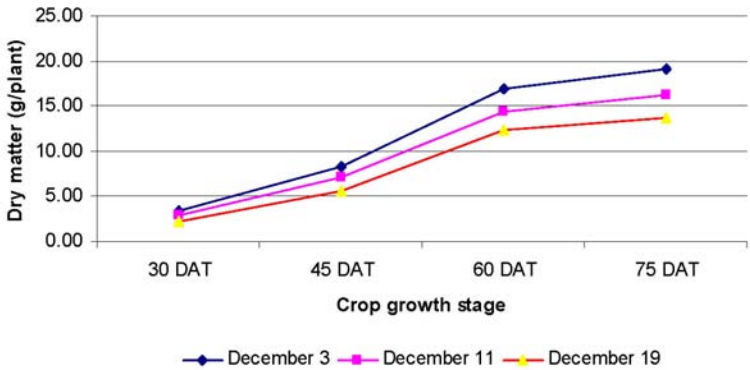

Figure 2 - Effect of transplanting date on dry matter accumulation at different stages of TPS hybrid

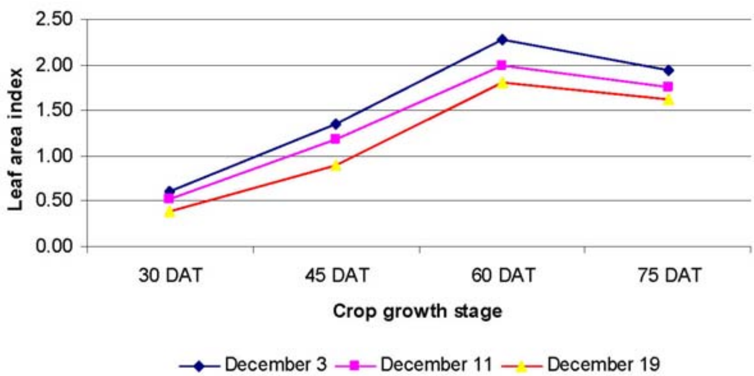

Figure 3 - Effect of transplanting date on leaf area index at different stages of TPS hybrid

Leaf area index (LAI) increased till 60 days after transplanting, after which it registered a sharp decline, irrespective of the dates of transplanting and crop geometry, during both the years (*Fig. 3*). Maximum leaf area index was recorded in early transplanted crop which found to be significant over intermediate and late transplanted crop at all the stages, during both years excluding that on 30 days after transplanting in 2007-‘08 and 75 days after transplanting in 2008-‘09, when early and intermediated transplanted crop remained at par in respect of LAI (*Table 2)*. Similarly, intermediate transplanted crop also registered significantly greater value of LAI over that of late transplanted crop at all the stages except 75 days after transplanting during 2008-‘09.

Table 2 - Effect of date of establishment and crop geometry on leaf area index at different stages

Particulars	2007-2008				2008-2009			
	30 DAT*	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Date								
December 3	0.54	1.28	2.17	1.87	0.68	1.42	2.40	2.02
December 11	0.50	1.10	1.94	1.72	0.54	1.25	2.03	1.78
December 19	0.40	0.92	1.77	1.59	0.39	0.88	1.83	1.64
CD (P=0.05)	0.08	0.04	0.12	0.08	0.08	0.08	0.12	0.28
Spacing								
40 cm X 10 cm	0.72	1.63	2.65	2.34	0.79	1.79	2.87	2.47
40 cm X 15 cm	0.47	1.07	1.93	1.69	0.53	1.13	2.05	1.78
50 cm X 10 cm	0.55	1.28	2.22	1.93	0.63	1.36	2.39	2.09
50 cm X 15 cm	0.37	0.84	1.62	1.43	0.41	0.92	1.70	1.48
60 cm X 10 cm	0.47	1.08	1.95	1.70	0.50	1.14	2.03	1.78
60 cm X 15 cm	0.31	0.70	1.41	1.26	0.36	0.77	1.47	1.28
CD (P=0.05)	0.06	0.09	0.09	0.09	0.03	0.09	0.12	0.12

* Days after transplanting

Crop geometry showed significant effect on the leaf area index. The LAI increased progressively as the crop spacing decreased. As such, maximum leaf area index was noted at the closest spacing (40 cm x 10 cm), and the lowest value of LAI was recorded from the sparsely planted crop at all the growth stages, during both years under study (*Table 2*). However, the crops transplanted at 40 cm x 15 cm and 60 cm x 10 cm spacing, having same plant density, did not vary much in recording the LAI. The results showed that LAI was regulated largely by plant density. Veerana *et. al.* (1997) also found an inverse relationship of LAI with crop spacing. The highest LAI in narrowly spaced crop was also noticed by Das (1998).

Crop growth rate (CGR) also showed a trend similar to that of dry matter accumulation under this study. The CGR increased steadily up to 60 days after transplanting, after which it declined gradually during both the years. Early transplanted crop recorded higher CGR than intermediate and late transplanted crop in all the growth periods during both the years (*Table 3*). However, CGR values did not vary much between early and intermediate planted crops during the period of 60 - 75 days after transplanting, in both the years. The late-planted crop (December 19) recorded the lowest CGR during all the periods except the period of 60-75 days after transplanting, during both the years. This was mainly due to poor growth of the late planted crop exposed under low temperature condition from the very beginning.

Table 3 - Effect of date of establishment and crop geometry on crop growth rate ($g.m^{-2}$ day^{-1}) during different periods

Particulars	2007-2008			2008-2009		
	30-45 DAT*	45-60 DAT	60-75 DAT	30-45 DAT	45-60 DAT	60-75 DAT
Date						
December 3	8.51	14.20	6.48	8.61	16.49	6.82
December 11	7.00	12.14	4.91	7.20	13.92	5.50
December 19	5.32	11.11	3.73	6.02	11.91	4.21
CD (P=0.05)	0.59	0.75	2.36	0.83	1.02	1.41
Spacing						
40 cm X 10 cm	10.02	15.51	7.10	11.01	17.92	7.88
40 cm X 15 cm	6.91	12.27	5.51	6.92	14.13	5.24
50 cm X 10 cm	7.94	13.73	5.40	8.41	16.10	6.20
50 cm X 15 cm	5.43	10.90	3.93	5.60	12.01	4.33
60 cm X 10 cm	6.78	12.62	4.72	6.88	14.04	5.41
60 cm X 15 cm	4.54	9.91	3.63	4.78	10.48	4.02
CD (P=0.05)	0.69	2.05	0.92	0.75	1.21	0.75

* Days after transplanting

Crop growth rate was the highest in narrowly spaced crop during all the growth stages in both the years and was significantly superior to all other spacing except the crop grown at 50 cm x 10 cm spacing during 45-60 days after transplanting in 2007-‘08 when both the spacing recorded CGR values at par with each other (*Table 3*). A trend of decreasing CGR values with increasing crop spacing was registered in all the growth periods during both the years. As such, the minimum CGR value was recorded from the widely spaced crop (60 cm x 15 cm). This might be attributed to the greater photosynthetic efficiency in closely spaced crop. Malik (2000) also found higher CGR in densely populated crop.

Tuber bulking rate (TBR) increased rapidly up to the peak growth period (45-60 days after transplanting) (*Table 4*). This might be due to increasing rate of photosynthesis with the development of the ‘source’ and better dry matter partitioning to the ‘sink’. While, during the late growing period (60-75 days after transplanting), bulking rate slowed down gradually as the crop proceeding towards maturity, during both the years. Among different dates of establishment, early transplanted (December 3) crop produced significantly higher value of TBR as compare to those obtained from December 11 and December 19 transplanted crop during all the crop growth periods except the period of 60-75 days after transplanting, during both the years, when crop transplanted at December 3 and December 11 recorded at par value of TBR. While, late transplanted crop showed the lowest TBR under this study.

Close spacing (40 cm x 10 cm) recorded significantly higher values of

TBR than other spacing combinations in all the growth periods during both the years (*Table 4*). This is in conformity with the findings of Das (1998). The lowest values of TBR, on the other hand, was registered by the widest spacing (60 cm x 15 cm). The results indicated the positive influence of plant density on TBR of TPS crop.

Table 4 - Effect of date of establishment and crop geometry on tuber bulking rate ($g.m^{-2}$ day^{-1}) during different periods

Particulars	2007-2008			2008-2009		
	30-45 DAT*	45-60 DAT	60-75 DAT	30-45 DAT	45-60 DAT	60-75 DAT
Date						
December 3	21.75	46.04	34.13	21.95	55.81	36.24
December 11	18.14	37.55	25.36	16.04	47.84	28.35
December 19	12.11	32.43	18.94	16.01	33.82	21.13
CD (P=0.05)	2.71	3.03	11.08	2.71	6.88	9.08
Spacing						
40 cm X 10 cm	24.41	49.11	36.72	27.01	59.44	41.87
40 cm X 15 cm	17.94	37.70	28.65	17.30	45.05	26.73
50 cm X 10 cm	19.35	42.45	27.84	21.51	52.13	32.22
50 cm X 15 cm	14.03	33.43	20.29	13.51	38.81	22.27
60 cm X 10 cm	16.78	39.11	25.01	16.64	45.51	27.71
60 cm X 15 cm	11.35	30.12	18.43	12.15	33.40	20.50
CD (P=0.05)	2.17	6.03	4.82	2.16	6.12	3.72

* Days after transplanting

Table 5 - Effect of date of establishment and crop geometry on tuber growth rate ($g.m^{-2}$ day^{-1}) during different periods

Particulars	2007-2008			2008-2009		
	30-45 DAT*	45-60 DAT	60-75 DAT	30-45 DAT	45-60 DAT	60-75 DAT
Date						
December 3	4.71	9.23	6.84	4.81	11.13	7.23
December 11	3.90	7.48	5.12	3.52	9.59	5.74
December 19	2.62	6.50	3.81	3.50	6.78	4.20
CD (P=0.05)	0.51	0.63	2.31	0.55	1.73	1.81
Spacing						
40 cm X 10 cm	5.33	9.82	7.31	5.90	11.91	8.39
40 cm X 15 cm	3.90	7.50	5.72	3.78	9.02	5.30
50 cm X 10 cm	4.21	8.53	5.60	4.71	10.44	6.43
50 cm X 15 cm	3.02	6.71	4.08	3.00	7.81	4.44
60 cm X 10 cm	3.68	7.80	5.03	3.72	9.16	5.51
60 cm X 15 cm	2.51	6.99	3.71	2.70	6.74	4.10
CD (P=0.05)	0.43	1.21	0.95	0.43	1.53	0.75

* Days after transplanting

Tuber growth rate (TGR). Initially (30-45 days after transplanting), TGR value was found to be low which gradually increased and attained its maximum value during the period of 45-60 days after transplanting, after which it followed a declining trend under this study (*Table 5*). The early transplanted crop (December 3) registered the highest TGR value during all the growth periods in both the years. The second date of transplanting (December 11) also recorded significantly greater value of TGR over the third date of transplanting (December 19) in all the periods excluding the periods of 60-75 days after transplanting in 2007-'08 and 30-45 and 60-75 days after transplanting in 2008-'09, when these two produced at par TGR value between each other.

Closure spacing (40 cm x 10 cm) recorded the highest tuber growth rate, which was significantly superior to all other spacing treatments during all the growth periods in both the years except during the period of 45-60 days after transplanting in 2008-'09 (*Table 5*). The value of TGR continued to decline with increasing crop spacing and the lowest value of TGR was noted from the widely spaced crop (60 cm x 15 cm); but was found to be statistically at par with that of the crop spaced at 50 cm x 15 cm. High leaf area index obtained at the early growth stages was mainly responsible for increasing tuber growth rate at high plant density as evidenced by positive and strong relationship between these two characters during early growth periods (Malik, 2000). Similar observations were also made by Singh and Singh (1988) and Vos (1998).

CONCLUSION

From the above results, it may be concluded that early transplanting (December 3) and narrow spacing (40 cm x 10 cm) of TPS seedling favours various growth attributes, which are considered to be useful indices for the productivity of the potato crop raised from TPS.

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