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STUDIES IN POTATO AGRONOMY

1 EFFECT OF LANT DENSITY AND TIME OF FERTILIZER APPLICATION ON GROWTH AND DEVELOPMENT OF POTATO VARIETIES

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Experiments conducted with different plant densities, time of fertilizer application and varieties revealed that a plant density of 100,000 plants/hectare (50 cm x 20 cm spacing) recorded quite high LAI, RGR, NAR and CGR of potato crop in most of the growth stages and this ultimately helped in producing high TGR and finally recorded high tuber yield per plant under this mild and short winter conditions of West Bengal. All growth parameters after their initial rise declined gradually as the crop progressed towards its maturity. Application of fertilizers (150, 100 and 100 kg/ha of N, P_2O_5 and K_2O respectively) in two splits-half at planting and half at 25 days after planting was found most conducive for high rates of growth and development of this crop particularly at the early growth stages which ultimately produced maxium tuber yield per plant. Both Kufri Chandramukhi and Kufri Jyoti performed well under this conditions, however, Kufri Chandramukhi gave early harvest while Kufri Jyoti produced maximum tuber yield per plant.

INTRODUCTION

Plant population and fertilization are most important factors that govern potato yield While considerable works on fertilizer requirement and plant density have been done (Collins, 1977; Lynch and Rowberry, 1977 and Banerjee, *et al.*, 1978), there is very little evidence linking the method and time of fertilization in potato crop to growth, development and tuber yield under varied plant populations particularly under short and mild winter conditions of West Bengal where tuberization period is limited by high temperature, both at planting and at maturity (Maity and Chatterjee, 1976). Generally, full dose of phosphorus & potassium and half dose of nitrogen are applied in seed rows at planting and remaining half nitrogen dose is side dressed at 25 to 30 days after planting (during earthing up). But Zandstra *et al.* (1969) found that high dose of fertilizer application in seed rows of potatoes at planting depressed the crop growth. Further, high plant population resulted in increased inter-plant competition (Moorby, 1970).

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Potato plants require continuous supply of nutrients after its establishment as haulm growth, stolonization and tuberization take place simultaneously in the field (Milthorpe and Moorby, 1967) and nutrient stress at any stage results in depressing the growth and yield of this crop. Ghosh (1981) obtained maximum tuber yield of potato with split application of phosphorus. However, no detailed work has been done regarding the effect of plant density and time of fertilizer application on growth, development and tuber formation of potato under mild and short winter conditions of West Bengal. In this study an attempt has been made to analyse the influence of plant density and time of fertilizer application on growth and development of potato varieties in lateritic acid tract of West Bengal with an ultimate objective to get an insight into the physiological basis of tuber yield variations under such conditions.

MATERIALS AND METHODS

The field expriment was conducted at the College of Agriculture Farm, Visva-Barati, Sriniketan, West Bengal during the *rabi* seasons of 1979-80 and 1980-81 in lateritic acid soil having 0.03 per cent total nitrogen, 8.6 Kg/ha available P and 115 Kg/ha available K with pH of 5.9. The place has a sub-humid climate with very slight winter rains. The daily minimum temperature remained below 20°C from 15 November to 15 February and it never went below 6°C during the period of experimentation

The experiment was laid out in randomised block design with three plant densities (120,000, 100,000 and 80,000 plants/ha), two times of fertilizer application (i-basal application of full dose of 150 Kg N, 100 Kg P_2O_5 and 100 Kg K_2O/ha and ii-Split application of above dose of fertilizers-half at planting, during earthing up) and two varieties (Kufri Chandramukhi and Kufri Jyoti) with three replications in 5m x 4m plots. The tubers were planted on 18 and 20 November during 1979 and 1980 respectively at plant to plant spacings of 16.7, 20 and 25cm in rows of 50cm apart. Weeding and earthing up were done at 25 days after planting. The crop received irrigations as and when needed and was adequately protected against insect-pests and diseases. Destructive samples of four plants at two locations in each plot were taken at 10 days intervals from 30 days after planting onwards for growth analysis. The green leaves, stems and tubers were separated and their dry weight were recorded. The ratio of area/weight of measured green leaves was used to determine the leaf area index (Kemp, 1960). Methods of growth analysis (Watson, 1952) involve the calculation of various paramaters from changes in plants weights (W_2 and W_1) and leaf area indices (L_2 and L_1) observed at two sampling periods (t_2-t_1) as follows:

$$\text{Net assimilation rate (NAR)} = \frac{(W_2 - W_1)\ (\log L_2 - \log L_1)}{(t_2 - t_1)\ (L_2 - L_1)}$$

Relative growth rate (RGR) = $\frac{(\text{Log } W_2 - \text{Log } W_1)}{(t_2 - t_1)}$

Crop growth rate (CGR) = $\frac{(W_2 - W_1)}{(t_2 - t_1)}$

Tuber growth rate (TGR) = $\frac{(T_2 - T_1)}{(t_2 - t_1)}$

Where, L, W and T represent the leaf area index, plant dry weight and tuber dry weight per unit of land area respectively. The tuber yield per plant was estimated from the fresh weight of tubers of the harvested plants at each stage.

RESULTS AND DISCUSSION

Leaf Area Index : Leaf are indices (LAI) increased with time to 60 days after planting at all plant densities (Fig. 1). The magnitude of this increase was almost at par with two high plant densities while at low plant density (30,000/plants/ha) the rate of increase was low resulting low LAI during the entire growth period. Leaf senescence in lower part of the canopy caused a decline of LAI with time and it started at 60 days after planting for all plant densities. This was mainly due to rapid rate of leaf senescence coupled with cessation of new leaf formation during these periods of crop growth. Although highest LAI was observed with highest plant density (120,000 plants / ha) during the early growth stages, but in later growth stages it declined rapidly due to inter plant competition and mutual shading and recorded relatively lower LAI than that observed in plant density of 100,000 plants per hectarer

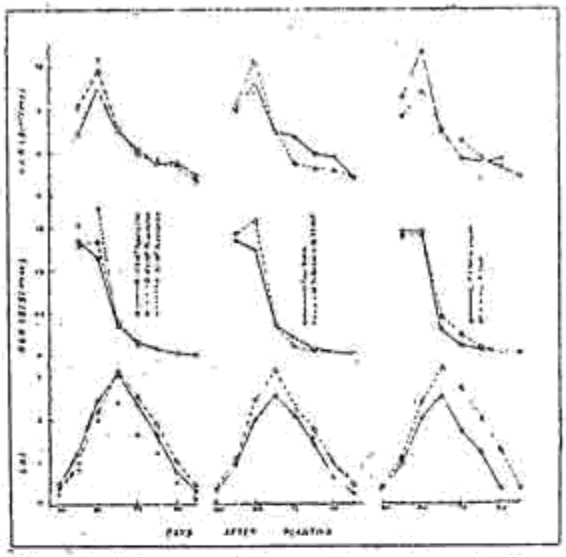

Fig. 1 Effect of plant density, fertilization method and variety on changes in leaf area index (LAI), relative growth rate (RGR) and net assimilation rate (NAR) with time in potato

This was also observed by Maity and Chatterjee (1976) in this mild and short winter conditions of West Bengal.

Full basal application of high dose of fertilizers (150, 100 and 100 kg/ha of N, P_2O_5 and K_2O respectively) resulted in lower LAI throughout the growth stages than that obtained with splitting the above fertilizer dose into two splits - half at planting and remaining half at 25 days after planting. This was due to the fact that large quantities of banded fertilizer depressed the rate of emergence and subsequent growth of potato plants. Among the two varieties Kufri Jyoti recorded higher LAI at all growth stages than that observed in Kufri Chandramukhi.

Relative Growth Rate and Net Assimilation Rate :

The relative growthrate (RGR) increased at early two growth stages except with highest plant density (120,000 pla

nts/ha) in which it decreased gradually. The netassimilation rate (NAR) increas ed steadily at all plant densities during the above growth stages (Fig. 1). The increase in RGR and NAR at early stages was due to low LAI with high photosynthetic efficiency. Both RGR and NAR at early two growth stages were inversely related to plant density. Similar trend of results were also observed by Collins (1970) in Canada. In subsequent growth stages both RGR and NAR decreased with time at all plant densities. This is the normal response to increased LAI and generally considered to be due to an increase in the proportion of leaves which as a consequence of mutual shading, have low photosynthetic rate (Lynch and Row Berry, 1977). Low plant population (80,000 plants / ha) recorded relatively higher values of RGR and NAR than those observed with high populations (both 100,000 and 120, 000 plants/ha) except at maturity. This was mainly due to low LAI obtained with low population. Highest plant density produced lowest RGR and NAR at all growth stages upto 80 days of crop growth.

Full basal application of fertilizer resulted in lower RGR and NAR than that observed with split application at early two growth stages (40 and 50 days of crop growth) while in the subsequent growth stages (except at maturity) split application of fertilizer resulted in lowering the RGR and NAR as compared to that of full basal application. This was due to the fact that split application of fertilizer recorded high crop growth and due to very high amount of initial plant materials at later growth stages both RGR and NAR declined although the total dry matter production was higher with split application than with full basal application of fertilizer. Kufri Chandramukhi being early maturing variety recorded higher RGR and NAR at early two growth stages while at subsequent growth stages Kufri Jyoti picked up the growth rate and maintained higher RGR and NAR than the former one. Similar varietal response was also observed by Maity and Dhatterjee (1976).

Crop Growth Rate and Tuber Growth Rate :

The crop growth rates (CGR) and tuber growth rates (TGR) increased initially at all plant densities and the maximum values of CGR were obtained at 50 days of crop growth (Table 1) while those of TGR were observed at 60 days stages [Table 2]. The pattern of increase in CGR and TGR with time closely paralleled that for LAI in all cases and initial peak values for TGR at 60 days after planting coincided with the attainment of maximum LAI values Both CGR and TGR values dropped to significantly lower levels at 70 days of crop growth and onwads for all plant densities. However, high plant densities (120,000 and 100,000 plants / ha) maintained both CGR and TGR values at all growth stages except at 50 days stage when both CGR and TGR did

TABLE 1. Effect of plant density, fertilization methods and Varieties on crop growth rate (CGR in g/m²/day) of potato from emergence to maturity

Treatment	Days of planting						
	40	50	60	70	80	90	100
plant density :							
120,000/ha	6.4	18.3	16.6	11.4	6 2	3.6	1.4
100,000/ha	5.6	18.6	17.0	11 8	6.9	3.4	1.4
80,000/ha	4.4	17.9	12.9	8.7	4.8	2.7	1.1
S. Em (±)	0.29	1.25	1.05	0.57	0.26	0.21	0.08
C. D. at 5%	0.84	—	3.1.	1.7	0.8	0.6	0.2
Fertilization*							
Full Basal	5.1	16.1	13.7	12.1	6.2	3.5	1.1
½ Basal+½ at 25 DAP	5.8	20.4	17.3	9.1	5.8	3.1	1.4
S. Em (±)	0.23	1.02	0.86	0.46	0.21	0.17	0.06
C. D. at 5%	0.68	2.99	2.5	1.4	—	—	0.2
Varieties							
K. Chm.	5 9	19.7	13.2	6 5	4.3	2.4	—
K. Jyoti	5 0	16.8	17.8	14.7	7.7	4.2	1.3
S. Em (±)	0.23	1.02	0.86	0.46	0.21	0.17	—
C. D. at 5%	0.68	2.99	2.5	1.4	0.6	0.5	—

* Fertilization at 150 kg N/ha and 100 kg N/ha each of P_2O_5 and K_2O were done full at planting and 1/2 at planting +1/2 25 DAP during earthing up.

not vary much among the different plant densities.

Split application of fertilizer-half at planting and remaining half at 25 days after planting resulted in significantly higher values of both CGR and TGR at the early three growth stages (upto 80 days) than those observed with full basal application but at 70 days stage, crop receiving split doses of fertilizer produced significantly lower values of both CGR and TGR than those obtained with full basal application [Table 1 and 2] The values of CGR and TGR did not vary much due to different time of fertilizer application at the later growth stages. Kufri Chandramukhi recorded CGR and TGR significantly higher than Kufri Jyoty at early two growth stages (upto 50 days). In subsequent growth stages Kufri Jyoti maintained significantly higher CGR and TGR till maturity of this crop. This variety also matured late by 10 days. The results indicated that tuber bulking was consistently greater in 120,000 and 100,000 plants/ha as compared to 80,000 plants per hactare.

TABLE 2 Effect of plant density, fertilization method and varieties on tuber growth rate (TGR in g/m²/day) of potato from emergence to maturity

Treatments	Days after planting						
	40	50	60	70	80	90	100
Plant density :							
120,000/ha	3.3	12.8	14.2	12.3	6.1	3.6	0.9
100,000/ha	3.2	12.7	14.2	13.1	7.0	3.4	0.7
80,000/ha	1.9	12.8	12.1	8.8	5.1	2.3	0.6
S. Em (±)	0.17	0.83	0.71	0.55	0.29	0.17	0.09
C. D. at 5%	0.5	—	2.1	1.6	0.8	0.5	0.1
Fertilization*							
Full Basal	2.5	11.5	12.5	12.2	6.1	3.1	0.6
½ Basal + ½ at 25 DAP	3.1	14.1	14.4	10.6	6.0	2.9	0.8
S. Em (±)	0.13	0.68	0.58	0.45	0.23	0.14	0 03
C. D. at 5%	0.4	2.0	1.7	1.3	—	—	0 1
Varieties							
K. Chm.	3.6	15.3	12.0	8 0	4.3	1.1	—
K. Jyoti	1.9	10.2	14.9	14 8	7 8	4.9	0.7
S. Em (±)	0.13	0.68	0.58	0.45	0.23	0.14	—
C. D. at 5%	0.4	2.0	1.7	1.3	0 7	0.4	—

* Fertilization at 150 kg N/ha and 100 kg/ha each of P_2O_5 and K_2O were done full at planting and 1/2 at planting + 1/2 at 25 DAP during earthing up.

Milthorpe and Moorby (1967) observed that the two or three weeks following the onset of tuber intiation were critical in determining final yield. Hence, the observed differeces in growth rates (both CGR and TGR) between 40 and 60 days may have had a significant effect on final yield.

Tuber yield per plant :

Tuber yield per plant (g) increased wtih a decrease in plant density exnept at early growth stages (Table 3). However, a population of 100,000 plants per hectare produced fairly high quantity of tubers per plant and this was on par with that produced by low plant population (80,000 plants/ha). This results indicated that a population of 100.000 plants per hectare was most conducive for obtaining high tuber yield. Highest density (120,000 plants/ha) recorded significantly lower tuber yield per plant than other two densitities at all growth stages except early two stages. This was due to the inter-plant competition prevailing at high plant densities

TABLE 3 Effect of plant density, fertilization method and varieties on tuber yield (g) per plant of potato from emergence to maturity.

Treatments	Days after planting							
	30	40	50	60	70	80	90	100
Plant density :								
120,000/ha	1.8	18.3	82	138	176	190	198	199
100,000/ha	1.6	22.1	97	166	215	235	244	245
80,000/ha	1.2	14.6	109	179	219	237	244	245
S. Em (±)	0.11	0.96	4.1	6.9	10.9	11.5	12.3	11.5
C. D. at 5%	0.3	2.8	12.0	20.2	32.0	22.6	36.0	33.8
Fertilization*								
Full Basal	1.4	17.1	86	149	197	213	223	224
½ Basal+½ at 25 DAP	1.7	19.5	106	173	209	228	235	236
S. Em (±)	0.09	0.78	3.4	5.6	8.9	9.3	10.0	9.4
C. D. at 5%	0.26	2.3	10.0	16.5	—	—	—	—
Varieties								
K. Chm.	2.4	24.4	111	163	195	204	206	—
K. Jyoti	0.7	12.3	81	159	212	238	251	253
S Em (±)	0.09	0.78	3.4	5.6	8.9	9.3	10.0	—
C. D. at 5%	0.26	2.3	10.0	—	—	27.5	29.4	—

* Fertilization at 150 kg N/ha and 100 kg/ha each of P_2O_5 and K_2O were done full at planting and 1/2 at planting + 1/2 at 25 DAP during earthing up.

particularly during later growth stages.

Crop receiving split doses of fertilizer recorded consistently higher tuber yield per plant throughout the growth periods [Table 3], however, the differences in tuber yield per plant were not very wide and significant at later part of crop growth (from 70 days onwards) between full basal and split application of fertilizer. Kufri Chandramukhi produced higher tuber yield per plant than Kufri Jyoti at early three growth stages after which the tuber yield per plant was at par between thsse varieties for 20 days (rom 50 to 70 days) when Kufri Jyoti picked up tuber growth and then Kufri Jyoti recorded significantly higher uber yield per plant than Kufri Chandramukhi.

The above results clearly indicated that a plant density of 100,000 plants per hectare was most conducive or good growth and proper development of potato tubers under the short and mild winter conditions of West Bengal. This population recorded fairly high LAI and CGR at most of

the growth stages. It also maintained adequate values RGR and NAR which ultimately resulted in high values of TGR and finally tuber yield per plant. Spilt application of fertilizer (150, 100 and 100 kg/ha of N, P_2O_5 and K_2O respectively) half at planting and remaining half at 25 days after planting recorded very high values of LAI throughout the growth period and produced higher values of RGR, NAR and CGR than full basal application at the early growth stages which ultimately resulted in high TGR and tuber yield per plant. Kufri Chandramukhi being early in maturity was found suitable for early harvest under this condition but Kufri Jyoti recorded high LAI, RGR, NAR and CGR particularly at the later growth stages and ultimately gave higher TGR for longer duration and finally produced higher tuber yield per plant than Kufri Chandramukhi.

This result suggests that a plant population of 100,000 plants per hectare [50cm x 20cm spacing] is most conducive for achieving proper growth and development of potato crop under this mild and short winter conditions of West Bengal. Split application of fertilizer [150, 100 and 100 kg/ha of N, P_2O_5 and K_2O respectively) - half at planting and remaining half at 25 days after planting further benefits the growth and development of this crop. Both Chandramukhi and Kufri Jyoti perform well under this condition but for early harvest Kufri Chandramukhi may be taken while for maximum tuber yield Kufri Jyoti may be the choice.

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