Effect of Rooting of Seed Tubers Presprouting and Nitrogen on the Yield of Potato (*Solanum tuberosum* L)

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INTRODUCTION

The use of minichitted seed tubers as planting material is the established practice in Sri Lanka. These are seeds which have just broken dormancy, with yellowish white sprouts about 1/2 cm in length. Such seed take almost 3 weeks to emerge and establish as individual plants. Thus, any agronomic practice which can shorten this period can be expected to extend foliage growth and prolong the period of tuber bulking which could lead to higher yield.

The presprouting of seed tubers alters the growth pattern of the plant in two distinct ways. Firstly, the seed tuber and sprouts undergo considerable modification before planting, and secondly, planting presprouted seed results in a partial displacement of the vegetative period (Toosey, 1963). At a given stage of growth, plants from presprouted seed are therefore exposed to a set of environmental conditions different from those arising from unsprouted seed (Emilsson, 1950).

Nitrogen also appreciably influences leaf growth and plays a significant role on the time of tuber initiation. An early tuber initiation is non conducive to leaf development and may result in the reduction of both the rate and duration of tuber bulking (Borah and Milthorpe 1959, 1962). Therefore, nitrogen controls and dominates two vital factors which determine potential yield, namely leaf growth and time of tuber initiation, and rate and duration of tuber bulking.

The foregoing evidence indicates that it is feasible to manipulate seed tubers and employ cultural practices which would result in increased tuber yield under a short growing period available for a potato crop in Sri Lanka. With the objective of exploiting the available short day regime, an experiment was designed using presprouted seed and artificial root inducement at base of sprouts prior to planting. As presprouted seed will result in an increased number of main stems and consequently a higher number of stems per hill, the response of different N levels was also incorporated into the investigations.

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METERIALS AND METHODS

The experiment was conducted at the Agricultural Research Station Sita Eliya, during October 1973-February 1974, following a two year rotation of grass. The soil was well drained and contained 5.3% organic matter, 0.44% available nitrogen, 113.12 kg/ha P_2O_5 and 0.40 me exchangeable potassium /100 g of soil. The pH was 4.9.

The climatic data are given in Table 1. During the first 65 days after planting (DAP) the rainfall received was well distributed, but a subsequent drought prevailed till final harvest. At 80 DAP, the crop was subjected to frost which caused negligible damage as the plants were senescing.

The treatments consisted of 3 levels of N. (low N–112 kg/ha; medium N–156 kg/ha and high N–200 kg/ha) two seed types, (presprouted and minichitted) with or without artificial root inducement at the sprout base. The seeds were presprouted by placing desprouted tubers in wooden trays stored in diffused sunlight at 20–22 °C for 50 days. This resulted in about 5 sturdy, dark green sprouts per tuber, 1 1/2 cm long. The minichitted seed was also desprouted and stored in the dark under conditions described for presprouting. This resulted in about 5 brittle, yellowish white sprouts per tuber, ½ cm long. Rooting was induced by placing seeds in wooden trays covered with moist sand. They were stored for 7 days at 20–22 °C; one lot in diffused sunlight to obtain presprouted seed, and the other in darkness for minichitted seed.

All treatments received a blanket application of 672 kg/ha concentrated super phosphate (42% P_2O_5); and 112 kg/ha muriate of potash (60% K_2O). At planting N as sulphate of amonia (21% N) was applied per treatments, basally. Tamaron and Antracol were sprayed at weekly intervals at 28/15g litres of water as a prophylactic measure for insect and disease control.

The treatments were arranged in a randomised block design, replicated 3 times. Each plot measured 3.05 mx4.88 m (14.9m^2). The plots were thrown into ridges and furrows at a spacing of 61 cm from the centre of one furrow to the other. The tubers were planted at a distance of 25.4 cm in the furrow on 27, October 1973. Each plot had 8 rows of potatoes, with 12 plants per row, giving a total of 96 plants per plot.

Sequential sampling was carried out at 15 day intervals commencing 30 DAP. Sampling was restricted to alternate plants in the centre rows, leaving 2 plants within each row as border plants. Two plants per plot were removed at each harvest for determining tuber fresh weight, tuber number and dry matter yield. Any swollen tip of a stolon was considered a tuber. At the final harvest tubers were grouped into 3 size grades based on diameter as follows; ware 45-55 mm; seed 35–45mm; and chat 25–35mm. The starch percentage in tubers was determined at the final harvest using a starch balance.

The leaf area was estimated by the disk method (Watson and Watson, 1953). The cross sectional area of the punch was 1.76 cm^2.

RESULTS AND DISCUSSION

Tuber fresh weight-yield

High N reached maximum tuber yield at 90 DAP, with increases of 4.7% and 3.4% over the low and medium N respectively (Table, 2). High N significantly outyielded the low and medium N at all harvests except at 75 DAP, showing a trend in response to increased N, mainly due to a longer period of tuber bulking (Fig:1). Thus, although increased N caused a 15 day delay in attaining maximum tuber yield, it amply compensated by outyielding both low and medium N. These results confirm the findings of several workers, Widdowson and Penny, (1962); Simpson (1962); Radley (1963); Ivins and Bremner (1965); and Gunasena (1969) who reported that with sufficient N, although crop maturity may be delayed due to a greater initial haulm growth, the final yields would be high owing to the presence of a larger leaf area at the stage of tuber development.

Presprouted seed increased final tuber yield by 12.4% at 75 DAP over minichitted seed which took 90 days to reach a maximum, (Table, 2) confirming the results of earlier reports. (de Vaz and Gunasena 1977). This could be associated with the physiologically advanced stage of growth in plants arising from presprouted seed compared with minichitted.

Except at 75 DAP, root inducement significantly increased tuber yield over non root induced tubers. At the initial (30 DAP) and final harvests (90 DAP) tuber yield with induced rooting was higher by 56% and 5.5% compared to those without root induction. This was probably due to quicker plant establishment and consequently an extended tuber bulking period.

Tuber number per plant

At 30 DAP, medium N recorded a significant increase of 23% in tubers per plant (16.5) compared with low and high N which had equal tuber numbers (13.42). In the subsequent harvests the differences were not significant (Table, 3). Maximum tubers per plant were seen at 30 DAP for medium N and 45 DAP for low and high N (Fig. 2). Consequently, the influence of N appeared to be a less critical factor for tuber initiation under a short growth period. Apparently, other factors such as hormones may be involved (Gregory, 1954; Chapman, 1958, Slater 1963).

The initial harvest (30 DAP) showed a 47% increase in tuber number per plant for presprouted seed over minichitted, (Table, 3) which could be attributable to earliness in the growth and a significantly greater partitioning of total dry matter for tuber development. At maximum tubers per plant, presprouted seed (17.2) gave an increase of 19% compared with minichitted seed (14.4).

Fig. 1 MAIN EFFECT OF TREATMENTS ON TUBER FRESH WEIGHT YIELD

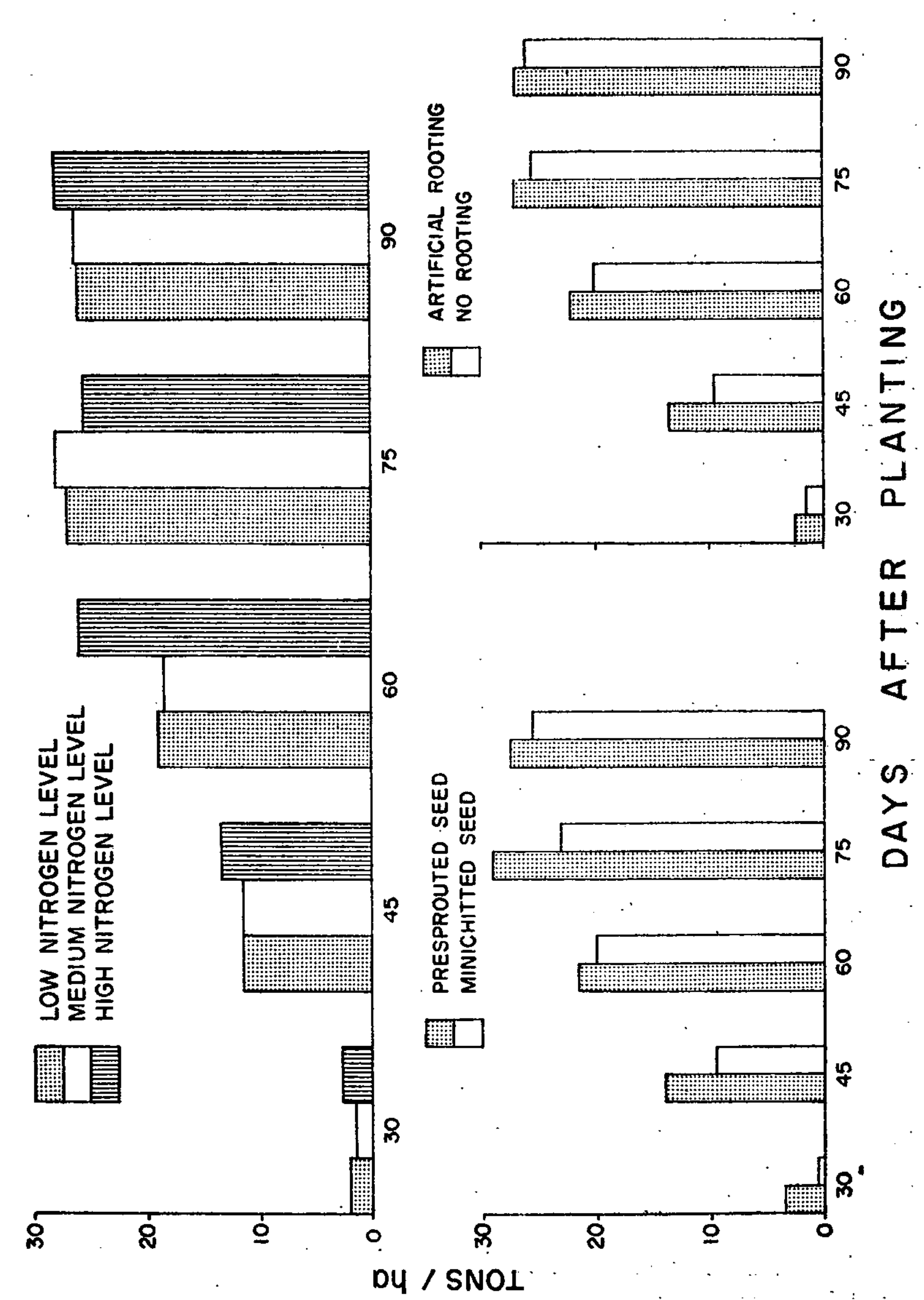
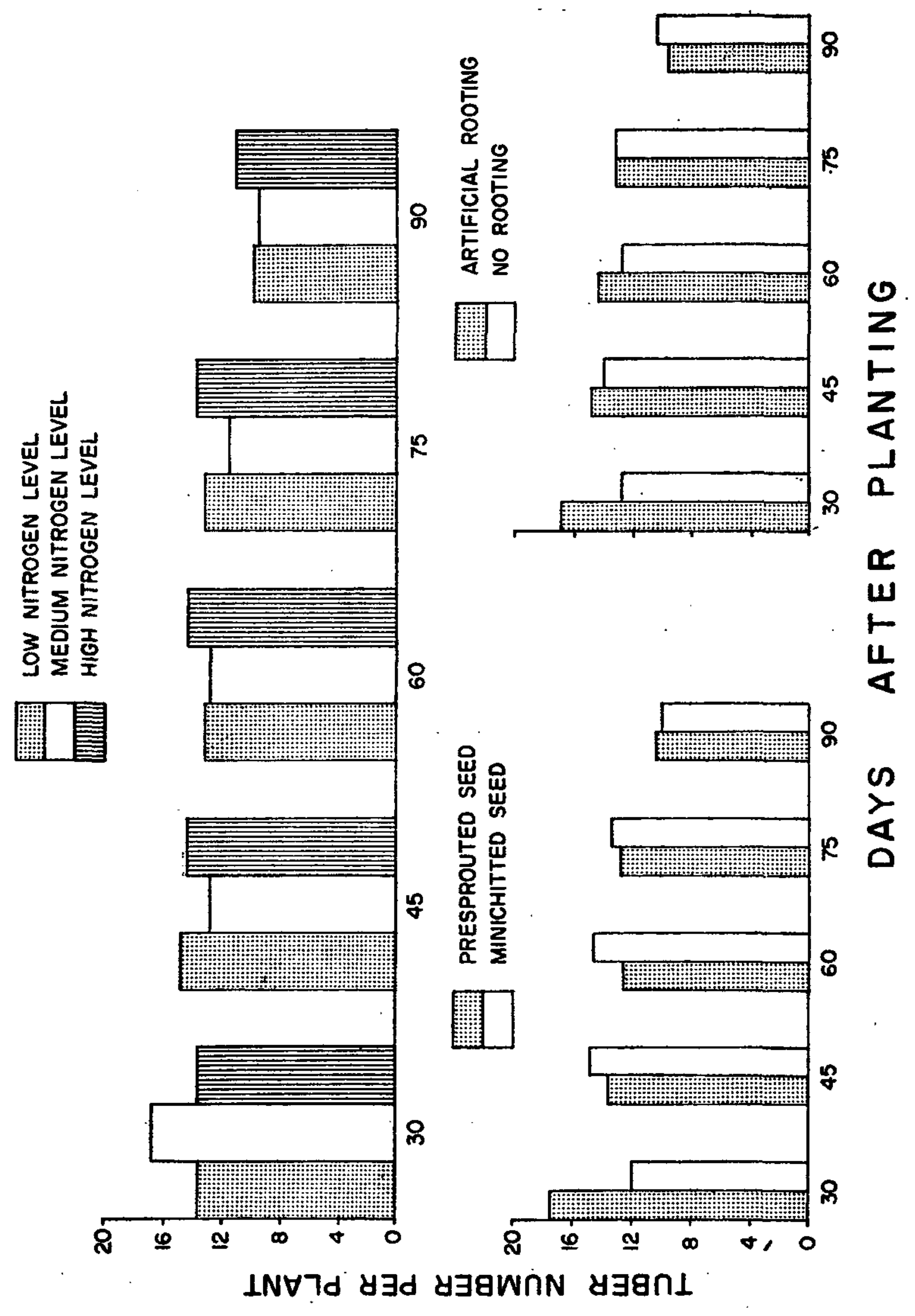


Fig. 2 MAIN EFFECT OF TREATMENTS ON TUBER NUMBER PER PLANT



At 30 and 60 DAP, artificial rooting increased tubers per plant by 31% and 12% over those without root inducement, (Table. 3) probably associated with increased nutrient uptake from a greater foraging area due to root initiation. However, at 75 and 90 DAP no significant differences were recorded between treatments which may de due to the non rooted tubers establishing an adequate root system as growth proceeded.

Tuber size distribution

Medium and high N increased ware size tubers by 77% and 100% respectively, compared with low N, (Table 4) which may be due to the lesser tubers per plant for medium and high N, compared with low N. There was no significant difference in the number of seed size tubers between low and medium N, but low N increased seed size tubers by 11% compared with high N. Nitrogen had no effect on chat size tubers. Presprouting significantly increased ware and seed size tubers by 41% and 7%. respectively over minichitted seed, (Table, 4) associated with the advantage of quick establishment of presprouted seed. Minichitted seed increased chat size tubers by 26% over presprouted seed. While root inducement significantly increased ware size tubers (90%) attributable to an initially greater foraging area by the root system, there was a decrease of 10% of seed size tubers compared with seed without root induction. Rooting had no effect on chat size tubers.

Tuber bulking rate

Tuber bulking rate was calculated from 4 weeks after planting till maximum tuber fresh weights were recorded at 10-12 weeks, using a linear regression equation $Y = a + b.t$, where Y = yield of tubers in kg/ha; a = a constant; b = bulking rate in kg/ha per week and t = time measured in weeks (Table, 5).

The tuber bulking rates were linear as indicated by the correlation coefficients. Both medium and low N showed higher tuber bulking rates over high N, (Table, 5). Tuber fresh weight yield was not correlated with bulking rate. Although tuber bulking rate was lower for high N compared to medium and low N, prolonged growth for 2 weeks for high N significantly influenced duration of tuber bulking. It is thus possible, that under a short day regime the length of tuber bulking is of greater consequence for increased tuber yield, provided the rate of bulking is maintained at an adequate level.

Total dry matter yield

Maximum total dry matter for all treatments was recorded at 75 DAP (Table, 6). At this harvest medium N significantly outyielded the low N in total dry matter, the differences between other two N levels being not significant.

At 30 DAP, presprouted seed recorded an increase of 96% in total dry matter yield over minichitted (Table, 6). Except at 60 DAP presprouted seed continued to outyield the minichitted seed in total dry matter, confirming the earliness in growth attributed to presprouting (Beukema, 1973; de Vaz & Gunasena, 1977).

Artificial rooting of tubers had no effect on maximum total dry matter yield at 75 DAP (Table, 6). At other harvests, seed with roots induced significantly outyielded the non rooted seed in total dry matter. with the initial harvest (30 DAP) recording a 56% increase. This could mainly be due to quicker plant establishment, greater foraging area and presumably more nutrient uptake in the root induced tubers.

Distribution of dry matter as percentage of total

During early growth, medium N increased total dry matter partitioned for tubers by 10% compared to low and high N levels (Table, 7). However, as the crop advanced in age, total dry matter for tuber growth increased to over 80% at 75 DAP. This demonstrated the general pattern of dry matter distribution in the potato; initially for haulm growth and subsequently for tuber development (Fig: 3a).

The initial harvest showed striking differences in the partitioning of total dry matter for tuber growth (Fig: 3b)in presprouted seed,(32%)compared with minichitted, (1.79%) due to the earliness in the many growth characters attributed to presprouting (Beukema, 1973; de Vaz & Gunasena 1977).

Leaf area index (L)

Each increment of N significantly increased L (Fig: 4). Maximum L was attained at 60 DAP for low and high N, and at 45 DAP for medium N, (Table, 8). At maximum, high N increased L by 20% and 39% compared with medium and low N respectively. While a L of above 3 was seen for medium and high N from 45 DAP, L for low N continued to remain below 3 during the entire growth period. This could be the result of adequate N availability for medium and high N over a longer period which enhanced leaf growth, compared with low N.

Both presprouted and minichitted seed reached maximum L at 60 DAP. Upto 45 DAP, presprouted seed recorded significant increases in L over minichitted, which could be due to the physiologically older condition of presprouted seed and consequent quicker vegetative growth. However, in the later harvest, minichitted seed increased L compared with presprouted.

Seed tubers with or without rooting attained maximum L at 60 DAP. The increase in L from 30-60 DAP was equal (50%) for both treatments, probably due to the root system in the non root induced seed growing to similar proportions as the root induced seed, with time.

Fig. 3a MAIN EFFECT OF NITROGEN LEVELS ON % DISTRIBUTION OF DRY MATTER
HAULMS Vs TUBERS

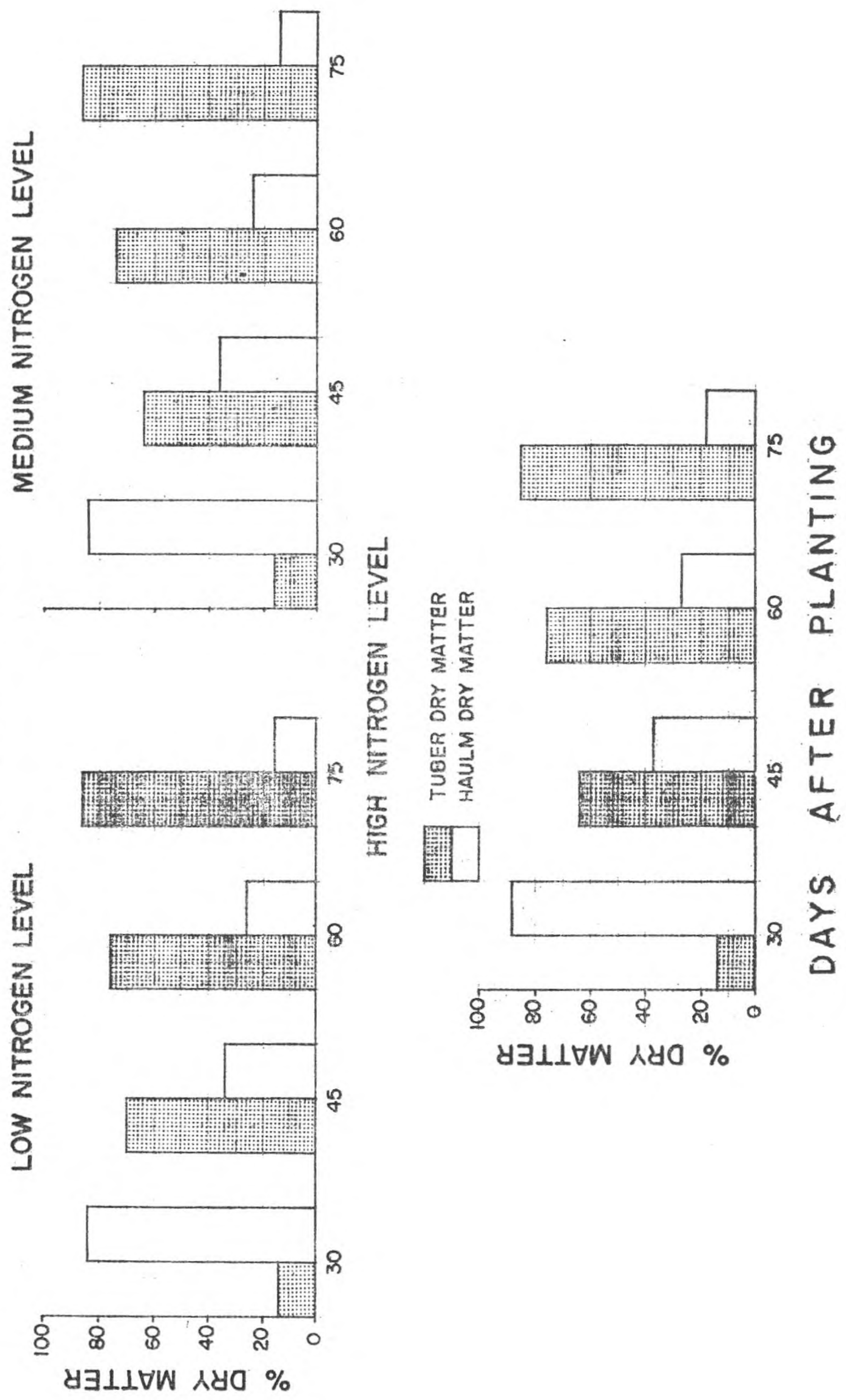


Fig. 3b MAIN EFFECT OF SEED TYPES & ROOTING OF SPROUTS ON % DISTRIBUTION OF DRY MATTER – HAULMS Vs TUBERS

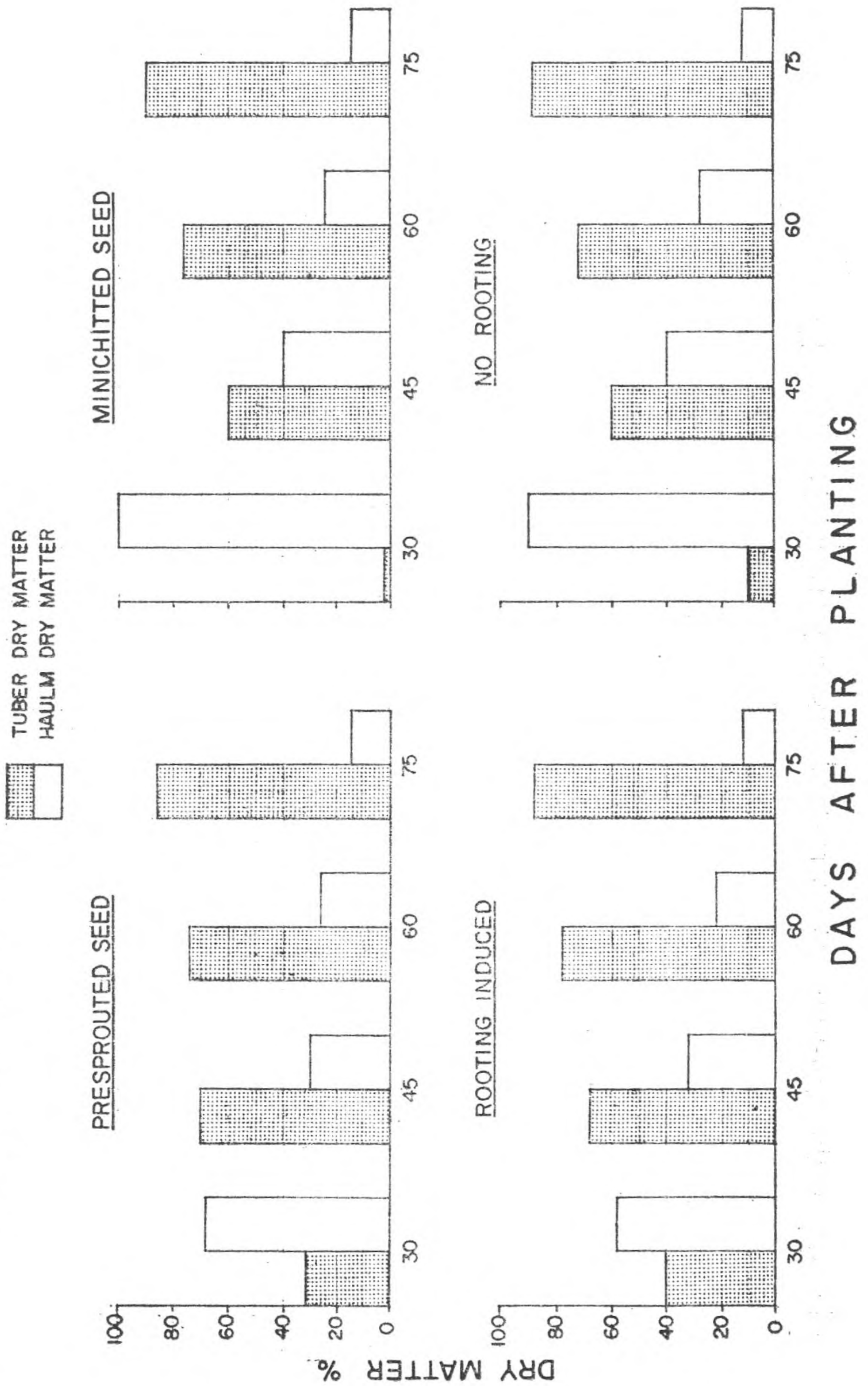
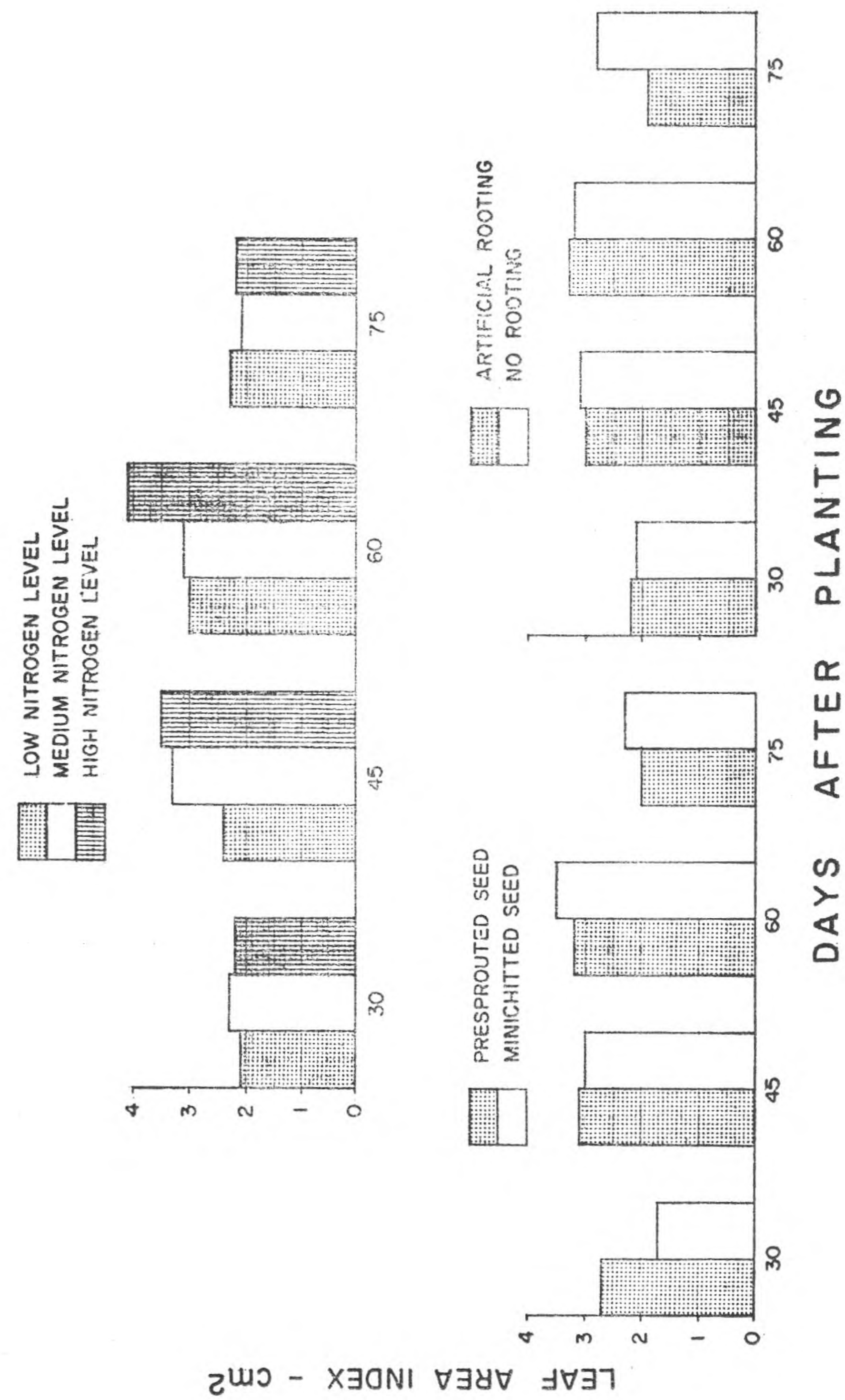


Fig. 4 MAIN EFFECT OF TREATMENTS ON LEAF AREA INDEX



Starch percentage in tubers

At the final harvest, presprouted seed and seed without root inducement recorded a significant 2% increase in starch, compared with the corresponding treatments (Table, 9).

Nitrogen had no significant effect on starch percentage in tubers.

SUMMARY

To exploit the short growing period available for a potato crop in Sri Lanka agronomic practices such as presprouting, root inducement on sprouts prior to planting and levels of N were tested with a view to influence the two parameters governing the yield of potato, namely rate and duration of tuber bulking.

The highest increment of N showed significantly more tuber yield and L, compared with medium or low N. Nitrogen appeared to be a less critical factor for tuber initiation and indicated the likelihood of other factors influencing the process. Presprouting seed tubers showed striking earliness in many growth aspects compared with minichitted. Presprouted seed while giving a significant increase in tuber yield 15 days earlier over minichitted, also increased the proportion of ware and seed size tubers. Artificial root inducement in tubers prior to planting, appeared beneficial for earlier emergence, tuberization and higher yields.

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Table 1. Climatic data, Sita Eliya, 1973/74

Period		*Temperature*		*Soil Temperature* ^{o}C	*Rainfall* *mm*	*Rainfall days*	*Frost days*
October 1973		*Min.*	*Max,*	(10 *cm depth*)			
October							
27–31	...	13.4	19.6	18.0	11.94	5	0
November							
1–15	...	12.0	15.2	17.8	3.05	7	0
16–30	...	11.0	19.0	17.8	10.67	9	0
December	...	11.0	19.0	17.2	5.84	8	0
1–15							
16–31	...	12.0	18.0	16.7	20.57	15	0
January 1974	...						
1–15	...	8.5	19.0	15.8	0	0	6
16–31	...	9.5	20.0	15.0	0	0	2
February							
1–15	...	9.0	20.0	17.2	3.30	3	2

Table 2. **Main effect of treatments on tuber fresh weight yield, tons/ha**

Treatments	30	45	60	75	90
	Days after planting				
(*a*) **Levels of nitrogen**					
112 kg/ha (low) ...	1.85	10.94	18.94	26.98	25.53
156 Kg/ha (medium)	1.62	11.31	18.04	27.30	26.24
200 Kg/ha (high)	2.39	13.03	25.75	24.88	28.24
L.S.D. (P=0.05)	0.45	1.04	1.39	1.77	1.45
(*b*) **Sprouting**					
Presprouted ...	3.53	14.04	21.69	28.98	27.56
Minichitted ...	0.60	9.48	20.14	23.78	25.78
L.S.D. (P=0.05)	0.37	0.85	1.13	1.45	1.19
(*c*) **Rooting**					
Rooting induced	2.52	13.86	21.75	26.95	27.37
Rooting not induced	1.61	9.67	20.07	25.82	25.95
L.S.D. (P=0.05)	0.37	0.85	1.13	NS	1.19
C.V.% ...	25.7	10.4	7.8	7.9	6.4

Table 3—**Main effect of treatments on tuber number per plant**

Treatments	30	45	60	75	90
	Days after planting				
(*a*) **Levels of nitrogen**					
112 Kg/ha (low)	13.4	14.7	13.0	13.0	9.9
156 Kg/ha(medium)	16.5	12.9	12.9	11.8	9.5
200 Kg/ha (high)	13.4	14.5	14.3	13.5	10.5
L.S.D. (P=0.05)	1.8	NS	NS	NS	NS
(*b*) **Sprouting**					
Presprouted ...	17.2	13.7	12.4	12.5	10.1
Minichitted ...	11.7	14.4	14.4	13.1	9.8
L.S.D. (P=0.05)	1.5	NS	1.1	NS	NS
(*c*) **Rooting**					
Rooting induced	16.4	14.3	14.2	12.8	9.5
Rooting not induced	12.5	13.8	12.7	12.8	10.5
L.S.D. (P=0.05)	1.5	NS	1.1	NS	NS
C.V. % ...	15.1	16.3	11.5	15.8	19.7

Table 4—**Main effect of treatments on size grading of tubers at final harvest**

Treatments	*Ware sizes per plant*	*ha*	*Seed sizes per plant*	*ha*	*Chat sizes per plant*	*ha*
(*a*) **Levels of nitrogen**						
112 Kg/ha (low)	0.09	5,808	5.81	374,983	2.84	183,296
156 Kg/ha (medium)	0.16	10,326	5.58	360,138	2.89	186,523
200 Kg/ha (high)	0.18	11,617	5.22	336,904	2.88	185,878
L.S.D. (P=0.05)	0.04	2,581	0.43	27,752	NS	NS
(*b*) **Sprouting**						
Presprouted	0.17	10,971	5.74	370,465	2.53	163,288
Minichitted	0.12	7,744	5.33	344,003	3.21	207,176
L.S.D (P=0.05)	0.03	1,936	0.35	22,589	0.33	21,298
(*c*) **Rooting**						
Rooting induced	0.19	12,262	5.23	337,549	2.84	183,296
Rooting not induced	0.10	6,454	5.85	577,564	2.91	187,814
L.S.D. (P=0.05)	0.03	1,936	0.35	22,589	NS	NS
C.V. %	29.79	29,79	9.25	9.25	16.56	16,56

Table 5—**Main effect of treatments on tuber bulking rate**

Treatments	*Tuber bulking rate* Kg/ha/week	*r*
(*a*) **Levels of nitrogen**		
112 Kg/ha (low)	3891	0.9995
156 Kg/ha (medium)	3909	0.9978
200 Kg/ha (high)	2965	0.9201
(*b*) **Sprouting**		
Presprouted	2940	0.9455
Minichitted	3019	0.9608
(*c*) **Rooting**		
Rooting induced	2930	0.9481
Rooting not induced	3020	0.9587

Table 6—**Main effect of treatments of total dry matter yield Kg/ha**

	Days after planting			
Treatments	30	45	60	75
(*a*) **Levels of nitrogen**				
112 Kg/ha (low)	916.74	2897.06	4892.71	6478.80
156 Kg/ha (medium)	1140.22	2753.53	4727.70	6668.51
200 Kg/ha (high)	1056.02	3422.00	5433.49	6581.08
L.S.D. (P=0.05)	141.50	147.40	122.52	140.83
(*b*) **Sprouting**				
Presprouted	1430.09	3383.29	4788.79	7147.54
Minichitted	730.49	2590.06	5220.46	5999.15
L.S.D. (P=0.05)	197.80	226.70	101.40	243.50
(*c*) **Rooting**				
Rooting induced	1532.68	3342.46	5087.66	6434.69
Rooting not induced	984.40	2703.31	4976.08	6552.78
L.S.D. (P=0.05)	198.80	226.70	101.40	NS
C.V.%	10.2	9.2	8.3	9.4

Table 7—**Distribution of dry matter as percentage of the total**

	Days after planting											
Treatments	30			45			60			75		
	**L*	*S*	*T*	*L*	*S*	*T*	*L*	*S*	*T*	*L*	*S*	*T*
(*a*) **Levels of nitrogen**												
112 Kg/ha (low) ...	55	30	15	22	11	67	17	7	76	9	6	85
156 Kg/ha (medium) ...	50	25	25	24	12	64	18	7	75	7	6	87
200 Kg/ha (high) ...	57	29	14	25	11	64	17	7	76	10	6	84
(*b*) **Sprouting**												
Presprouted ...	46	22	32	22	9	69	19	6	75	7	6	87
Minichitted ...	62	36	2	26	14	60	15	8	77	10	7	83
(*c*) **Rooting**												
Rooting induced ...	40	20	40	21	11	68	15	7	78	5	6	89
Rooting not induced ...	62	28	10	27	12	61	20	7	73	10	6	84

**L* Leaf
S Stem
T Tuber

Table 8—**Main effect of treatments on leaf area index**

Treatments	Days after planting 30	40	60	75
(*a*) **Levels of nitrogen**				
112 Kg/ha (low)	1.95	2.31	2.80	2.30
156 Kg/ha (medium)	2.30	3.25	3.03	2.06
200 Kg/ha (high)	2.24	3.58	3.90	2.09
L.S.D. (P=0.05)	0.13	0.15	0.13	0.14
(*b*) **Sprouting**				
Presprouting	2.64	3.09	3.12	1.96
Minichitted	1.68	2.87	3.37	2.34
L.S.D. (P=0.05)	0.11	0.12	0.11	0.11
(*c*) **Rooting**				
Rooting induced	2.20	2.96	3.28	1.78
Rooting not induced	2.12	3.00	3.20	2.52
L.S.D. (P=0.05)	NS	NS	NS	0.11
C.V. %	7.04	5.90	4.78	7.42

Table 9—**Main effect of treatments on starch percentage in tuber at final harvest**

Treatments	*Starch percentage in tuber*
(*a*) **Levels of nitrogen**	
112 Kg/ha (low)	15.81
156 Kg/ha medium)	15.73
200 Kg/ha (high)	16.06
L.S.D. (P=0.05)	NS
(*b*) **Sprouting**	
Presprouted	16.04
Minichitted	15.69
L.S.D. (P=0.05)	0.32
(*c*) **Rooting**	
Rooting induced	15.69
Rooting not induced	16.04
L.S.D. (P=0.05)	0.32
C.V. %	2.92