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A STUDY OF THE GROWTH CHARACTERISTICS OF CASSAVA BY RAPID PROPAGATION METHOD

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INTRODUCTION

Cassava (Manihot esculenta Crantz) is usually propagated by stem cuttings. It may by taken from plants that are at least ten months old and which are about 25-35 cm. long. It have been found that any parts of the cassava stems can be used, but the best part is its mature portion (6.9). The buds from the older cuttings had been found sprout earlier than those from the young ones; the percentage of germination from the base or old cuttings were the highest, middle cuttings were the next, and the lowest percentages of germination were obtained from the young or top cuttings (7). The shoots belonging to the basal and the lower half of the middle zones were more vigorous and healthier than the olders from the remaining regions of the stems, three buds of the top end of the stem did not sprout (13).

Althoug the vegetative method of propagation is used in commercial plantings, but it gives a slow rate of plantmultiplication, and are not sufficiantly rapid to give large short-terms increases in planting material from new varieties or to supply disease free stock for commercial planting (5). Chant and Marden (4) found that green wood cuttings, 15 cm. long, taken with a heel of lignified tissue were rooted succesfully to give a three-fold multiplication rate every four weeks. More recently, it has been found that non-lignified shoots without the lignified heel also produced roots (1,10,11). Similarly, rooting shoot tips have been successfully used in an attampt to produce plants free from cassava bacterial blight (8). This has been shown that rapid propagation is

very important and widely used.

Development of techniques for rapid propagation of cassava was initiated at CIAT in 1971. A propagation frame was developed, faster shoot production occurred in this propagation frame. Small green shoots were easily rooted in peat pots filled with sterilized soil and placed in the propagation frame(2). Wholey and Cock (12) shown that single and two-node woody-cutting which grown in the propagation frame produced more shoots per-node than longer cutting under mist. However, they suggested that the efficiency of this system depends upon the success of two phases: (a) shoot production and (b) rooting and establishment of shoots. It was found recently that young green shoots rooted in sterile water were satisfactorily, this plantlets can be transplanted directly to the field if it well prepared (3).

The objectives of this experiment were:(1) to study the shoot production on two-node cuttings with different planting position and qualities of buds, (2) to study the shoot production of two-node cuttings of two varieties of cassava taken from three parts of the stem, (3) to study the effects of shoot sizes on two varieties of cassava growing in the flasks and then in the field.

MATERIALS AND METHODS

Experiment I

Propagation frames of the type described by Cock *et al.* (5) were filled with clay loam soil. The soil was sterilized before use by fumigation with methye bromide at the rate of 1 lb/cu.yd. Two hundred

cuttings with 2-normal buds and two hundred cuttingswith one bud bruised and 1 bud normal were taken from cassava stem, variety CMC 40 which were 12 months old. The cuttings were treated with the combination of fungicide (0.1% Manzate D + 0.2% Dithane, in water) by dipping for five minutes to prevent from the attack of soil-born fungi. After drying the cuttings for 2 hours, they were planted horizontally in a propagation frame 1 cm. below the soil surface.

The propagation frame was divided into eight compartments. In each compartment, fifty cuttings with different quality buds and planting possitions were planted, as shown in the following.

Treatment 1: two normal bud cuttings were planted with buds orientated sideways position.

Treatment 2: Two normal bud cuttings were planted with buds facing upwards.

Treatment 3: two node cuttings with one bud bruised and one bud normal were planted with buds orientated side ways position.

Treatment 4: two-node cuttings with one bud bruised and one bud normal were planted with buds facing upwards.

The above four treatments used in this experiment were designed in 2 x 2 factorial in completely randomized with 2 raplications.

The germination on cuttings of each treatment was recorded up to 21 days after planting. The 5 cm. tall shoots were excised by a razor blade sterilized with 80% alcohol. The number of shoots were

also recorded, and one hundred shoots from each treatment were placed in small bottles containing sterilize water in rooting chamber in order to examine callus formation, root initiation, and the percentage of surviving shoots. Dialy temperature of this propagation frame were also recorded.

Experiment II

Two-node cuttings from each of the two varieties, CMC 40 and M Col 22, were taken from three parts of 12 months old stems. The cuttings were treated with the combination of fungicides (0.1% Manzate D+ 0.2% Dithane in water) by dipping for five minutes as the experiment I. After drying these cuttings, they were planted horizontally at 1 cm. below the soil surface in three propagation frames. In each propagation frame was divided into four compartments containing methyl bromide fumigated soil. The cutting of two varieties were planted with different treatment as follows.

Treatment 1: two-node cuttings taken from basal part of stem (variety CMC 40)

Treatment 2: two-node cuttings taken from middle part of stem (variety CMC 40)

Treatment 3: two-node cuttings taken from apical part of stem (variety CMC 40)

Treatment 4: two-node cuttings taken from basal part of stem (variety M Col 22)

Treatment 5: two-node cuttings taken from middle part of stem (variety M Col 22)

Treatment 6: two-node cuttings taken from apical part of stem (variety M Col 22)

Each treatment contains 100 cuttings. All of these treatments were designed in 3 x 2 factorial in completely randomized with 2 replications.

Two to three weeks after planting, the germination of cutting were recorded. The 5 cm. shoots were excised and done the same method to the experiment 1 in order to examine the callus formation, root initiation and percentage of surviving shoots.

Experiment III

Two hundred cuttings of variety CMC 40 and two hundred of variety M Col 22 which taken from the 12 months old stems were planted horizontally in a propagation frames 1 cm. below the soil surface. Each cutting has two node only. The propagation frames were divided into four compartments containing the same soil with cuttings having different treatments as shown in the following.

Treatment 1: One hundred cuttings of variety CMC 40 were planted in compartment I. When 5 cm. tall shoots were excised as soon as they reached that height, fifty of these shoots rooted in flasks containing sterile water in a rooting chamber 20 days before planting out in the field in replicate 1. Another fifty of the 5 cm. shoots were repeated with treatment 1 for planting in Replicate 2. Extra 5 cm. shoots from the cuttings were then simply removed and their number recorded in order to know the total number of 5cm. shoots produced by the 100 cuttings in a given period. The number of rooted shoots in the flasks and number of shoots finally surviving in the field were recorded.

Treatment 2-3: One hundred cuttings of variety CMC 40 were planted in compartment II when 25 cm, tall shoots were excised as soon as they

reached that height. For treatment 2, fifty of these shoots placed in flasks 20 days for rooting and then planted in the field in Replicate 1. Another fifty of the 25 cm. shoots were planted directly out in the field (Treatment 3) in Replicate 1 additional 25 cm. shoots produced by the same 100 cuttings were again used to repeat treatment 2 and 3 for planting in Replicate 2. Any extra 25 cm. shoots from the cuttings were simply removed and their number recorded. The number of rooted shoots in the flasked and the number of shoots surviving in the field with treatment 2 and 3 were recorded.

Treatment 4: One hundred two node cuttings of variety M Col 22 were planted in compartment III and the 5 cm. shoots were treated exactly as treatment 1 except that a different variety was used. Again the 100 cuttings provided shoots for Replicate 1 and 2.

Treatment 5-6: One hundred cuttings of variety M Col 22 were planted in compartment IV. Treatment 5, 6 were the same as treatment 2 and 3 respectively except that variety M Col 22 was used instead of variety CMC 40.

There were two propagation frames. Each propagation frame represented to each replication. In a propagation frame consisted of 200 cuttings of variety CMC 40 and 200 cuttings of variety M Col 22 provided enough shoots for growing in the field for Rep. I and Rep. II and another provided shoots for Replication III and IV.

Field Experiment

The field was prepared in ridges, 1 meter apart, and divided into four plots. Each plot consisted of six rows where randomly arranged, one

row represented of one treatment which was replicated four times. Treatment 1 and 4 shoots should be planted as deep as the lowest leaves were at the soil level, while treatments 2, 3, 5 and 6 shoots were planted about 15 cm. deep. Planting should be taken care to avoid damaging or roots especially in treatment 1, 2, 4 and 5. Plants were watered daily for the first 21 days. The shoots establishment in each treatment was recorded at one month after planting.

RESULTS

Experiment 1

Percentage of germination

The percentage of germination of the cuttings planted in different positions and qualities of buds in experiment 1 are shown in Table 1. Significant difference were found between treatments at the 5% level 21 days after planting. Treatment 1 gave 87.5%, the highest percentage of germination and treatment 2, 3 and 4 were 72.5, 58.0 and 57.0 percent, respectively.

Rates of germination of four treatments within the period of 21 days after planting are shown in Fig 1, these rates increased reapidly from the 6th day, except treatment 2 began from the 3rd day. The rates of germination in every treatment reached the peak rapidly at 12 day and then increased slowly until 21 days.

Shoot production

The number of shoots produced in each month within the period of 5 months shown in Table 2. Significant differences were found between treatments at the 5% level in the 1st-3rd month. However, there were no

significant differences between treatments at the 4 th-5th month. It has shown that the number of shoots produced in each treatment was highest in the second month, then it would be decrease slowly in the rest period (Fig. 2).

Significant differences on total number of shoots produced in 5 month at the 5% level were found between treatments (Table 3). Treatment 1 produced 553.5 shoots, that more than the treatments 2, 3 and 4 were 479.5, 416.5 and 421.5 respectively. However, it was found that the rate of total shoot production in all treatments were nearly similar (Fig 3).

Callus formation and Root initiation

The callus formation all treatments were found eight day after rooting in the rooting chamber. Two days after callus formation the roots initiated, and after eighteen days shoots in all treatments shown more than 90% rooting (Table 4).

Experiment 2

Percentage of germination

The germination of the cutting taken from the different parts of the stem of two varieties 21 days after planting, are shown in Table 5. There were significant differences at 1% level between treatments. The highest percentage of germination was 96.25%, it was the cutting taken from the middle part of stem of variety CMC 40. Anotherhand the cutting taken from the apical part of stem of variety M Col 22 gave the lowest percentage (ie. 68.50%). However, these germination could be divided

into two groups concerning varieties. The first group was the cuttings taken from different part of stem of variety CMC 40. All of cutting in this group gave the germination more than 90%. While the cuttings taken from variety M Col 22 gave the germination less than 80%. It was further noted that the cuttings that gave the highest percentage of germination was taken from the middle part of stem of the both group.

Rates of germination of this experiment in 21 days after planting are shown in Fig 4, these rates increased rapidly from the 6th day and reached the peak at the 12th day, after that it increased slowly.

Shoot production

The number of shoots produced in each month during the period of 6 months are shown in table 6. It was shown that the number of shoots produced of each treatment was increased from the first month and highest in the second month, then decreased gradually at the rest period (Fig 5), except the treatment 6. However, it was observed that the decreasing rate of variety CMC 40 at the 3nd and 4th month were rapidly than the group of cutting taken from the variety M Col 22 at the same time.

Significant differences at 1% level of total number of shoots produced during 6 months were found between treatments, as shown in Table 7. Treatment 1 and 2 gave the highest average number of shoot production (1481.5 and 1453.5), while treatment 3, 4 and 5 were 1209.0, 1018.0 and 817.0 shoots, respectively. The treatment 6 gave lowest shoot production (656.5).

Rates of shoot production of treatment 1, 2 and 3 were increased rapidly in the first three months and these rates were reduced gradually

after three months, but treatments 4, 5 and 6, the rates were nearly similar at all period (Fig 6).

The capacity of shoot production per node of each treatment have shown in Table 8. There were significant differences at 1% level between treatments. It found that treatment 1 gave the best shoots production per node it produced average 8.08 shoots per node in 6 months after planting, and treatment 2, 3, 4 and 5 were 7.69, 6.62, 7.10 and 5.29 shoots per node, respectively. Treatment 6 gave lowest shoots per node (4.79).

Callus formation and Root initiation

The callus formation was found 8 days after rooting in the rooting chamber, the following one or two day the root would be appear as shown in Table 9. It has seen that the shoots from variety CMC 40 had percentage of root initiation higher than the shoots from variety MCol 22 at the same time, and 18 days after rooting, the percentage of root initiation in all of the treatment reached 90%.

Experiment III

Shoot production

The number of shoots produced in each month within the period of 5 months is shown in Table 10. There were significant differences at 1% level between treatments throughout the periods. At the 5th month, treatment 1 gave the greatest number of shoot production (ie.1067.5), and treatments 4, 2-3 were 692.0 and 461.5 shoots, respectively. Treatment 5-6 gave the smallest number of shoot production (ie.272.5).

The rate of shoot production in each treatment in shown in Fig 7.

The shoot production capacity of cuttings in each treatment shown in Table 11. There were significant differences between treatments at the 1% level. The greatest number shoots production per node in treatment 1 was average 6.69, treatment 4 and 2-3 were 5.26 and 2.97 shoot per node, respectively. Treatment 5-6 gave the lowest capacity of shoot production that was 1.98 shoots per node.

Shoot establishment

It was found that the shoots of every treatment (except treatment 3, 6) gave roots 100% in the rooting chamber 20 day before planting in the field. The percentage surviving shoots which planted in the field were found to be significant differences at 1% level as shown in Table 12. These results varied from 87.5% in treatment 5 to 41.0 percent in treatment 3, while the number of plants established in the field by calculating from the percentage surviving shoots in the field with the number of shoots produced in the propagation frame in 5 months varied from 795.29 plants in treatment 1 to 159.41 plants in treatment 6.

DISCUSSION

From the experiment 1, it was shown that the quality and the planting position of cutting affected to the germination and shoot production of cuttings. Furthermore, it was found that there were also interactions between these factors.

Two normal bud cuttings planted with buds oriented sideways position (Treatment 1) gave highest germination of shoots; two normal bud cuttings planted with bud facing upwards (Treatment 2) gave secondary

shoot germination, but the two node cuttings with one bud bruised and one bud normal planted with both position (Treatment 3 & 4) gave unsignificant difference in shoot germination (Table 2). This indicates that the planting position of cuttings affect in germination of shoot only two normal buds cutting treatments. In case of two node cutting with one bud bruised and one bud normal, planting position of buds is not affect in germination of shoots. This may be because of these cutting have only one healthy bud. According to these reason the single healthy bud should have higher germination potential than the buds of two normal buds cutting. Therefore, even planting the cuttings with one bud normal and one bud bruised with oriented sideway position or buds facing upwards these cuttings should have the equal germination capacity. So, the germination of two node cuttings with one bud bruised and one bud normal planted with both position were not significantly difference affected. In the case of shoot production in experiment 1 was demonstrated that the shoot production was closely correlated with the number of germinated cuttings, that is the number of shoot production was high while the germination of cutting was also high.

Two node cuttings taken from different varieties will give different percentage of germination. However, it shows that the percentage of germination of the cuttings taken from different parts of the stems of the same variety are not significantly different (Table 5). Also, it was found that the total number of shoot production of the two node cuttings taken from the different variety would be different at the same period. As shown in Experiment 2, the two node cuttings taken from the stems of variety CMC 40 gave the number of shoot production more than

the cutting taken from the stem of variety M Col 22. In this case, it may be due to the different size of the cuttings (cuttings of variety CMC 40 was larger than the cutting of variety M Col 22). It was further noted that, the cuttings taken from the basal part of the stem should be given more shoot production than the cutting taken from the other parts of the stems of the same variety (Table 7). It was observed that the cutting taken from the basal parts of stems gave more shoot production per node than other ones (Table 8); this may be explained by the mentioned reasons that why the cuttings taken from the basal part of stem give highest shoot production.

The 5 cm. shoot production in propagation frams within 5 month was more than the 25 cm. shoot production (Table 10). This may be because of the 5 cm. shoots were cut shorter and more frequent than the 25 cm. shoots. This accelerated the germination and vigor of new shoots. It was found that, however, both kind of shoots were transplanted in the field about 20 days after rooting in the rooting chamber. These two sizes of shoots have been obtained unsignificant difference in establishment; ie. the percentage of shoot establishment obtained more than 70 percent. The 25 cm. shoots which absent roots could be also planted directly in to the field but the percentage of establishment was rather low, which was 40-60 percent that varied to varieties (Table 12). From this experiment could be suggested that 5 cm. shoots present roots were suitable for multiplying the propagation materials by rapid propagation.

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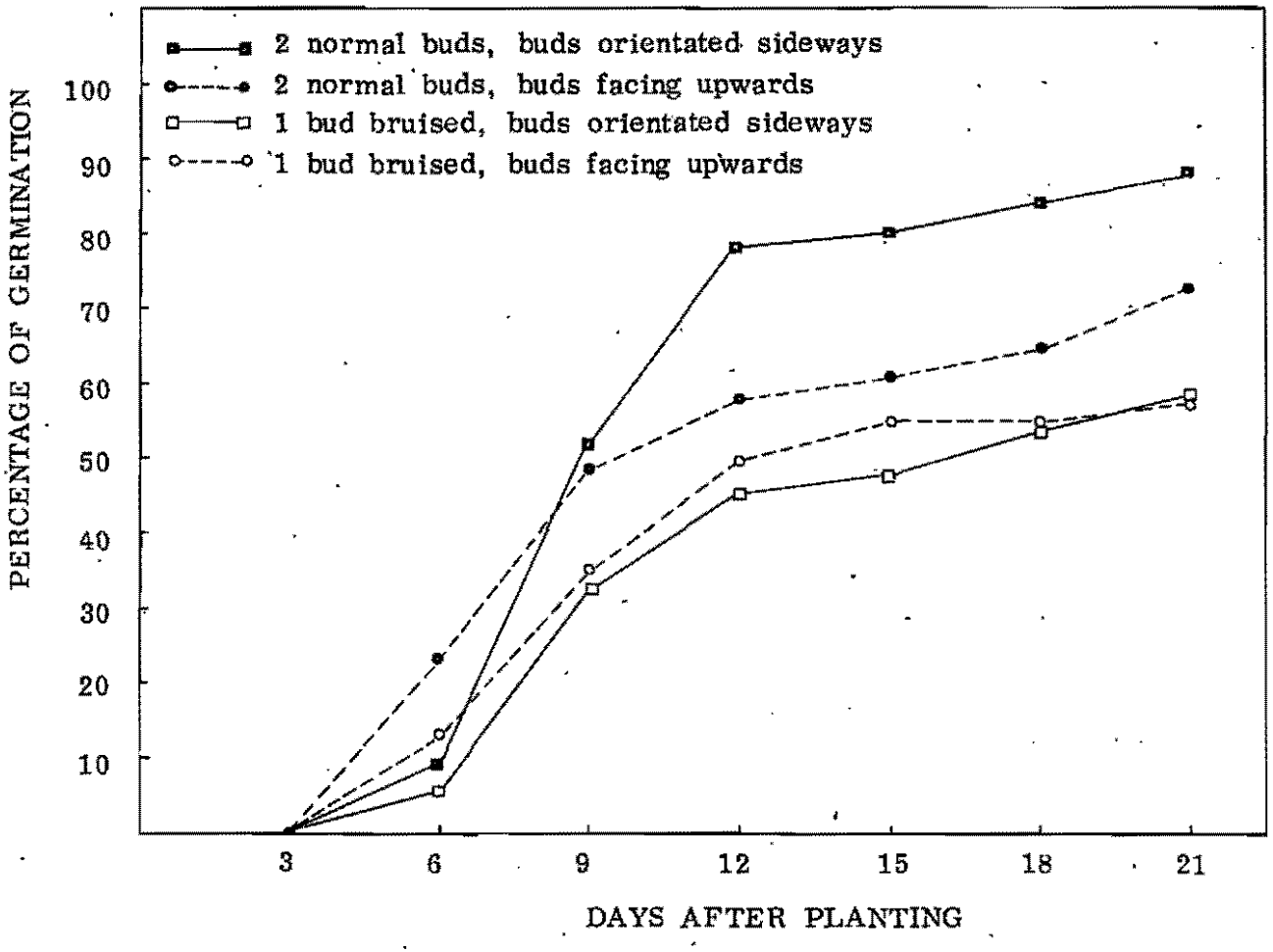

Figure 1. Germination of 2-node cuttings planted in different planting positions and qualities of bud after 21 days of planting (Experiment 1).

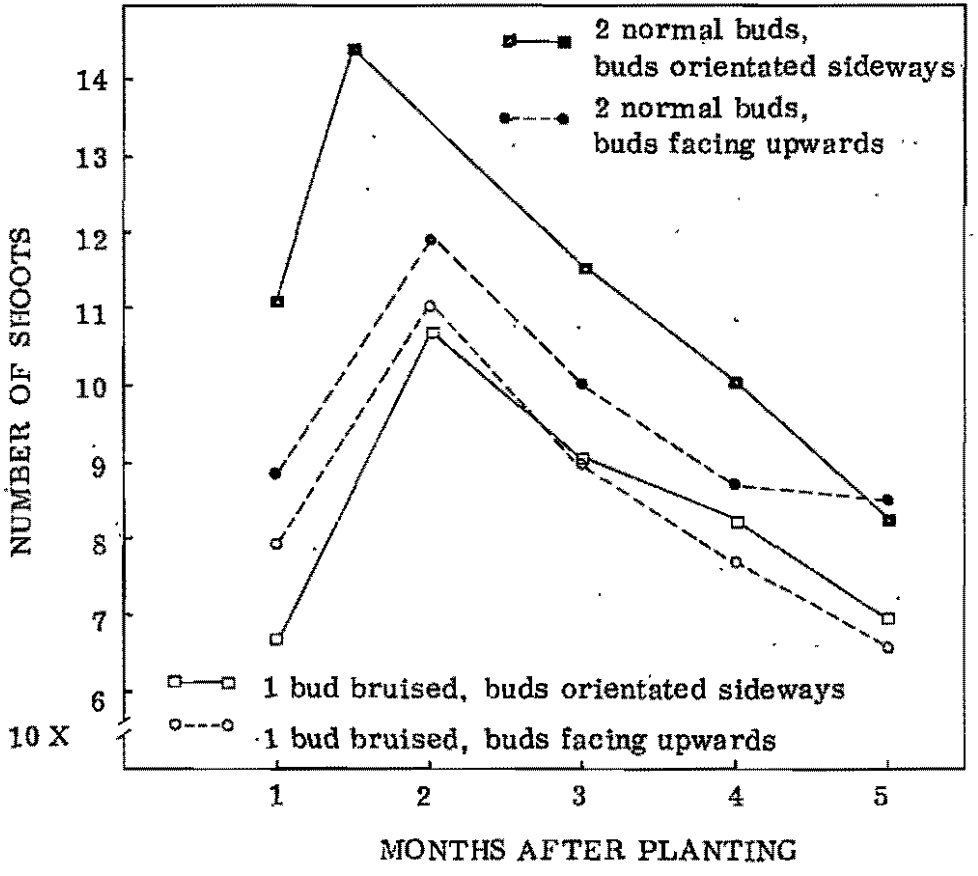

Figure 2. Monthly rate of shoot production of 2-node cuttings planted in different planting positions and qualities of buds for the period of 5 months (Experiment 1).

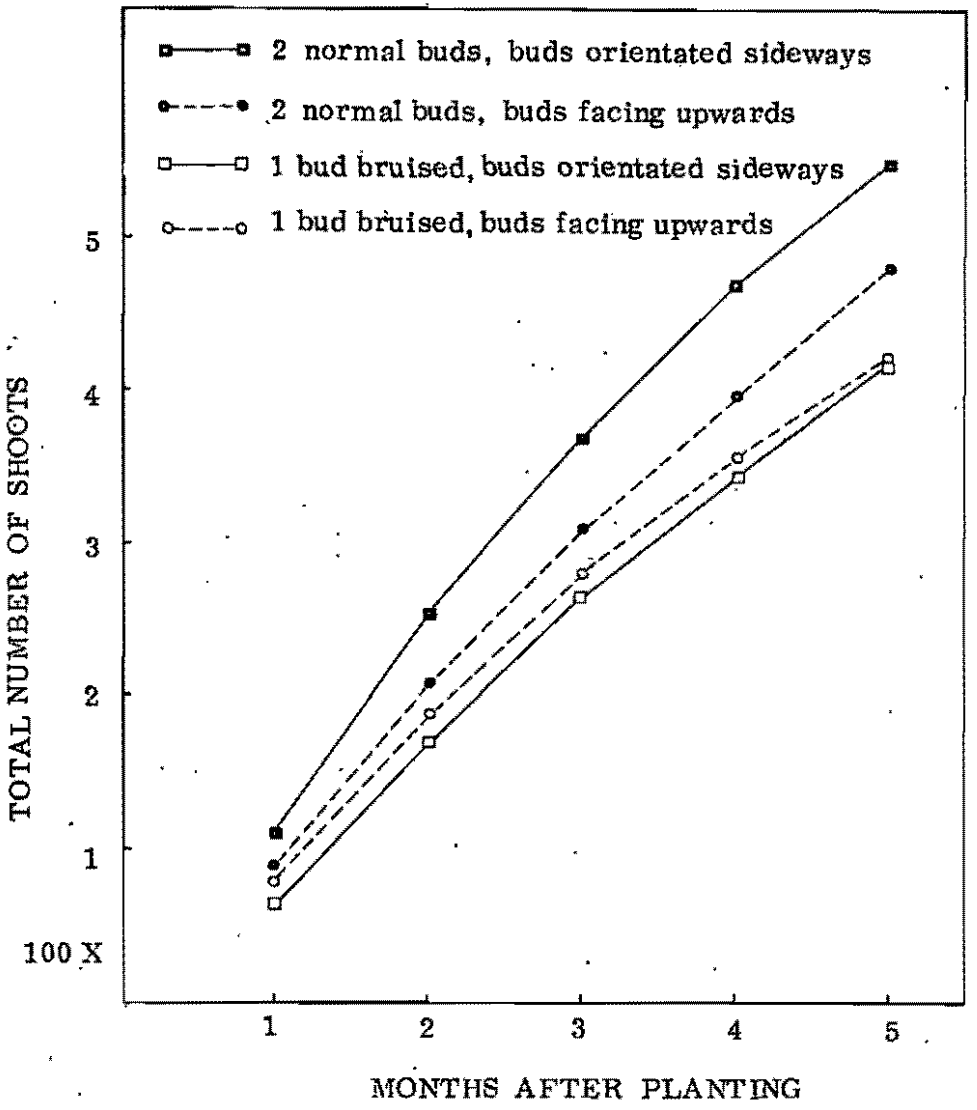

Figure 3. Rate of total shoot production of 2-node cuttings planted in different planting positions and qualities of buds for the period of 5 months (Experiment 1).

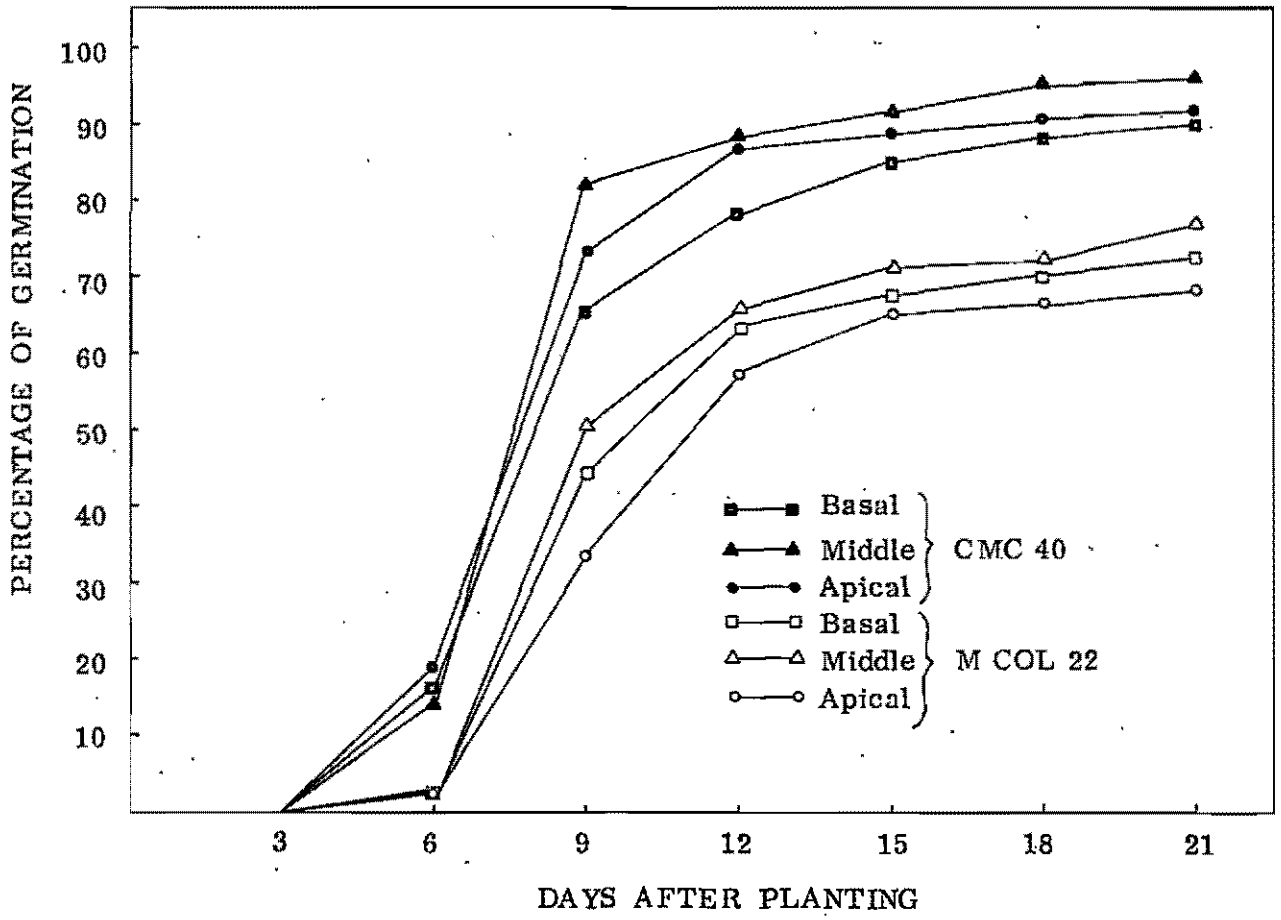

Figure 4. Germination (%) of 2-node cuttings taken from different parts of the stem of two varieties after 21 days of planting (Experiment 2).

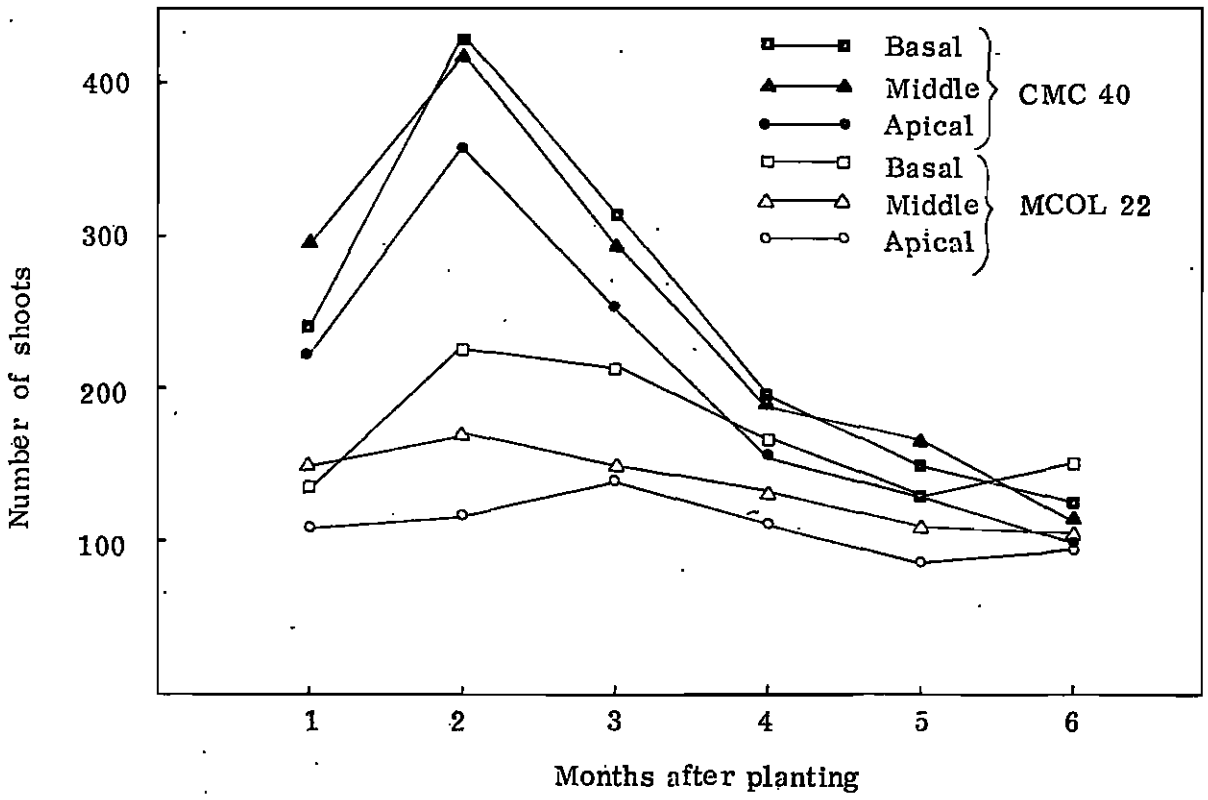

Figure 5. Monthly rate of shoot production of 2-node cuttings taken from different parts of the stem of two varieties for the period of 6 months (Experiment 2).

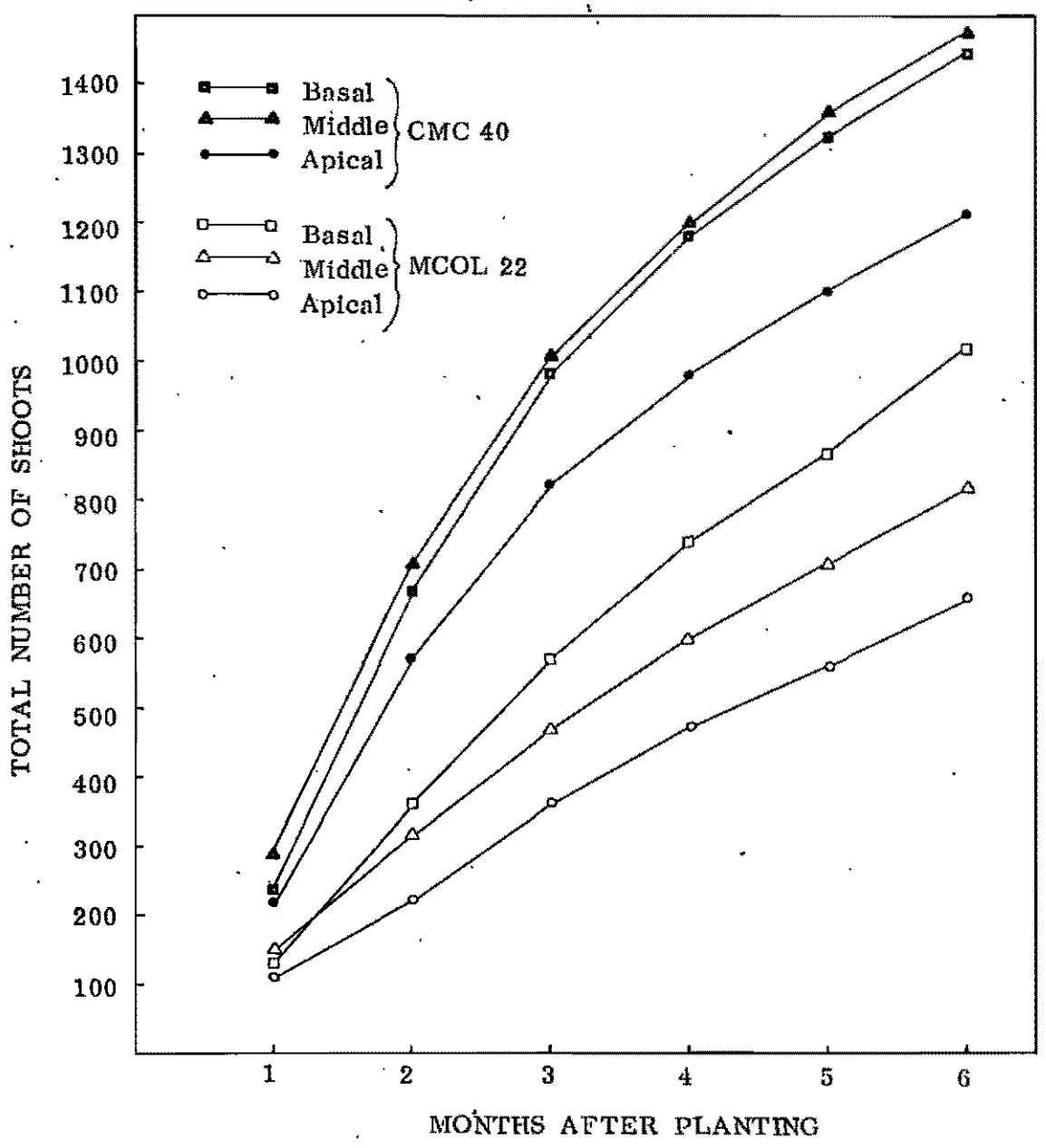

Figure 6. Rate of total shoot production of 2-node cuttings taken from different parts of the stem of two varieties for the period of 6 months (Experiment 2).

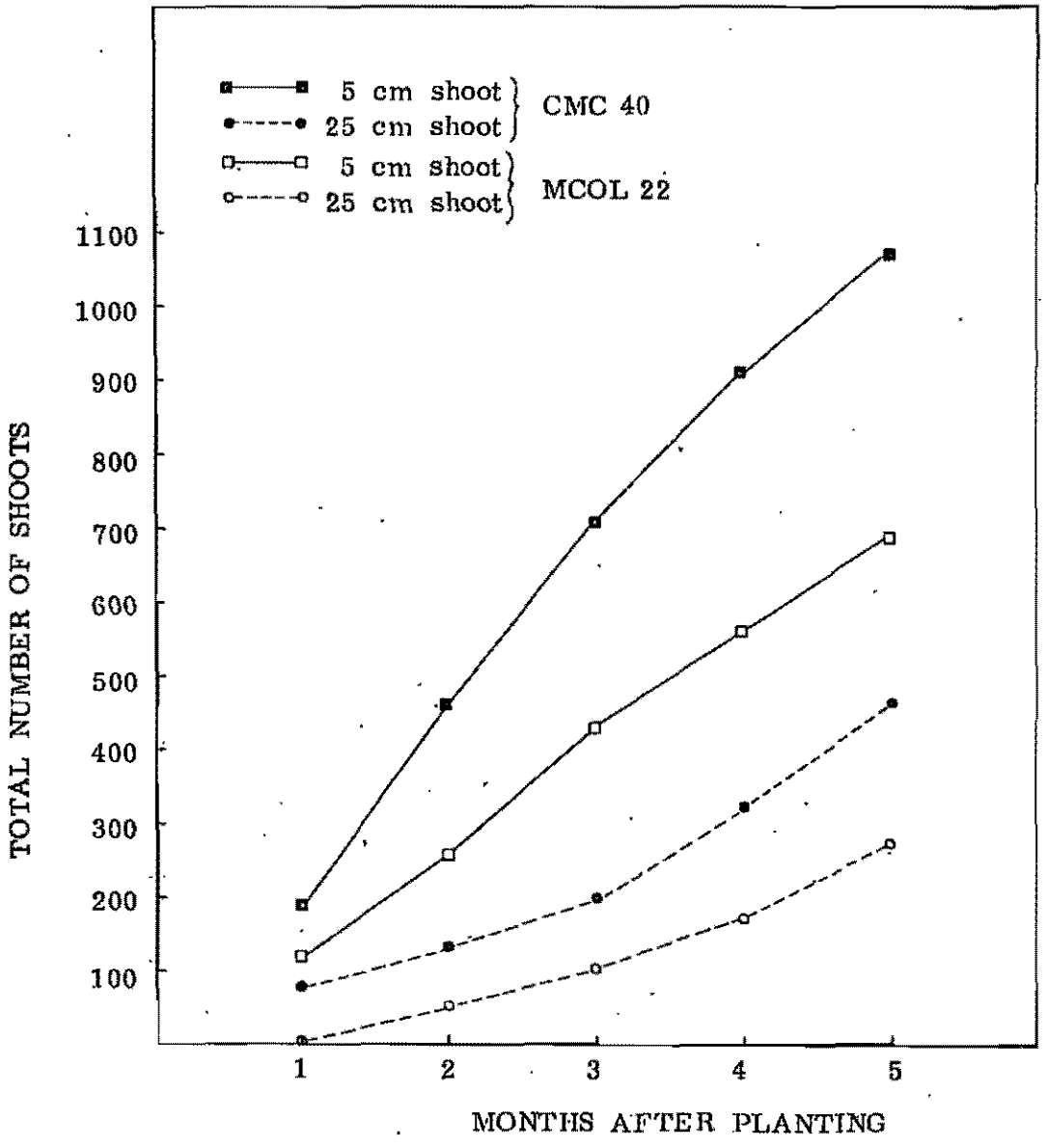

Figure 7. Rate of shoot production (of length 5cm and 25cm) of 2-node cuttings of two varieties for the period of 5 months (Experiment 3).

Table 3. Total number of shoots produced of 2-node cuttings planted in different planting positions and qualities of bud for the period of 5 months (Experiment 1).

Treatments	Months after planting				
	1	2	3	4	5
1	111.0 a	255.0 a	370.5 a	471.0 a	553.5 a
2	88.5 b	208.0 b	308.0 b	395.0 b	479.5 b
3	66.5 c	173.5 c	264.5 c	347.0 c	416.5 c
4	79.0 bc	189.5 b	279.5 c	356.0 c	421.5 c
C.V.(%)	7.83	3.12	2.52	1.82	2.25

Note: Values in the same column having the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 4. Percentage of callus formation and root initiation of shoots excised of each treatment in Experiment I after 22 days of rooting in Rooting chamber.

Treatments	Days after rooting in the Rooting chamber															
	8		10		12		14		16		18		20		22	
	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root
1	6	-	38	3	73	37	87	70	94	89	96	95	98	96	98	98
2	3	-	32	1	67	17	82	62	93	85	96	92	98	92	98	98
3	12	-	65	10	87	47	96	83	98	96	98	98	98	98	98	98
4	10	-	49	4	74	39	92	77	97	93	98	97	98	98	98	98

Table 7. Total number of shoots produced of 2-node cuttings taken from different parts of the stem of two varieties (CMC 40 + M Col 22) for the period of 6 months (Experiment 2).

Treatments	Months after planting					
	1	2	3	4	5	6
1	241.0 ab	670.0 ab	985.0 a	1181.5 ab	1328.5 a	1453.5 a
2	295.0 a	713.5 a	1006.5 a	1198.0 a	1364.5 a	1481.5 a
3	220.5 ab	577.0 ab	824.0 b	978.5 b	1107.5 b	1209.0 b
4	134.5 b	359.5 ab	573.0 c	737.0 c	869.0 c	1018.0 bc
5	148.0 b	321.5 ab	470.0 cd	602.0 cd	712.0 cd	817.0 cd
6	107.5 b	224.0 b	365.0 d	476.0 d	561.5 d	656.5 d
C.V.(%)	13.31	22.45	4.97	5.99	5.23	4.91

Note: Values in the same column having the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

Table 9. Percentage of callus formation and root initiation of shoots excised of each treatment in Experiment 2, after 22 days of rooting.

Treatments	Days after rooting in the Rooting chamber															
	8		10		12		14		16		18		20		22	
	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root	Call	Root
1	50	-	86	43	99	92	99	98	99	99	99	99	99	99	99	99
2	43	-	85	40	95	83	96	95	99	98	99	99	99	99	99	99
3	48	-	85	48	94	87	99	95	99	98	99	99	99	99	99	99
4	18	-	37	7	66	28	85	63	89	79	95	90	97	95	97	97
5	13	-	27	12	60	24	83	50	90	75	96	90	96	96	96	96
6	51	-	81	29	91	70	97	87	98	94	98	98	98	98	98	98

Table 10. Total number of 5 cm shoots and 25 cm. shoots produced by two node cuttings of two varieties (CMC 40 + MCol 22) for a period of 5 months in the propagation frame (Exp. 3).

Treatments*	Months after planting				
	1	2	3	4	5
1	190.5 a	465.0 a	713.5 a	911.5 a	1067.5 a
2-3	80.5 c	136.0 c	197.5 c	325.0 c	461.5 b
4	119.0 b	261.5 b	429.0 b	560.0 b	692.0 c
5-6	0 d	50.5 d	99.0 d	173.0 d	272.5 d
V.C.(%)	3.05	3.29	1.59	1.31	0.66

Note: Values in the same column having the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

*Treatment 1: 5c.m. shoot, CMC 40

2-3: 25 c.m. shoots, CMC 40

4: 5 c.m. shoots, M Col 22

5-6: 25 c.m. shoots, M Col 22

Table 11. Germination, total number of different size shoot production and shoots produced per node of two node cuttings of two varieties 5 months after planting in the propagation frame (Experiment 3).

Treatments	No. germinated	Total No. of shoot production	No. of shoots produced per node
1	159.5 a	1067.5 a	6.69 a
2- 3	155.5 a	461.5 c	2.97 c
4	131.5 b	692.0 b	5.26 b
5- 6	137.5 b	272.5 d	1.98 d
C.V.(%)	1.68	0.66	1.74

Note: Values in the same column having the same letter are not significantly different at the 1% level according to Duncan's multiple rante test.

Table 12. Percentage of shoot establishment in the rooting chamber and in the field of the different size shoots and planting methods, and total number of plants obtained in the field. (Experiment 3)

TREATMENTS	% shoot establishment in the rooting chamber	% shoot* establishment in the field	Total number ** of shoot production	Total no. of plant*** obtained in the field
1	100	74.5 ab	1067.5 a	795.29 a
2.	100	73.0 ab	461.5 c	336.89 c
3	-	41.0 c		189.21 d
4	100	77.5 ab	692.0 b	536.30 b
5	100	87.5 a	272.5 d	238.44 cd
6	-	58.5 bc		159.41 d
C.V.(%)		14.35	0.66	16.83

Note: Values in the same column having the same letter are not significantly different at the 1% level according to Duncan's new multiple range test.

* After planting in the field 1 month

** After planting in the propagation frame 5 months

*** Calculated from % shoot establishment in the field and total number of shoot production

Table 13. Average temperature in each month in propagation frame of Experiment I, II and out side

Months	*Temperature (°C) in propagation frame of Experiment I			**Temp.(°C)in propagation frame of Experiment II			***Temp.(°C)out side		
	7 AM	12AM	5PM	7AM	12AM	5pm	7AM	12AM	5PM
October	-	-	-	23.87	43.22	31.25	21.31	31.80	27.33
November	-	-	-	23.69	40.46	31.06	21.62	32.33	28.30
December	24.03	43.86	32.68	23.95	40.35	31.61	21.87	33.07	29.29
January	23.53	45.98	34.42	23.60	44.37	33.61	21.74	35.21	31.69
February	23.67	46.78	34.44	23.33	45.47	33.45	21.56	33.26	30.45
March	23.88	47.80	34.61	24.13	46.06	33.76	22.24	33.30	31.17
April	24.03	45.52	33.57	-	-	-	21.46	31.02	29.07

* Average from daily temperature (1 propagation frame)

** Average from daily temperature (3 propagation frame)

*** Average from daily temperature.