

SOME ASPECTS OF THE PLANT GROWTH AND DEVELOPMENT OF IMPROVED RICE VARIETIES IN SRI LANKA*

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ABSTRACT

Seedling growth, tillering capacity and leaf development of 10 improved rice varieties were studied under screenhouse conditions for direct-sown plants, plants raised in lowland nursery and dapog nursery. Seedlings raised under direct sown condition produced more leaves and tillers during the 21 day period after sowing than those under standard nursery and dapog nursery. Direct - sown varieties produced 60 tillers per plant compared to 36 tillers in transplanted varieties. Duration for full emergence of the first 7 leaves did not vary with the varieties although the time taken for emergence varied widely as the leaf number advanced from the 8th leaf to flag leaf. Leaf stage at panicle primordia initiation varied with the varieties. There was also a variation in the relative leaf lengths, the longest being the lower 3rd or 4th from the flag-leaf.

INTRODUCTION

Direct sowing of sprouted seeds and transplanting of seedlings raised in lowland nursery beds are the most popular rice crop - establishment methods in Sri Lanka. Sowing of unsprouted seeds on drylands prior to the rains is also commonly practised in some rainfed low-lands in the dry and intermediate zones. Since growth and development of the rice plant are known to differ under different climatic and cultural conditions (Dutta, 1981), these establishment methods could be expected to influence inherent plant growth pattern and grain yield. A series of experiments was therefore initiated to investigate the following aspects of growth and development using some popular high yielding varieties with improved plant type:

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1. seedling growth (leaf development and tillering capacity) under density levels recommended for direct sowing, standard lowland nursery and dapog nursery;
2. tillering capacity as affected by direct sowing and transplanting; and
3. leaf development in relation to the different growth phases of the rice plant.

MATERIALS AND METHODS

Ten rice varieties belonging to maturity durations ranging from 90 to 135 days were selected for this study (Table 1). Except IR 8, others are popularly grown varieties in Sri Lanka.

These experiments were conducted in cement pots with a surface area of about 1000 cm² and 15 cm deep. Soil was adequately fertilized and watered regularly. Plants grown in these pots were treated with granular insecticides and kept inside a screenhouse throughout the experiment.

Experiment 1 Seedling growth. Sprouted seeds of the test varieties were sown in cement pots at densities recommended for direct sowing (10 g/m²) standard lowland nursery (50 g/m²) and dapog nursery (2000 g/m²) separately. Number of seeds per pot was about 25, 150 and 6000 respectively for direct sown, standard lowland nursery and dapog nursery. Twenty-one days after sowing (DAS) 10 seedlings were uprooted randomly from each pot and their leaf and tiller numbers were recorded.

Experiment 2 Tillering capacity. Sprouted seeds of the test entries were sown in pots at the rate of 5 seeds per pot and replicated 10 times. These pots were divided into two sets each with 5 replicates.

At 21 DAS, in one set of pots (5 replicates) all seedlings except one per pot were uprooted leaving the remaining seedlings to grow. In the second set of pots (5 replicates) all seedlings were uprooted and transplanted except only one seedling per pot. These plants were then maintained until maturity.

Same procedure was adopted to simulate the conditions of direct sowing (1st set of plants) and transplanting (2nd set of plants) while eliminating the effects of inter-plant competition on their performance. Since the initial seedling number was maintained at five plants per pot it was not subjected to any measurable competition at the seedling stage. Tillers produced and leaves developed in each plant were recorded until maturity.

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Experiment 3 Leaf development. Sprouted seed of the test entries were sown in pots at a rate equivalent to direct sowing (25 seeds/pot). Using ten plants per test variety, the developing leaves of the main culm were numbered (using oil paint) and the time taken for full emergence of each leaf was recorded. Growth stages of the plants were simultaneously noted.

RESULTS AND DISCUSSION

Experiment 1 Seedling growth. Seedling growth as measured by leaf and tiller number was found to be a direct function of the plant density. Seedlings grew faster, produced more leaves and tillers under low densities than at high densities.

At 14 DAS (time at which dapog seedlings are usually ready for planting) the dapog seedlings had grown upto 3—4 leaf stage and had only the main culm. Standard nursery seedlings, on the other hand, had grown up to 4—5 leaf stage but had not tillered. Seedlings grown under direct sown conditions however had developed up to 5—6 leaf stage with an additional tiller. (Data on leaf and tiller number at 14 DAS not included.)

At 21 DAS the dapog seedlings had 5 leaves and the main culm only (Table 1). This was followed by the standard nursery seedlings which had grown upto the 6th leaf stage with 2.1 tillers (including main culm) and finally the seedlings in the direct sown pots were at the 8th leaf stage and had 3 tillers (including main culm).

Initial stage of seedling growth is largely dependent on the seed reserve and is supplemented gradually by photosynthesis on which the plants completely depend at the 3.7 leaf stage (Yoshida, 1981). Dapog nursery seedlings which thrive at a very high seedling pressure, (6000 plants/ft² (1000 cm²)) could hardly compete with each other to produce enough photosynthates to grow beyond 14 days. Therefore, in reality they are not growing but only struggling for survival.

After 21 days of development seedlings which grew under conditions similar to direct sowing had produced at least 2 additional leaves and one more tiller than those grown under standard nursery conditions. Therefore, the seedlings which grew under direct sown conditions were physiologically ahead of the standard nursery seedlings.

Table 1. Tillers produced and leaves developed (on the main culm at 21 days after sowing in direct sown, standard nursery and dapog nursery seedlings¹. CRBS, Batalagoda, Maha 82 / 83.

<i>Variety</i> <i>Maturity duration</i>	<i>Leaf number²</i>			<i>Tiller number³</i>		
	<i>DS</i>	<i>SN</i>	<i>DN</i>	<i>DS</i>	<i>SN</i>	<i>DN</i>
90 days						
Bg 276—5	8.0	6.5	5.5	4.0	1.4	1
Bg 34—8	7.8	6.5	5.5	4.4	1.4	1
105 days						
Bg 34—6	7.3	5.5	5.5	5.0	2.5	1
Bg 94—1	7.5	5.3	5.5	4.8	2.3	1
Bg 304—1	7.8	5.0	5.5	3.8	1.0	1
120 days						
Bg 380	7.8	6.0	5.5	3.2	2.6	1
135 days						
Bg 37 '—2	8.0	6.7	5.5	3.8	2.0	1
Bg 400—1	8.0	5.5	5.5	3.8	2.0	1
Bg 11—11	7.8	5.5	5.5	3.0	2.4	1
IR 8 (check)	7.8	5.5	5.5	3.2	2.4	1
Average	7.8	5.8	5.5	3.9	2.0	1

1. Mean of 10 seedlings per variety per treatment (DS, SN, DN)

2. Leaf number on the main culm.

3. Tiller number including the main culm.

DS Direct sown, *SN* standard nursery, *DN* Dapog nursery.

Setback of seedling growth as observed in standard nursery seedlings could be mainly due to competition created by high seedling density which directly affected its nutrient uptake. Thus, the lengthening of crop age under transplanted conditions could invariably be due to the physiological retardation at the early vegetative phase. However this should not rule out the set back in growth due to transplanting shock.

Any remarkable varietal difference was not observed in seedling growth among test entries under the different density levels tested. However, the effect of maturity duration on the rate of seedling growth (leaf and tiller development) should be investigated further for any conclusion.

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Experiment 2 – Tillering capacity. Tillering capacity (number of tillers produced by a plant) is a varietal character and is subjected to high variation. Environmental factors, including pests, diseases, soil fertility and nutrient availability and cultural methods such as spacing, depth of planting and method of establishment are some of the known causes that affect the tillering of a particular variety. Under optimum conditions tillering ability of a variety could be realized when raised as a seedling from a direct sown seed without subjection to any pressure from adjacent plants.

Tillering capacity of a transplanted seedling is known to be affected by the depth of planting. In the present experiment uprooted seedlings were placed at a very low depth (1.0 cm) in the soil. This resulted in an average 40% reduction in tiller number (measured as the panicle number at heading) of all the test varieties (Table 2).

Table 2. Number of panicles produced under direct sown and transplanted conditions (without subjection to any interplant competition)¹ CRBS, Batalagoda, 1983 wet season.

Variety	Panicle number		% tiller reduced
	Direct sown	Transplanted	
Maturity duration			
90 days			
Bg 276—5	64	31	52
Bg 34—8	50	26	50
105 days			
Bg 34—6	61	32	48
Bg 94—1	74	39	47
Bg 304—1	78	52	33
120 days			
Bg 380	47	36	23
135 days			
Bg 379—2	68	35	48
Bg 400—1	47	29	38
Bg 11—11	68	48	28
IR 8 (check)	61	37	39
average	60.1	36.5	40

¹ mean of 5 plant per variety per treatment (direct sown and transplanted)

In the absence of competition the direct sown varieties produced an average of 60.1 tillers per plant. Being low tillering varieties Bg 400—1 and Bg 380 produced an average of 47 tillers. High tillering varieties Bg 94—1 and Bg 304—1 yielded 74—78 tillers. Reduction in tiller number due to the act of transplanting ranged from 23% in Bg 380 to 52% in Bg 276—5.

Growth of transplanted crops is retarded twice at the seedling (nursery) and tillering (transplanting) stages and this prolongs the age of the crop and probably affects the yield potential. But these disadvantages of transplanted crops over direct sown crops are balanced by the high interplant competition in the later stages of direct sown crops. Better weed competitive ability, improved straw strength and better stand establishment in transplanted crops have an edge over direct sown crops when the performance of plant populations is considered.

Experiment 3 Leaf Development. Duration for full-emergence of the first seven leaves and the rest of the leaves upto the flagleaf was tabulated separately for convenience (Tables 3 & 4). There was hardly any difference in time taken for emergence of leaf 1 to leaf 7 in the varieties tested. Except the first leaf which took 5 days to develop, others unfurled in 2 to 3.4 day intervals. Therefore irrespective of the maturity duration and the variety, leaf development at the seedling stage has followed a similar pattern. The first tiller appeared at 4—5 leaf stage in all the test varieties (Table 3).

Table 3. Duration (days) for full emergence of first seven leaves in seedlings grown under direct sown condition¹. CRBS, Batalagoda, 82 / 83 wet season.

Variety	Leaf number							Rate of leaf Development days / leaf
	1	2	3	4	5	6	7	
Maturity Duration								
90 days								
Bg 276—5	5.0	2.0	2.0	2.0*	3.0	3.0	3.0	2.8
Bg 34—8	5.0	2.0	2.0	3.0*	3.0	3.0	3.3	3.0
105 days								
Bg 34—6	5.0	2.0	2.0	3.0*	3.0	3.0	4.4	3.2
Bg 94—1	5.0	2.0	2.0	3.0*	3.0	3.0	4.2	3.2
Bg 304—1	5.0	2.0	3.0	3.0	3.0*	3.0	3.2	3.2
120 days								
Bg 380	5.0	2.0	2.0	3.0	3.0*	3.0	3.3	3.0
135 days								
Bg 379—2	5.0	2.0	2.0	3.0	3.0*	3.0	3.0	3.0
Bg 400—1	5.0	2.0	2.0	3.0	3.0*	3.0	3.0	3.0
Bg 11—11	5.0	2.0	2.0	3.0	3.0*	3.0	3.4	3.0
IR 8	5.0	2.0	2.0	3.0	3.0*	3.0	3.2	3.0
Mean	5.0	2.0	2.5	2.9	3.0	3.0	3.4	

¹ Average 10 seedlings per variety

* Development of first tiller.

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Time taken for leaf emergence varied widely as the leaf number advanced from the 8th leaf. In the test varieties duration for emergence of the 8th leaf ranged from 3—4.6 days and the 11th leaf took 4.6—7 days (Table 4). In general the longer the leaf blade the more the time taken for full emergence of the leaf. For example, in Bg 276—5 the 12th leaf is the longest leaf and it took 7.8 days to unfurl. The flag leaf (14th leaf) on the other hand emerged in 5.2 days. In Bg 380 the 13th leaf, which is the longest leaf, took 10.2 days to emerge when compared to other leaves which took 4.1 to 10 days.

Table 4 also summarises panicle primodium and panicle initiation stages of the varieties in terms of leaf number. Initiation of panicle primodium roughly corresponds with the emergence and unfurling of the 3rd or 4th leaf from the top. It is wrong to correspond the development of the longest leaf with panicle primodium initiation. Developing panicles may be competing with leaves to be unfurled and this could be the reason for the gradual shortening of the last few leaves of the plant.

Table 4. Duration (days) for full emergence of the leaves from 8th leaf to the flag leaf under direct sown condition¹. CRBS, Batalagoda, Maha 83 / 84.

Variety Maturity duration (days)	Leaf number										Rate of leaf development	
	8	9	10	11	12	13	14	15	16	17	8th flag leaf	1st flag leaf
90 days												
Bg 276—5	3.6	4.0	5.0*	5.4	7.8††	7.8	5.2	—	—	—	5.2	3.9
Bg 34—8	3.5	4.6	6.0*	6.2‡	8.4†	5.4	4.2	—	—	—	5.5	3.9
105 days												
Bg 34—6	4.6	4.8	5.2*	6.4‡	8.6	6.8	5.2	—	—	—	5.9	4.3
Bg 94—1	4.6	5.2	6.4	7.0*	7.2††	9.6	8.6	4.8	—	—	6.6	4.8
Bg 304—1	4.2	4.4	4.8	5.0	6.6*	8.2†‡	7.8	7.8	6.2	—	6.1	4.6
120 days												
Bg 380	4.1	4.2	4.6	5.4	8.4*	10.2††	10.0	6.8	6.2	—	6.6	4.8
135 days												
Bg 379—2	3.0	4.4	6.2	7.0	7.2	10.6*‡	9.0	8.8	5.0	—	6.6	4.9
Bg 400—1	3.0	4.4	5.6	6.4	6.8	7.6*‡	10.8‡	8.2†	7.6	—	6.7	4.8
Bg 11—11	3.6	4.8	5.2	5.6	6.7	8.5	12.2*‡	12.8†	11.6	9.4	7.9	4.8
1R 8 (check)	3.6	4.2	4.4	4.6	6.0	6.4	9.6*‡	8.4†	7.8	7.8	6.2	4.7

¹ Average of 10 plants per variety

* Panicle primodia initiation

† Panicle initiation (2mm stage)

‡ Longest leaf

For easy comparison relative lengths of the leaf blades in the test varieties are given in Figures 1—6. These ten varieties fell into 6 groups according to the total leaf number and the relative leaf lengths. (1. Bg 276—5 2. Bg 34—6 and Bg 34—8, 3. Bg 94—1, 4. Bg 304—1, Bg 380 and Bg 379—2, 5. Bg 400—1, 6. Bg 11—11 and IR 8).

Duration for panicle initiation (2 mm stage), 50% heading and maturity of transplanted crops of test varieties are presented in Table 5. In general an extension of maturity duration by five to seven days could be expected during Yala (March—August) season. This is primarily due to the effect of photoperiodism (long-day lengths during Yala).

Growth duration of a variety is highly locational and season specific because of the interactions between the variety's photoperiodism and temperature sensitivity and the weather conditions (Yoshida 1981). During its life cycle the rice plant follows vegetative, reproductive and ripening phases. Although these phases are characterised by some morphological and physiological changes in the plant, they are considerably overlapped and not distinctly demarcated from one another.

Table 5. Duration in days from sowing to visual panicle (2 cm), heading and maturity in transplanted crops.

<i>Variety</i>	<i>Visual PI</i>	<i>50% Heading</i>	<i>Maturity</i>
90 days			
Bg 276—5	44	67	97
Bg 34—8	46	69	99
105 days			
Bg 34—6	50	74	104
Bg 94—1	53	78	108
Bg 304—1	57	80	110
120 days			
Bg 380	60	83	118
135 days			
Bg 379—2	72	95	125
Bg 400—1	74	96	126
Bg 11—11	80	104	135
IR 8	72	96	126

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Seedling stage which is the early vegetative phase of the plant could no longer be specified because tillering and leaf development are dependent on inter-plant competition in the plant community. Fourteen-day-old plants of a variety can be at different stages of growth depending on the intensity of the competition in the nursery (dapog, standard or direct sown). To avoid complications the term "seedling" should therefore be considered a loose term to indicate young plants in the nurseries that could be transplanted without causing much damage to the crop and its yield potential. Leaf number on the main culm at any particular time would be a better indicator of the stage of growth than the age of the crop itself, particularly in photo-insensitive and thermo-insensitive varieties.

In table 6 some important growth stages are indicated in terms of leaf number on the main culm for the test varieties. Evidently varieties with short maturity durations are producing leaves at a faster rate, virtually a leaf in every four days (Bg 276-5, Bg 34-8).

At panicle primordia initiation there are about 3-4 unfurled leaves developing within the plant. They are the most important functional leaves at maturity and responsible for grain filling. Although the transition from vegetative to reproductive phases begins with primordia initiation there is an overlapping of these two phases until the complete emergence of flag leaf (7-10 days prior to heading) which is the end of the vegetative phase.

Therefore, it is of paramount importance to manage the rice crop with an understanding of its growth and development, particularly the short duration varieties, to derive the full benefit of their potential.

Table 6. Growth stages of the plant in relation to leaf number in direct sown crops and the rates of leaf development.

Variety	First tiller	PI*	Leaf number at		Total	No. days per leaf
			Visual PI	Longest leaf		
Bg 276-5	4	10	12	12	14	3.91
Bg 34-8	4	10	12	11	14	3.97
Bg 34-6	4	10	12	11	14	4.29
Bg 94-1	4	11	12	12	15	4.77
Bg 304-1	5	12	13	13	16	4.56
Bg 380	5	12	13	13	16	4.83
Bg 379-2	5	13	14	13	16	4.89
Bg 400-1	5	13	15	14	16	4.84
Bg 11-11	5	14	15	14	17	5.75
IR 8	5	14	15	14	17	4.70

PI* Assuming that panicle primordia initiation takes place 10—13 days before the visual panicle (2 mm).

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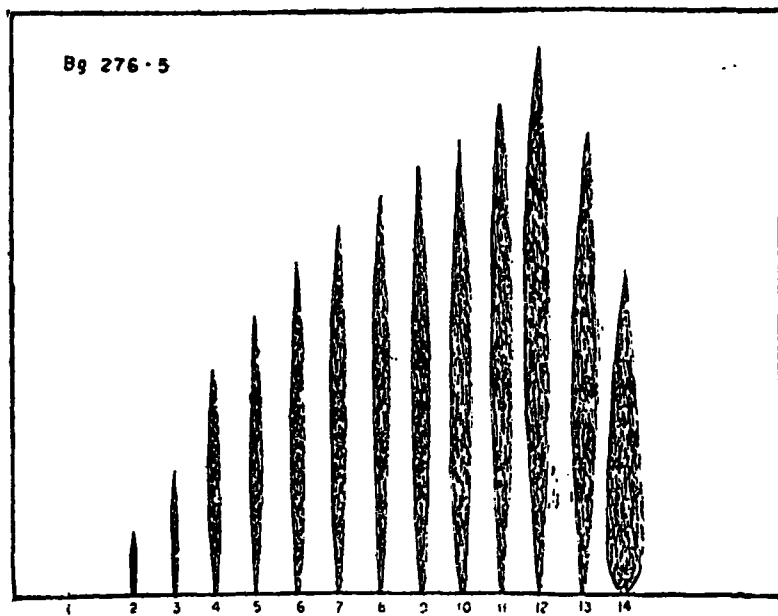


Fig. 1. Relative lengths of leaves of Bg 276-5

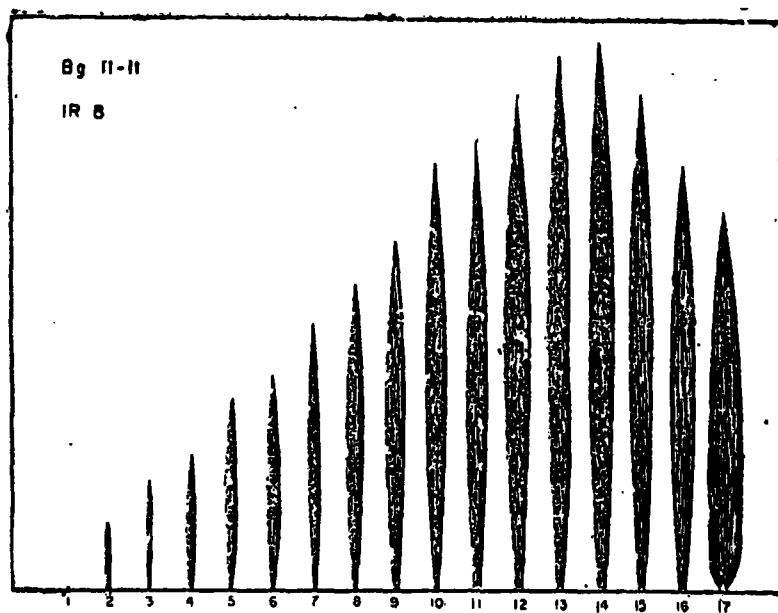


Fig. 2. Relative lengths of leaves of Bg 11-11

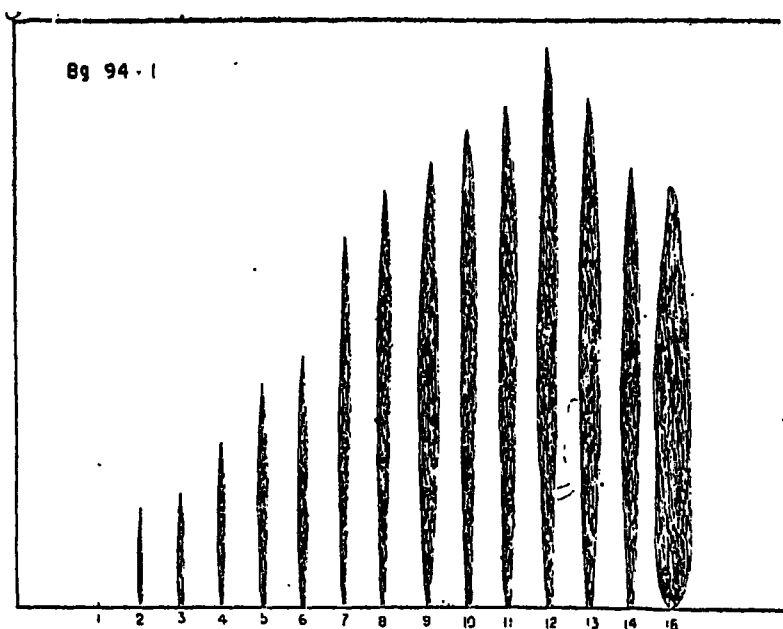


Fig. 3. Relative lengths of leaves of Bg 94 - 1

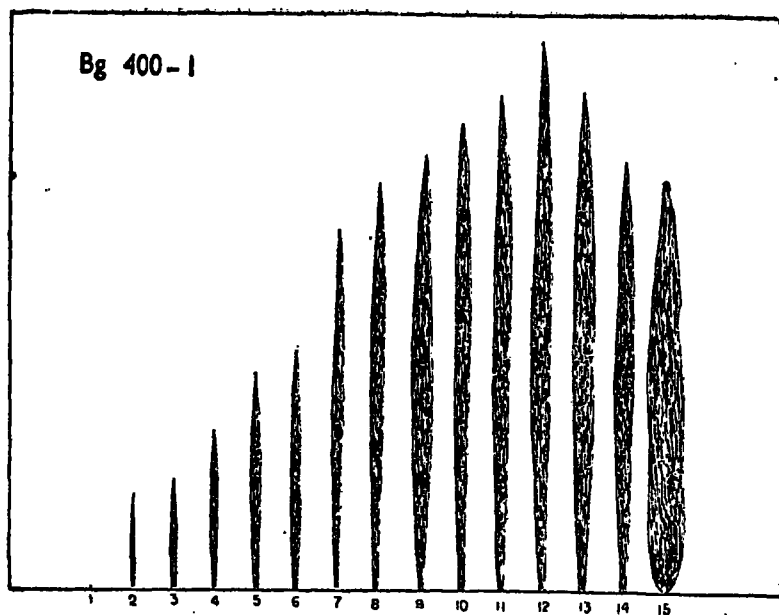


Fig. 4. Relative lengths of leaves of Bg 400 - 1

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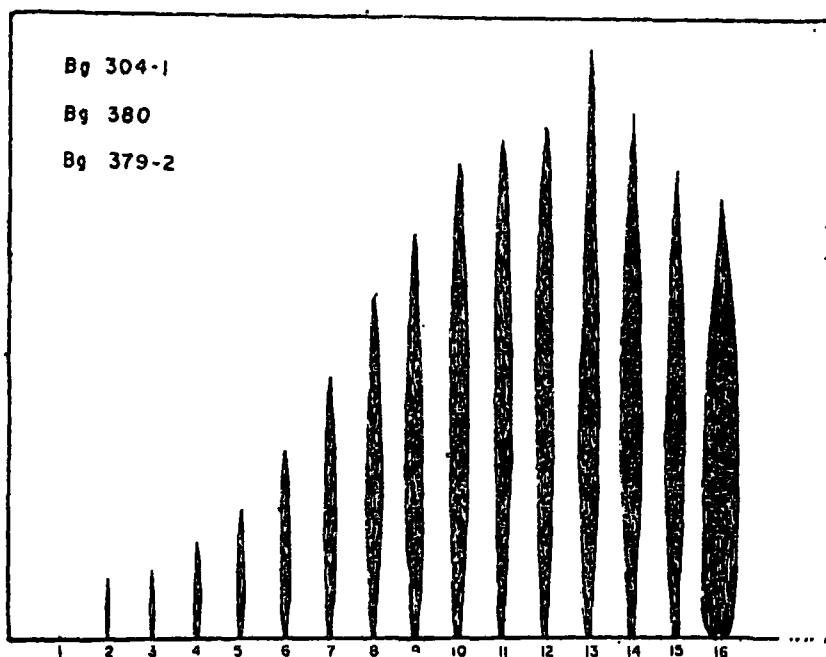


Fig. 5. Relative lengths of leaves of Bg 304-1, Bg 380, Bg 379-2

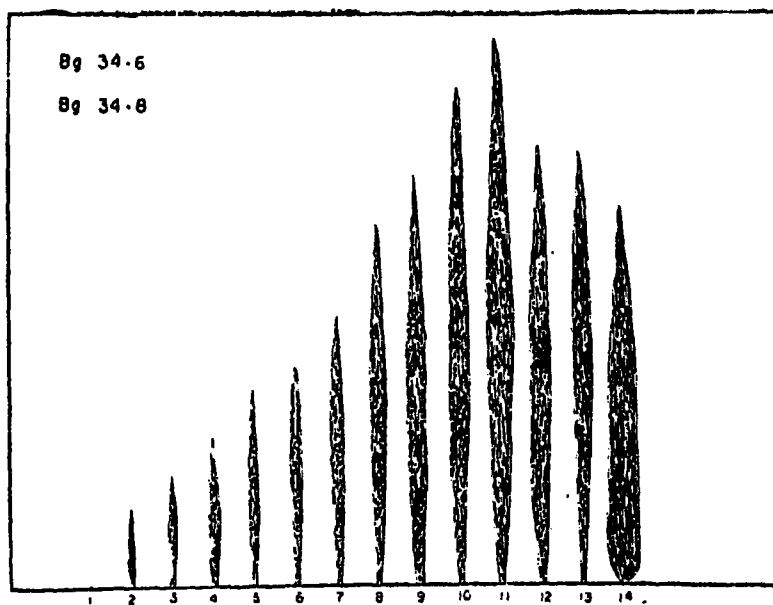


Fig. 6. Relative lengths of leaves of Bg 34-6 and Bg 34-8