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A Study on Growth and Development of Five Leguminous Plant Species: Gram *(Cicer arietinum),* Peas *(Pisum sativum),* Lobia *(Vigna cinensis),* Mung *(Phaseolus aureus)* and Rajma *(Dotichos lablab)* in Antarctic Soil during Polar Day

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Abstract

A study on growth of five leguminous plant species viz. gram *(Cicer arietinum),* peas *(Pisum sativum),* lobia *(Vigna sinensis),* mung *(Phaseolus aureus)* and rajma *(Dolichos lablab)* in Tenth Antarctic Expedition during polar summer 1990-91 is described. The experiment was conducted at Maitri station using Antarctic soil. Growth analysis was carried out by measuring RLA, RGR, LAR and NAR. Growth was poor. Flowering and seed formation were observed in peas after 34 and 40 days of sowing the seed. Weekly increase in plant height and leaf area for all four crops are presented. Average values of weekly increase in plant height and leaf area for all four crops are presented. Shoot FW (Fresh weight) per plant of gram, peas, rajma, lobia and mung were 1171±160, 2934±290, 2545±280, 1880+170, 1567±160 mg respectively after five weeks of emergence. Average weekly increase in plant height was 9.84,3.70,5.36,2.80 and 1.90 cm; in leaf area was 9.84,24.20,7.65,3.22, 1.58 cm ; in shoot FW was 289, 644, 624, 480, 419 mg for gram, peas, rajma, lobia and mung respectively. The average values of RLA, RGR, NAR and LAR for first five weeks were 14.18 mm ^{2} day^{-1},0.0246 mg mg^{-1} day^{-1},0.0195 mg mm^{-2}day^{-1}, 2.98 mm^2 mg^{-1} for gram; 32.50,0.0369,0.0100, 3.70 for peas; 1.80,0.0344,0.0148, 1.85 for rajma; 3.24, 0.0299, 0.0435, 0.0671 for lobia and 2.41, 0.0508,0.1414,0.34 for mung respectively. The study demonstrated the unsuitability of Antarctic soil for growing crops. Use of some other growing mediums e.g. peatmoss, vermiculite, rockwool/hydroponics is recommended.

Introduction

Antarctica is an isolated glacial continent having an area of 14 million km^2. Only *2%* of this area is free of ice. Apart from snow algae, plant life is limited to these ice free zones. The severe Antarctic climate limits the no. of land plants that are able to grow. Only two native vascular plants — *Deschampsia antarctica* and *Colobanthus quitensis* — grow in Antarctic peninsula. On the main land grow many non-flowering plants: lichens, moss, algae such as *Prasiola* and *Nostoc* (prominent in lakes) and microscopic soil fungi *(Readers Digest,* 1985; Fifield, 1987). A. remarkable flora of blue green algae and other microorganisms inhibit the near surface zone within some rocks. These plants have limited growth because of

extreme cold, nonavailability of nutrients in Antarctic soil and water (Lars, 1988; Joshi and Banerjee, 1988).

Higher plants can't survive in Antarctica as these require a minimum temperature of 1 to 16°C (Kononkov and Kiran, 1988). The only possibility of growing these in Antarctica is through protected cultivation (controlled environmental technique) in green houses. Increasing scientific activity and prolonged stay of scientists in Antarctica raised the need for fresh food. This led expeditioners to grow plants {*Readers Digest,* 1985; Joshi and Banerjee, 1988). A study on growing various crop plants was carried out during Tenth Indian Scientific Expedition to Antarctica. As a part of it leguminous plants were also grown. In order to study the growth of five leguminous plant species, an experiment was conducted in greenhouse at Maitri station during polar summer (Jan.-Feb.) of 1991. The results of this experiment are reported here.

Materials and Methods

The experiment was conducted in the greenhouse at Maitri (India's permanent research station; Lat.70°4-5' 39.4":Long.l 1°41' 48.6") during the polar summer of 1990-91. The greenhouse was sufficiently airtight for snow and cold winds. Temperature (20°C) was maintained by hot water radiators and electrical heaters. Relative humidity of 64% was maintained by humidifiers. Plants were grown in natural light. The experiment was performed in pots in randomized block design with three replicates. Well sterilised seeds of five species of leguminous plants viz. gram (cv. K-4), peas (cv. Arkel), rajma (cv. Pusa early prolific), lobia (cv. Pusa phalguni) and mung (cv. Pusa baisakhi) were sown on 3 Jan.91. Soil was collected from the area around the station and filtered with a fine mesh. Total 5 kg soil was taken. Its composition was 4.5 kg soil and 0.5 kg soil mixed with moss (both naturally occurring in Antarctica). This soil was fortified with 10 g urea and 10 g KH_2PO_4. This medium was filled in pots for growing plants. Plant height, fresh weight, leaf area, no. of leaves, root length and dry weight were recorded regularly by periodic sampling.

The temperature and relative humidity inside the greenhouse were recorded by thermohygrograph. Outdoor temperature was recorded by mercury thermometer, PAR (Photosynthetically active radiation) was measured by a luxmeter. The temperatures of soil and water were recorded by an electronic thermometer. The leaf area was measured by an optical planimeter. FW and DW were measured by an electronic balance. DW was measured after heating samples in a ventilated oven for 7 days at 60°C. CO_2 level inside the greenhouse was recorded by a gas analyser. Growth analysis was carried out by computing RLA (data x 100), RGR, NAR

(data/10) and LAR (data X 10)* as described by Hunt (1978), Fawusi (1981) and Nilwik(1981).

Results and Discussion

Table 1 shows the comparative growth and development of the crops. Figs 1 to 4 show the growth analysis. Average weekly growth in plant height was found to be 5.18, 3.70, 5.36, 2.80 and 1.90 cms; the increase in leaf area was 9.84, 24.20, 7.65, 3.22, 1.58 cm^2 and increase in shoot FW were 289, 644, 624, 480 and 419 mg respectively in gram, peas, rajma, lobia and mung. The rate of increase in leaf area and FW was maximum in peas followed by rajma and lobia. The rate of increase in plant height was maximum in rajma followed by gram and peas. Mung had the lowest growth rate. Flowering and pod formation was observed in peas after 34 and 40 days of sowing the seed. Flowering was not observed in other crops.

The plant environment in Antarctica was totally different from that one existing on the mainland. Plants were subjected to a CO_2 level of 400 ppm (normal is 350 ppm), average temperature of 22°C, 64% relative humidity and 24 hour photope-

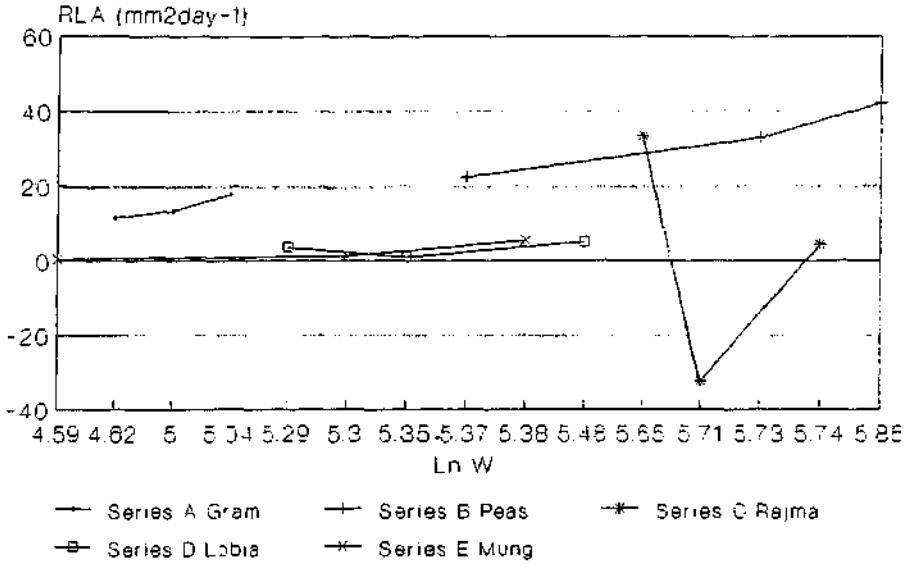


Fig. 1. Growth analysis of leguminous plants RLA.

*The values of RLA, NAR and LAR be read as
RLA: to get actual value multiply the data by 100
NAR: to get actual value divide by 10
LAR: to get actual value multiply by 10

Table 1: Growth and Development of Five Species of Leguminous Plants in Antarctic Soil during Polar Day

Cultivar	Days after emergence											
	9	10	13	19	20	23	29	30	33	34	35	38
Shoot fresh wt. (mg/plant)												
Gram	-	-	613	-	-	781	-	-	1101	-	-	1171
Peas	-	-	814	-	-	1799	-	-	2550	-	-	2934
Rajma	910	-	-	2430	-	-	2532	-	-	2545	-	-
Ldbia	-	777	-	-	1532	-	-	1585	-	-	1880	-
Mung	400	-	-	737	-	-	1480	-	-	1567	-	-
Root fresh wt. (mg/plant)												
Gram	-	-	170	-	-	233	-	-	381	-	-	391
Peas	-	-	347	-	-	468	-	-	535	-	-	546
Rajma	240	-	-	437	-	-	480	-	-	485	-	-
Lobia		333	-	-	457	-	-	518	-	-	522	-
Mung	100	-	-	246	-	-	522	-	-	531	-	-
No. of leaves (no.)												
Gram	-	-	5	-	-	7	-	-	10	-	-	12
Peas	-	-	5	-	-	7	-	-	10	-	-	12
Rajma	2	-	-	3	-	-	2	-	-	2	-	-
Lobia	-	2	-	-	3	-	-	3	-	-	4	-
Mung	2	-	-	3	-	-	3	-	-	4	-	-
Leaf area (cm /plant)												
Gram	-	-	19.53	-	-	31.00	-	-	44.28	-	-	
Peas	-	-	54.40	-	-	76.78	-		109,68	-	-	
Rajma	33.89	-	-	67.20	-	-	34.91	-	-	37.10	-	-
Lobia	-	8.96	-	-	12.56	-	-	13.56	-	-	16.12	-
Mung	2.88	-	-	3.34	-	-	4.59	-	-	7.91	-	-
Stem length (cm)												
Gram	-	-	12.00	-	-	21.00	-	-	24.00	-	-	28.00
Peas	-	-	9.00	-	-	17.10	-	-	18.20	-	-	20.00
Rajma	9.80	-	-	22.50	-	-	23.50	-	-	26.00	-	-
Lobia	-	6.30	-	-	9.50	-	-	11.20	-	-	14.00	-
Mung	4.00	-	-	6.00	-	-	8.00	-	-	9.50	-	-

Contd...

Table 1: *Contd.*

Root length (cm)												
Gram	-	-	3.80	-	-	4.60	-	-	5.00	-	-	6.10
Peas	-	-	4.90	-	-	6.10	-	-	7.20	-	-	8.00
Rajma	3.00	-	-	3.40	-	-	4.60	-	-	5.40	-	-
Lobia	-	4.10	-	-	5.70	-	-	6.90	-	-	7.50	-
Mung	3.10	-	-	4.00	-	-	6.00	-	-	7.00	-	
Fresh wt./Dry wt.												
Gram	-	-	10.03	-	-	9.94	-	-	9.92	-	-	9.90
Peas	-	-	10.01	-	-	9.98	-	-	9.92	-	-	9.90
Raj ma	10.00	-	-	9.98	-	-	9.97	-	-	9.60	-	-
Lobia	-	10.00	-	-	9.99	-	-	9.96	-	-	9.94	-
Mung	10.00	-	-	9.92	-	-	9.91	-	-	9.57	-	-

Standard errors :	Min.	Max.
Weight	90.00	290.00
Area	0.80	2.20
Length	1.0	2.2
FW/DW	1.00	2.00

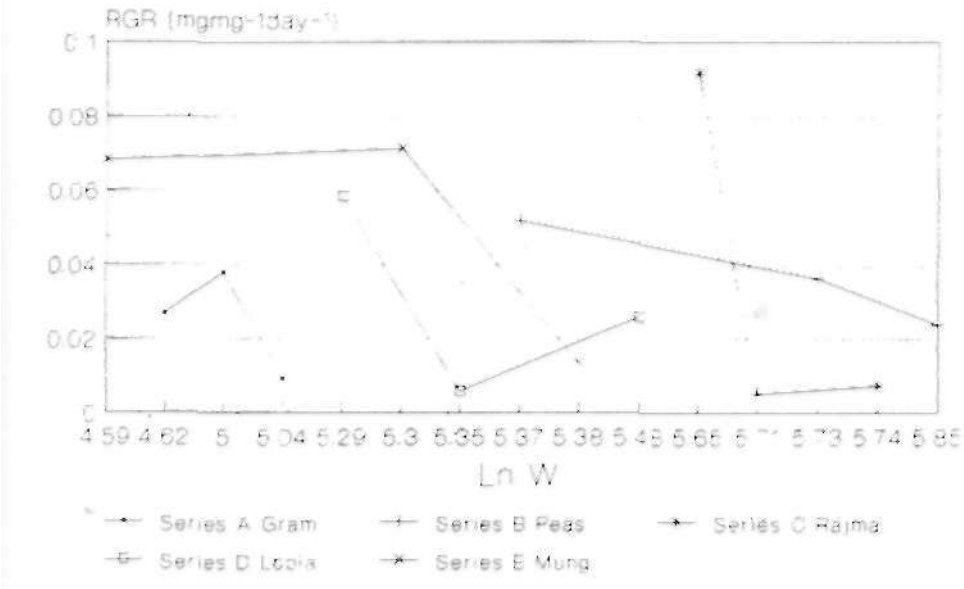
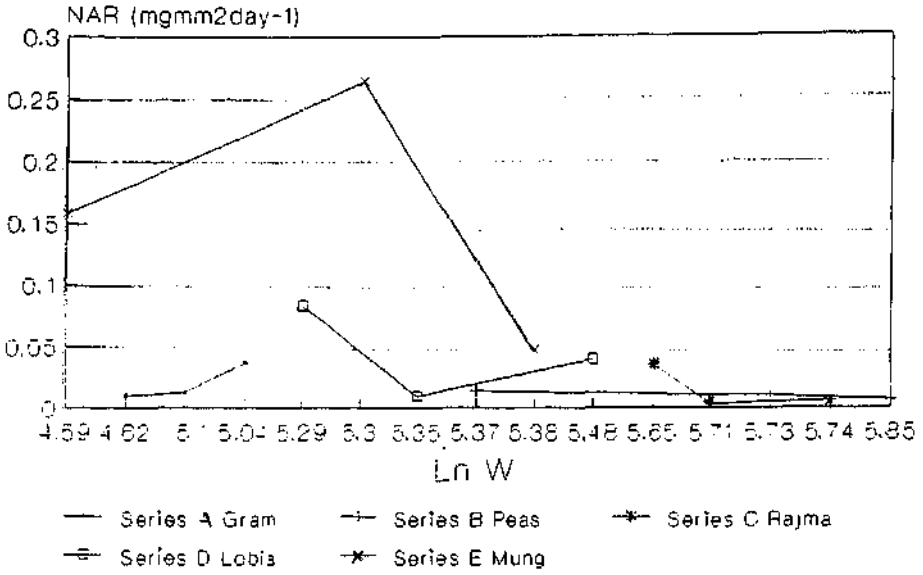


Fig. 2. Growth analysis of leguminous plants RGR



Fig, 3. Growth analysis of leguminous plants NAR,

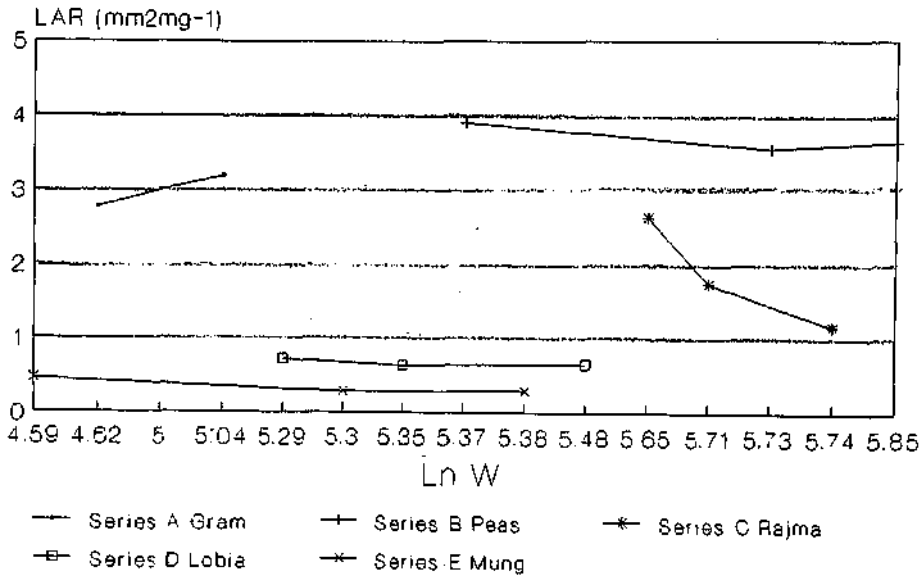


Fig. 4. Growth analysis of leguminous plants LAR.

riod. The PAR level inside greenhouse varied from 100 to 45000 lux and a minimum of 100 lux was always available to the plants. The plants followed the usual thermoperiodism i. e. a high day time temperature was followed by a low night time temp. (20°C). Although there was no night but time interval during which light intensity was low (below 1000 lux) was treated as night/dark period.

In general, growth must be higher at higher temperature, higher CO_2 level and higher integrated PAR but Table 1 reveals a different picture. Overall a poor growth resulted in Antarctica. This was probably due to nutrient deficiency, physico-chemical characteristics of Antarctic soil, interacting effects of environmental factors including root environment and 24 h day length. The Antarctic soil was clay type soil, which had cement like properties.

For the purpose of studying the growth and effect of environmental conditions on plant growth a number of techniques and concepts of growth analysis have been developed (Hughes and Freeman, 1967; Richards, 1969; Evans, 1972; Hunt, 1978). Periodic sampling during growth period provides not only information on the increase in plant weight as influenced by environmental and ontogenetical stage but also shows hpw plant morphology and the distribution pattern of the newly formed assimilates is affected by these factors (Newton, 1963; Cockshull and Hughes, 1969). This approach is the most appropriate method to study plant growth and development.

Growth parameters in general exhibit a strong ontogenetical pattern. Strong changes in RLA, RGR, NAR and LAR were observed. These quantities were plotted against the total DW since this representation provides a better measure of the ontogenetical stage of the plants as compared to the experimental time scale (Hughes and Cockshull, 1969). For the same reason mean values were not calculated for a certain time interval but rather during two dates between which a certain dry matter increment was realised. It should be remarked that the identity RGR = NAR * LAR was valid implying that growth pattern in Antarctica was not altered.

Increased leaf number and larger leaf area have been reported by Newton (1963), Milthorpe and Newton (1963) when increasing the daily radiation total for cucumber. Prolonged growth in continuous irradiance results in leaf yellowing and leaf drop (Nilwik, 1981). The same results were observed for tomato in an extensive study by Kristofferson (1963) who attributed it to a slowly decreasing turgor pressure. A dark period would be necessary to restore the leaf turgor. Leaf yellowing and yellowing of leaf margins alongwith stunted plant growth was observed in Antarctica, confirming reporting of Nilwik (1981); however it may also be due to nutrient deficiency. Some plants were darkened for 6 hour/day and visual comparison of growth was done. Poor growth was observed, confirming that poor growth was not due to continuous light. It implied that poor growth was due to use of Antarctic soil. Schwabe (1956) carried out a detailed study of growth-analysis of

some long and short day plants in Arctic latitudes. Increase in leaf area and NAR- were observed. Appearance of the continuous day light plants resembled that of plants suffering from nitrogen deficiency. Similar observations we recorded in Antarctica.

The study was conducted during polar day when there is continuous light for 24 hours. In the case of plants below a certain light level; compensation point plants reduce (stop) photosynthesis and time till which light level remains below this level can be treated as dark period for the plants. Bohning and Brunside (1956) have determined this level as 1000 to 16000 lux for *Phaseolus vulgaris*. According to this, plants enjoyed a dark period of 2 to 4 hours when PAR dropped below lOOO lux (Fig. 3). This factor was probably responsible for non violation of the identity RGR = NAR * LAR in Antarctica.

This paper reports the growth of five leguminous crops in Antarctic soil during polar day in Antarctica. Because of brief summer period, growth could get studied upto five weeks only. Detailed studies of interacting environmental factors on crop growth are required for better understanding. This study however demonstrated that Antarctic soil was unsuitable for growing plants emphasising the use of some other growing medium such as peatmoss, vermiculite, rockwool etc. for crop production in Antarctica.

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