CHAPTER 6

GROWTH PERFORMANCE IN CULTURE EXPERIMENTS

Introduction - Growth, development and distribution of all organisms are determined by the sum total of all physical and biological conditions, their extremes, and the interactions between them. Mason (1936) stated that each and every plant species is able to exist and reproduce successfully only within a definite range of climatic and edaphic conditions. As conditions vary from the ideal, the efficiency of metabolic processes decreases, vigour declines, and growth diminishes proportionately. The influence of different kinds of environmental factors on plant life is very complex. It varies widely with differences in the combinations of various factors and their intensities. Further, different plant species and their growth stages are affected differently.

Numerous studies have been made on growth of various plant species in relation to different edaphic components (Misra, 1944b; Pearsall, 1952; Russell, 1961; Gopal, 1968; etc.). Recently number of investigators have critically examined and quantitatively analysed the effect of various environmental factors, especially light and temperature on the growth performance of many annual legumes and other plants (Goodall, 1945; Watson, 1956; Black, 1957; Evans and Hughes, 1961; Hughes and Evans, 1964; Blackman, 1968; etc.). Similarly the effect of biotic factors, especially in the form of intra-specific and interspecific competition has been critically studied by several investigators (Salisbury, 1942; Bleasdale, 1960; Swan and Furtick, 1962; Nelson and Nylund, 1962; Tripathi, 1968; Singh, 1969 and Misra et al., 1970).

An attempt has been made in this chapter to analyse the effect of some of the climatic, edaphic and biotic factors on the growth performance of A. ramosum. This has been done with the help of culture experiments for an understanding of the field observations.

6.1. Climatic Factors

Climate which is the major factor influencing the range of native plants, has largely been overlooked in the investigation of weed distribution. If it can be shown that climate influences the mass ranges of some weeds, it becomes a matter of considerable practical importance to study the behaviour of a weed within and out of its climatic optimum. Moreover, if the spread of a weed is limited by climate, it may be possible to predict the ultimate area to be occupied by the plant (Lindsay, 1953). The growth form, the life cycle and the ecological amplitude of the species are to be considered in relation to the periodicity of the climatic factors. In the present investigation an attempt has been made to critically examine the effect of one of the most important climatic factors, viz. light intensity on the growth performance of A. ramosum.

Light intensity and growth performance

The role of light in governing distribution, growth and reproduction of many plants has been recognised for the last many years. Light intensity is an important environmental factor which affects the growth of plants indirectly through the process of photosynthesis and transpiration (Kozlowsky, 1949). The growth performance of plants in sun and shade differs. Some plants show their luxuriant growth in open sunlight, and others do better in shade. Change in light intensity is known to result in marked changes in the vegetative growth (Ashby, 1950; Wiggans, 1959; Jarvis, 1964). Effect of light intensity on growth performance of plants has been studied by several workers (Pathak, 1967; Singhal, 1967; Singh, 1968; Ratra, 1970; Gupta, 1973; Singh and Gopal, 1973; Bechu Lal, 1976). The following culture experiment was conducted to study the effect of light intensity on the growth performance of A. ramosum.

Experimental Procedure - Rectangular bamboo frames (2.0 m long, 1.0 m broad and 1.5 m high) were erected and were covered on all sides and at the top with 1, 2 or 3 layers of thin cotton cloth. Thus varying light intensities were obtained under the artificial shades of 1, 2 or 3 layers of the cloth, which transmitted approximately 75, 50 and 25% of sunlight respectively.

Seedlings raised from seeds of A. ramosum were transplanted at leaf stage to earthen pots of uniform size filled with garden soil. Three seedlings were transplanted and grown in each pot, and five replicates were kept for each treatment. The pots were arranged in four different sets for being subjected to four different treatments of varying light intensities as follows :-

Set T_1 : Pots kept in open to provide full sunlight i.e. 100% of the available sunlight.

Set T_2 : Pots kept under the artificial shade of one layer of cloth, which transmitted approximately 75% sunlight.

Set T_3 : Pots kept under the artificial shade of two layers of cloth, which transmitted approximately 50% sunlight.

Set T_4 : Pots kept under the artificial shade of three layers of cloth, which transmitted approximately 25% sunlight.

Pots were moderately watered daily and the experiment was continued for about two and a half months from March to May, 1979. Finally the plants were harvested and the growth responses were measured taking various parameters into consideration. The experimental data were analysed statistically and are presented in Table 6.1 and graphs 18, 19 and 20. Plate 10.

Results and Discussion - The plant responds differently to different light intensities. Maximum values of shoot and root circumference, number of inflorescence axes, fresh and dry weights of shoot and root were observed in plants grown in T_2. Maximum values of shoot length, number of leaves, length of the largest leaf and leaf index were observed in plants grown in T_4. Maximum values of root length and breadth of the largest leaf were observed in plants of T_3, while maximum values of root : shoot ratio both on fresh weight and dry weight basis were observed in plants of T_1. Thus various parameters respond differently to different light intensities. The overall growth was much suppressed and stunted in plants of T_1. In most of the parameters studied, the plants of T_2 showed better performance, which gradually decreased in those of T_3 and T_4.

Maximum accumulation of fresh and dry matter was under T_2 i.e. 75% sunlight, which also favoured the reproductive growth manifested by the number of inflorescence axes. These characters were adversely affected by further decrease or increase in the intensity of light. The adverse effect of full sunlight on fresh and dry matter accumulation was more pronounced in shoot as compared to root, which is indicated by the maximum value of root : shoot ratio both on fresh and dry weight basis obtained in that treatment. Shoot length, leaf size and the number of leaves were favourably affected by the decrease in the intensity of light.

The statistical analysis reveals that the overall effect of varying light intensity is significant at 1% level with respect to all the parameters studied except the circumference of shoot, where the level of significance is 5%, and the circumference of root, where the differences among the treatments are not significant.

However, looking to the LSD values, it is revealed that there is no significant difference between the plants of T_2 and T_3 with respect to circumference of shoot, number of leaves, fresh weight of shoot and that of root. Similarly there is no significant difference between the plants of T_3 and T_4 with respect to length and breadth of the largest leaf, and between the plants of T_2 and T_4 with respect to length of root. The differences among the plants of various light treatments with respect to shoot length are significant at 1% level.

Singhal (1967) working with Phyllanthus urinaria observed maximum root : shoot ratio in plants grown in open sunlight. Blackman and Templeman (1940) have also reported that root : top ratios under shade are lower than in full daylight. Further Singhal (1967) observed minimum values for length of shoot and length and breadth of leaf in plants grown in open sunlight. Increase in leaf area with the reduction in light intensity has also been reported by Blackmann and Rutter (1948) and Anderson (1955). The results obtained by the present author in A. ramosum are in accordance with the aforesaid findings.

Bechu Lal (1976) working with Scoparia dulcis observed minimum values of length of shoot and number of leaves in plants grown in deep shade. These findings are in contrast to those of the present author in A. ramosum which may be due to the different light requirements of different species.

It was further observed in the present investigation that floral initiation and maturity took place earlier in plants of T_2 and T_1 than in those of T_3, while in T_4 the plants did not show any floral initiation within the period of the experiment. Probably the plant shows a tendency to delay in commencement of the reproductive growth with the decrease in the light intensity. Fritsch and Salisbury (1965) have also recognised that in the formation of flower bud, a higher light intensity is necessary.

Thus from the results obtained in the present experiment it is evident that the intensity of light has a profound influence on the growth performance of A. ramosum.

6.2. Edaphic Factors

Edaphic factors are indeed responsible for the supply of moisture and salts to the plants. They also constitute the environment of the underground part of the plant and soil biota (Misra, 1959). Edaphic environment constitutes a complex and dynamic system which immensely influences the plant growth. It plays a great role in the ecesis of the plants. The soil complex has been represented by Misra and Puri (1954) as integration of mineral, organic, biotic, solution and gaseous systems. Each of these is of great significance to plant life. The individual soil factors and their interactions produce a mosaic of different edaphic situations in any area. A number of reviews (Hagan, 1952; Richards and Wadleigh, 1952; Lutz, 1952; Russel, 1952) have considered overall plant growth as affected by soil conditions (Wiersma, 1959). During the past few years, ecologists have recognised the importance of soils in plant ecology. Weeds of a restricted distribution may in extreme cases act as indicators of the nature of soil, if they grow only under very specialized conditions. Moreover, such plants are rare, but the relative abundance of certain species may give an accurate indication as to the nature of the soil treatment (Warington, 1924). In the present investigation an attempt has been made to critically examine the effect of two important edaphic factors, viz. soil moisture regime and organic matter content in the soil on the growth performance of A. ramosum.

6.2.1. Soil moisture regime and growth performance

It is a basic biological principle that the quantity and quality of growth in a plant is controlled by its hereditary potentialities and its environment (Kramer, 1959).

Water is the integral part of the internal and a major component of external climate (Leopold, 1964). It has a profound effect on energy balance of the plant body (Philips, 1958). Many studies have shown that soil moisture is an extremely important aspect of the environment and that response to variation in it are quite diverse (Daubenmire, 1959). Moisture stress also affects the distribution of growth within the plant such as the root growth is stimulated by moisture stress (Davidson, 1969). Plant responses to moisture stress have been investigated by several workers (Benedict et al., 1947; Richards and Wadleigh, 1952; Hagan, 1952; Gates, 1955, 1957; Stanhill, 1957; Hagan et al., 1957; Russel, 1959; Kramer, 1963; Hsiao, 1973; Ashenden et al., 1975; Jones, 1975). As it is evident from the aforesaid works, different plant species respond differently to the variation in soil moisture levels. The following culture experiment was conducted to study the effect of soil moisture regime on the growth performance of A. ramosum.

Experimental Procedure - Seedlings raised from seeds of A. ramosum were transplanted at four-leaf stage to earthen pots of uniform size filled with garden soil. Two seedlings were transplanted and grown in each pot, and four replicates were kept for each treatment. The pots were arranged in five different sets for being subjected to five different treatments of varying soil moisture regime as follows :-

Set T_0 - Waterlogged condition - This condition was maintained by keeping the experimental plant pot in a bigger pot filled with water to such an extent as to have about 5 cm of overlying water level in the earthen pot.

Set T_1 - Watering daily.

Set T_2 - Watering thrice a week.

Set T_3 - Watering twice a week.

Set T_4 - Watering once a week.

Two litres of water were supplied to each pot on each irrigation day during the course of the experiment. The experiment was conducted in wire house, and was continued for about three and a half months from January to April, 1980. Finally the plants were harvested and the growth responses were measured taking various parameters into consideration. The experimental data were analysed statistically and are presented in Table 6.2 and graphs 21, 22 and 23.

<u>Results and Discussion</u> - <u>A. ramosum</u> seems to be highly susceptible to waterlogged condition. The plants could not withstand waterlogged condition for more than a few weeks. Growth seemed to be suspended under this treatment, and the plants died after a few weeks. The death of the plants may be due to lack of soil aeration which prevents the development of deep and healthy roots.

A glance at Table 6.2 clearly shows that maximum values for most of the parameters studied were observed in plants grown in T_1, and minimum values in those of T_4. Thus in most of the parameters studied, the plants of T_1 showed better performance, which gradually decreased in those of T_2, T_3 and T_4. However, maximum values of fresh and dry weights of root and root : shoot ratio (on fresh weight basis) were observed in plants of T_2, root length was maximum in plants of T_3, and root : shoot ratio (on dry weight basis) was maximum in plants of T_4. Daily watering treatment helped to maintain favourable level of soil moisture, and so the plants under that treatment could show better performance with respect to most of the parameters, while treatment of watering once a week could not maintain favourable level of soil moisture, and so the plants under that treatment showed poor performance with respect to most of the parameters.

The statistical analysis reveals that the overall effect of varying soil moisture regime is significant at 1% level with respect to most of the parameters studied. In case of two parameters, viz. number of fruits per plant and dry weight of root, the difference is significant at 5% level, while in case of two parameters, viz. length of root and that of longest axillary branch, the difference is not significant. However, looking to the LSD values, it is revealed that there is no significant difference between the plants of T_1 and T_2 with respect to length and diameter of shoot, diameter of root, length of the largest leaf, and fresh and dry weight of shoot. Similarly there is no significant difference among the plants of T_1, T_2 and T_3 with respect to breadth of the largest leaf, number of fruits and dry weight of root, and also between the plants of T_2 and T_3 with respect to length of the largest leaf, number of flowers, fresh weight of root and dry weight of shoot. This indicates that delayed watering treatment to the extent of watering thriee a week had no adverse effect on growth performance with respect to most of the parameters, while with respect to certain parameters, viz. breadth of the largest leaf, number of fruits and dry weight of root, the plants could withstand delayed watering treatment to the extent of watering twice a week without showing any adverse effect. However, when watering was delayed to the extent of only once a week, the growth was adversely affected and the plants showed much poorer performance. Further, it was observed during the course of the experiment, that plants under treatment of watering once a week showed signs of temporary wilting on the last dry day of each watering cycle i.e. on the day just before each succeeding irrigation day. This indicates that the plants could not have tolerated any further water stress.

Similar results have been reported by many other workers. Singhal (1967) working with <u>Phyllanthus</u> <u>urinaria</u> observed that the growth of the plant increased with the increase in moisture content of the soil. However, under waterlogged condition it was reduced, and maximum growth of all the parts ofthe plant was obtained at field capacity. Further, she observed that plants under watering treatment at intervals of 3 days could not survive for more than a few days. Biswas (1967) working with Rauvolfia sp. reported that maximum values for different morphological characters were observed in daily watered plants, and minimum values in fourth day watered plants. Plants did not survive when watering was delayed upto the fifth day. Lavania (1971) working with Melilotus indica reported best results with plants watered every third day, and a gradual decline in the growth characters was observed in both the directions i.e. with further increase or decrease in the period between two successive watering days. Gupta (1972) working with Rumex sp. reported that the plant survived over a wide range of soil moisture, but growth performance was adversely affected by higher and lower levels of soil moisture. It was also observed that plants did not survive when watering was delayed upto seven days. Bechu Lal (1976) working with Chrozophora rottleri observed that the plant could not survive water-logged condition, and that best growth was found in plants watered on alternate days. Further, he observed that growth was comparatively better in plants watered once a week than in plants watered daily, which indicates that high level of soil moisture is not essential for the luxuriant growth of the plant.

The results of the present experiment indicate that though *A. ramosum* can survive under once a week watering treatment, comparatively higher levels of soil moisture are needed for favourable effect on growth.

6.2.3. Organic matter content in soil and growth performance

Soil organic matter is an important source of nitrogen and phosphorus and it increases the water holding capacity of the soil. Daubenmire (1959) states that "a given amount of organic matter may hold as much as nine times its own weight of water, a proportion considerably greater than is ever true of clay colloids". Organic matter also improves soil structure and adsorptive capacity. Organic matter like clay, can hold by adsorption quantities of nutrients in ionic form, but it differs from clay in that its adsorptive capacity may be a hundredfold (Daubenmire, 1959). In general, the amount of organic matter is an index of soil fertility (Misra, 1968).

The field observations on *A. ramosum* suggest that growth of the plant is highly favoured by the presence of decomposed leaf litter as it grows under the shade of trees. The following culture experiment was conducted to study the effect of organic matter content in soil on the growth performance of *A. ramosum*.

Experimental Procedure - Five different sets of soil with varying levels of organic matter were prepared by taking garden soil and farm-yard manure in varying proportion as follows :-

	Garden soil		Farm-yard manure
Set T_1 -	1	:	0
Set T_2 -	3	:	1
Set T_3 -	1	:	1
Set T_4 -	1	:	3
Set T_5 -	0	:	1

The manure was thoroughly mixed with the soil and left as such for a week. The organic matter content in the soils of the five sets was roughly estimated (by loss on ignition method), and was found to be 3.0, 5.4, 7.6, 10.4 and 21.8% respectively. Soil of the various sets was filled in earthen pots of uniform size. Seedlings raised from seeds of _A. ramosum_ were transplanted at four-leaf stage to the pots. Two seedlings were transplanted and grown in each pot, and four replicates were kept for each treatment. The pots were moderately watered once daily in the morning. The experiment was conducted in wire house and was continued for about three and a half months from December, 1979 to March, 1980. Finally the plants were harvested and the growth responses were measured taking various parameters into consideration. The experimental data were analysed statistically and are presented in Table 6.3 and graphs 24, 25 and 26.

Results and Discussion - It is evident from the data that growth performance of the plant is very much affected by the presence of organic manure in the soil. In general, the best growth of the plant was observed either in Set T_4 or T_5, and the growth was poorest in set T_1. This clearly shows that organic matter has favourable effect on the growth performance of the plant. Almost all parameters exhibit a gradual increase in values proceeding from the treatments T_1 to T_5. Maximum value of root : shoot ratio both on fresh weight and dry weight basis was obtained in plants of T_1 treatment. This indicates that the adverse effect of lack of addition of manure to the soil on growth was more pronounced in shoot than in root.

The statistical analysis reveals that the overall effect of the differential manuring is significant at 1% level with respect to all the parameters studied, except length of the longest axillary branch, where the level of significance is 5%, and length of root where the effect is not significant. Further, the plants under treatment T_1 (where no manure was added to the garden soil) showed poorest growth performance differing significantly from those under the rest of the treatments with respect to all parameters except length of the longest axillary branch and fresh weight of root. However, the differences among the plants of T_2, T_3, T_4 and T_5 with respect to number of leaves, length of the longest axillary branch and number of flowers are not significant. Similarly, with respect to diameter of root, breadth of leaf, number of fruits, fresh and dry weight of shoot and root, the differences between the plants of T_2 and T_3 treatments are not significant. The differences between the plants of T_4 and T_5 treatments are also not significant with respect to many of the parameters studied. The results of the experiment thus clearly indicate that organic matter content in the soil favourably affects the growth of A. ramosum.

Singhal (1967) working with Phyllanthus urinaria observed that organic matter brought about an increase in growth performance of the plant. Biswas (1967) working with Rauvolfia tetraphylla reported favourable effect of organic manure on growth performance of the plant. Similar observations have been reported by several other workers, viz. Ratra (1970) in case of Achyranthes aspera, Lavania (1971) in case of Melilotus indica, Gupta (1972) in case of Rumex dentatus, Bechu Lal (1976) in case of Scoparia dulcis.

6.3. Biotic Factors

Organisms do not exist alone in nature but in a matrix of other organisms of many species. The biotic factors include all living things and the interrelated actions and reactions which individual organisms directly or indirectly impose on each other (Treshow, 1970). In fact, living organisms are most potent factors in the growth and development of each other (Misra and Puri, 1954). The environment of any organism is always in part biologic as well as physical (Daubenmire, 1959). The amounts of heat, light, moisture and nutrients available to one plant are all conditioned by the proximity of other plants. There is a constant struggle between organisms for the necessary environmental needs of light, moisture, nutrients, etc. This we call as competition. Almost anything needed from the environment may be the object of competition. From seed to senescence, plants are competing for whatever among their needs is in the shortest supply at a given time and place (Treshow, 1970).

Salisbury (1929) and a number of botanists have emphasized the importance of competition in the geographical distribution of plants. Certain plants survive better in pure than in mixed cultures, while others flourish better in mixed than in pure cultures. The seedlings of all the plants compete, at least, for a while, on equal terms and their survival will depend upon their capacity for adaptation. Afterwards all the plants that have survived competition will tend to attain equilibrium resulting in a climax plant community (Varma, 1938).

The competitive interaction between neighbouring individuals leads to a poorer performance of the species (Kira et al., 1953; Haynes and Sayre, 1956; Yoda et al., 1963; Bleasdale, 1967). In a cropland ecosystem the associated weeds bring about a considerable loss to the growth and yield by reducing the efficiency of primary producers through competition (Blackman and Templeman, 1938; Salisbury, 1942; Harper and Gajic, 1961; Nelson and Nylund, 1962).

The competition will probably be severest between individuals making similar demands but differing in their biological equipment. Competition may be intra- or inter-specific, depending upon whether the individuals of the same or different species are involved. According to Bleasdale (1960) "Two plants are in competition with each other, when the growth of either one or both of them is reduced or their form modified as compared with their growth in isolation". The complexity of the process further increases by the varied method of cultivation suggesting to perform competition experiments in culture, which according to Clements et al. (1929) are more readily controlled as compared to those in the field. Culture experiments to study the effect of intra-specific and interspecific competition on growth performance of *A. ramosum* were, therefore, conducted during the course of the present investigation.

6.3.1. Intraspecific competition and growth performance

Experimental Procedure - Seedlings raised from seeds of *A. ramosum* were transplanted at four-leaf stage to earthen pots of uniform size filled with garden soil. The pots were arranged into 5 sets having varying density of seedlings per pot as follows :-

Set T_1 : One seedling per pot,

Set T_2 : Three seedlings per pot,

Set T_3 : Five seedlings per pot,

Set T_4 : Eight seedlings per pot,

Set T_5 : Twelve seedlings per pot.

Three replicates were kept for each treatment except the T. treatment for which there were six replicates. The pots were moderately watered once daily in the morning. The experiment was conducted in wire house and was continued for about three and a half months from September to December, 1979. Finally the plants were harvested and the growth responses were measured taking various parameters into consideration. The experimental data were analysed statistically and are presented in Table 6.4 and graphs 27, 28 and 2 .

Results and Discussion - It was observed that growth of A. racsum plants with respect to all the parameters studied suffered heavily under the stress of competition with increasing population density. In absence of competition the growth performance of the plant was much better, while heavy reduction in the growth performance of the plant on account of intraspecific competition was observed. The effect of increasing population density was manifested in decrease in the size, number, fresh and dry weights of the vegetative organs. There was also decrease in the reproductive potential as evidenced by the number of flowers and fruits per plant. The data reveal that maximum values for all the parameters studied are obtained in plants of T_1 treatment where there was no competition, and a progressive decline in the values for all the parameters is observed as we pass from T_1 to T_5 i.e. with the increasing intensity of intraspecific competition. There is a conspicuous reduction in the dry matter yield of shoot and root. The deleterious effect of the increasing density is, however, more pronounced on dry weight of shoot than that of root as indicated by increasing root : shoot ratio.

The statistical analysis reveals that the growth performance of the plant under varying population density differs significantly. The variance ratios for all the parameters (except the length of main root) are significant at 1% level. The decline in growth performance is most conspicuous from T_3 onwards. The LSD values presented in Table 6.4 reveal that the growth performance of the plants with respect to most of the parameters from T_3 onwards differs significantly at 1% level from that in T_1.

Similar results have been obtained by Srivastava (1963) in Malvastrum tricuspidatum, Singhal (1967) in Phyllanthus urinaria, Singh (1969) in Cassia tora, Marshall and Jain (1969) in Avena fatua and A. barbata, and Lavania (1971) in Melilotus indica.

6.3.: . Interspecific competition and growth performance

Experimental Procedure - Seedlings raised from seeds of A. ramosum were transplanted at four-leaf stage to earthen pots of uniform size filled with garden soil. The pots were arranged into 2 sets as follows :-

Set T_1 : Pots were kept free from weeds by weeding out regularly.

Set T_2 : Weeds were allowed to flourish in the pots along with the experimental plants.

Six replicates of one seedling per pot were kept for each treatment. The pots were moderately watered once daily in the morning. The experiment was conducted in wire house and was continued for about three and a half months from September to December, 1979. Finally the plants were harvested and the growth responses were measured taking various parameters into consideration. The experimental data were analysed statistically and are presented in Table 6.5 and graphs 30 and 31.

Results and Discussion - It was observed that at the time of harvesting 15 to 24 individuals belonging to 5 to 9 different weed species were flourishing in the pots of T_2 treatment. A glance at the table clearly shows that the interspecific competition had markedly deleterious effect on the growth performance of A. ramosum plants. The values of most of the parameters in plants of T_2 treatment are reduced to about one-half of those in plants of T_1 treatment. The deleterious effect was, however, more pronounced with respect to number of fruits/plant and fresh and dry weights of shoot and root. The values of root : shoot ratios in T_2 are markedly higher than those in T_1, which indicates that shoot suffered highly as compared to root under this treatment.

The statistical analysis reveals that the effect of interspecific competition on growth performance of the plant is highly significant. 't' values obtained for all the parameters except length of root are significant at 1% level.

Similar results have been reported by several workers in case of different plants (Srivastava, 1963; Singhal, 1967; Lavania, 1971 and others).

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