S E C T I O N I I

ECOLOGY OF *ABUTILON RAMOSUM* GUILL. & PERR.

CHAPTER 4

TAXONOMY, DISTRIBUTION AND MORPHOLOGY

4.1. Systematic Position

Abutilon ramosum Guill. & Perr. is a member of the family Malvaceae.

4.2. Distribution

The distribution of *A. ramosum* in India and other countries according to the various authors is presented in Table 4.1.

As it has been already pointed out in Chapter 1, the distribution of this plant is very peculiar in Baroda. It is abundant in certain parts of L. V. Palace compound, viz., Temple area, Navlakhi area, Museum area etc., but is not found outside this locality anywhere else in Baroda.

4.3. Habit and Habitat

It is an erect, much-branched, small, perennial shrub, 1-1.5 m or sometimes upto 2 m high, with white or ash-coloured bark.

It grows under the shade of trees, in soils rich in humus.

Plates 2 and 3.

4.4. Morphology

Root - It is a tap root system with well developed lateral branches.

Stem - It is terete, somewhat densely glandular-viscid, intermixed with short, dense, stellate and long, spreading, soft hairs. Branches downy with a few spreading hairs intermixed.

Leaves - They are 4-13 X 3-11 cm in size, long-petioled, broadly ovate-cordate, suborbicular, often sub-trilobate, apex acuminate, sometimes 3-cuspidate, crenate-serrate with minutely apiculate serrations, angles usually acute; palmately 5-7-nerved; slightly hairy, membranous and green on both surfaces; upper dark-green, lower somewhat paler; petioles 3-9 cm long, tomentose, longitudinally sulcate; stipules 1-1.3 cm long, subulate, linear.

Flowers - They are on slender, axillary and terminal peduncles, the latter are trichotomous and as long as or longer than the petioles; cymosely 2-4-flowered; pedicels jointed near the apex, 1.2-2.6 cm long, frequently divided into 2 branches near the top; bracteoles 0.

Flowers usually open in the afternoon.

Calyx - Sepals 5, valvate, gamosepalous, forming a broadly cup-shaped structure, 0.5-0.6 cm long, divided nearly to the middle, viscous-pubescent; lobes ovate, usually acuminate-cuspidate.

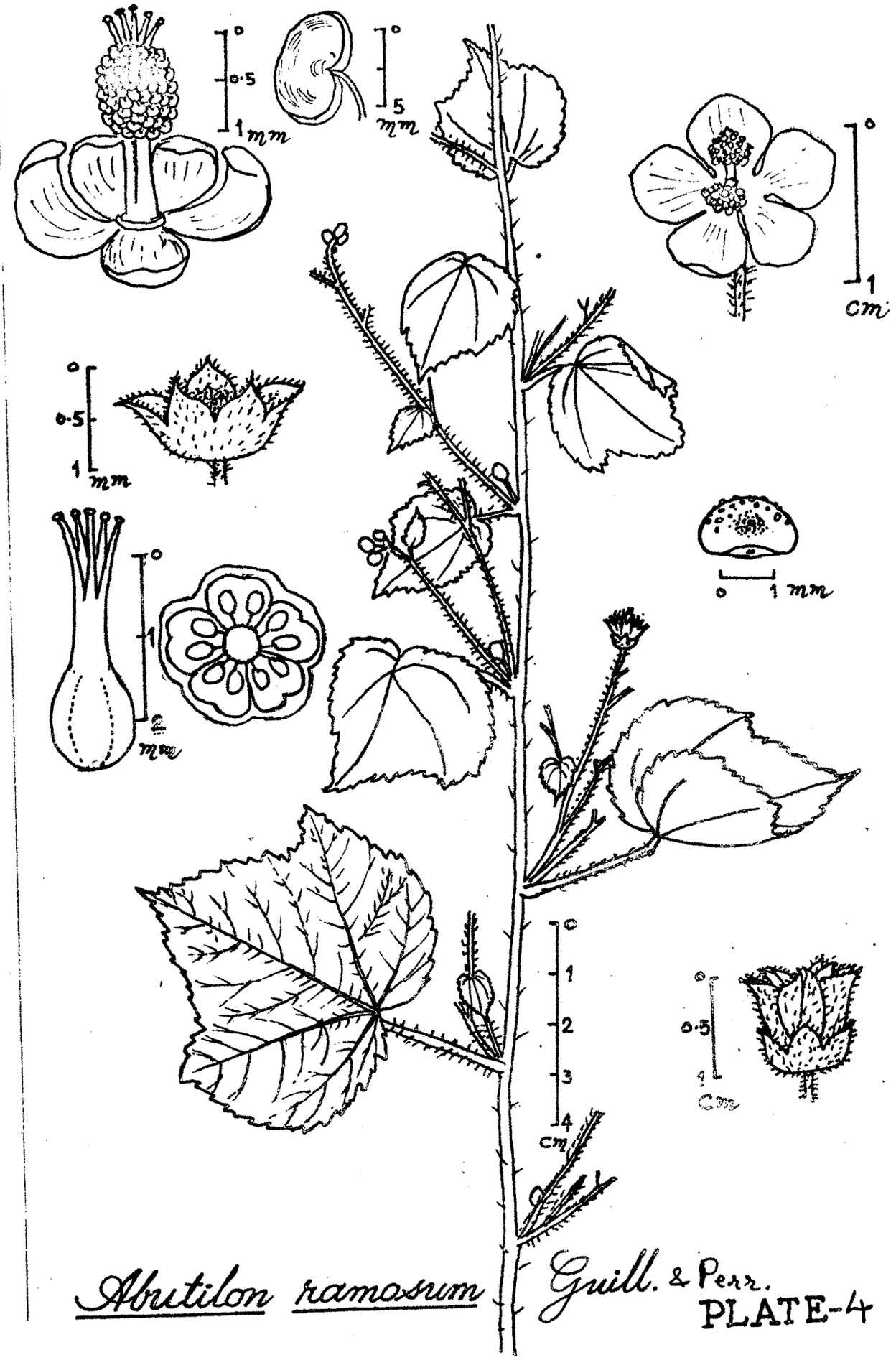
Corolla - It is 1.5 - 2 cm in diameter, yellow; petals 5 in number, 5-7 mm long, free above, connate below and adnate to the staminal tube.

Androecium - Staminal tube densely stellate-hairy, dividing at the summit into numerous anther-bearing filaments.

Gynaecium - Carpels 5-7, rarely 8, acute, mucronate, glutinous, pubescent; styles as many as carpels. The number of carpels in A. ramosum as mentioned in the various floras (referred to in Table 4.1) is 8-10 or less. However, in our material the number was found to be 5-7, rarely 8. This was carefully confirmed by counting the number of carpels in 700 fruits randomly collected from the plants growing in the different study sites. The data are presented below :-

Number of carpels per fruit	Number of fruits	% of total number of fruits
5	75	10.71
6	475	67.86
7	148	21.14
8	2	0.29
Total	700	100.00

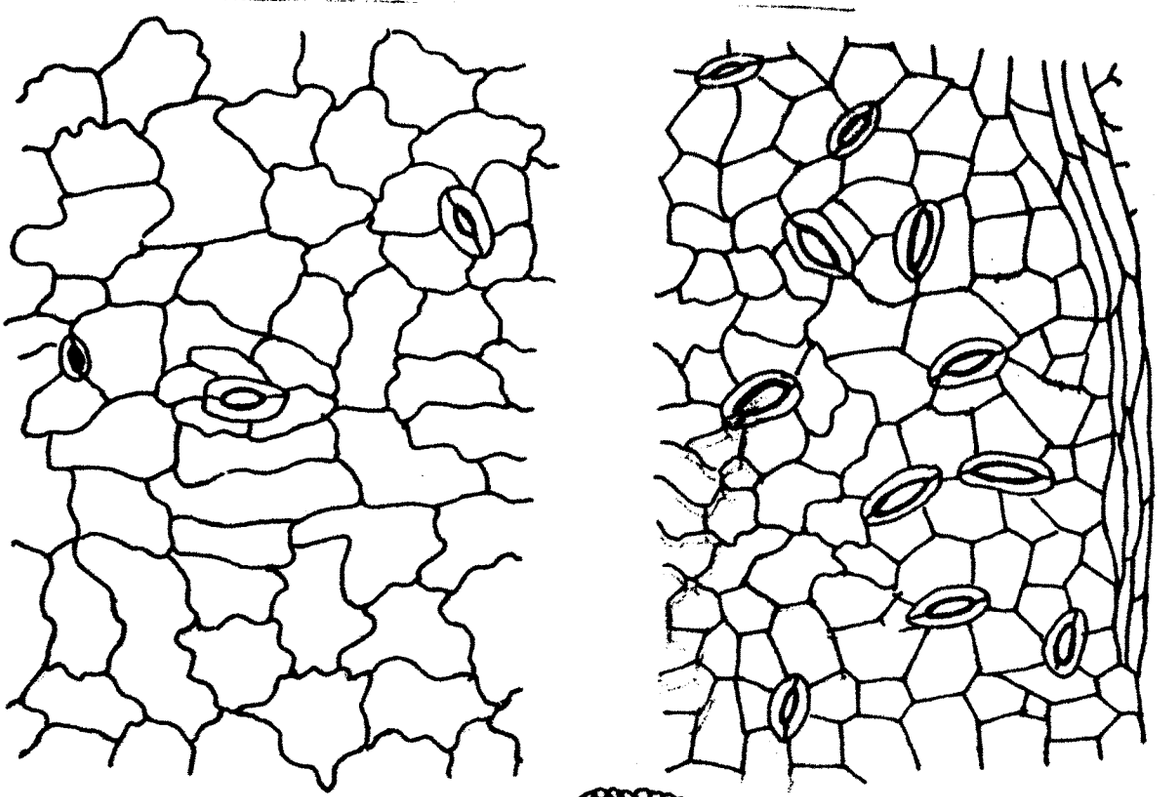
Fruit - It is short, cylindric, 9-11 mm long, nearly as much in diameter; carpels 5-7, rarely 8, glutinous-pubescent, each terminating into a deflexed subulate awn,



Abutilon ramosum Guill. & Perr.

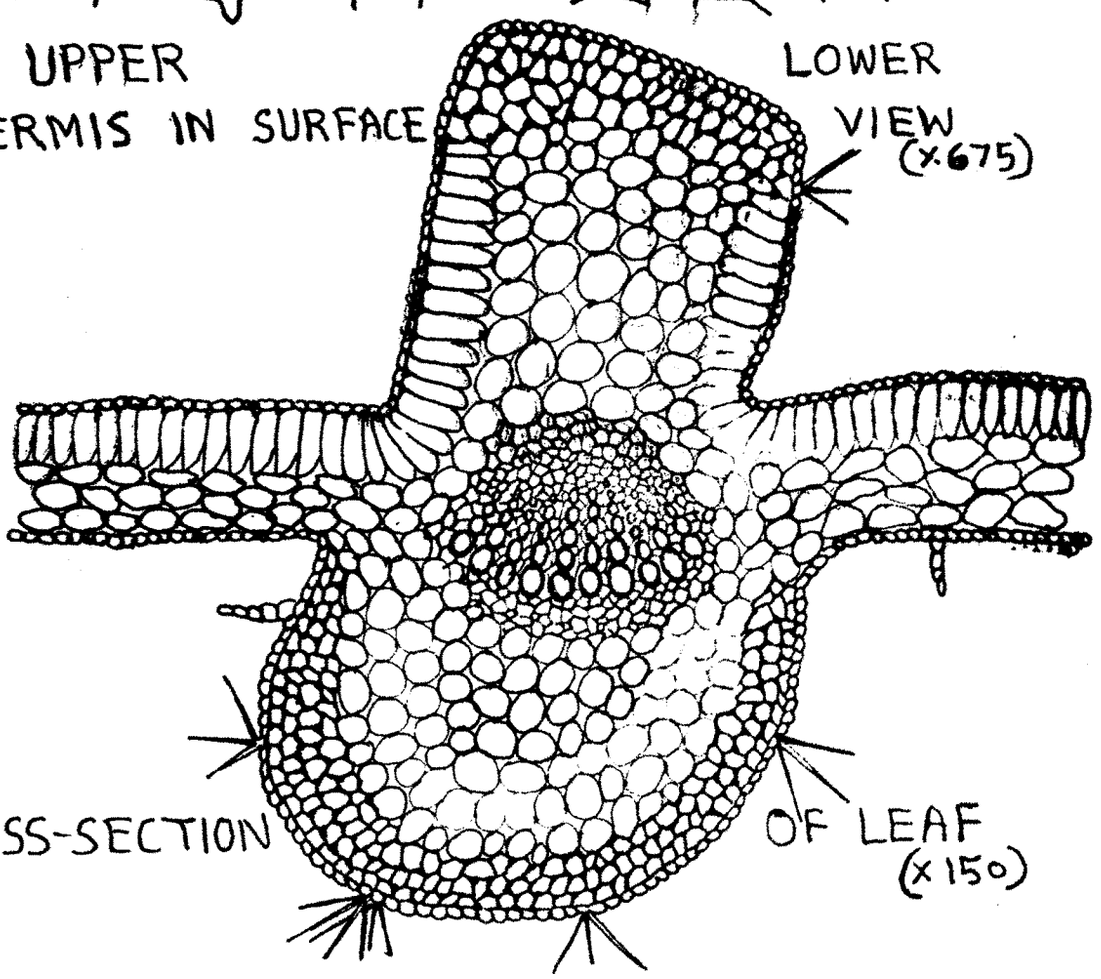
PLATE-4

A. RAMOSUM PLATE 7



UPPER EPIDERMIS IN SURFACE VIEW

LOWER (×675)



CROSS-SECTION OF LEAF (×150)

(iv) poorly developed mechanical tissue system especially in leaf.

4.8. Stomatal Index

The significance of stomatal frequency and index in ecological studies has been well emphasised by Salisbury (1927), since they have a close correlation with the environmental conditions of plants.

The stomatal frequency and index of a mature leaf of A. ramosum were determined and are given below :-

Region of the leaf	Average Number of stomata per sq. mm	Average Number of epidermal cells/sq. mm	Stomatal Index
Upper Epidermis			
Apical	61.40	1452.63	4.06
Middle	49.12	1450.88	3.27
Basal	43.86	1782.46	2.40
Lower Epidermis			
Apical	331.58	1901.75	14.85
Middle	370.18	1849.12	16.68
Basal	349.12	1873.68	15.71

The data indicate that - (i) the stomatal frequency and

Size : (Values based on 100 observations)

Length (mm)	2.172±0.095
Breadth (mm)	1.896±0.172
Thickness (mm)	1.483±0.145
Shape Index (Length/Breadth Ratio)	1.155±0.090

Weight : (Values based on 10 observations of averages drawn from weight of seeds in lots of 100 each).

Date of seed collection	Weight of one seed (mg)
24-10-1977	3.82±0.05
19-10-1978	3.88±0.05

Moisture content (%) : (Values based on 3 observations of moisture content of seeds in lots of 100 each).

9.95±0.59

Note : Values represent Mean± Standard Deviation.

5.2. Imbibition rate

Imbibition is the first process occurring during germination. The imbibition rate of the seeds of A. ramosum

after dry storage for different durations and without giving any pretreatment was studied under laboratory conditions, the procedure of which is given under 2.7 in Chapter 2. The same was also studied after giving high temperature (60°C) pretreatment to the seeds for 14 h. The data are presented in Table 5.0.

The data reveal that the imbibition rate of the seeds which were given high temperature pretreatment is considerably high than that of the untreated seeds. 100% water was imbibed within 10 h by the treated seeds, while per cent imbibition by the untreated seeds ranged between 4.08 and 26.81 during the imbibition period of upto 7X24 h. Further, the imbibition rate seems to improve with the longer dry storage period.

Among the values of per cent imbibition by the untreated seeds, those ranging from 9.06 to 26.81% seem to be somewhat higher, and may be probably due to a few seeds which could imbibe greater amount of water and were able to germinate during the course of the experiment.

It appears that the seed coat of these seeds is impermeable or only slightly permeable to water and that the high temperature treatment could make the seed coat permeable.

5.3. Seed output

Seed output is the potential capacity of a species to reproduce itself. The average seed output is determined by

Table 5.0 : Imbibition rate of seeds of A. ramosum.

Locality of seed collection : L. V. Palace compound

	Date of seed Collection and duration of dry storage	Range of Temp. during the entire period of imbibition Expt. (°C) Max.	Min.	Per cent Imbibition after soaking for h: 16	1X24	2X24	3X24	4X24	5X24	6X24	7X24
A : Imbibition rate of untreated seeds											
I.	24-10-77	29.7 to	11.4 to	Not tried	12.35	19.01	26.81	14.52	25.10	16.10	Not tried
	27 months	33.2	14.6								
II.	19-10-78	29.2 to	14.2 to	4.08	5.30	5.85	15.95	12.54	3.72	18.01	11.34
	14 months	34.7	18.9								
III.	26-12-79	30.9 to	11.9 to	Not tried	6.30	9.59	5.99	5.90	Not tried	9.06	9.22
	1.5 months	38.3	16.6								

B : Imbibition rate of seeds pretreated with high temp. (60°C) for 14 h

				Per cent Imbibition after soaking for h: 1	2	3	4	5	6	8	10
IV.	19-10-78	27.4 to	20.4 to	3.62	35.18	66.40	81.01	85.75	91.07	97.02	100.00
	13 months	32.4	20.8								

taking the mean of the products of the number of seeds per fruit and the number of fruits per plant (Salisbury, 1942). For the purpose of seed output study 40 mature plants of A. ramosum randomly selected from the different study sites were observed during their fruiting period, and the number of fruits per plant and the number of seeds per fruit were recorded, and the average seed output was calculated. The data are given below :-

	Range	Mean± SD
No. of fruits per plant	70 to 241	145.30±48.69
No. of seeds per fruit	12 21	15.93± 2.20
Average seed output	2314.63 i.e. 2315	

5.4. Dispersal of seeds

The dispersal of seeds of A. ramosum seems to be very poor, since, seed morphology does not show any specialised mechanism for wide dispersal. The ripe dehisced fruits remain attached to the parent plant, and the seeds from these fruits may fall on the ground when the branches bearing the fruits bend under the influence of strong winds. If the ripe fruits are disturbed by human agency, they immediately break off at the joint on the pedicel, allowing

the seeds to fall on the ground. The seeds lack any special device for dispersal by wind or animals or other agency, and hence are not carried far from the parent plant. The probable dispersing agency appears to be the strong water current during the rainy season, but it may not be efficient to carry the seeds to longer distances.

5.5. Germination studies

Germination is an important phase in the life history of a plant. It involves a series of morphological, physiological and biochemical changes in the seed, and accordingly it can be defined in several ways as has been done by Jann and Amen (1977). According to the definitions given by them : "Biologically, seed germination is the awakening of an embryo from a quasi-cryptobiotic state; it is the re-expression of the developmental genetic program. Morphologically, germination is the transformation of an embryo into a seedling. Physiologically, germination is the resumption of the metabolism and growth which were earlier depressed or suspended, and the switching on of the transcription of new portions of the genetic program. Biochemically, germination is a sequential differentiation of oxidative and synthetic pathways and the restoration of biochemic pathways typical of vegetative growth and development. Essentially, therefore, germination is the bringing of the embryonic axis into a state of continued growth which was temporarily suspended

during quiescence or dormancy, and the initiation of new genetic programs".

Weaver and Clements (1938) considered germination as the first critical phase of ecesis. Clapham (1956) associated the presence of a seed plant in a habitat because of its successful germination. Went (1957) concluded that distribution of a plant depends not only on its climatic tolerance but upon its germination which sometimes limits the distribution owing to its different requirements from those of the growth phases. Hence study directed towards the understanding of physiology and ecology of seed germination assumes considerable importance in autecological studies. So to understand the ecology of seed germination, experiments to study seed dormancy and various methods of breaking it; germination under different conditions of soil, temperature and light; effect of some chemicals and growth regulators on germination were carried out extensively during the course of the present work.

5.5.1 Dormancy of seeds

Untreated seeds of A. ramosum freshly collected and those after dry storage for different durations upto 29 months, when kept for germination, did not germinate or showed only negligible germination even after continuing the experiment for 20-30 or more days. Further, the seeds thus kept for germination did not seem to swell or show any

recognizable sign of imbibition. Hence, seed coat was presumed to be impermeable to water and thus hard seed coat type dormancy was suspected.

In order to break this type of dormancy of the seeds various methods, viz., mechanical scarification, chemical scarification, treatment with organic solvents, high temperature treatment, dry and wet heating etc. were employed.

5.5.2 Effect of Mechanical scarification

Experimental Procedure - Seeds of A. ramosum collected on dt. 24-10-77 and after dry storage for two and a half months were used in this experiment. The seeds were mechanically scarified by rubbing them between two sand papers for a few minutes. As a result of this treatment some minute cracks appeared in the seed coat which could be clearly observed under a microscope. The germination of these treated seeds was then studied as per the experimental procedure given under 2.7, Chapter 2. Untreated seeds were kept as control. The maximum and minimum temperatures ranged from 26.5 to 33.9°C and 6.8 to 15.6°C respectively during the course of the experiment. The results of the experiment are presented in Table 5.1 and graph 6 - (iv).

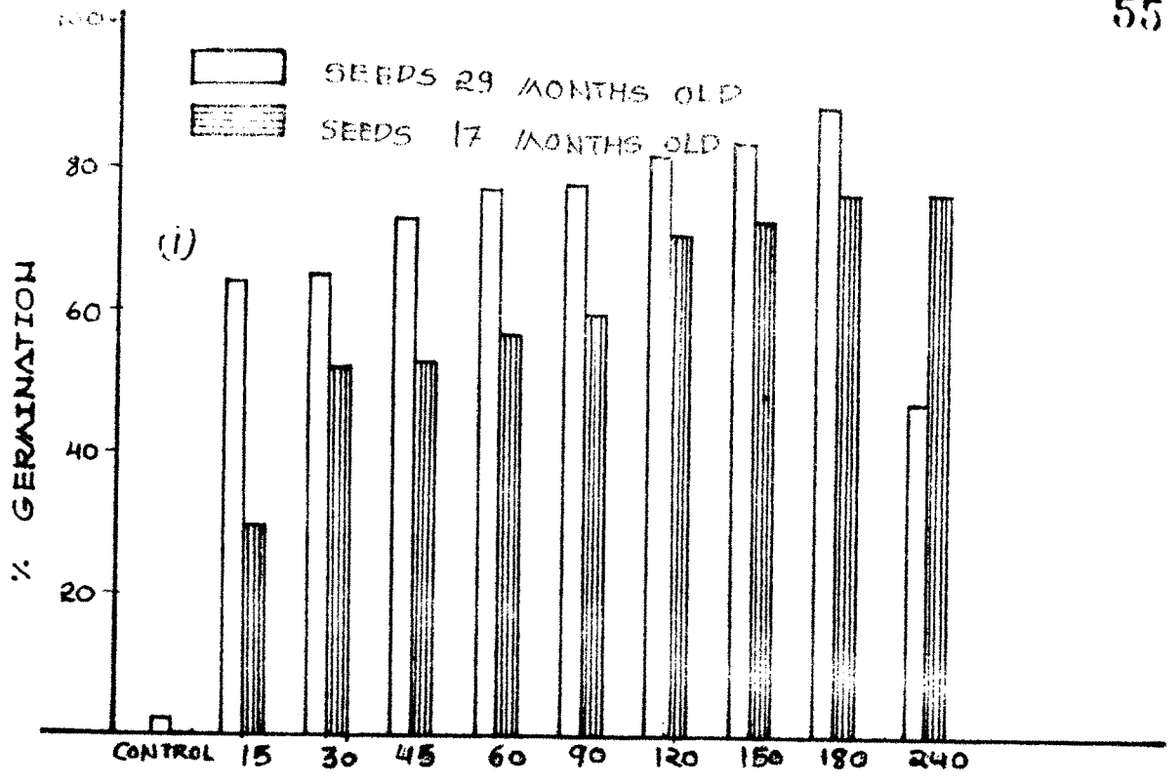
Results and Discussion - Untreated seeds showed no germination, while the treated seeds showed 84.67% germination.

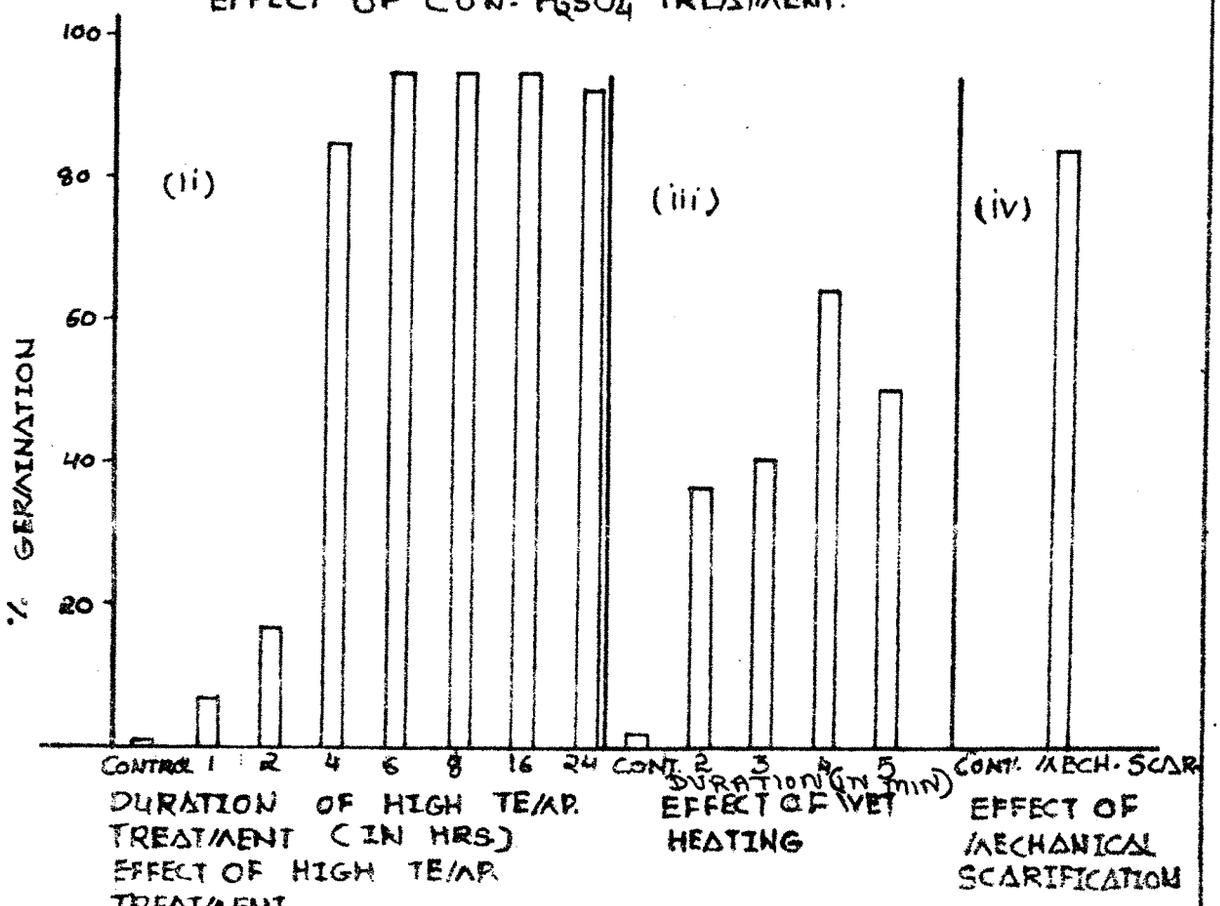
Table 5.1 : Effect of mechanical scarification on germination of seeds of A. ramosum

Sr. No.	Treatment	No. of seeds germinated/50	% Germination
1.	Untreated (Control)	0.00 (-)	0.00
2.	Mechanical scarification (Rubbing the seeds between two sand papers for a few minutes)	42.33 (1.53)	84.67

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.





GERMINATION OF SEEDS OF A. RAMOSUM GRAPH-6

Thus the treatment used in the experiment was successful in breaking dormancy of the seeds. It can be presumed that through the cracks produced in the seed coat by this treatment, the seeds could imbibe water necessary for germination.

Mechanical scarification by this or some other method has been successfully employed to break the hard seed coat type of dormancy by several workers, viz., Hamly (1932), Watson (1948), Shankar (1968), Tripathi (1968), Lavania (1971) and many others.

5.5.3 Effect of Chemical scarification

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-77 and Dt. 26-10-78 and after dry storage for 29 and 17 months respectively were used in this experiment. The seeds were chemically scarified by con. H_2SO_4 treatment for different durations varying from 15 to 240 min. The treated seeds were thoroughly washed in running tap water and subsequently, with distilled water to remove traces of the acid. The seeds were then kept for germination as usual. Untreated seeds were kept as control. The maximum and minimum temperatures ranged from 40.0 to 44.1°C and 22.0 to 28.6°C respectively during the course of the experiment. The experimental data were statistically analysed and are presented in Tables 5.2 a and 5.2 b respectively and in graph 6 (i).

Table 5: 2 B : Effect of chemical scarification (con. H_2SO_4 treatment) on germination of A. ramosum seeds.

Expt. II : After dry storage of seeds for 17 months (seeds collected in Oct., 1978).

Sr. No.	Duration of con. H_2SO_4 treatment	No. of seeds germinated/50	% Germination
1.	Untreated (Control)	0.00 (-)	0.00
2.	15 Min.	14.67 (2.31)	29.33
3.	30 "	25.33 (3.21)	50.67
4.	45 "	26.00 (2.00)	52.00
5.	60 "	28.00 (2.65)	56.00
6.	90 "	29.67 (3.06)	59.33
7.	120 "	35.00 (2.65)	70.00
8.	150 "	36.00 (2.65)	72.00
9.	180 "	38.00 (1.00)	76.00
10.	240. "	38.00 (1.73)	76.00

L S D = 4.20 at 5% level; L S D = 5.76 at 1% level.

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	1397.85	8	174.73	29.12 **
Within treatments	108.00	18	6.00	
Total	1505.85	26		

Table value of F = 2.51 at 5% level; F = 3.71 at 1% level.

(Untreated seeds not considered in analysis of variance)

Results and Discussion - Untreated seeds with dry storage for 17 months gave no germination, and those with dry storage for 29 months gave only 2.00% germination. Treated seeds in both cases gave good results, overall germination ranging from 29.33 to 88.00%. In both cases a gradual increase in per cent germination was obtained with the increase in duration of the acid treatment. However, in 29 months old seeds, a sharp decrease in per cent germination was observed, when the duration of the acid treatment extended upto 240 min. Further, the seeds with longer period of dry storage gave better response to all durations of acid treatment, except in the last one (of 240 min), as compared to those with shorter period of dry storage. Thus in 17 months old seeds 76.00% germination was obtained after acid treatment for 240 min, while in 29 months old seeds, that much per cent germination was obtained after acid treatment for only 60 min. This shows that with the increase in dry storage period, the effective duration of acid treatment decreases, and that longer duration of acid treatment beyond 180 min proves to be harmful.

The statistical analysis reveals that the overall effect of varying durations of acid treatment differs significantly at 1% level in both cases. However, there is no significant difference between the effects of most of the two consecutive durations. e.g. There is significant difference between the results obtained by durations of 30 amd 60 min or of 45 and

120 min, but there is no significant difference between the results obtained by durations of 45 and 60 min or of 60 and 90 min.

Chemical scarification by acid treatment to break the hard seed coat type dormancy is a very common method that has been successfully employed by various workers, viz. Srivastava (1963), Shankar (1968), Tripathi (1968), Lavania (1971) and many others. The effective duration of acid treatment to obtain the best results varies from a few minutes to 3-4 or more hours depending upon the species. A. ramosum seeds can endure comparatively longer durations of acid treatment without harm to the embryo as can be seen from Tables 5.2 a and 5.2 b.

Interaction among (i) temperatures prevailing during the course of the experiment, (ii) duration of acid treatment and (iii) duration of dry storage of seeds :

The per cent germination in A. ramosum seeds seems to be probably influenced also by the temperatures prevailing during the course of the experiment besides the duration of the acid treatment and duration of the dry storage of seeds. There seems to be probably a complicated interaction among the aforesaid three factors. This can be brought out clearly from the data of series of experiments carried out during different months and with seeds of different durations of dry storage and with varying durations of con. H_2SO_4 pretreatment which are presented in Table 5.2 c. Whatever may be the nature of interaction, one fact is clearly brought out from the data,

that with the increase in duration of the acid treatment (ranging from 5 to 60 min), there is an increase in germination percentage.

Further in most of the aforesaid experiments per cent germination ranging from about 70 to 90% or more was obtained with 30 min of the acid pretreatment. So, taking this duration (30 min) of acid treatment as the most suitable and convenient, it was decided to follow it for making the seed coat permeable in the rest of the experiments to study germination of A. ramosum seeds under different conditions of soil, temperature and light and also to study the effect of various chemicals on germination of these seeds.

5.5.4 Effect of pretreatment with organic solvents

Experimental Procedure - Seeds of A. ramosum collected on Dt. 19-10-78 and after 10 months of dry storage were used in this experiment. Seeds were pretreated with some organic solvents, viz., absolute alcohol, acetone and chloroform for 24 and 48 h. Seeds soaked in distilled water for 24 and 48 h served as control. Treated seeds were thoroughly washed in running tap water and subsequently in distilled water and then were kept for germination as usual. The maximum and minimum temperatures ranged from 31.1 to 37.2°C and 22.2 to 25.6°C respectively during the course of the experiment. The results are presented in Table 5.3.

Table 5.3 : Effect of pretreatment with some organic solvents on germination of seeds of A. ramosum.

Sr. No.	Treatment and duration	No. of seeds germinated/50	% Germination
1.	Dist. water (Control) - 24 hrs.	1.00 (1.00)	2.00
2.	Dist. water - 48 hrs. (Control)	C.67 (C.58)	1.33
3.	Absolute Alcohol - 24 hrs.	C.00 (-)	0.00
4.	" " - 48 "	0.00 (-)	0.00
5.	Acetone - 24 hrs.	0.00 (-)	0.00
6.	" - 48 hrs.	1.00 (1.00)	2.00
7.	Chloroform - 24 hrs.	0.67 (0.58)	1.33
8.	" - 48 hrs.	0.33 (0.58)	0.67

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.

Table 5.4 : Effect of high temperature treatment on germination of seeds of A. ramosum.

Sr. No.	Duration of high temp. treatment (Hrs.)	No. of seeds germinated/50	% Germination
1.	Untreated (Control)	0.67 (0.58)	1.33
2.	1	3.67 (0.58)	7.33
3.	2	8.67 (0.58)	17.33
4.	4	42.67 (0.58)	85.33
5.	6	47.67 (1.15)	95.33
6.	8	47.33 (0.58)	94.67
7.	16	47.67 (0.58)	95.33
8.	24	46.67 (0.58)	93.33

L S D = 1.21 at 5% level. L S D = 1.68 at 1% level

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of variance

Source of variation	S S	df	M S S	F
Between treatments	7029.14	6	1171.52	2440.67 **
Within treatments	6.67	14	0.48	
Total	7035.81	20		

Table value of F : F = 2.85 at 5% level, F = 4.46 at 1% level.

(untreated seeds not considered in analysis of variance).

germination. But it is evident from the data that high temperature pretreatment is quite effective in making the seed coat permeable and thereby breaking dormancy of the seeds. Per cent germination increased with the increase in duration of the treatment upto 6 h but further increase in the duration of the treatment upto 24 h did not show any significant difference in germination percentage.

The statistical analysis reveals that the overall effect of varying durations of high temperature treatment differs significantly at 1% level. Further, the differences among durations of 1, 2, 4 and 6 h are significant at 1% level, while those among durations of 6, 8, 16 and 24 h are not significant. Thus optimum duration of the treatment for obtaining best results seems to be 6 h, however longer durations upto 24 h were also found to be equally effective.

High temperature (85 to 90°C) increased permeability to water and also germination in seeds of alfaalfa (Staker, 1925 c/f. Weaver and Clements, 1938). Pachpor (1977) reported that pretreatment of seeds of Cassia auriculata at 75°C for 6 h favourably affected the percentage and speed of germination. Chatterji and Baxi (1966) observed beneficial effect of dry heating on the germination percentage of certain annual as well as perennial legumes of Western Rajasthan. Bechu Lal (1976), however, reported decrease in germination percentage of Chrozophora rottleri seeds after dry heating of the seeds at 45°C in an incubator for different durations.

5.5.6 Effect of Dry and wet heating

Experimental Procedure - Seeds of A. ramosum collected on Dt. 19-10-78 and after dry storage of 13 months were used in this experiment. Three kinds of treatments were tried here. In one set seeds were heated dry on a hot plate for 2, 3, 4 and 5 min. In another set seeds were heated in tap water (250 ml) in a beaker on a direct flame of a bunsen burner for 2, 3, 4 and 5 min. In still another set seeds were heated in boiling water for 1, 2 and 5 min. Treated seeds were kept for germination as usual. Untreated seeds served as control. The maximum and minimum temperatures ranged from 27.4 to 32.8°C and 15.2 to 21.4°C respectively during the course of the experiment. The results are presented in Table 5.5 and graph 6 (iii).

Results and Discussion - Untreated seeds gave only 2.0% (negligible) germination. Dry heating on a hot plate softened the seed coat but seemed to be severely harmful to the embryo, as the treated seeds could imbibe water and swell, but failed to germinate. Wet heating in hot water was fairly successful, and heating upto 2, 3 and 4 min gradually increased germination percentage, but a decrease in germination percentage was observed by heating for 5 min. Germination percentage was maximum (65.33%) with 4 min of wet heating. Wet heating in boiling water softened the seed coat but seemed to be severely harmful to the embryo, as the treated seeds could imbibe water and

Table 5.5 : Effect of dry and wet heating on germination of seeds of A. ramosum.

Sr. No.	Treatment and Duration	No. of seeds germinated/50	% Germination
1.	Untreated (control)	1.00 (1.00)	2.00
2.	Dry heating on a hot plate - 2 min.	0.00 (-)	0.00
3.	" " 3 "	0.00 (-)	0.00
4.	" " 4 "	0.00 (-)	0.00
5.	" " 5 "	0.00 (-)	0.00
6.	Wet heating in hot water - 2 min.	18.67 (2.52)	37.33
7.	" " 3 "	20.33 (3.06)	40.67
8.	" " 4 "	32.67 (1.53)	65.33
9.	" " 5 "	25.67 (0.58)	51.33
10.	Wet heating in boiling water -1 "	2.33 (0.58)	4.67
11.	" " 2 "	1.67 (0.58)	3.33
12.	" " 5 "	0.00 (-)	0.00

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.

swell, but failed to germinate or gave only negligible germination.

Lavania (1971) reported good results with dry and wet heating of seeds for one minute, but continued heating for more than one minute proved injurious.

5.5.7 Effect of burial of seeds in soil at different depths

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-78 and after dry stcrage of 4 months were used in this experiment. Seeds were placed in porous nylon bags (10 X 5 cm) and glass specimen tubes (tightly corked and sealed with wax), which were buried in soil at different depths (6, 12, 18 and 24 cm). The seeds kept in the porous nylon bags were better exposed to the actions of edaphic factors and had ready access to the soil moisture than those kept in stoppered glass specimen tubes which served as controls. At intervals of 3,6, 9 and 12 months the nylon bags and specimen tubes were dug out from the soil and the required number of seeds were taken out from them, and then they were again buried in soil as before. The seeds taken out like this every time were cleaned and thoroughly washed in tap water and subsequently in distilled water, and then were kept for germination as usual. The experimental data are presented in Table 5.6.

Results and Discussion - It is evident from the table that burial at any depth and for any of the durations tried

Table 5.6 : Effect of burial on germination of seeds of *A. ramosum*.

Sr. No.	Container and depth of burial	% Germination — Period of Burial (Months)			
		3	6	9	12
1.	Specimen tubes 6 cm	0.00	0.00	0.00	0.00
2.	" " 12 "	0.00	0.00	0.00	0.00
3.	" " 18 "	2.00	3.00	0.00	0.00
4.	" " 24 "	0.00	0.00	0.00	0.00
5.	Nylon bags - 6 cm	0.00	0.00	0.00	2.00
6.	" " 12 "	0.00	0.00	0.00	0.00
7.	" " 18 "	0.00	0.00	0.00	0.00
8.	" " 24 "	0.00	0.00	0.00	0.00

was not effective in breaking the dormancy of seeds. The treated seeds gave no germination or only negligible germination. The results suggest that probably in nature also the seeds may have dormancy period of more than one year. As it has been observed, these seeds remained dormant even after dry storage of 29 months under laboratory conditions. Thus burial of seeds of A. ramosum for a period of 12 months may not be sufficient to bring about softening of the seed coat through the agency of natural edaphic factors.

In contrast to this, Shankar (1968) reported favourable influence of burial of seeds in nylon bags for a period of only 3 months in a similar experiment with Trichodesma amplexicaule seeds. Lavania (1971) also reported favourable influence of burial of seeds in nylon bags in a similar experiment with Melilotus indica seeds. He observed a gradual increase in germination percentage with the increase in the duration of burial. He achieved maximum germination percentage by burial at 10 cm depth for a period of 12 months.

5.5.8 Effect of type of soil

Experimental Procedure - Seeds of A. ramosum collected on 24-10-78 and after dry storage for 4 months were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. Air-dried soils of four different types - clayey soil, sandy soil,

wasteland soil and garden soil were filled in small pots of equal size. 20 seeds were sown at 1 cm depth in each pot and 5 replicates of each treatment were kept. The pots were kept in wire house and were moderately watered once daily in the morning.The criterion of germination was based on the emergence of the seedling above the soil surface. The number of seeds germinated was recorded once daily. The maximum and minimum temperatures ranged from 27.9 to 39.0°C and 9.2 to 21.2°C respectively during the ccurse of the experiment. The experimental data were analysed statistically and are presented in Table 5.7 and graph 9 (i).

Results and Discussion - The germination percentage was maximum (78.00%) in garden soil and minimum (58.00%) in sand. The overall effect of different types of soil on germination is significant at 1% level. However, LSD values reveal that there is no significant difference among the effects of clay, wasteland soil and garden soil; and also between those of clay and sand, but the effect of sand differs significantly from that of wasteland soil and garden soil. Thus as far as germination is concerned, garden soil, wasteland soil and clay are equally favourable, while sand is somewhat less favourable.

5.5.9 Effect of depth of sowing

Experimental procedure - Seeds of A. ramosum collected

Table 5.7 : Effect of type of soil on germination of seeds of A. ramosum.

Sr. No.	Type of soil	No. of seeds germinated/20	% Germination
1.	Clay	13.60 (1.14)	68.00
2.	Sand	11.60 (2.30)	58.00
3.	Wasteland soil	15.20 (1.48)	76.00
4.	Garden soil	15.60 (1.34)	78.00

L S D = 2.18 at 5% level; L S D = 3.01 at 1% level.

Note : (1) Values are based on five observations.

(2) Figures in parentheses are standard deviations.

Analysis of variance

Source of variation	S S	df	M S S	F
Between treatments	49.6	3	16.53	6.24**
Within treatments	42.4	16	2.65	
Total	92.0	19		

Table value of F : F = 3.24 at 5% level

F = 5.29 at 1% level

on Dt. 24-10-78 and after four and a half months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. Seeds were sown at varying depths (0.5, 1, 2, 3, 4, 6, 8 and 10 cm) in garden soil filled in small pots of equal size. 15 seeds were sown in each pot and 5 replicates of each treatment were kept. The pots were kept in wire house and were moderately watered once daily in the morning. The criterion of germination was based on the emergence of the seedling above the soil surface. The number of seeds germinated was recorded once daily.The maximum and minimum temperatures ranged from 28.6 to 39.0°C and 9.2 to 21.2°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.8 and graph 3.

Results and Discussion - A glance at the Table 5.8 clearly shows that depths ranging from 0.5 to 3 cm were most favourable and gave germination ranging from 90.67 to 94.67%. There was a sharp decrease in germination percentage at 4 cm depth and still greater depths seemed to be very unfavourable giving considerably less germination percentage. The statistical analysis reveals that the overall effect of varying depths of sowing is significant at 1% level. There is no significant difference among the effects of depths ranging from 0.5 to 3 cm, however, with greater depths beyond 3 cm significant differences in results are observed.

Table 5.8 : Effect of depth of sowing on germination of seeds of *A. ramosum*.

Sr. No.	Depth of sowing (cm)	No. of seeds germinated/15	% Germination
1.	0.5	13.60 (1.14)	90.67
2.	1	14.20 (0.84)	94.67
3.	2	14.20 (0.45)	94.67
4.	3	14.00 (0.71)	93.33
5.	4	5.20 (0.84)	34.67
6.	5	1.60 (0.89)	10.67
7.	6	1.40 (0.55)	9.33
8.	8	1.20 (0.45)	8.00
9.	10	1.20 (0.45)	8.00

L S D = 0.94 at 5% level; LSD = 1.27 at 1% level.

Note : (1) Values are based on five observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	1629.2	8	203.65	377.13 **
Within treatments	19.6	36	0.54	
Total	1648.8	44		

Table value of F : F = 2.21 at 5% level
F = 3.04 at 1% level

Decrease in germination percentage with increase in the depth of sowing has been repcrted by several workers, viz.,Mall (1956), Chakravorty and Verma (1968), Babu and Joshi (1970), Kaul (1974), Bechu Lal (1976) and many others.

5.5.10 Effect of soil moisture content

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-78 and after 6 months of dry storage were used in this experiment. Weighed quantity of oven dry garden soil was taken in Petri dishes (Corning - 14 cm diam.). Tap water was added in required amount to the soil in the Petri dishes so as to bring the soil moisture content to 20, 30, 40, 50 and 60% on dry weight basis. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. 25 weeds were sown in each Petri dish, keeping 4 replicates of each treatment. The experiment was conducted under laboratory conditions, and the different levels of soil moisture were maintained by daily supply of water lost by evaporation. To bring down the rate of evaporation of water, the Petri dishes were covered with their lids. The criterion of germination was based on the emergence of the seedling above the soil surface. The number of seeds germinated was recorded once daily. The maximum and minimum temperatures ranged from 37.2-44.9°C and 22.6 to 29.2°C during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.9 and graph 9 (ii).

Table 5.9 : Effect of soil moisture content on germination of seeds of A. ramosum.

Sr. No.	Soil moisture content (%)	No. of seeds germinated/25	% Germination
1.	20	5.50 (1.73)	22.00
2.	30	15.50 (1.00)	62.00
3.	40	24.00 (1.15)	96.00
4.	50	22.50 (1.00)	90.00
5.	60	18.00 (1.63)	72.00

L S D = 2.02 at 5% level; L S D = 2.80 at 1% level.

Note : (1) Values are based on four observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of Variation	S S	df	M S S	F
Between treatments	858.80	4	214.70	119.28 **
Within treatments	27.00	15	1.80	
Total	885.80	19		

Table value of F : F = 3.06 at 5% level
F = 4.89 at 1% level

Results and Discussion - The germination percentage was lowest (22.00%) in soil with 20% moisture content, and highest (96.00%) in soil with 40% moisture content. The statistical analysis reveals that the overall effect of varying level of soil moisture content is significant at 1% level. However, there is no significant difference between the effects of 40 and 50% levels of soil moisture, but both of these differ significantly from those of the remaining levels.

Kaul (1974) in a similar experiment with Hemigraphis dura seeds reported maximum germination at 50% level of soil moisture, and gradual decrease in germination percentage with change in the level of soil moisture in either direction. Wakhloo (1964) working with Rauvolfia serpentina seeds reported maximum germination at 10% and gradual decrease in germination percentage with increasing level of soil moisture upto 25%. No germination was observed, when the level of soil moisture was beyond 25%. Singhal (1967) working with Phyllanthus urinaria seeds obtained maximum germination at 35-38% level of soil moisture, and at levels of soil moisture lower than 35% the germination percentage decreased.

5.5.11 Effect of temperature

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-77 and after nine and a half months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. The seeds were then kept for

germination as usual at constant temperatures (low temp. 30°C and 40°C) which were maintained in the incubators and refrigerator. The results are presented in Table 5.10.

Results and Discussion - Germination was negligible at 40°C, so this temperature may be probably harmful for the embryo. At 30°C the germination percentage was 56.00%, but at low temperature it further came down to 43.33%.

Shankar (1968) working with seeds of Trichodesma amplexicaule obtained equally high germination percentage at 13±2°, 20°, 30° and 40°C after mechanical or chemical scarification of the seeds. Bechu Lal (1976) reported that the seeds of Scoparia dulcis germinate in a wide range of temperatures from 0° to 45°C, but the best results were obtained at 25°C. Sen and Bhawan (1969) observed that germination becomes slow beyond 30°C in Asteracantha longifolia.

5.5.12 Effect of light on germination

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-77 and after 11 months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pre-treatment for 30 min in order to make the seed coat permeable. The seeds were then kept for germination as usual under three different light conditions as follows :-

(i) Alternate diffuse light (during day) and darkness (during night) as obtained under laboratory conditions,

Table 5.10 : Effect of temperature on germination of seeds of A. ramosum.

Sr. No.	Treatment	No. of seeds germinated/50	% Germination	Germination speed
1.	Constant low temp.in fridge	21.67 (0.58)	43.33	4
2.	Constant 30°C	28.00 (1.00)	56.00	3
3.	Constant 40°C	0.67 (0.58)	1.33	6

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.

(ii) continuous light obtained from a fluorescent tube kept at the height of 1 m from the seed level,

(iii) continuous darkness in a light-proof wooden box.

Daily observations for recording the number of germinated seeds from those kept in continucus darkness were made under safe dim green light in a dark room. The maximum and minimum temperatures ranged from 31.9 to 39.2°C and 18.4 to 25.9°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.11 and graph 10 (i).

Results and Discussion - The germination percentage was apparently higher in alternate diffuse light and darkness than ~~then~~ that in continuous light or continuous darkness. However, the statistical analysis revealed that the effect of different light conditions was not significant at 5% level. Thus the seeds of A. ramosum are photoblastically neutral as far as germination is concerned.

Pachpor (1977) reported that the seeds of Cassia auriculata are photoblastically neutral. Shankar (1968) reported that mechanically or chemically scarified seeds of Trichodesma amplexicaule give equally high germination percentage under different light conditions.

5.5.13 Effect of colour (wavelength) of light

Experimental Procedure - Seeds of A. ramosum collected

Table 5.11 : Effect of light on germination of seeds of A. ramosum.

Sr. No.	Light condition	No. of seeds germinated/50	% Germination
1.	Alternate diffuse light and darkness	40.67 (1.53)	81.33
2.	Continuous light	38.00 (2.00)	76.00
3.	Continuous darkness	37.67 (1.53)	75.33

Note : (1) Values are based on three observations.

(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	16.23	2	8.12	2.81 NS
Within treatments	17.33	6	2.89	
Total	33.56	8		

Table value of F = 5.14 at 5% level

=10.92 at 1% level

on Dt. 24-10-77 and after 11 months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pre-treatment for 30 min in order to make the seed coat permeable. The seeds were then kept for germination as usual under different colours (wavelengths) of light, which were provided by wrapping the Petri dishes with cellophane papers of different colours, viz., white, red, yellow, green, blue and far-red (obtained by two layers of red and two layers of blue cellophane papers). One set of Petri dishes was kept without cellophane paper as control. Daily observations for recording the number of germinated seeds were made under safe dim green light in a dark room. The maximum and minimum temperatures ranged from 32.5 to 38.2°C and 23.4 to 25.9°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.12 and graph 10 (ii).

Results and Discussion - Red, yellow, blue and green colours gave almost equal germination percentage, while white and far-red colours gave a little less germination percentage. Light of all colours was effective in giving highly good results, as in none of them the germination percentage was less than 90%. Strangely, however, the germination percentage was comparatively less (86.00%) in control set (without cellophane paper) than all of those with coloured or white cellophane paper.

The statistical analysis reveals that overall effect of

Table 5.12 : Effect of colour of light on germination of seeds of *A. ramosum*.

Sr. No.	Colour of light	Number of seeds germinated/50	% Germination
1.	Control (without cellophane paper)	43.00 (1.00)	86.00
2.	White	45.33 (0.58)	90.67
3.	Red	47.67 (1.53)	95.33
4.	Yellow	47.33 (0.58)	94.67
5.	Blue	47.33 (0.58)	94.67
6.	Green	48.67 (1.53)	97.33
7.	Far-Red	45.67 (1.53)	91.33

L S D = 1.99 at 5% level
= 2.76 at 1% level.

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of Variation	S S	df	M S S	F
Between treatments	2808.00	6	468.00	362.79 **
Within treatments	18.00	14	1.29	
Total	2826.00	20		

Table value of F = 2.85 at 5% level
= 4.46 at 1% level

different colours of light is significant at 1% level. However, there is no significant difference among the effects of red, yellow, blue and green light. The effect of white and far-red light differs significantly from that of all other colours.

Singhal (1967) working with Phyllanthus urinaria seeds obtained highest germination in yellow and green light, while in red and blue light the germination percentage considerably decreased and in far-red light it was zero. Kaul (1974) working with Hemigraphis dura seeds obtained maximum (100%) germination percentage in yellow light, 96% in white light and 74% in red light, while in far-red light it was as low as 6%. As reported by Chawan and Sen (1973a), among Sida spp. red and blue lights produced inhibitory effects on S. grewioides; whereas almost no spectral sensitivity was found in S. spinosa. Kaul (1972) reported that germination of Alternanthera sessilis seeds was better (ranging from 75 to 78%) in red, orange and blue light than that in white light (66%); in green it was very poor(1%), while in far-red it was zero.

5.5.14 Effect of Inorganic salts

Experimental Procedure - Experiment - I : Seeds of A. ramosum collected on Dt. 24-10-78 and after three and a half months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order

to make the seed coat permeable. Using 'Analar' grades of chlorides and nitrates of Calcium, Potassium and Sodium 0.5, 1.0, 1.5 and 2.0 per cent solutions of the salts were prepared in double glass distilled water. The seeds after the aforesaid acid pretreatment were kept for germination as usual in Petri dishes on a single filter paper which was kept moist with the respective salt solution. One set with double glass distilled water used in place of salt solution was also kept which served as control. The maximum and minimum temperatures ranged from 28.3 to 37.4°C and 11.1 to 21.2°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.13 and graph 11.

Experiment - II : Seeds of A. ramosum collected on Dt. 19-10-78 and after fourteen and a half months of dry storage were used in this experiment. The procedure of this experiment was same as that of Experiment - I, but lower concentrations, viz. 0.1, 0.2, 0.3 and 0.5 per cent, of the same salt solutions were used. The maximum and minimum temperatures ranged from 28.2 to 33.2°C and 10.6 to 14.6°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.14 and graph 12.

Results and Discussion - Experiment - I : A glance at the table clearly shows that maximum germination percentage (76.00%) was obtained in the control set. In all of the salt

Table 5.13 : Effect of inorganic salts on germination of seeds of A. ramosum - I.

Sr. No.	Treatment		No. of seeds germinated/50	% Germination
1.	Dist. water (Control)		38.00 (2.65)	76.00
2.	$CaCl_2$	0.5%	35.00 (2.65)	70.00
3.	"	1.0%	22.33 (1.15)	44.67
4.	"	1.5%	8.33 (2.52)	16.67
5.	"	2.0%	0.33 (0.58)	0.67
6.	$Ca(NO_3)_2$	0.5%	34.33 (2.52)	68.67
7.	"	1.0%	21.67 (2.89)	43.33
8.	"	1.5%	4.00 (2.00)	8.00
9.	"	2.0%	1.33 (0.58)	2.67
10.	KCl	0.5%	34.33 (1.53)	68.67
11.	"	1.0%	12.67 (0.58)	25.33
12.	"	1.5%	0.00 (-)	0.00
13.	"	2.0%	0.00 (-)	0.00
14.	KNO_3	0.5%	35.00 (2.65)	70.00
15.	"	1.0%	13.00 (2.65)	26.00
16.	"	1.5%	0.33 (0.58)	0.67

Table 5.13 : Contd.

Sr. No.	Treatment		No. of seeds germinated/50	% Germination
17.	KNO_3	2.0%	0.00 (-)	0.00
18.	NaCl	0.5%	17.33 (2.52)	34.67
19.	"	1.0%	0.67 (0.58)	1.33
20.	"	1.5%	0.00 (-)	0.00
21.	"	2.0%	0.00 (-)	0.00
22.	$NaNO_3$	0.5%	31.00 (2.65)	62.00
23.	"	1.0%	2.67 (0.58)	5.33
24.	"	1.5%	0.00 (-)	0.00
25.	"	2.0%	0.00 (-)	0.00

L S D = 2.78 at 5% level; L S D = 3.71 at 1% level.

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of Variation	S S	df	M S S	F
Between treatments	15010.75	24	625.45	217.17**
Within treatments	144.00	50	2.88	
Total	15154.75	74		

Table value of F = 1.74 at 5% level
= 2.18 at 1% level

Table 5.14 : Effect of inorganic salts on germination of seeds of A. ramosum - II.

Sr. No.	Treatment		No. of seeds germinated/50	% Germination
1.	Dist. water (Control)		29.67 (1.53)	59.33
2.	$CaCl_2$	0.1%	21.33 (0.58)	42.67
3.	"	0.2%	21.00 (2.65)	42.00
4.	"	0.3%	20.67 (2.52)	41.33
5.	"	0.5%	14.33 (1.15)	28.67
6.	$Ca(NO_3)_2$	0.1%	29.00 (1.00)	58.00
7.	"	0.2%	32.33 (2.08)	64.67
8.	"	0.3%	28.67 (2.52)	57.33
9.	"	0.5%	28.33 (0.58)	56.67
10.	KCl	0.1%	26.67 (2.52)	53.33
11.	"	0.2%	22.33 (2.08)	44.67
12.	"	0.3%	21.33 (3.06)	42.67
13.	"	0.5%	21.67 (0.58)	43.33
14.	KNO_3	0.1%	24.00 (2.00)	48.00
15.	"	0.2%	23.67 (3.79)	47.33
16.	"	0.3%	23.33 (3.51)	46.67
17.	"	0.5%	22.67 (0.58)	45.33

Table 5.14 : contd.

Sr. No.	Treatment		No. cf seeds germinated/50	% Germination
18.	NaCl	0.1%	21.67 (1.53)	43.33
19.	"	0.2%	22.00 (1.73)	44.00
20.	"	0.3%	21.67 (2.52)	43.33
21.	"	0.5%	19.67 (2.52)	39.33
22.	$NaNO_3$	0.1%	23.67 (2.52)	47.33
23.	"	0.2%	23.33 (1.15)	46.67
24.	"	0.3%	22.67 (2.52)	45.33
25.	"	0.5%	22.33 (1.15)	44.67

L S D = 3.50 at 5% level; L S D = 4.67 at 1% level.

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	1036.72	24	43.20	9.47 * *
Within treatments	228.00	50	4.56	
Total	1264.72	74		

Table value of F = 1.74 at 5% level
= 2.18 at 1% level

solutions, the germination percentage sharply decreased with the increase in the concentration of the salt solution. Some concentrations, viz., $CaCl_2$ - 2.0%; $Ca(NO_3)_2$ - 2.0%; KCl - 1.5 and 2.0%; KNO_3 - 1.5 and 2.0%; NaCl - 1.0, 1.5 and 2.0% and $NaNO_3$ - 1.5 and 2.0% proved to be highly toxic and inhibited germination totally or almost totally. The seeds could fairly withstand 0.5% concentration of all the salts (the germination percentage ranging from 62.00 to 70.00 %), except that of NaCl, where germination percentage decreased upto 34.67%.

The statistical analysis reveals that the overall effect of the various concentrations of the inorganic salts used is significant at 1% level. There is significant difference between the effects of the control set and any of the concentrations of all the salts. 0.5% concentrations of $CaCl_2$, $Ca(NO_3)_2$, KCl and KNO_3 give almost equal germination (34.33 to 35.00%), while that of $NaNO_3$ gives 31.00% and of NaCl gives only 17.33% germination .

Experiment - II : The germination percentage in the control set was comparatively higher than that in any of the concentrations of all the salts except 0.2% $Ca(NO_3)_2$, which gave the maximum germination. However, the differences among the effects of control set and all concentrations of $Ca(NO_3)_2$ and also 0.1% of KCl are not significant, but the effects of all of them significantly differ from those of the remaining treatments.

The effect of inorganic salts on germination of seeds of different plants has been studied by many workers. Srivastava (1963) working with Malvastrum tricuspidatum seeds found that KNO_3 (at 0.02 to 0.5% conc.) and NH_4NO_3 (at 0.1% conc.) did not show any marked effect on percentage germination. Datta (1965) working with seeds of Launaea glomerata and Launaea mucronata found that KNO_3 at 0.125% conc. gave considerably higher percentage germination in L. glomerata, and only slightly higher in L. mucronata as compared to control. However, with the increase in concentration of the salt, the percentage germination decreased sharply in L. glomerata, and gradually in L. mucronata.

Jayachandra (1967) studied the effect of chlorides and nitrates of sodium, potassium and calcium on germination of seeds of three weeds, viz., Acanthospermum australe, Croton bonplandianum and Stachytarpheta urticifolia. He found that the chlorides of sodium, potassium and calcium (at 0.5 to 2.0% conc.) inhibited germination in all the three weeds, and that the inhibition increased with the increase in the concentration of chlorides. The nitrates of sodium, potassium and calcium (at 0.5 to 2.0% conc.) inhibited germination in A. australe. In C. bonplandianum $Ca(NO_3)_2$ (at 0.5 to 2.0% conc.) promoted germination, but the promoting effect was reduced progressively with the increase in the concentration. KNO_3 and $NaNO_3$ were distinctly inhibitory from 1.5% concentration onwards. In S. urticaefolia all the three nitrates

had slight promoting effect at 0.5% level, but 1.0% onwards, there was progressive inhibition.

Pandya (1971) working with Celosia argentea seeds found that NaCl at 20 and 50 ppm concentration enhanced percentage germination but at higher concentration (100 ppm and above) it had inhibitory effect. KNO_3 at lower concentrations (20 and 50 ppm) showed inhibitory effect, while at higher concentrations (100 and 200 ppm) had no significant effect. Kaul (1972) working with Alternanthera sessilis seeds found that NH_4NO_3, KNO_3 and $Ca(NO_3)_2$ at concentrations ranging from 0.02 to 0.5% gave considerably better results as compared to control. Dagar et al. (1977) working with Parthenium hysterophorus seeds reported that NaCl and KNO_3 at concentrations ranging from 10 to 200 ppm gave better results as compared to control. Pachpor (1977) studied the effect of pretreatment of seeds of Cassia auriculata with different concentrations of several inorganic salts for varying durations. He found that pretreatment with NH_4NO_3 at 5000, 10000 and 20000 ppm concentrations for 6, 12, 24 and even 48 h gave significantly superior results as compared to control. Pretreatment with KNO_3 at various concentrations and durations gave significantly inferior results as compared to control. Pretreatment with $Ca(NO_3)_2$ at 5000 and 10000 ppm concentration for 6 h and 5000 ppm for 12 and 24 h durations significantly enhanced both the speed and percentage germination.

5.5.15 Effect of nitrates on germination in darkness

Experimental Procedure - Seeds of A. ramosum collected on Dt. 19-10-78 and after fifteen months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. Using 'Analar' grades of nitrates of Calcium, Potassium, Sodium and Ammonium 0.1, 0.2, 0.3 and 0.5 per cent solutions were prepared in double glass distilled water. The seeds after the aforesaid acid pretreatment were kept for germination as usual in Petri dishes on a single filter paper which was kept moist with the respective salt solution. One set with double glass distilled water used in place of salt solution was also kept which served as control. The experiment was conducted in total darkness condition, which was provided by keeping the Petri dishes all the time in a tightly closed light-proof cupboard with moderate aeration in a dark room. Daily observations were made under safe dim green light in dark room. The maximum and minimum temperatures ranged from 25.9 to 33.3°C and 10.0 to 14.8°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.15 and graph 13.

Results and Discussion - The data reveal that germination percentage in all concentrations of $Ca(NO_3)_2$ was slightly less than that in control. Certain concentrations of the remaining three nitrates, viz. 0.2, 0.3 and 0.5% KNO_3; 0.1 and 0.2%

Table 5.15 : Effect of nitrates on germination of seeds of A. ramosum in darkness.

Sr. No.	Treatment		No. of seeds germinated/50	% Germination
1.	Dist. water (Control)		30.33 (2.08)	60.67
2.	$Ca(NO_3)_2$	0.1%	28.33 (1.15)	56.67
3.	"	0.2%	29.67 (1.53)	59.33
4.	"	0.3%	29.33 (1.53)	58.67
5.	"	0.5%	29.67 (2.52)	59.33
6.	KNO_3	0.1%	28.67 (2.52)	57.33
7.	"	0.2%	32.33 (2.52)	64.67
8.	"	0.3%	32.67 (2.52)	65.33
9.	"	0.5%	33.67 (2.52)	67.33
10.	$NaNO_3$	0.1%	31.67 (0.58)	63.33
11.	"	0.2%	31.33 (0.58)	62.67
12.	"	0.3%	27.67 (0.58)	55.33

Table 5.15 : Contd.

Sr. No.	Treatment		No. of seeds germinated/50	% Germination
13.	$NaNO_3$	0.5%	25.67 (2.52)	51.33
14.	$(NH_4)NO_3$	0.1%	28.00 (2.00)	56.00
15.	"	0.2%	31.67 (2.52)	63.33
16.	"	0.3%	29.67 (2.52)	59.33
17.	"	0.5%	27.33 (1.15)	54.67

L S D = 3.25 at 5% level; L S D = 4.37 at 1% level.

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	221.37	16	13.84	3.49 * *
Within treatments	134.67	34	3.96	
Total	356.04	50		

Table value of F = 1.95 at 5% level
= 2.58 at 1% level

$NaNO_3$; and 0.2% NH_4NO_3 gave slightly better germination percentage than control.

The statistical analysis reveals that the overall effect of the treatments given is significant at 1% level. However, LSD value (5% level) makes it clear that only 0.5% KNO_3 gave significantly higher germination, and only 0.5% $NaNO_3$ gave significantly lower germination than control.

Kaul (1974) working with Henigraphis dura seeds found that NH_4NO_3 was much effective in promoting germination of seeds in dark, maximum germination occurring at 0.1% concentration.

5.5.16 Effect of Thiourea

Experimental Procedure - Seeds of A. ramosum collected on Dt. 19-10-78 and after 16 months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. The treated seeds were then kept for germination as usual in Petri dishes on a single filter paper which was kept moist with thiourea solution. Five different concentrations, viz. 50, 100, 200, 500 and 1000 ppm of thiourea solution were used in the experiment. One set in which double glass distilled water was used in place of thiourea solution served as control. The maximum and minimum temperatures ranged from 29.6 to 39.3°C and 11.6 to 20.6°C respectively during the

course of the experiment. The experimental data were analysed statistically and are presented in Table 5.16 and graph 14.

Results and Discussion - The data reveal that all the concentrations of thiourea solution used gave better germination percentage than control. Maximum germination percentage was obtained in 500 ppm thiourea solution. With the increase in concentration of thiourea solution from 50 upto 500 ppm, there was a gradual increase in percentage germination, however, at 1000 ppm concentration, a decrease in germination percentage was observed.

The statistical analysis reveals that per cent germination in only 500 ppm thiourea solution is significantly higher (at 1% level) than that in control as well as in all other concentrations.

Agarwal (1971) working with Verbena bipinnatifida seeds reported increase in germination percentage with increase in duration of treatment and concentrations of thiourea. Kaul (1974) working with Hemigraphis dura seeds reported increase in germination percentage in darkness with increase in concentration of thiourea solution. Pachpor (1977) reported that pretreatment of Cassia auriculata seeds with 20000 ppm thicurea solution for 6 to 48 h gave significantly higher germination percentage.

Table 5.16 : Effect of thiourea on germination of seeds of A. ramosum.

Sr. No.	Treatment	No. of seeds germinated/50	% Germination	Germination speed
1.	Dist. water (Control)	31.00 (2.00)	62.00	1
2.	Thiourea 50 ppm	32.67 (1.53)	65.33	1
3.	" 100 "	33.33 (1.53)	66.67	1
4.	" 200 "	33.33 (2.08)	66.67	1
5.	" 500 "	39.67 (2.52)	79.33	1
6.	" 1000 "	34.00 (1.00)	68.00	1

L S D = 3.28 at 5% level
= 4.59 at 1% level

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	131.33	5	26.27	7.75**
Within treatments	40.67	12	3.39	
Total	172.00	17		

Table value of F = 3.11 at 5% level
= 5.06 at 1% level

5.5.17 Effect of GA_3

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-78 and after 15 and a half months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. The treated seeds were then kept for germination as usual in Petri dishes on a single filter paper which was kept moist with GA_3 solution. Nine different concentrations viz. 50, 100, 200, 500, 1000, 1500, 2000, 2500 and 3000 ppm of GA_3 solution were used in the experiment. One set in which double glass distilled water was used in place of GA_3 solution served as control. The maximum and minimum temperatures ranged from 30.9 to 39.0°C and 11.9 to 19.2°C respectively during the course of the experiment. The experimental data were analysed statistically and are presented in Table 5.17 and graph 15.

Results and Discussion - The data show that control gave better results than all concentrations of GA_3 solution used in the experiment. The germination percentage was minimum in 3000 ppm concentration of GA_3 solution.

The statistical analysis reveals that the difference between the effects of control (distilled water) and any of the concentrations from 50 to 2500 ppm of GA_3 solution is only apparent and not statistically significant. The percentage germination obtained in only 300C ppm concentration of GA_3

Table 5.17 : Effect of GA_3 on germination of seeds of A. ramosum.

Sr. No.	Treatment	No. of seeds germinated/50	% Germination	Germination speed
1.	Dist. water (Control)	38.33 (0.58)	76.67	1
2.	GA_3 50 ppm	36.33 (0.58)	72.67	1
3.	" 100 "	37.67 (2.52)	75.33	1
4.	" 200 "	35.67 (0.58)	71.33	1
5.	" 500 "	36.67 (1.53)	73.33	1
6.	" 1000 "	36.33 (3.06)	72.67	1
7.	" 1500 "	37.33 (1.15)	74.67	1
8.	" 2000 "	36.00 (2.00)	72.00	2
9.	" 2500 "	35.67 (1.53)	71.33	2
10.	" 3000 "	31.33 (1.15)	62.67	2

L S D = 2.85 at 5% level
= 3.89 at 1% level

Note : (1) Values based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	97.47	9	10.83	3.87 * *
Within treatments	56.00	20	2.80	
Total	153.47	29		

Table value of F = 2.40 at 5% level
= 3.45 at 1% level

solution is significantly lower at 1% level than that obtained in any other concentration as well as control. Thus it can be stated that GA_3 at concentrations ranging from 50 to 2500 ppm has no effect either stimulatory or inhibitory on germination, and that at concentrations higher than 2500 ppm has inhibitory effect on germination of A. ramosum seeds.

Lona (1956) found that gibberellin stimulates germination of Lactuca scariola seeds. Kallic and Piironen (1959) studied the effect of gibberellin on germination of 50 species and found that the germination was enhanced by gibberellin only in eight species, viz. Luzula parviflora, Trollius europaeus, Erysimum hieraciifolium, Draba hirta, Geranium silvaticum, Diapensia lapponica, Gentiana nivalis, and Bartsia alpina. Biswas (1967) working with Rauvolfia tetraphylla seeds found that GA_3 upto 250 ppm concentration promoted germination, but at concentrations beyond 250 ppm it had inhibitory effect. Pandya (1971) working with Celosia argentea seeds reported that GA at 200 ppm concentration showed inhibitory effect, while lower concentrations had no significant effect. Kaul (1974) working with Hemigraphis dura seeds observed that GA was very effective in promoting germination in dark. Dagar et al. (1977) using GA_3 at 10 to 200 ppm concentrations obtained higher percentage germination as compared to control in Parthenium hysterophorus. Pachpor (1977) found that GA_3 had no effect on the ultimate percentage germination of Cassia auriculata seeds, however, it reduced the dormancy period from 90 days to 7 only.

5.5.18 Effect of kinetin

Experimental Procedure - Seeds of A. ramosum collected on Dt. 24-10-78 and after 15 months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pre-treatment for 30 min in order to make the seed coat permeable. The treated seeds were then kept for germination as usual in Petri dishes on a single filter paper which was kept moist with kinetin solution. Nine different concentrations viz. 1, 5, 10, 20, 50, 100, 200, 300 and 500 ppm of kinetin solution were used in the experiment. One set in which double glass distilled water was used in place of kinetin solution served as control. The maximum and minimum temperatures ranged from 28.1 to 38.3°C and 9.0 to19.2°C respectively during the course of the experiment. The experimental data were statistically analysed and are presented in Table 5.18 and graph 16.

Results and Discussion - The data reveal that only 10 ppm concentration of kinetin had significantly favourable effect on germination. 1,5, 20 and 50 ppm concentrations apparently showed favourable effects as compared to control, but the differences are not significant.The concentrations of kinetin beyond 50 ppm showed increasingly inhibitory effects so much so that germination percentage was negligible at 500 ppm concentration.

The statistical analysis reveals that the overall effect

Table 5.18 : Effect of kinetin on germination of seeds of A. ramosum.

Sr. No.	Treatment	No. of seeds germinated/50	% Germination	Germination speed
1.	Dist. water (Control)	44.67 (1.53)	89.33	2
2.	Kinetin 1 ppm	45.67 (0.58)	91.33	2
3.	" 5 "	46.67 (0.58)	93.33	2
4.	" 10 "	48.67 (0.58)	97.33	2
5.	" 20 "	45.67 (2.52)	91.33	2
6.	" 50 "	46.33 (0.58)	92.67	2
7.	" 100 "	40.33 (3.06)	80.67	2
8.	" 200 "	23.67 (0.58)	47.33	4
9.	" 300 "	11.67 (1.53)	23.33	4
10.	" 500 "	1.67 (0.58)	3.33	6

L S D = 2.54 at 5% level
= 3.47 at 1% level

Note : (1) Values are based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of Variance

Source of variation	S S	df	M S S	F
Between treatments	7746.83	9	860.76	385.99 **
Within treatments	44.67	20	2.23	
Total	7791.50	29		

Table value of F = 2.40 at 5% level
= 3.45 at 1% level

of varying concentration of kinetin is significant at 1% level. However, as it has been already pointed out only 10 ppm concentration gives significantly higher and concentrations beyond 50 ppm give significantly lower germination percentage.

Sankhla and Sankhla (1972) reported favourable effect of kinetin (at 1 and 10 ppm concentrations) on germination percentage of Lactuca sativa seeds. Pachpor (1977) observed that kinetin (1500 and 2000 ppm) very significantly enhanced the germination percentage in Cassia auriculata seeds.

5.5.19 Effect of 2,4-D

Experimental Procedure - Seeds of A. ramosum collected on Dt. 19-10-78 and after 16 months of dry storage were used in this experiment. The seeds were given con. H_2SO_4 pretreatment for 30 min in order to make the seed coat permeable. The treated seeds were then kept for germination as usual in Petri dishes on a single filter paper which was kept moist with 2,4-D solution. 11 different concentrations, viz. 0.5, 1, 5, 10, 20, 50, 100, 200, 500, 1000 and 2000 ppm of 2,4-D solution were used in the experiment. One set in which double glass distilled water was used in place of 2,4-D solution served as control. The maximum and minimum temperatures ranged from 29.6 to 39.3°C and 11.6 to 20.6°C respectively during the course of the experiment. The experimental

data were statistically analysed and are presented in Table 5.19 and graph 17.

Results and Discussion - A glance at the table makes it clear that 2,4-D at lower concentrations, ranging from 0.5 to 20 ppm, gave slightly better results as compared to control. The concentrations ranging from 50 to 1000 ppm of 2,4-D gave percentage germination almost equal to that obtained in control. However, percentage germination decreased considerably at 2000 ppm concentration of 2,4-D.

The statistical analysis reveals that overall effect of varying concentrations of 2,4-D is significant at 1% level. However, only 0.5 and 5 ppm concentrations of 2,4-D gave significantly higher percentage germination than control. There is no significant difference between the effects of control and any of the concentrations ranging from 10 to 1000 ppm of 2,4-D. Highly significant decrease in percentage germination was observed at 2000 ppm concentration of 2,4-D.

Jaychandra (1967) studied the effect of 2,4-D on germination in three weeds, viz. Acanthospermum australe, Croton bonplandianum and Stachytarpheta urticaefolia. He found that 2,4-D at concentration from 100 mg/l onwards inhibited the germination of A. australe seeds. All the concentrations ranging from 1 to 200 mg/l of 2,4-D inhibited the germination in C. bonplandianum and S. urticaefolia. Chawan and Sen (1970) observed that with the increase in concentration of 2,4-D

Table 5.19 : Effect of 2,4-D on germination of seeds of A. ramosum.

Sr. No.	Treatment	No. of seeds germinated/50	% Germination	Germination speed
1.	Dist. water (Control)	31.00 (2.00)	62.00	1
2.	2,4-D 0.5 ppm	34.33 (1.53)	68.67	2
3.	" 1 ppm	33.67 (1.53)	67.33	2
4.	" 5 "	34.67 (1.53)	69.33	2
5.	" 10 "	33.33 (1.15)	66.67	2
6.	" 20 "	33.33 (0.58)	66.67	2
7.	" 50 "	31.37 (0.58)	63.33	2
8.	" 100 "	30.67 (2.52)	61.33	2
9.	" 200 "	31.67 (2.08)	63.33	2
10.	" 500 "	30.67 (2.52)	61.33	2
11.	" 1000 "	31.33 (2.52)	62.67	2
12.	" 2000 "	20.00 (3.00)	40.00	2

L S D = 3.28 at 5% level
= 4.45 at 1% level

Note : (1) Values based on three observations.
(2) Figures in parentheses are standard deviations.

Analysis of variance

Source of variation	S S	df	M S S	F
Between treatments	489.64	11	44.51	11.78 **
Within treatments	90.67	24	3.78	
Total	580.31	35		

Table value of F = 2.22 at 5% level
= 3.09 at 1% level

from 1 to 100 ppm the germination was retarded in case of Asteracantha longifolia, and that the total percentage germination also decreased with the increase in concentration from 10 upto 100 ppm. Mayer and Poljakoff-Mayber (1975) have compiled the data of various authors, and accordingly 2,4-D has been reported to inhibit germination at comparatively low concentrations in cress, radish, mustard, carrot, beet-root, Taraxacum, cabbage, onion, lettuce and wheat. Dubey and Mall (1975) working with Digera alternifolia seeds reported decrease in percentage germination with increase in concentration of 2,4-D (from 100 upto 2000 ppm). Dagar et al. (1977) working with Parthenium hysterophorus seeds found that 2,4-D at 10 ppm concentration showed stimulatory effect, but concentrations beyond that had inhibitory effect so much so that at 200 ppm concentration germination was zero. Pachpor (1977) working with Cassia auriculata seeds observed that pretreatment of the seeds with certain concentrations of 2,4-D especially 500 and 1000 ppm for 6, 12 and 24 h durations significantly accelerated the germination speed.

5.6. Reproductive capacity

Salisbury (1942a) has studied the reproductive capacity of a large number of species. As defined by him, reproductive capacity of a plant is the product of the average seed output and the fraction represented by the percentage germination. It indicates the intrinsic capacity of the species to increase

in time, provided the ecizing factors are favourable. It determines to a great deal the ecological success of a species. Reproductive capacity of a number of plants has been recently worked out, since the reproductive capacity of a species is, as much as characteristic, as any other specific feature and one, moreover, of greatest ecological significance.

Average seed output of A. ramosum as has been calculated under 5.3 of the present Chapter is 2315. The average of the different values of maximum percentage germination obtained in the different experiments in A. ramosum seeds works out to be 80.18% i.e. 80%. This value is taken as representing the average percentage germination for the present purpose. The reproductive capacity of A. ramosum as calculated by the following formula works out to be -

$$\text{Reproductive capacity} = \frac{\text{Av. seed output X av. \% germination}}{100}$$

$$= \frac{2315 \times 80}{100}$$

$$= 1852.$$

5.7. Seedling Morphology

Plate 9.

The germination of seeds of A. ramosum is epigeal. The

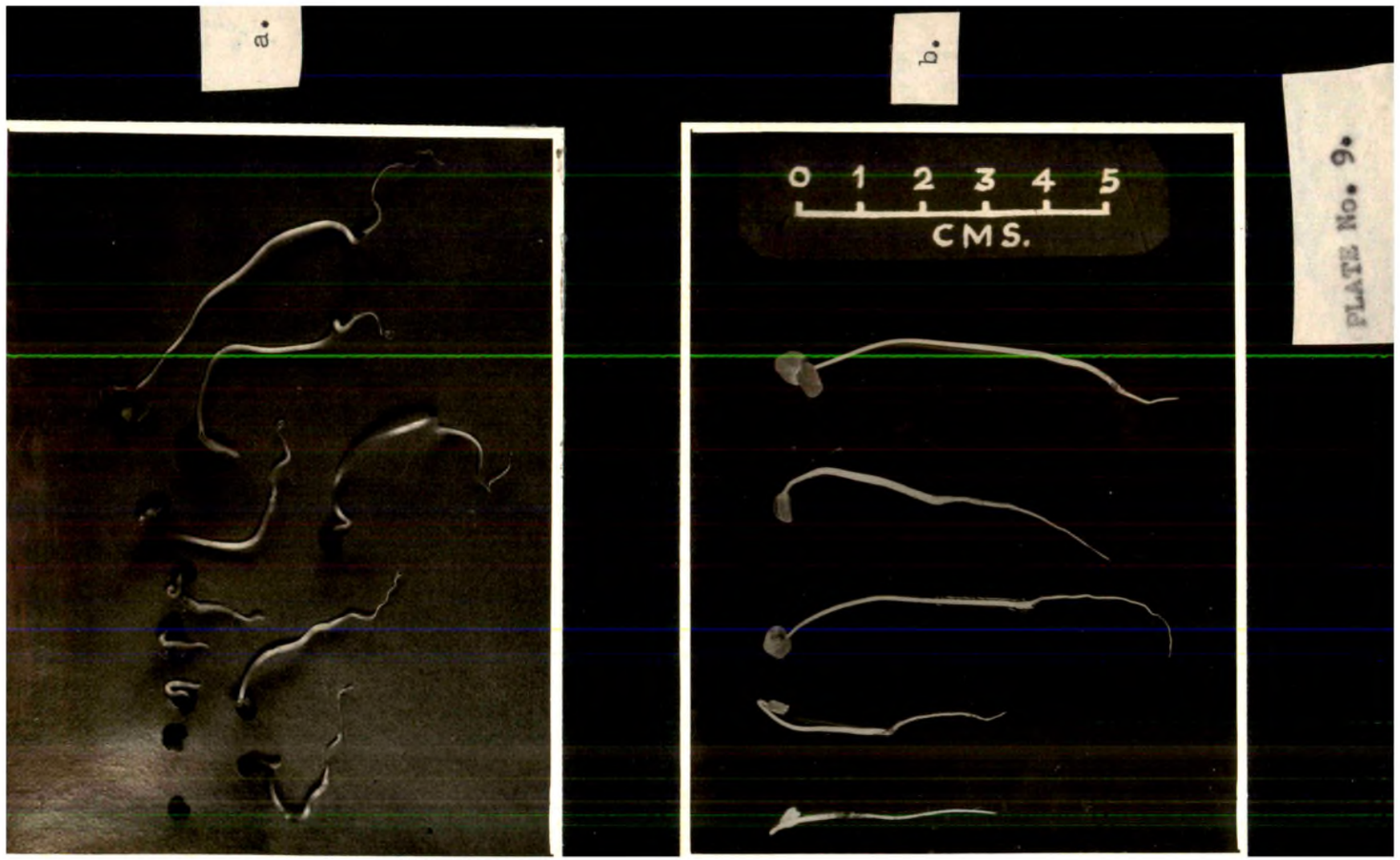

a.
b.
0 1 2 3 4 5
CMS.
PLATE No. 9.

PLATE No. 1

PLATE No. 11.

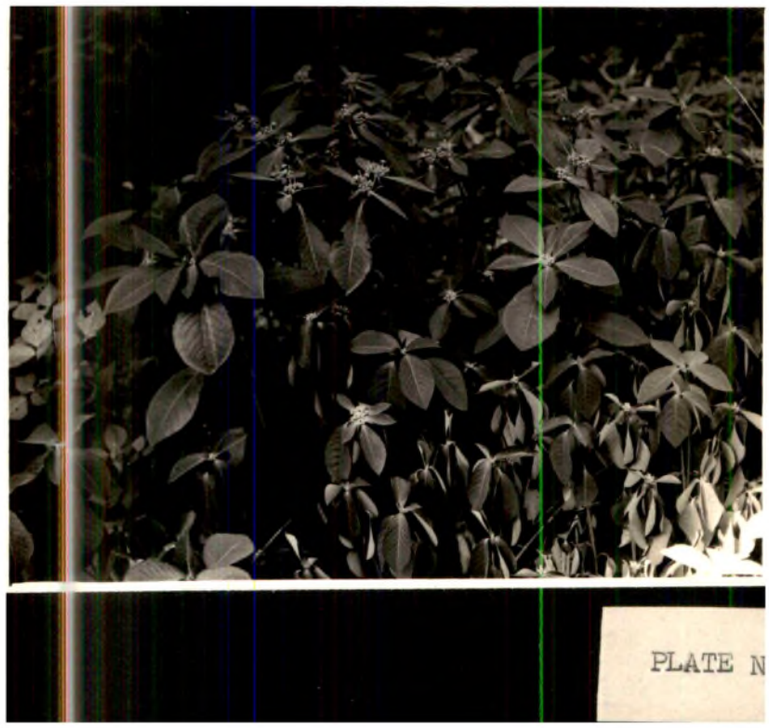


PLATE N

a.

b.

PLATE No. 13.

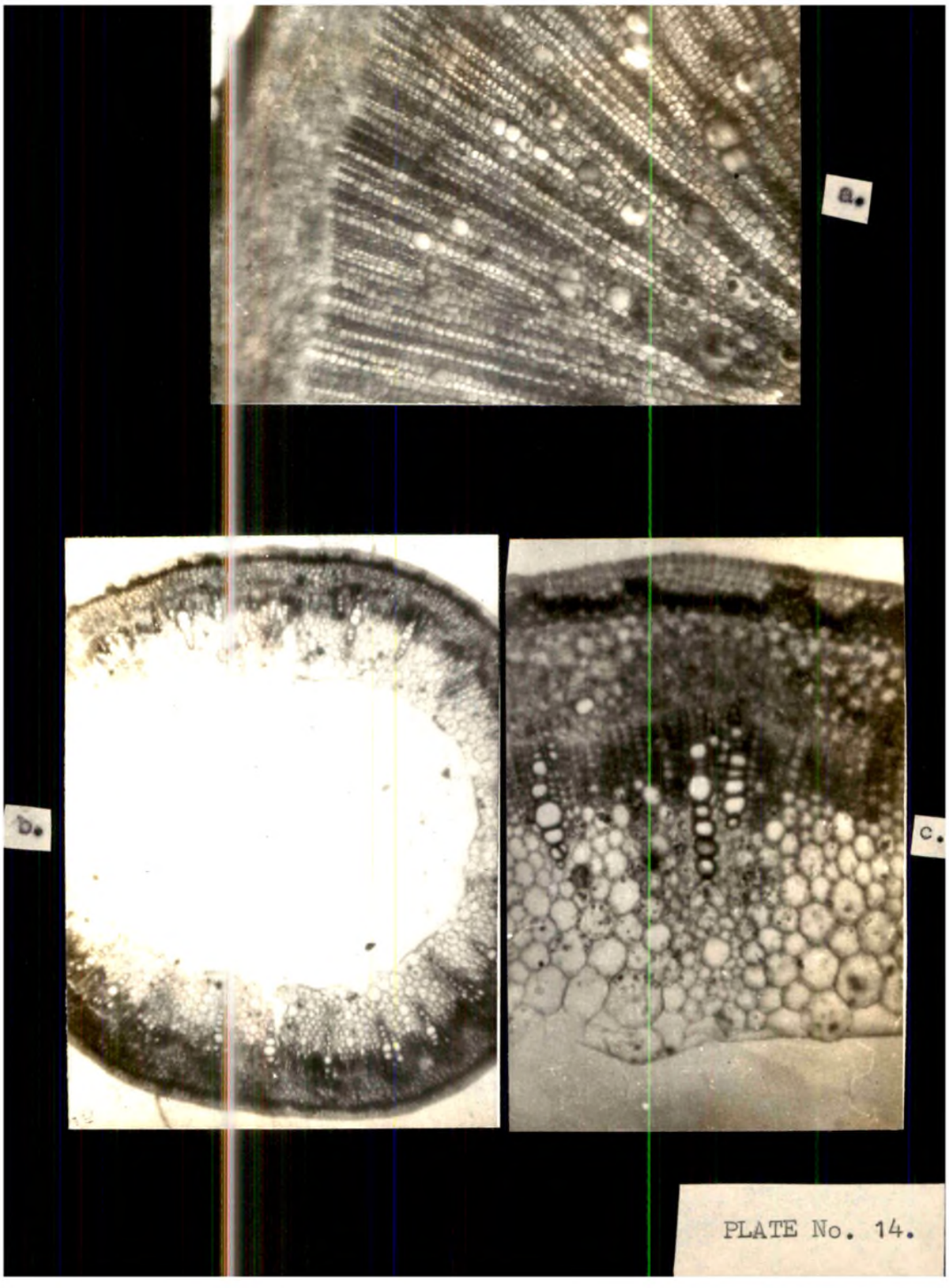


PLATE No. 14.

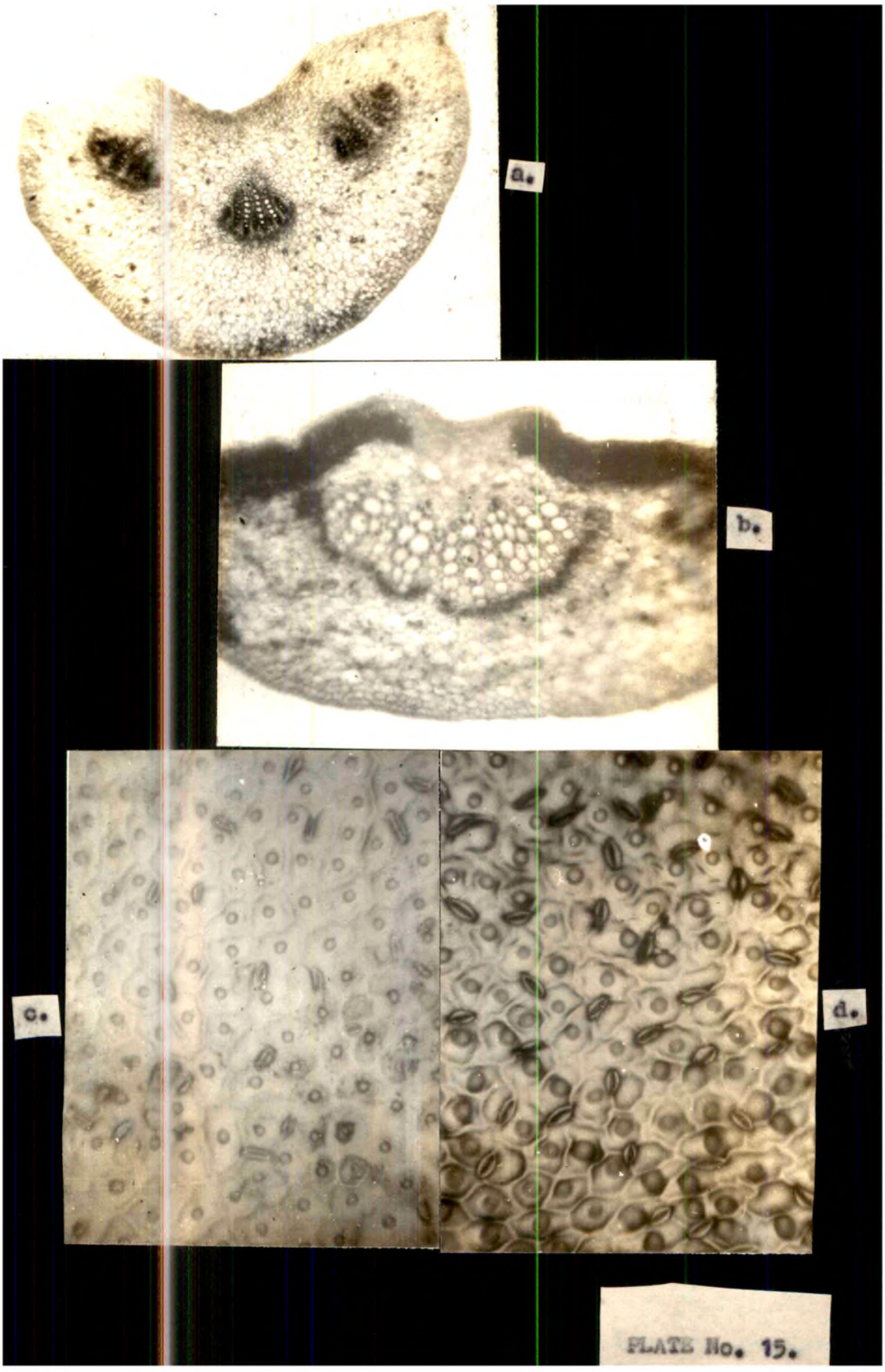


PLATE No. 15.

PLATE No. 17.

radicle emerges from the micropylar end of the seed, by a split in the testa. When the radicle is a few mm long, the hypocytyl elongates forming a hook and comea above the soil surface along with the cotyledons in the folded condition. The hypocotyl hook straightens and the cotyledons are raised. The cotyledons now unfold, turn green and become the first pair of leaves. These leaves differ from the true leaves in having lamina not lobed and with entire margin. The true leaves now gradually appear in succession and the embryonic leaves persist until few of the true leaves are well developed.

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