CHAPTER-6

SEED GERMINATION AND SEEDLING SURVIVABILITY OF *Streptocaulon sylvestre* WIGHT

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6.1 INTRODUCTION

Knowledge about plant community structure, dynamics and succession must include information about plant reproduction, dispersal and establishment in which seed characteristics are central (Vazquez - Yanes & Orozco - Segovia, 1996). Among various methods of plant reproduction the most common happens to be the germination of seeds.

Seed germination is one of the most important events in the life cycle which *inter alia* determines the chances of survival of a species. It is initiated and triggered off as a result of enzymatic action on stored food material of the seed. The biological clock of the seed is so delicately balanced against climatic complex that germination is initiated only when the conditions are congenial to radicle emergence and also to provide a boost to the processes of growth and reproduction to follow (Kumar & Sinha, 1992). Seed is thus a great sensor of the conditions providing optimum chances of radicle emergence. Langer (1979) described the germination process in terms of morphological and biochemical events.

Each species has its own characteristic set of germination requirements. The differences in the seed germination behaviour of different populations of the same species have been reported by some workers (Harper, 1965; Cavers & Harper, 1966; Mc Naughton, 1966) suggesting the plasticity in germinability of seeds while others (Lauer, 1953; Thompson, 1973; Semwal & Purohit, 1980) could not find sizeable differences between populations and concluded that germinability is basically a stable character of the species. Other workers (Thompson, 1969; Evans & Dunstone, 1970; Karssen, 1970; Juntilla, 1971; Kigel et al. 1977) have reported considerable influence of the environment on the germinability of the seeds.

Natural regeneration of different plant species depends on the production and germination capacity of the seeds. Survival and distribution of species are affected by not only germination behaviour (Went, 1948; Datta & Chakravarty, 1962) but also the amount of seed output and regeneration by vegetative parts, collectively called reproductive capacity (Sant, 1963). In angiosperms, the adaptive significance of seeds is associated with the reproductive effeciency and successful establishment of seedlings in nature (Stebbeins, 1971). Seed affects the plant stand by its extent of ability to germinate under field conditions as well as its potentiality to supply nutrients to growing seedlings. Thus establishment of a seedling is an important factor in plant regeneration and it is largely depends on the seed germination and seedling vigour which are greatly influenced by environmental conditions.

The environment has a profound effect on germination behaviour, which is brought about in two ways: (i) the environment prevailing during seed formation as well as (ii) the location of the seed on the parent plant, affect subsequent germination behaviour. Thus, germination process is controlled by a system of interacting reactions of the environmental factors that must be kept in a proper balance (Koller, 1972). A high correlation exists between the environmental conditions of a particular habitat and the successful germination in a particular seed (Sen, 1977).

The major environmental conditions necessary for germination are access to water, a suitable range of temperature, different concentrations of inorganic salts, oxygen, carbon dioxide and for some seeds exposure to light. Mayer and Shain (1974) suggested that environmental factors control germination by acting on specific sites of metabolic sequences. The chemical conditions which obtain in a seed's microenvironment can be a determining factor in promoting or inhibiting germination. The chemical environment of a seed may also be influenced by biotic factors such as the presence of specific microorganisms in the immediate vicinity (Lovett & Sagar, 1978; Van Leeuwen, 1981). The detailed microtopography of the soil is an important feature regulating germination. It seems that soil moisture is one of the major limiting factor for the seed germination. Low soil moisture delays germination, radicle emergence and reduces seedling growth (Turner and Kramer, 1980; Strabac *et al.* 1991). The growth regulators also control several processes in plants such as germination, the shoot and root elongation, cotyledonary expansion and flowering. The role of growth regulators on seed germination has been observed with great interest due to its characteristic occurrence in the seeds and related physiological metabolic effects during germination (Kahn *et al.*, 1957; Paleg, 1969).

Fenner (1985) noted that a seedling is considered to be fully established when it has become effectively independent of its seed reserves. Mayer and Poljakoff - Mayber (1975) mentioned that the germinating seed must first of all establish anchorage by the root in the soil and ensure commencement of water and solute absorption. Root growth ensuring water supply, seedling vigour in piercing the soil surface and the ability to begin photosynthesis are some of the factors which ensure the establishment, especially of the seedlings. The hazards faced during the process of seedling survivability comprise the last of the hurdles which the plant has to negotiate in the process of regeneration through seed. The major hazards are desiccation and burial of the seedling. In addition, biotic factor such as competition, predation and disease also play their role in seedling survivability.

Streptocaulon sylvestre Wight is a little known prostrate endangered and endemic herb of Asclepiadaceae. It is now growing in two very small herbaceous grass dominated vegetation in the foot hill region of the Darjeeling Himalaya in Eastern India. The speceis is now Critically Endangered and to be extinct on any day after any type of modification of its natural habitat within the campus of the North Bengal University. Realising this threat, it is now very much essential to find out the difficulties in its propagation and dispersal.

S. sylvestre flowers almost round the year and viable seeds are produced during the months of September to March. Plants produce few number of seeds which are dispersed by wind taking the help of their parachute like coma.

The speceis is not cultivated, and neither the germination of seeds nor the regeneration of the plant in its natural habitat has been studied by any other worker. To understand the mechanisms of natural regeneration of this speceis, investigations on seed germination and seedling survivability are pre-requisities.

The methodology used for this work has been described under the Chapter-2 (Materials and Methods).

6.2. RESULTS AND DISCUSSION

The investigations on seed germination and seedling survivability of *Streptocaulon sylvestre* Wight were carried out during the period of 1997 to 2000. The mode of germination was epigeal. During the study, fifteen aspects on seed character, seed germination and seedling behaviour were taken into consideration in which thirteen aspects were considered directly on germination behaviour. These are :

1. Fruit and seed characters.
2. Seed viability.
3. Effect of seed size on rate of germination.
4. Germination of seed under different temperature regimes.
5. Effect of light period on seed germination.
6. Seed germination at different position and orientation in soil.
7. Seed germination at different position and orientation in sand.
8. Effect of water logging in soil and sand on seed germination.
9. Seed germination at different pH levels.
10. Effect of Sodium Chloride on seed germination and seedling growth.

11. Effect of Gibberellic Acid on seed germination and seedling growth.
12. Effect of 6 - Benzyl amino purine on seed germination and seedling growth.
13. Effect of Indole acetic acid on seed germination and seedling growth.
14. Effect of 2,4-Dichlorophenoxy acetic acid on seed germination and seedling growth, and
15. Reproductive capacity and seedling survivability.

6.2.1. CHARACTERISTICS OF FRUIT AND SEED OF *Streptocaulon sylvestre* WIGHT

6.2.1.1 FRUIT CHARACTERS

Different parameters of fruit characters of *Streptocaulon sylvestre* Wight are shown in Table-6.1. A pair of follicles generally developed from a pair of free ovaries of its syncarpus pristil. But in many cases only one follicle developed and the other remain abortive (Plate-IV). Follicles were elongated, slightly curved, terete but slightly compressed with a longitudinal ventral furrow, almost glabrous to minutely villous.

Table 6.1 : Fruit characteristics of *Streptocaulon sylvestre* Wight

Parameters	Fruit Size		
	Large	Medium	Small
Fruit type	Follicle	Follicle	Follicle
Fruit size	Large	Medium	Small
Fruit shape	Nearly oblong, tapering from middle to tip, slightly narrowed towards the base	Oblong, tapering from middle to tip, slightly narrowed towards the base	Oblong to elliptic, tapering from middle to tip, narrowed towards the base
Length of fruit (cm)	7.78 ± 0.45	6.00 ± 0.11	3.58 ± 0.16
Circumference to middle area of fruit (cm)	3.12 ± 0.11	3.82 ± 0.07	2.84 ± 0.15
Fruits per fruit bearing plant	3.80 ± 0.37	4.60 ± 1.12	5.80 ± 1.74
Seeds per fruit	32.47 ± 2.35	41.73 ± 4.23	20.65 ± 1.47
Seeds per fruit bearing plant	123.40 ± 12.47	192.00 ± 57.13	119.80 ± 37.67
Size of produced seeds	Large	Large & Medium	Medium & small

The fruits were graded into three size classes: large, medium and small (Plate-IV). All the three types of fruits were generally produced in seperate plants. Average number of fruits per fruit producing plant was only 4.73 ± 0.68.

a) Large fruit : The large fruit was nearly oblong, tapering from middle to tip and slightly narrowed towards the base. The length and circumference of the fruits was 7.78 ± 0.45 and 3.12 ± 0.11 cm, respectively. The average number of large fruits per fruit bearing plant was 3.80 ± 0.37. Each large fruit produced an average of 32.47 ± 2.35 large type seeds and each large fruit bearing plant produced an average of 123.40 ± 12.47 seeds.

b) Medium Fruit : The shape of medium fruit was also oblong and tapering from middle to tip and slightly narrowed towards the base. Its length and circumference was 6.00 ± 0.11 and 3.82 ± 0.07 cm, respectively. Each fruit bearing plant produced an average of 4.60 ± 1.12 medium size fruits and each medium size fruit produced average 41.73 ± 4.23 large or medium size seeds. Besides an average of 192.00 ± 57.13 large or medium size seeds were produced by each medium fruit producing plant.

c) Small Fruit: The small fruit was oblong to elliptic and tapering from middle to tip and narrowed towards the base. The length and circumference of small fruit was 3.58 ± 0.16 and 2.84 ± 0.15 cm, respectively. The average number of small fruits per fruit producing plant was 5.80 ± 1.74. Each small fruit produced an average of 20.65 ± 1.47 small or medium size seeds and each small fruit bearing plant produced an average of 119.80 ± 37.67 seeds.

6.2.1.2. SEED CHARACTERS

Different parameters of morphological characters of seed of *Streptocaulon sylvestre* Wight are presented in Table-6.2. Like fruits, seeds of *S. sylvestre* were also of three types : large, medium and small sized. However, all of these three types were provided with a tuff of white and silky coma (Plate-IV).

a) Large Seed : The large seed was oblong to elliptic, inner side flat, outer slightly convex, lower end acute, brown to reddish brown. Its length and breadth were 9.08 ± 0.47 and 3.32 ± 0.26 mm, respectively. Its shape index was 2.807 ± 0.298 which indicated that the length was about thrice than the breadth. The size index of large seed was 30.22 ± 3.11 mm. The weight of 100 dry large seeds was 1.756 ± 0.070 g with hairy coma and 1.004 ± 0.043 g without coma.

b) Medium Seed : Medium seed was elliptical to slightly obovate, flat, one face slightly concave, other side distinctly convex, lower end acute, brown to reddish brown. Its length was 6.96 ± 0.16 mm and breadth was 3.30 ± 0.19 mm. Its size index and shape index were 22.96 ± 1.03 mm and 2.11 ± 0.15, respectively, which indicated that the length was twice than its breadth. The weight of 100 dry medium seeds with coma was 1.393 ± 0.020 g and without coma was 0.768 ± 0.037 g.

Table 6.2 : Seed characteristics of *Streptocaulon sylvestre* Wight

Parameters	Seed Size		
	Large	**Medium**	**Small**
Seed shape	Oblong to elliptic inner side flat, outer slightly convex	Elliptic to slightly ovate, flat	Oblong to ovate, ends rounded-obtuse, flat
Seed colour	Brown to reddish brown	Brown to reddish brown	Brown/creamish brown
Seed length (mm)	9.08 ± 0.47	6.96 ± 0.16	5.10 ± 0.40
Seed breadth (mm)	3.32 ± 0.26	3.30 ± 0.19	2.84 ± 0.10
Wt. of 100 dry seeds with hairs of coma (g)	1.756 ± 0.070	1.393 ± 0.020	1.079 ± 0.063
Wt. of 100 dry seeds without hairs of coma (g)	1.004 ± 0.043	0.768 ± 0.037	0.540 ± 0.035
Seed shape index (mm) (L/B)	2.807 ± 0.298	2.11 ± 0.15	1.79 ± 0.125
Seed size index (mm) (L×B)	30.22 ± 3.11	22.96 ± 1.03	14.56 ± 1.47
Length of hair of coma (mm)	30.00 ± 2.51	23.20 ± 2.47	21.20 ± 0.58
Wt. of hairs of coma of 100 seeds (g)	0.752 ± 0.045	0.625 ± 0.022	0.540 ± 0.054
Colour of hairs of coma	Shining white	Shining white	Shining white
Ratio of wt. of seed / wt. of hairs of coma	1.335	1.23	1.0
Ratio of length of seed / length of hair of coma	0.302	0.30	0.24

c) Small Seeds : Small seeds were oblong, ends rounded-obtuse, flat, one face slightly convex, brown to creamish brown. Its length and breadth were 5.10 ± 0.40 and 2.84 ± 0.10 mm, respectively. Its shape index was 1.79 ± 0.125 and size index was 14.56 ± 1.47 mm. The weight of 100 dry small seeds with coma was 1.079 ± 0.063 g and without coma was 0.540 ± 0.035 g.

It was also observed that the length of hairy coma of large, medium and small seeds were 30.00 ± 2.51, 23.20 ± 2.47 and 21.20 ± 0.58 mm, respctively. The weight of hairy coma of 100 dry large, medium and small seeds were 0.752 ± 0.045, 0.625 ± 0.022 and 0.54 ± 0.054 g, respectively.

In this investigation it was seen that the shape index was higher in larger ones than medium and smaller seeds. This indicated that the large seeds were narrow and elongated. The size index was more in large seeds and correlated with dry weight due to more stored food in the endosperm. The ratio of length of large/medium seeds was 1.30 and medium/small seeds was 1.36. Similarly, the ratio of length of large and small seeds was 1.78. Thus the length ratio of large, medium and small seeds were 1.78 : 1.36 : 1. The ratio of weight of 100 large and medium seeds (without coma) was 1.31 and medium / small seeds was 1.42. Besides, the ratio of weight of 100 dry large and small seeds was 1.86. Therefore, the weight ratio of large, medium and small seeds were 1.86 : 1.42 : 1. This indicated that seed length was correlated with seed dry weight. The ratio of breadth of large / medium seeds was 1.006 and medium / small seeds was 1.16. Moreover breadth ratio of large / small seeds was 1.17. So the ratio of breadth of large, medium and small seeds were 1.17 : 1.16 : 1 which indicated that breadth of all the three categories of seeds were almost similar. The ratio of weight of seed and hairy coma of large, medium and small seeds were 1.335, 1.23 and 1.0, respectively.

Harper *et al.* (1970) mentioned that although seed size and shape show a remarkable constancy, and are genetically determined, the phenomenon of somatic polymorphism is well known. In such polymorphic seeds, produced on the same plant, different ecological roles and differences in dormancy and in germination behaviour are often associated with the different seed forms. In some cases differences in seed shape, size or weight may ensure differences in seed distribution in space (Mayer & Poljakoff-Mayber, 1975). Cook (1975) and Wardlaw & Dunstone (1984) observed that in some species mean seed size varied markedly with the parental growth conditions.

On a world-wide basis it has been calculated that trees, shrubs and herbaceous plants have mean seed weight of 328, 69 and 7 mg, respectively (Levin & Kerster, 1974). In *Streptocaulon sylvestre* it was observed that mean weight of single seed was 14.09 mg with coma and 7.70 mg without coma. Seed weight is also responsible for the dispersal mechanism of the plants to a large extent. Sheldon & Burrows (1973) indicated that the effectiveness of dispersal may be related to the ratio of the sizes of the pappus and the achene, although this relationship is considerably modified by the fine details of the pappus structure. In this case, *S. sylvestre* produced flat and compressed seeds with fine hairs of coma. The ratio of the length of seed and coma of large, medium and small seeds were 0.302, 0.30 & 0.240, respectively. These seeds were enable to float in air and they were carried to great distance by the wind.

6.2.2. SEED VIABILITY

In the present investigation seeds were tested after sutiable intervals (4 months) of dry storage. The effect of age on viability percentage of seeds for *Streptocaulon sylvestre* are presented in Table-6.3. Results reveal that immediately after harvest, i.e. without storage, 89.00 ± 3.41 % seeds were able to germinate i.e. initially the species did not show sufficient dormancy. However, the rate of germination increased slightly to 94.00 ± 1.15 % after 4 months and 96.00 ± 1.63 % after 8 months of dry storage. After one year, 95.00 ± 1.91 % seeds were viable. Subsequently, germination percentage remained almost equal for the period of 3 years (from the date of collection) of storage (36 months). Moreover, decrease in viability after 3 years of storage was conspicuous which fell to 80.00 ± 3.65 % after 40 months and 69.00 ± 2.52 % after 44 months of dry storage. The extent of viability was almost equal both in both daylight and complete dark condition of text experiment.

From the foregoing discussion, it is clear that dispersed seeds of *S. sylvestre* have almost no dormancy and over 50 % seeds remain viable for over 44 months if stored under dry condition. This sort of behaviour has been recorded by Wesson and Wareing (1969). They found that freshly collected seeds of a range of herbaceous species germinate readily in both light and dark conditions and remain viable for long period.

Viability depends both on the storage condition and on the type of seed. It is known today that dry seeds generally remain viable for longer periods if stored in a dry condition. Griffiths (1942) observed that lettuce seeds kept much longer if their moisture was reduced from air-dry to half of this value. Roberts (1972) showed the relationship between viability, storage temperature and moisture content of cereal seeds. Loss of germinability usually occurs before the maximum water content is reached (Barton, 1961).

Mayer & Poljakoff-Mayber (1975) noted that seed viability is not only a function of storage environment. A variety of factors to which the parent plant is exposed during seed formation and ripening can also profoundly affect subsequent viability of seeds, after dispersion or harvest. Gutterman (1980) presented an excellent review of some of the ways in which maternal effects determine the germination behaviour of mature seeds. Harrington & Thompson (1952) examined the germinability of *Lactuca sativa* (lettuce) seeds which had been produced in different locations in California and Arizona. They found that germinability was inversely proportional to the mean temperature of the parents' growing conditions during the 30 days before seed harvest. Van der Vegte (1978) observed a similar effect in *Stellaria media* (Chick weed). Seeds of this species produced at cool periodes of the year were found to have a higher degree of dormancy than those produced at warmer periods. Gutterman (1982) studied a clear relationship between daylength experienced by the parent plant (especially during the last few days of seed maturation) and germinability in *Polygonum monspeliensis* and *Carrichtera annua*. Although these are many examples of the effects of parental growth conditions on seed viability, little work has been done to determine the ecological consequences for the seeds involved.

Table 6.3 : Effect of age (dry storage) on viability percentage of seeds for *Streptocaulon sylvestre* Wight.

Storage period (month)	Germination percentage	Storage period (month)	Germination percentage
0 (immediately after harvest i.e. without storage)	89.00 ± 3.41	24	90.00 ± 2.58
4	94.00 ± 1.15	28	90.00 ± 1.15
8	96.00 ± 1.63	32	89.00 ± 1.91
12	95.00 ± 1.91	36	88.00 ± 1.63
16	95.00 ± 3.83	40	80.00 ± 3.65
20	89.00 ± 4.72	44	69.00 ± 2.52

In this case, the fact that almost 90.00 % seed germination was obtained in *S. sylvestre* with 36 months, which indicates that seeds can stay viable for more than three years; representing an additional advantage for the species. The results also provided evidence that seeds have low (or lack of) initial dormancy which would allow rapid germination once the seeds are dispersed to a favourable environment. It has been postulated that lack of early dormancy is of disadvantage to the continuance of the species because it has no capacity to prevents germination under circumstances uncongenial to seedling survival.

6.2.3. EFFECT OF SEED SIZE ON GERMINATION PERCENTAGE OF *Streptocaulon sylvestre* WIGHT

In this investigation seeds of *Streptocaulon sylvestre* Wight were graded into large, medium ad small size and were tested for gemination. The aim of the study was ot understand the differences of germination behaviour of three types of seeds. The effect of seed size on germination percentage is presented in Table-6.4 and Fig-6.1. Data exhibits that large, medium and small seeds had almost identical percentage of germination. Although the highest germination percentage of 96.00 ± 1.63 was obtained from large seeds and both medium and small seeds exhibited 95.00 % of germination.

Table 6.4 : Effect of seed size on germination percentage of *Streptocaulon sylvestre* Wight.

Seed size	Average days required for 1st emergence of radicle	Average days required for completing germination	Percentage Germination	Nonviable percentage	Index of speed of germination
Large	3.75	10.25	96.00 ± 1.63	4.00	18.26 ± 0.45
Medium	3.50	10.00	95.00 ± 2.51	5.00	18.78 ± 0.71
Small	3.25	9.25	95.00 ± 1.91	5.00	19.25 ± 0.87

The large seeds required comparatively longer periods (average 3.75 days) for the 1st emergence of radicle and for completing the germination (average 10.25 days).Although in large seeds germination was started on the third day and was completed on the eleventh day after sowing (Fig-6.1). On the other hand the small seeds required comparatively less period for the 1st emergence of radicle (average 3.25 days) and for completing the germination (average 9.25 days). The medium seeds took 3.50 days for first emergence of radicle and 10.00 days for completing the process. Both medium and small seeds started germination on the third day and completed on the eleventh and tenth day after sowing, respectively (Fig-6.1).

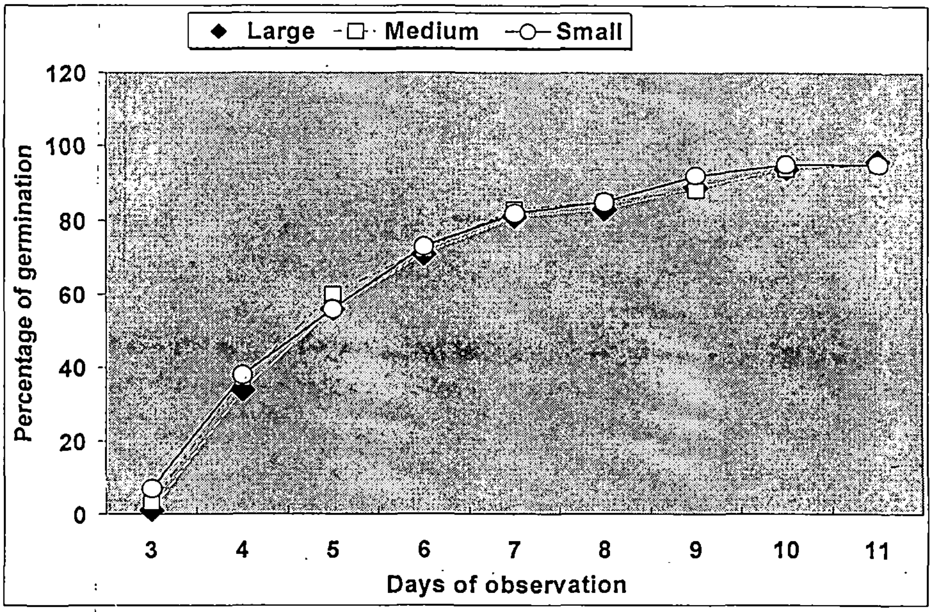


Fig-6.1- Dynamics of seed germination of different sizes of seeds of *Streptocaulon sylvestre* Wight

In this study it was observed that the speed of germination was decreased with increase in seed size. Germination was faster in small seeds than medium and large seeds. The small, medium and large seeds showed index of speed of germination of 19.25 ± 0.87, 18.78 ± 0.71 and 18.26 ± 0.45 respectively. At the beginning the percentage of germination was 7.00 in small seeds, whereas it was 3.00 in medium seeds and 1.00 in large seeds (fig-6.1).

Roberts (1972) mentioned that seed size and weight, besides other morphological and physiological factors, are known to be related with germination and seedling vigour. Bhingarde & Dumbre (1993) observed that in *Vigna radiata* (L.) (green gram) the germination percentage differ significantly with respect to seed size. Harper *et al.* (1970) and Pathak *et al.* (1974) discussed the seed polymorphism with a differential germination behaviour. Kumar & Joshi (1970) found that in several desert grasses with dimorphic seeds, the larger seeds show a higher germination percentage and quicker growth.

In *Streptocaulon sylvestre* the large seeds showed comparatively a higher percentage of germination than the medium and small seeds. In this case. it was also found that the small seeds germinate faster than others and germination was delayed in large seeds. This observations corroborate the finding of Ponnuswamy & Ramakrishnan (1985). They reported that in peanut the speed of field emergence decreased with increase in seed size. The possible cause of delayed germination of large seeds is the presence of hard seed coat, as the hard seed coat may be less permeable to water. Small seed contain comparatively thin seed coat which can imbibe water earlier and subsequently germinate. Also, large seeds need to absorb more water to awake the sleeping embryo, which is supposed to take a longer period.

6.2.4. GERMINATION OF SEED OF *Streptocaulon sylvestre* WIGHT UNDER DIFFERENT TEMPERATURE REGIMES

In this investigation seed germination of *Streptocaulon sylvestre* Wight was conducted at different temperature regimes. The purpose of this work was to assess the effect of temperature on the germination of seeds and to find out the optimum temperature. Results are presented in Table-6.5 and Fig-6.2. From the perusal of the data it is observed that the seeds of *S. sylvestre* were able to germinate under a wide range of temperature i.e. 10°C to 40°C. Germination increased with the increase in temperature upto 25°C but it started to decline thereafter. No germination was recorded at 0°C. At 10° and 20°C germination percentage was 90.00 ± 2.58 and 93.00 ± 1.91, respectively. The highest germination percentage of 95.00 ± 1.91 was obtained from seeds placed at 25°C. It required an average of 3.5 days for first emergence of radicle and 9.50 days for the completion of germination. Results suggest that the optimum temperature for the germination of seeds was about 25°C.

Though the germination percentage was as high as 94.00 ± 2.00 and 83.00 ± 3.00 at 30° and 35°C, respectively, but it was found to be quite poor at 40°C (62.00 ± 3.46) and it required a longer incubation for the first emergence of radicle (i.e. 5.75 days) and also for completing the germination (i.e. 11.00 days). On the other hand, at 10, 30 and 35°C, seeds required average 4.00 days for first emergence of radicle and 9.50, 9.75 and 10.50 days for completing the process, respectively.

In the investigation, it was seen that the highest index of speed of germination (18.37 ± 0.26) was obtained at 25°C and lowest index of speed of germination (7.79 ± 0.72) was obtained at 40°C. Furthermore, at 10, 20, 30 and 35°C, the index of speed of germination were 16.88 ± 0.32, 17.97 ± 0.12, 17.83 ± 0.29 and 14.24 ± 0.53, respectively. However, germination was faster at 25° and 20°C, where it was

Table 6.5 : Effect of temperature on the germination of seeds of *Streptocaulon sylvestre* Wight

Temperature °C	Average days required for 1st emergence of radicle	Average days required for completing germination	Germination percentage	Nonviable percentage	Index of speed of germination
0	-	-	-	100.00	-
10	4.00	9.50	90.00 ± 2.58	10.00	16.88 ± 0.32
20	3.75	9.50	93.00 ± 1.91	7.00	17.97 ± 0.12
25	3.50	9.50	95.00 ± 1.91	5.00	18.37 ± 0.26
30	4.00	9.75	94.00 ± 2.00	6.00	17.83 ± 0.29
35	4.00	10.50	83.00 ± 3.00	17.00	14.21 ± 0.53
40	5.75	11.00	62.00 ± 3.46	38.00	7.79 ± 0.72

started on the third day and was completed on the tenth day (Fig- 6.2). Besides, germination became very slow at 40°C, where it was initiated on the fifth day and was completed on the eleventh day.

Breadsell & Richards (1987) mentioned that the most important environmental factor influencing germination in most plant species is temperature. A change in temperature can effect each constituent step in the process of germination individually (Toole *et al,* 1956; Cohen, 1958; Mayer & Poljakoff-Mayber, 1975). Bewley & Black (1985) expressed the opinion that temperature affects both the capacity for germination and the rate of germination. In each species, seeds have the capacity to germinate over a defined range. Bewley & Black (1982) noted that when seeds are set to germinate over a temperature range an optimum soon becomes apparent.

In the experiment conducted to find out the effects of temperature regimes it was observed that 25°C was the most suitable temperature for the rate as well as for the quantum i.e. percentage of germination of seeds of *S. sylvestre*. Evidently, seeds of this species are adapted to germinate in a relatively wide range of temperature. Range of temperature suitable for germination was 10° to 30°C. A wide range of temperature for germination of arid zone seeds has been reported by Sen (1977) and Mullick (1978). The response of seeds of *Streptocaulon sylvestre* conform more or less to the temperature conditions of its natural habitat. For instance, the mean annual

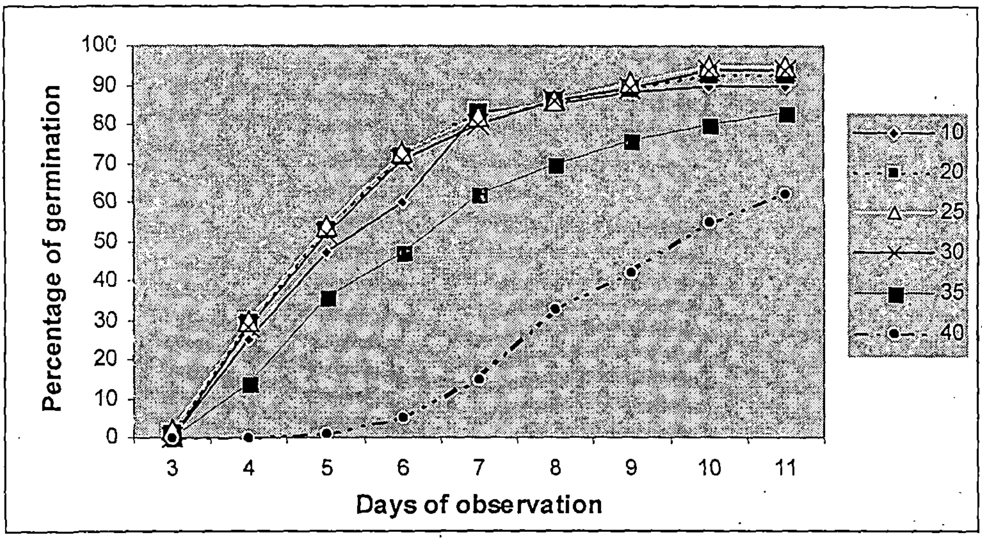


Fig-6.2 Dynamics of seed germination of *Streptocaulon sylvestre* Wight under different temperature regimes

temperature of the localities from which seeds of this species were collected falls within the range 10-35°C. At 40°C, germination was markedly reduced. At 0°C, germination was nil, but after the completion of 12 days experimental period when seeds were kept in the laboratory 94% germination was achieved. This showed its adaptation to temperature fluctuations in nature. In the foot hill region of Darjeeling District night temperature sometimes goes below 5°C and it rises above 37°C. Therefore, areas with the appropriate temperature ranges (10-30°C) should be selected in future conservation designs or for the cultivation of this critically endangered species of plant.

6.2.5. EFFECT OF LIGHT PERIOD ON SEED GERMINATION OF *Streptocaulon sylvestre* WIGHT

In the present investigation germination of seeds of *Streptocaulon sylvestre* Wight was carried out at different period of light and under conplete darkness condition. The results are exhibited in Table-6.6 and in Fig-6.3. The data from different experiments demonstrates that maximum percentage of germination was obtained in complete darkness and minimum at condition of continuous light. At complete darkness and continuous light germination was 96.00 ± 1.63 % and 64.00 ± 4.90 %, respectively. Very little decrease in germination percentage was observed under daylight (diffuse light i.e. natural reflected light during day and the normal darkness during night) and 8 hrs. light conditions as compared to complete darkness. At daylight and 8 hrs. light treatments germination percentage was 95.00 ± 2.51 and

94.00 ± 2.58, respectively. In addition, germination percentage of 93.00 ± 1.91 and 88.00 ± 2.83 were obtained from seeds placed at 12 hrs. and 16 hrs. light treatments, respectively.

Table 6.6 : Effect of light period on seed germination of *Streptocaulon sylvestre* Wight

Light period (hr)	Average days required for 1st emergence of radicle	Average days required for completing germination	Germination percentage	Nonviable percentage	Index of speed of germination
0 (complete darkness)	3.00	9.00	96.00 ± 1.63	4.00	19.82 ± 0.67
8	4.00	10.00	94.00 ± 2.58	6.00	17.73 ± 0.65
12	4.00	10.50	93.00 ± 1.91	7.00	16.89 ± 0.23
16	4.00	11.25	88.00 ± 2.83	12.00	15.26 ± 0.43
24 (continuous light)	6.25	11.25	64.00 ± 4.90	36.00	7.65 ± 0.62
Day light (diffuse)	3.50	10.00	95.00 ± 2.51	5.00	18.20 ± 0.49

The average period for first emergence of radicle and average days for completing the germination were comparatively less, when germination experiments were carried out under complete darkness. It required average 3.00 days for first emergence of radicle and 9.00 days for completing the germination. On the other hand, at continuous light treatments, it required longer incubation for the first emergence of radicle (6.25 days) and for completing the process (11.25 days). Besides, at daylight condition, seeds required 3.50 days for the first emergence of radicle and 10.00 days for the completion of germination. Similarly, 4.00 days were required for the first emergence of radicle and 10.00, 10.50 and 11.25 days were required for completing the germination at 8, 12 and 16 hrs. light treatments, respectively.

In the present study, it was also observed that the highest index of speed of germination (19.82 ± 0.67) was obtained at complete darkness condition. Besides, the index of speed of germination was found to be poor (7.65 ± 0.62) at continuous light condition (24 hrs.). In comparison with complete darkness, slightly decreased index of speed of germination was observed at daylight treatment (18.20 ± 0.49). At 8, 12 and 16 hrs. light treatment the index of speed of germination were 17.73 ± 0.65, 16.89 ± 0.23 and 15.26 ± 0.43, respectively.

However, a comparison of the index of speed of germination at different periods of exposure to light and complete darkness revealed that germination was fastest under complete darkness and slowest at continuous light exposure in *Streptocaulon sylvstre*. In complete darkness, 39.00 percent seed germination achieved within four days and more than 50.00 percent germination occurred within five days. Besides, in continuous light condition, more than 50.00 percent seeds were germinated after ninth day. Furthermore, it was also observed that rate of germination was faster at daylight (diffuse light), where 28.00 percent germination achieved within four days and more than 50.00 percent germination occurred within five days after sowing (Fig-6.3).

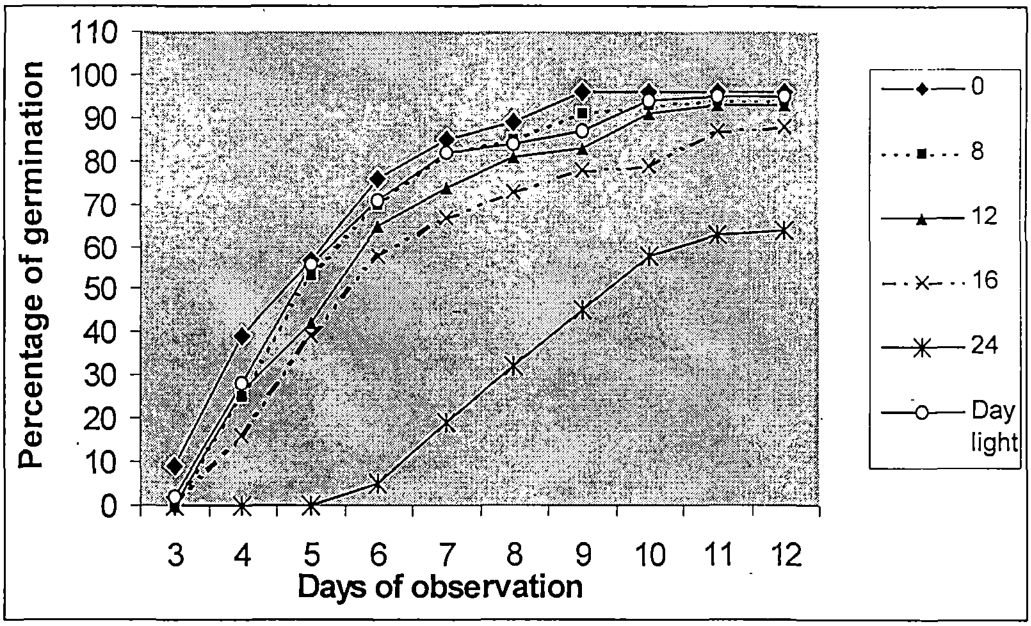


Fig-6.3 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different light period.

Mayer & Poljakoff- Mayber (1975) expressed the opinion that light is known to affect the absolute germination percentage and the rate of germination. Some seeds have an absolute requirement of exposure to light in order to germinate, while in other, germination is associated with a photo-periodic response (Borthwick *et al,* 1954; Toole *et al,* 1955). While working with *Cenchrus ciliaris, C. setigerus* and *Lasiurus sindicus*. Lahiri & Kharbanda (1964) found that in continuous light seed germination was decreased in these grasses and this inhibition was nullified on their transfer to darkness. Negbi & Koller (1964) proved that light inhibited the germination of seeds of *Cryzopsis miliocea,* but, when it was shifted to darkness, germination was stimulated. In the present investigation germination of the seeds of *S. sylvestre* was affected by longer light period. It was decreased with the increase of length of light period. So, light is not a necessity for the germination of the seeds of *Streptocaulon sylvestre* because percentage of germination was almost equal in complete darkness and daylight condition.

6.2.6. SEED GERMINATION OF *Streptocaulon sylvestre* WIGHT AT DIFFERENT POSITION AND ORIENTATION IN SOIL.

Position and orientation of seed in soil may also exert evidential influence on seed germination. This study aims at finding out what effect of position and orientation of seed's placement in soil will have on germination of *Streptocaulon sylvestre* Wright. Seeds were sown in vertical, horizontal and inverted orientation into the surface (top) and 2.00 cm depth of the soil. Results are shown in the Table-6.7 and in Fig- 6.4 & 6.5.

Results reveal that the position of seeds had major effect on its germination. In general, seeds sown at top of the soil germinated more than those at 2.00 cm depth. Although the orientation of seeds had no major effect on the number of germination.

At top of the soil, there was 55.00 ± 3.00 % germination when the seeds were placed in vertical position (Plate-IV). It took an average of 4.5 days after sowing for first emergence of radicle and 8.50 days for completing the germination. 53.00 % germination was also observed within 8.75 and 9.50 days when seeds were arranged in horizontal and inverted orientations, respectively. First emergence of radicle on soil surface in horizontal orientation required an average of 4.5 days, whereas in inverted orientation, it took 6.00 days.

In 2.00 cm depth of soil, vertical orientation registered more germination followed by horizontal and inverted orientation, respectively. 40.00 ± 1.63 %

germination was recorded within an average of 17.50 days after sowing when seeds were placed in the vertical orientation. It also required an average of 15 days for first emergence of seedlings. Sowing at horizontal orientation recorded 38.00 ± 3.46 % germination within 18.75 days and the inverted orientation recorded 37.00 ± 1.91 % but took a longer period of 19 days. In both the orientation, it took 15.25 days for first emergence of seedling.

In this investigation, it was also observed that more (but poor) index of speed of germination was recorded at top of the soil than the position at 2.00 cm depth. Seeds placed in vertical, horizontal and inverted orientation at the top of the soil showed 8.99 ± 0.49, 8.44 ± 0.35 and 7.57 ± 0.38 index of speed of germination, respectively, which was 2.51 ± 1.0, 2.25 ± 0.18 and 2.13 ± 0.12, respectively, for the seeds placed at 2 cm depth.

Table 6.7 : Seed germination of *Streptocaulon sylvestre* Wight at different position and orientation in soil

Position of seeds	Orientation of seeds placement	Average days required for 1st emergence of radicle/ seedling	Average days required for completing germination	Germination percentage	Nonviable percentage	Index of speed of germina-tion
Top of Soil (surface)	Vertical	4.50	8.50	55.00 ± 3.00	45.00	8.99 ± 0.49
	Horizontal	4.50	8.75	53.00 ± 1.91	47.00	8.44 ± 0.35
	Inverted	6.00	9.50	53.00 ± 4.43	47.00	7.57 ±0.38
2 cm depth of Soil	Vertical	15.00	17.50	40.00 ± 1.63	60.00	2.51 ± 0.10
	Horizontal	15.25	18.75	38.00 ± 3.46	62.00	2.25 ± 0.18
	Inverted	15.25	19.00	37.00 ± 1.91	63.00	2.13 ± 0.12

A comparison between the rate (speed) of germination at both positions exhibited that germination was slow at top of the soil and was much slower at 2.00 cm depth (Fig-6.4 & 6.5). It was also noted that in both the positions vertical orientation showed better rate of germination.

From the above discussion it is clear that seeds of *Streptocaulon sylvestre* Wight germinate poor in soil than in control (filter paper, Table-6.4) and in water logged soil (Table-6.9). This points to the fact that soil conditions, probably moisture, nutrients and microbial activities exert some detrimental effects to reduce its rate of germination. As the available water content of the soil is considered to be the most important factor for germination, certainly, affect the germinability of seeds. In this investigation, the moisture in the surface layer of the soil was continuously depleted due to evaporation and seeds lying on soil surfaces were exposed to the risk of dehydration. Fenner (1985) stated that seeds lying on soil surfaces are exposed to the risk of dehydration, and will only germinate if water is absorbed more quickly than it is lost. Hunter & Erickson (1952) expressed that there is a critical soil water content permitting germination, which is very much species specific.

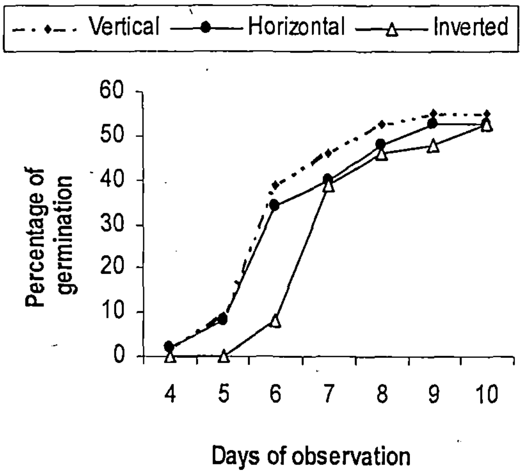


Fig-6.4 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different orientation in top of soil.

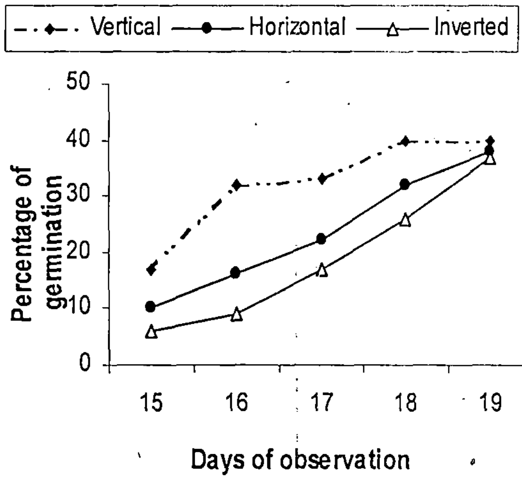


Fig-6.5 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different orientation in 2.00 cm depth of soil.

Another cause for the poor percentage of germination of *S. sylvestre* seeds in soil was probably controlled by the amount or extent of contact between the seed and the soil surface. Collis-George & Hector (1966) showed that when seed-soil contact was poor, the germination percentage was reduced even with high water potentials of the soil. Hadas & Russo (1984) reported that a poor seed-soil moisture contact reduced the rate of water uptake and thus caused delayed or less germination. In *S. sylvestre*, very light weight seeds (in relation to their size and shape) and their hairy coma may cause poor seed-soil moisture contact, causing less water uptake, and thus resulting in poor germination.

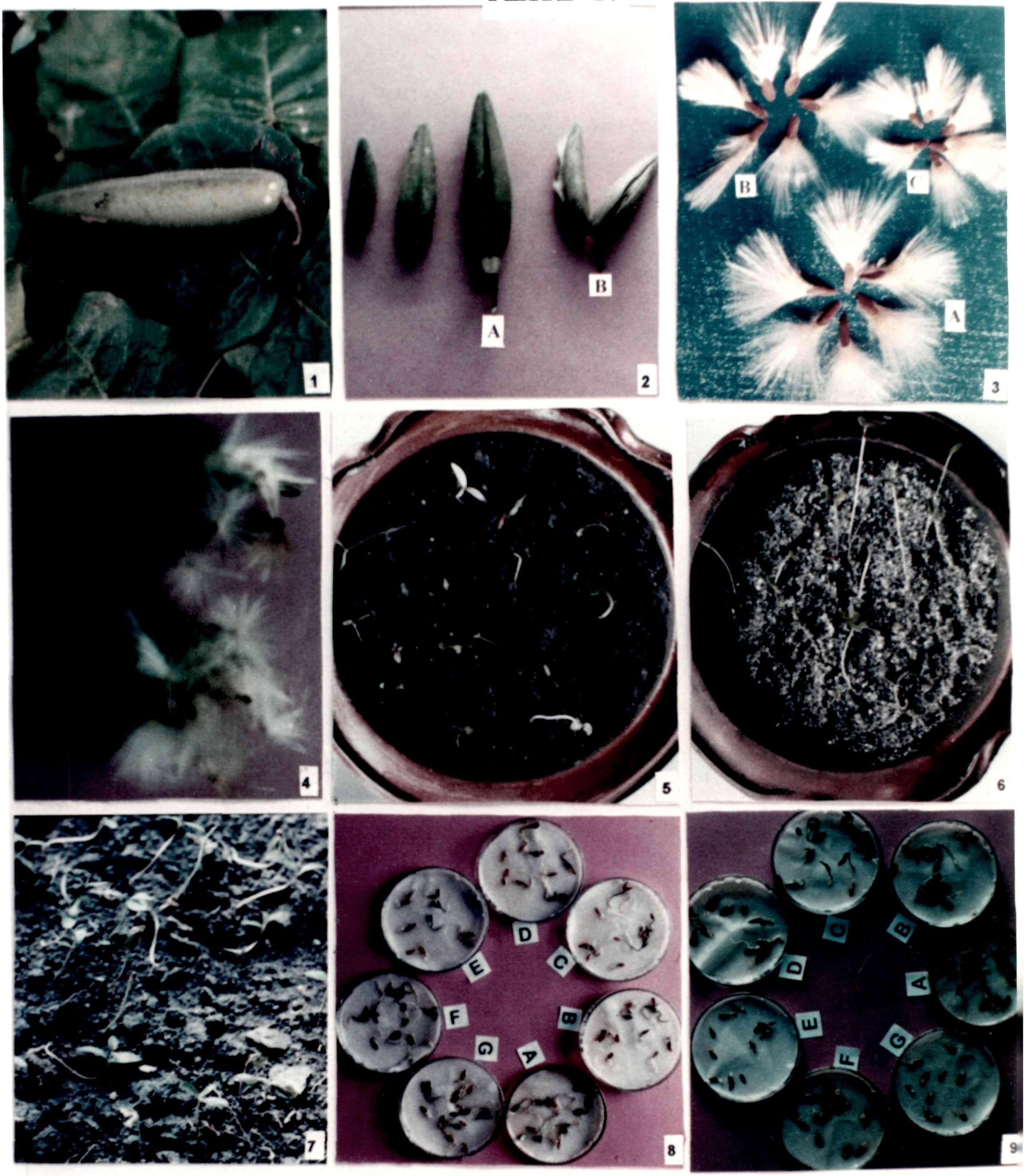
In an elegant study of the behaviour of seeds on soil surfaces, Sheldon (1974)

EXPLANATIONS OF PHOTOGRAPHS

Plate IV.
Streptocaulon sylvestre Wight – fruits, seeds and germination:

Photo 1. Generally one of the pair of follicles develop (large fruit type)
Photo 2. Medium (A) and Small (B) fruit types
Photo 3. Seeds from (A) large, (B) medium and (C) small fruits
Photo 4. During rainy season (September) sometimes green fruits dehisces and seeds are released
Photo 5. Seed germination in soil on pots
Photo 6. Seed germination in sand on pots
Photo 7. Seed germination in the garden seed-bed
Photo 8. Germination with different concentration of IAA [A= Control; B= 0.1 mg/l; C= 0.2 mg/l; D= 0.5 mg/l; E= 1.0 mg/l; F= 2.0 mg/l; G= 5.0 mg/l]
Photo 9. Germination with different concentration of 2,4-D [A= Control; B= 0.1 mg/l; C= 0.2 mg/l; D= 0.5 mg/l; E= 1.0 mg/l; F= 2.0 mg/l; G= 5.0 mg/l]

PLATE IV



proved that in *Taraxacum officinale* the exact orientation of the seed on the ground can markedly affect the probability of its germination. Earlier reports of Bennet-Clack & Bal (1951) and Thapliyal (1979) also support the existence of the effect of orientation of seeds on their germination. According to El Bagoury (1973), seeds of some cereals with their embryo end upwards emerged more rapidly than those with the embryo ends placed down-ward because of the shorter distance between the embryo and the soil surface. In *S. sylvestre* it is found that vertical orientation was superior for all the parameters and the seeds placed at 2.00 cm depth resulted into the poorer rate of germination. One of the possible reasons for this behaviour may be its nature and need of hook formation due to the faster growth of hypocotyler region, typical of epigeally germinated seeds, protects the delicate meristematic zone as it is pulled off from seed coat rather than pushed through the soil. In the vertical orientation, radicle comes out from the micropylar end and grows downwards thus enabling a hook formation at the hypocotyl region. Hook formation may be possible to some extent in the horizontal orientation, whereas in the inverted position, no chance exists for hook formation and the cotylendons are only pushed up along with the seed coat through the soil. Probably because of this reason that the germination was poor in soil and the vertical orientation was favourable for seedling emergence in *S. sylvestre* Wight.

Thus, it is concluded that in *Streptocaulon sylvestre* Wight sowing seeds at soil surface and in vertical orientation may be favourable for germination in field condition.

6.2.7. SEED GERMINATION OF *Streptocaulon sylvestre* WIGHT AT DIFFERENT POSITION AND ORIENTATION IN SAND.

The choice of sand for germination was due to the fact that the soil of the habitat for *S. sylvestre* is sandy. Objective of this study was to gain insight into the influence of position and orientation of seeds in sand on the rate of germination or more precisely on the successful emergence of seedlings. Methods followed for this experiment was exactly similar with the previous experiment with exception of the nature of substratum i.e; fine sand has replaced the soil. Seeds were sown in vertical, horizontal and inverted position on the surface (top) and at 2 cm depth. Results of this experiment are presented in Table-6.8, in Fig-6.6 & 6.7 & Plate-IV.

The analysis of data shows that the germination in *S. sylvestre* was favoured when its seeds were placed at top of sand than those placed at 2 cm depth. Here again, germination was maximum (82.00 ± 3.46 %) in seeds placed in vertical orientation.

It required an average 4.25 days, after sowing, for the first emergence of radicle and 9.5 days for completing the process. On the other hand 81.00 % gemination was recorded when seeds were arranged in horizontal and inverted positions. In horizontal orientation it took an average of 4.5 days for first emergence of radicle and 10 days for completion. Besides, in inverted orientation it required 5.25 days, after sowing, for first emergence of radicle and 10.25 days to complete the process.

Table 6.8 : Effect of position and orientation of seeds in sand on seed germination of *Streptocaulon sylvestre* Wight

Position of seeds	Orientation of seeds placement	Average days required for 1st emergence of radicle/ seedling	Average days required for completing germination	Germination percentage	Nonviable percentage	Index of speed of germina-tion
Top of Soil (surface)	Vertical	4.25	9.50	82.00 ± 3.46	18.00	11.23 ± 0.54
	Horizontal	4.50	10.00	81.00 ± 4.43	19.00	11.23 ± 0.79
	Inverted	5.25	10.25	81.00 ± 3.41	19.00	10.14 ±0.28
2 cm depth of Soil	Vertical	10.00	15.75	58.00 ± 4.16	42.00	4.39 ± 0.25
	Horizontal	10.50	16.00	57.00 ± 2.52	43.00	4.31 ± 0.23
	Inverted	10.50	15.75	55.00 ± 2.52	45.00	4.08 ± 0.18

Seeds placed at 2 cm depth in sand showed 58.00 ± 4.16 % germination when placed in vertical orientation. It took an average of 10 days after sowing for the first emergence of seedlings and 15.75 days for completing the germination. The germination of 57 ± 2.52 % seeds were recorded in horizontal orientation within 16 days after sowing. Similarly, sowing at inverted orientation achieved 55.00 ± 2.52 % germination within 15.75 days. In both the orientations, horizontal and inverted, it required an average of 10.5 days for the first emergence of seedlings.

In the present investigation, it was seen that higher index of speed of germination was recorded when seeds were placed at top of sand and less index of speed of germination was obtained when placed at 2 cm depth. Again, at top of the sand, the maximum index of speed of germination (11.23 ± 0.54 and 11.23 ± 0.79) was observed in vertical and horizontal position. In comparison, slightly decreased index of speed of germination was found with seeds placed in inverted orientation (10.14 ± 0.28). For the seeds placed at 2 cm depth in sand the index of speed of germination were 4.39 ± 0.25, 4.31 ± 0.23 and 4.08 ± 0.18 at vertical, horizontal and inverted orientations, respectively.

However, a comparison of the rate of germination at different positions and orientations revealed that germination was fast at top of the sand as compared to those at 2 cm depth. Moreover, at both the positions, top and at 2 cm depth in sand, vertical orientation proved to be the superior orientation. Besides, inverted orientation proved as most inferior orientation. At top of the sand germination was started on the fourth day and was completed on the tenth day (Fig-6.6) in vertical orientation. The emergence of 50.00 % radicle was achieved there within eight days. Whereas in inverted orientation radicle emergence initiated on the fifth day and was completed on the eleventh day after sowing, 50.00 % radicle emergence was achieved there within nine days.

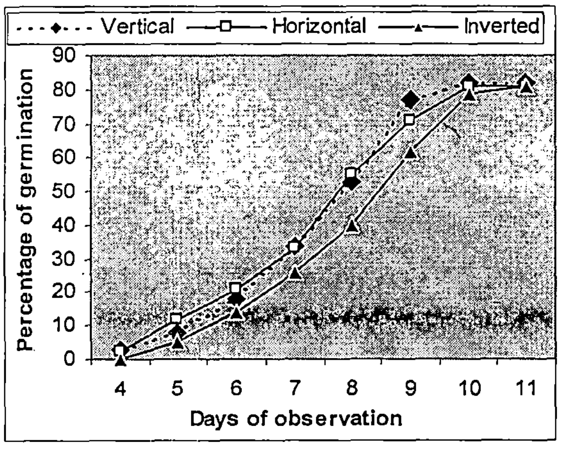


Fig-6.6 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different orientation in top of sand.

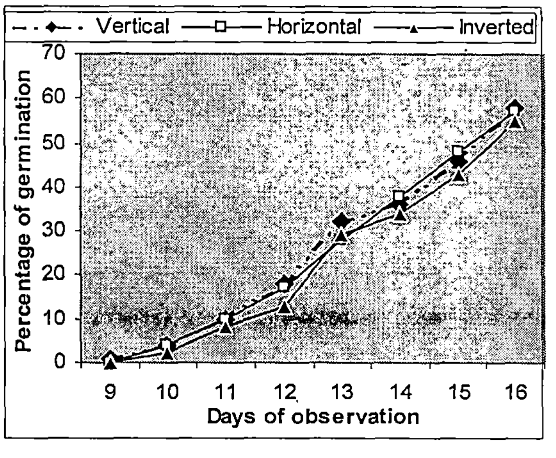


Fig-6.7 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different orientation in 2.00 cm depth of sand.

At 2 cm depth (Fig-6.7) seedling emergence was started on the ninth day and was completed on the sixteenth day after sowing in vertical orientation. On the other hand with inverted orientation seedling emergence was started on the tenth day and was completed on the sixteenth day.

Sharma & Purohit (1980) expressed the opinion that failure of seeds to germinate or seedlings to emerge have been found in some plants due to the effects of soil types, Agboola et al (1993) observed that the seeds of *Terminalia ivorensis* and *Terminalia superba* germinated better in sand which had low water-retaining capacity. Such is the case with *Streptocaulon sylvestre* whose seeds showed better germination in sand.

6.2.8. EFFECT OF WATER LOGGING IN SOIL AND SAND ON THE GERMINATION OF SEEDS OF *Streptocaulon sylvestre* WIGHT.

Germination behaviour of *Streptocaulon sylvestre* Wight in water-logged soil and sand condition is shown in Table-6.9 and in Fig-6.8. Seeds were sown in water logged soil and sand seperately, at top and at 2 cm depth (submerged). Results indicate that at the top of water logging soil and sand seeds had almost identical percentage of germination. Not a single seed was germinated when those were placed at 2.00 cm depth in both the media (soil and sand).

Seeds placed at top of waterlogged soil showed 88.00 ± 2.83 % germination within 10.75 days after sowing. It required an average of 4.50 days for the initiation of radicle emergence. On the other hand, there was 86.00 ± 3.83 % germination within 10.00 days when the seeds were placed at the top of water logged sand. If also required an average 4.25 days for the first emergence of radicle.

Table 6.9 : Effect of water logging in soil and sand on seed germination of *Streptocaulon sylvestre* Wight (Seed placed vertically)

Position of Seeds	Average days required for 1st emergence of radicle/ seedling	Average days required for completing germination	Germination Percentage	Nonviable percentage	Index of speed of germination
Top of Soil	4.50	10.75	88.00 ± 2.83	12.00	12.29 ± 0.08
2cm depth of soil	00.00	00.00	00.00	100.00	00.00
Top of Sand	4.25	10.00	86.00 ± 3.83	14.00	13.73 ± 0.54
2cm depth of sand	00.00	00.00	00.00	100.00	00.00

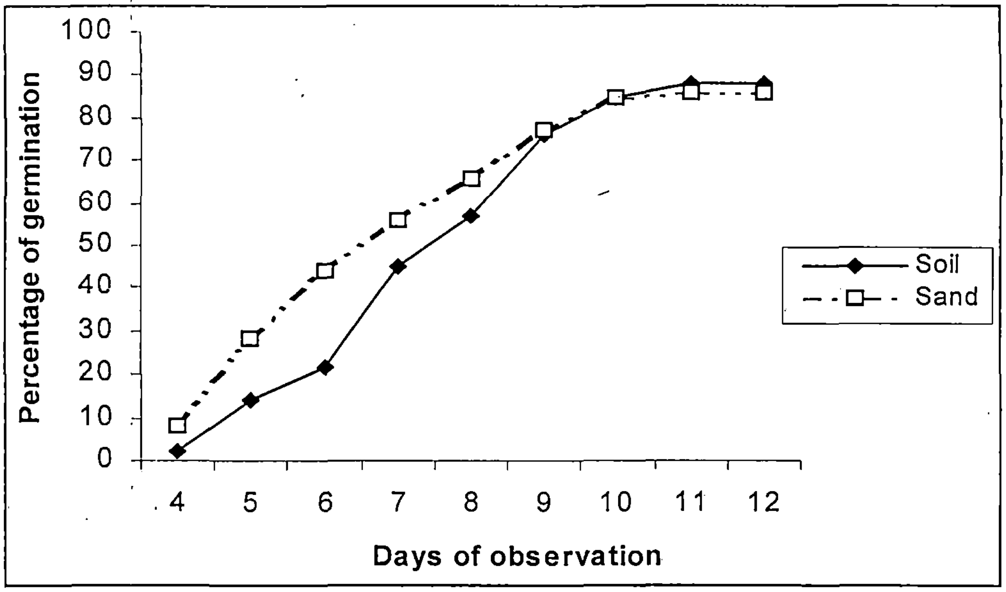


Fig-6.8 Dynamics of seed germination of *Streptocaulon sylvestre* Wight in water logged soil and sand (seed placed vertically at the top)

In this study the index of speed of germination was observed to be higher in sand (13.73 ± 0.54) then in soil (12.29 ± 0.08). However the rate of germination was also faster at top of the sand as compared to soil. At top of the water logged sand germination was started on the fourth day and was completed on the eleventh day after sowing (Fig-6.8). 28.00 % seed germination was recored there within five days and 56.00 % within seven days. Similarly at top of the water logged soil germination was started on the fourth day and was completed on the eleventh day after sowing. 14.00 % seed germination was observed there within five days and only 45.00 % within seven days.

The inability of seeds to germinate at 2 cm depth in water logged soil will not allow the regeneration of *Streptocaulon sylvestre* Wight in areas which remain submerged for longer periods because submerged and buried seeds do not germinate.

6.2.9. SEED GERMINATION OF *Streptocaulon sylvestre* WIGHT AT DIFFERENT pH LEVELS.

In this investigation, seeds of *Streptocaulon sylvestre* Wight were sown at different pH solutions. The effect of different pH levels on germination percentage of seeds are presented in Table-6.10 and Fig-6.9. Data on germination percentage indicate that seeds of *Streptocaulon sylvestre* Wight were able to germinate under a wide range of pH levels (4.00 to 9.00). Seeds were sensitive to higher pH instead of lower than 7.00. Maximum amount of germination i.e. 96.00 % was obtained from seeds placed at pH 6.00 and 7.00. Very little decrease in percentage of germination was observed at pH 8.00 when compared to pH 7.00. At pH 8.00 a good as 95.00 ± 2.51 % seeds were germinated. However, only 63.00 ± 1.91 % seeds were germinated at pH 4.00. On the other hand at pH 5.00 and 9.00 the percentage of germination were 92.00 ± 1.63 and 84.00 ± 2.83, respectively.

Table 6.10 : Effect of different pH levels on seed germination of *Streptocaulon sylvestre* Wight

pH Level	Average days required for 1st emergence of radicle	Average days required for completing germination	Germination Percentage	Nonviable percentage	Index of speed of germination
4.00	5.50	10.50	63.00 ± 1.91	37.00	8.49 ± 0.11
5.00	4.00	9.00	92.00 ± 1.63	8.00	17.67 ± 0.28
6.00	3.50	9.50	96.00 ± 1.63	4.00	18.59 ± 0.29
7.00	3.25	9.25	96.00 ± 2.83	4.00	18.93 ± 0.57
8.00	4.00	10.00	95.00 ± 2.51	5.00	17.62 ± 0.45
9.00	5.25	10.50	84.00 ± 2.83	16.00	13.74 ± 0.75

The average time for the first emergence of radicle and for the completion of the process of germination were comparatively less, when it was set at pH 7. It required 3.25 days for the first emergence of radicle and 9.25 days for completing the process. On the other hand, at pH 5.00 and 8.00, seeds took 4.00 days for the initiation of radicle emergence and 9.00 and 10.00 days to complete the germination, respectively. At slightly acidic (pH 6.00) solution, it required 3.50 days for the first emergence of radicle and 9.50 days for completion of germination. Besides, at highly acidic (pH 4.00) level, it required a much longer period for the first emergence of radicle (5.50 days) and also for completion (i.e. 10.50 days). The response was nearly similar, i.e. 5.25 and 10.5 days, respectively, for initiation and completion of germination in highly alkaline solution (i.e. pH 9.00).

In the present study, it was observed that the highest index of speed of germination (18.93 ± 0.57) was achieved at pH 7.00. In comparison with pH 7.00, slightly decreased index of speed of germination was found at pH 6.00 level (18.59 ± 0.29). Besides, at pH 5.00 and 8.00 solutions, the index of speed of germination were 17.67 ± 0.28 and 17.62 ± 0.45, respectively. However, the index of speed of germination was found to be quite poor at pH 4.00 and 9.00 (8.49 ± 0.11and 13.74 ± 0.75, respectively).

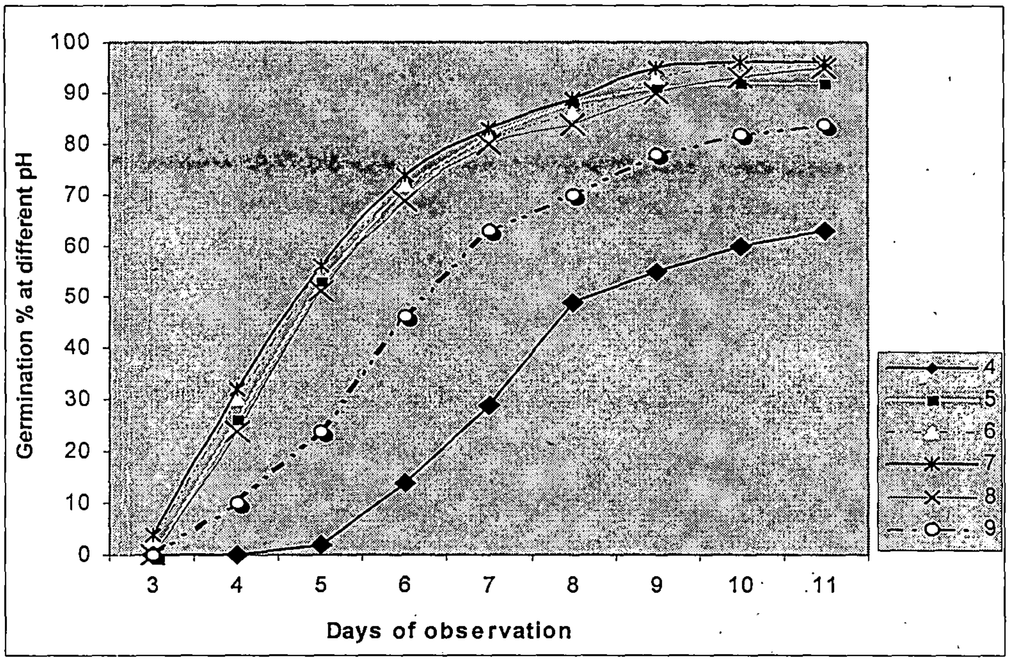


Fig-6.9 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different pH levels.

In this investigation, germination dynamics (Fig-6.9) and index of speed of germination at different pH levels showed that the rate of germination of *Streptocaulon sylvestre* Wight was faster at pH 6.00 and 7.00 levels and slower at pH 4.00 level. In pH 6.00 and 7.00 germination was started on the third day and was completed on the tenth day (Fig-6.9). 30.00 % seed germination achieved within four days and 56.00 % within five days under pH 6.00. Besides, at pH 7.00 within four days 32.00 % and within five days 56.00 % seeds were germinated. On the other hand at pH 4.00 germination was started on the fifth day and was completed on the eleventh day after sowing. Just over 50.00 % seeds were germinated upto ninth day of incubation.

Wiggans and Gardner (1959) demonstrated that soil acidity, alkalinity and low moisture content inhibit imbibition and reduce the ability of seeds to germinate in several osmotica. Bishnoi *et al* (1997) suggested that some cultivars (S C283 and Csm 63) of *Sorghum bicolor* may comparatively reduce the risk of germination failure in low osmotic potentials and at higher pH, respectively, whereas, cultivars IS 7173c and IS 7419c would be better selections to minimize stand failure at a pH lower than 5.0. In this case, it was found that variation of pH levels had some effect on seed germination of *Streptocaulon sylvestre* Wight. This species was tolerant to pH 5.00 to 8.00 and responded differently to changes in pH values of the germination solution. Furthermore, it also tended to show more tolerance to lower pH, instead of higher.

6.2.10. EFFECT OF SODIUM CHLORIDE ON SEED GERMINATION AND SEEDLING GROWTH OF *Streptocaulon sylvestre* WIGHT.

Soil salinity is a major factor which determines the type of plant species to be grown in a particular place as it directly affects germination and growth in numerous plants. Therefore, germination and early seedling growth of different species can serve as an indicator of their tolerance to salinity. The objective of present study was to examine the effect of different concentrations of sodium chloride on the germination of seed and seedling growth of *Streptocaulon sylvestre* Wight, aiming to understand the possiblities of growing the species in habitats with saline soil for its effective conservation.

In this investigation effects of seven dilutions of Sodium Chloride (NaCl) salinity on seed germination and early seedling growth of *Streptocaulon sylvestre* Wight has been studied. Results of germination and seedling growth are shown in Table-6.11 and Fig-6.10. Results reveal that sodium chloride stress decreased the germination percentage of *Streptocaulon sylvestre* Wight. Increase in salt concentration progressively reduced the percentage of germination. Germination percentage decreased slowly with the increase in the concentration of sodium chloride solution until 4.00 g / l, but started to decline markedly thereafter. The 8.00 g / l NaCl solution strongly inhibited the germination of *S. sylvestre* seeds and no seeds were able to germinate in the 10.00 g / l NaCl solution. Treatment with minimum concentration of NaCl solution (0.5 g / l) achieved 90.00 ± 3.16 % seed germination resulted in 6.25 % inhibition as compared to control (96.00 ± 2.45). On the other hand, 8.00 g / l sodium chloride solution showed 16.00 ± 2.45 % seed germination causing 83.33 % decline against control. Moreover application of 1.00, 2.00, 4.00 and 6.00 g / l sodium chloride solutions exhibited 8.33, 8.33, 14.58 and 50.00 %

Table 6.11 : Effect of Sodium Chloride on seed germination and seedling growth of *Streptocaulon sylvestre* Wight
(+ / - indicates stimulation / inhibition of germination or seedling growth).

NaCl concentration (g/l)	Germination %	Germination % Inhibition or stimulation	Average days required for 1st emergence of radicle	Average days required for complete germination	Index of speed of germination	Nonviable %	Mean shoot length (cm) per seedling	Shoot length inhibition or stimulation %	Mean root length (cm) per seedling	Root length inhibition or stimulation %	Mean length (cm) per seedling	Seedling length inhibition or stimulation %	Mean number of lateral roots	Shoot vigour Index	Root vigour Index	Seedling vigour index	Shoot/ Root ratio
0.5	90.00 ± 3.16	-6.25	4.00	8.60	17.71 ± 0.62	10.00	3.22 ± 0.68	+10.27	1.32 ± 0.20	-40.00	4.54 ± 0.79	-11.33	0.60	289.80	118.80	408.60	2.44
1.0	88.00 ± 3.74	-8.33	4.00	9.20	16.59 ± 0.63	12.00	3.26 ± 0.58	+11.64	1.36 ± 0.14	-38.18	4.62 ± 0.63	-9.76	0.40	286.88	119.68	406.56	2.40
2.0	88.00 ± 2.00	-8.33	4.20	9.00	16.40 ± 0.54	12.00	3.30 ± 0.70	+13.01	1.28 ± 0.18	-41.81	4.58 ± 0.86	-10.54	0.60	290.40	112.64	403.04	2.58
4.0	82.00 ± 3.74	-14.58	4.20	9.20	14.47 ± 0.54	18.00	1.70 ± 0.34	-41.78	1.28 ± 0.31	-41.81	2.98 ± 0.61	-41.79	0.20	139.40	104.96	244.36	1.33
6.0	48.00 ± 5.83	-50.00	5.00	7.60	8.08 ± 0.94	52.00	0.80 ± 0.13	-72.60	0.68 ± 0.08	-69.09	1.48 ± 0.21	-71.09	00.00	38.40	32.64	71.04	1.17
8.0	16.00 ± 2.45	-83.33	5.40	6.00	2.81 ± 0.42	84.00	0.18 ± 0.02	-93.83	0.14 ± 0.02	-93.63	0.32 ± 0.03	-93.75	00.00	2.88	2.24	5.12	1.28
10.00	00.00	-100.00	00.00	00.00	00.00	100.00	00.00	-100.00	00.00	-100.00	00.00	-100.00	00.00	00.00	00.00	00.00	00.00
Control	96.00 ± 2.45	00.00	3.60	8.80	19.12 ± 0.36	4.00	2.92 ± 0.47	00.00	2.20 ± 0.23	00.00	5.12 ± 0.52	00.00	1.20	280.32	211.20	491.52	1.33

inhibition in seed germination, respectively, as compared to control.

The average time for first emergence of radicle were comparatively longer, when germination occured at different levels of sodium chloride solutions, than the control. It required average 4.00 days for first emergence of radicle at lower levels of NaCl solutions (0.5 and 1.00 g / l). On the other hand it was 5.0 and 5.4 days at 6.00 and 8.00 g / l levels of NaCl solutions, respectively. However, time requirement was moderate at 2.00 and 4.00 g/l solutions, where it was 4.2 days only. The range of average days for the completion of germination was 6.00 to 9.20 in lowest to highest concentration of solutions.

In the present study, sodium chloride stress also decreased the index of speed of germination. It was observed that at the lowest concentration of sodium chloride solution (0.5 g / l) the index of speed of germination was maximum (17.71 ± 0.62), which was lower than the control (19.12 ± 0.36). The index of speed of germination was found to be much poorer (2.81 ± 0.42) at 8.00 g / l NaCl solution. Besides at 1.00, 2.00, 4.00 and 6.00 g / l NaCl solutions the index of speed of germination were 16.59 ± 0.63, 16.40 ± 0.54, 14.47 ± 0.54 and 8.08 ± 0.94, respectively.

The rate of germination was invariably delayed with increasing salinity. A comparison of the rate of germination at different concentrations of NaCl solution revealed that germination was fastest at lowest concentration (0.5 g/l) and slowest at highest concentration (8.00 g / l) (Fig-6.10). Treatment with 0.5 g / l salt solution

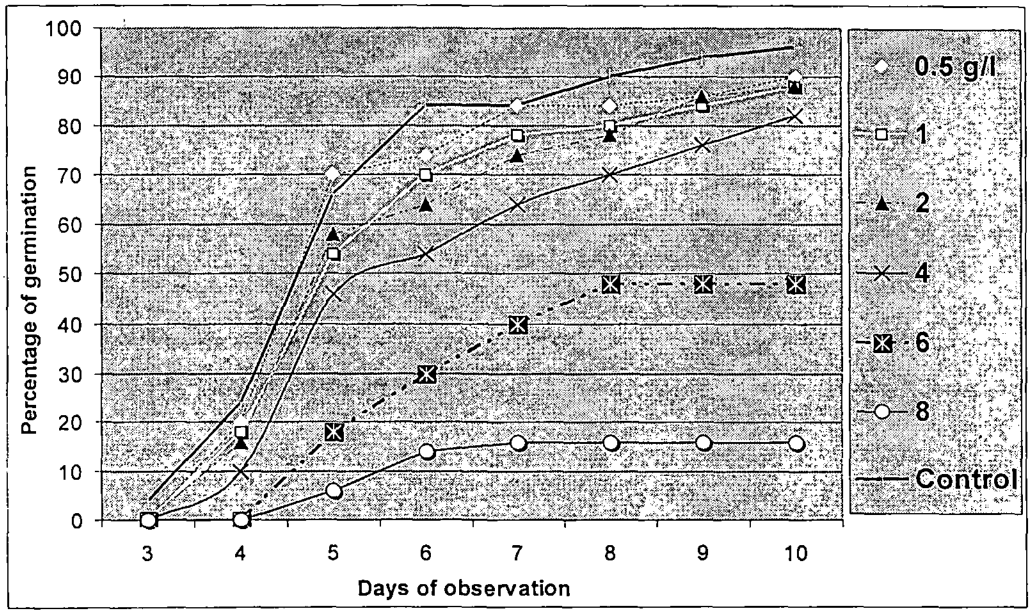


Fig-6.10 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different concentrations of Sodium Chloride germination of seeds was started on the fourth day and was completed on the tenth day after sowing. 70.00 % seed germination was achieved there within five days and more than 80.00 % germination occurred within seven days. Besides, at 8.00 g / l salt solution germination was started on the fifth day and was completed on the seventh day. Moreover, the rate of germination was also faster at 1.00 and 2.00 g / l salt solutions.

The early seedling growth of *S. sylvestre* was affected variably in different concentration of sodium chloride solutions. The shoot length was appeared to be promoted at almost all lower concentration of salt solutions. It was retarded and reduced markedly with higher concentration of salt solutions. Application of sodium chloride solutions, namely 0.5, 1.00 and 2.00 g / l showed 10.27, 11.64 and 13.01 % stimulation in shoot length over control, respectively. On the other hand, higher concentration of salt solutions, namely 4.00, 6.00 and 8.00 g / l exhibited 41.78, 72.60 and 93.83 % inhibition in shoot length as against control, respectively.

The root length of *S. sylvestre* was also progressively decreased with the increasing levels of salinity, resulting in 40.00, 38.18, 41.81, 41.81, 69.09 and 93.63 % decline in root length at 0.5, 1.00, 2.00, 4.00, 6.00 and 8.00 g / l NaCl solutions in comparison with control, respectively. Meanwhile lateral roots were also initiated in all lower concentration of sodium chloride solutions. The shoot : root ratio was also higher at all the lower concentration than the control indicating more inhibition of root growth than that of shoot. Moreover the seedling vigour index was lower at all concentration of NaCl solutions than in the control.

Pearce - Pinto *et al* (1990) noted that the ability of a seed to germinate and emerge under salt stress is an indication that the plant genotype has salt tolerance potential, at least in initial stage. In this investigation, germination of *S. sylvestre* was decreased and delayed with the increase in salinity and, subsequently, was inhibited at 6.00 g / l sodium chloride solution. Maximum germinated was obtained in the nonsaline control and no seed was germinated in the 10.00 g / l NaCl solution. The reduction in germination was more marked above 4.00 g / l NaCl solution. Similar results of decreased and delayed seed germination for other species in response to salinity were reported earlier for many other plants including *Psidium guajava* and *Emblica officinalis* (Hooda & Yamdagni, 1991), *Atriplex griffithii* (Khan & Rizvi, 1994) and *Jacquinia brasiliensis* (Garcia, 1999).

Mayer & Poljakoff - Mayber (1975) noted that the high salt content of soils, especially of sodium chloride can inhibit germination primarily due to osmotic effects and in such saline environment the development of the seedling is extremely poor.

In the present study it was observed that seedling length of *S. sylvestre* was considerably inhibited by sodium chloride salinity, although shoot growth was more resistant to low salinity. Such reduction in seedling growth with increasing salinity levels was reported by Bartolini *et al* (1991) in olive and Singh & Pathak (1992) in guava. Low concentration-induced promotive effect of shoot and root growth was also reported by Kole & Gupta (1982) in Sunflower and Safflower. According to Tagawa & Ishizaka (1963) the primary cause of salt-induced adverse effect was due to accumulation of chloride ions in the shoots.

However it is concluded that increase in salinity delayed and depressed the seed germination and caused reduction in seedling growth of *Streptocaulon sylvestre*. It is also concluded that seedlings of this critically endangered species can be maintained successfully with 88.00 % seed germination and satisfactorily with shoot growth in sodium chloride solutions upto 2.00 g / l concentrations. So, trials to grow this species in the areas of mild salinity (i.e. 0.2 % salt) may be made and this is a good chance of successful introduction if other habitat factors are fulfilled.

6.2.11. EFFECT OF GIBBERELLIC ACID ON SEED GERMINATION AND SEEDLING GROWTH OF *Streptocaulon sylvestre* WIGHT.

In this set of experiment an attempt has been made to asses the impact of gibberellic acid (GA_3) on the germination of seeds and early seedling growth of *Streptocaulon sylvestre* Wight. The data obtained for different parameters have been given in Table- 6.12 and in Fig-6.11. From the perusal of the data it is seen that gibberellic acid was observed to be ineffective or slight promotive to limited extent on seed germination in this near- extinct species of *Asclepiadaceae*. Maximum germination percentage (98.00 ± 2.00) was achieved at 0.2 and 0.5 mg / l GA_3 solutions resulted in 2.08 % stimulation over control (96.00 ± 2.45 %). The germination figure of 94.00 % was lowest at the levels of 0.1 and 2.00 mg / l GA_3 solutions which caused 2.08 % inhibition in seed germination as against the control. Inspite of that, treatment with 1.00 and 5.00 mg / l GA_3 solutions showed equal (96.00 %) proportion of germination to that of control sets.

The average time taken for the first emergence of radicle was slightly more in comparison to control, when germination occurred at different concentrations of GA_3 solution. It required 3.60 days for the first emergence of radicle at 0.1, 0.2, 0.5 and 1.0 mg /l levels of GA_3 solutions. Similarly at 2.0 and 5.0 mg /l GA_3 solutions, 3.80 and 4.00 days were taken for the first emergence of radicle, respectively. For

Table 6.12 : Effect of Gibberellic acid(GA_3) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight

GA3 concentration mg/l	Germination %	Germination % Inhibition or stimulation	Average days required for 1st emergence of radicle	Average days required for complete germination	Index of speed of germination	Nonvaible %	Mean shoot length (cm) per seedling	Shoot length inhibition or stimulation %	Mean root length (cm) per seedling	Root length inhibition or stimulation %	Mean length (cm) per seedling	Seedling length inhibition or stimulation %	Mean number of lateral roots	Shoot vigour Index	Root vigour Index	Seedling vigour index	Shoot/ Root ratio
0.1	94.00 ± 4.00	-2.08	3.60	7.20	18.70 ± 0.30	6.00	3.08 ± 0.50	+4.76	1.98 ± 0.32	-6.60	5.06 ± 0.79	00.00	1.60	289.52	186.12	475.64	1.55
0.2	98.00 ± 2.00	+2.08	3.60	7.20	21.22 ± 0.59	2.00	2.74 ± 0.42	-6.80	1.62 ± 0.20	-23.58	4.36 ± 0.60	-13.83	0.80	268.52	158.76	427.28	1.69
0.5	98.00 ± 2.00	+2.08	3.60	8.00	20.40 ± 0.50	2.00	3.60 ± 0.60	+22.45	1.96 ± 0.53	-7.55	5.56 ± 1.13	+9.88	1.40	352.80	192.08	544.88	1.83
1.0	96.00 ± 2.45	00.00	3.60	6.40	20.63 ± 0.45	4.00	3.98 ± 0.28	+35.37	1.54 ± 0.35	-27.36	5.52 ± 0.49	+9.09	3.20	382.08	147.84	529.92	2.58
2.0	94.00 ± 2.45	-2.08	3.80	7.80	19.57 ± 0.51	6.00	4.30 ± 0.48	+46.26	0.74 ± 0.14	-65.09	5.04 ± 0.61	-0.39	2.00	404.20	69.56	473.76	5.81
5.0	96.00 ± 4.00	00.00	4.0	8.20	19.03 ± 0.52	4.00	2.90 ± 0.42	-1.36	0.12 ± 0.02	-94.34	3. ± 0.44	-40.31	00.00	278.40	11.52	289.92	24.16
Control	96.00 ± 2.45	00.00	3.40	8.80	19.35 ± 0.41	4.00	2.94 ± 0.32	00.00	2.12 ± 0.40	00.00	5.06 ± 0.67	00.00	0.60	282.24	203.52	485.76	1.38

Number of '+' signs indicates stimulation and '-' signs indicates inhibition.

control set, this figure was 3.40 days. The average days for the completion of germination were comparatively less in GA_3 treatments than the control. It took the minimum length of time (6.40 days) at 1.0 mg /l GA_3 treatment. At 0.1 and 0.2 mg / l levels of GA_3 solutions, it required 7.20 days for the completion. Maximum period of 8.20 days were taken for completing the germination when experiments were conducted at 5.00 mg /l GA_3 solution. Moreover, an average of 8.00 and 7.80 days were required at 0.5 and 2.0 mg /l GA_3 treatments for completing the process of germination.

The present investigation exhibited higher index of speed of germination in almost all concentrations of GA_3. At 0.2, 0.5, 1.0 and 2.0 mg /l GA_3 treatments, the index of speed of germination were 21.22 ± 0.59, 20.40 ± 0.50, 20.63 ± 0.45 and 19.57 ± 0.51, respectively. In comparison with control (19.35 ± 0.41) slightly reduced index of speed of germination was observed at 0.1 and 5.0 mg /l GA_3 solutions (18.70 ± 0.30 and 19.03 ± 0.52, respectively).

A comparison of the rate of germination under different GA_3 concentrations reveal that germination was faster with all concentrations in *S. sylvestre* (Fig-6.11). Moreover at 0.2 and 1.00 mg/l GA_3 treatments the rate of gemination was higher, where germination was started on the third day and was completed on the nineth and seventh days, respectively. About 80.00 % seed germination was obtained there within five days and 96.00 % germination was occurred within seven days. In addition, 0.5 mg/l GA_3 solution showed quick germination, where 38.00 % seeds were germinated within four days and 84.00 percent within six days.

The shoot and root length of seedlings showed considerable dissimilarities within the same germination medium (Plate-V). As regards to the shoot elongation, GA_3 at 0.1, 0.5, 1.0 and 2.0 mg/l levels proved most effective which caused 4.76, 22.45, 35.37 and 46.26 % stimulation in shoot length, respectively, over control. Besides, 0.2 and 5.0 mg/l GA_3 solution showed slight inhibitory effect in shoot length. In this investigation it was also seen that the healthy hypocotyles were produced at 1.0 and 2.0 mg/l GA_3 treatments. Expanded cotyledons and healthy hpocotyles were observed at 5.0 mg/l GA_3 treatments.

The root growth rate did not follow the same trend as that of the shoot. The root elongation was retarded markedly under the influence of GA_3 in different concentrations. The maximum (1.98 ± 0.32 cm) and minimum (0.12 ± 0.02 cm) root length were under 0.1 mg/l (lowest) and 5.0 mg/l (highest) levels of GA_3 , respectively, as compared to the 2.12 ± 0.40 cm attained under control. However, application of 0.2, 0.5, 1.0 and 2.0 mg/l GA_3 solutions exhibited 23.58, 7.55, 27.36

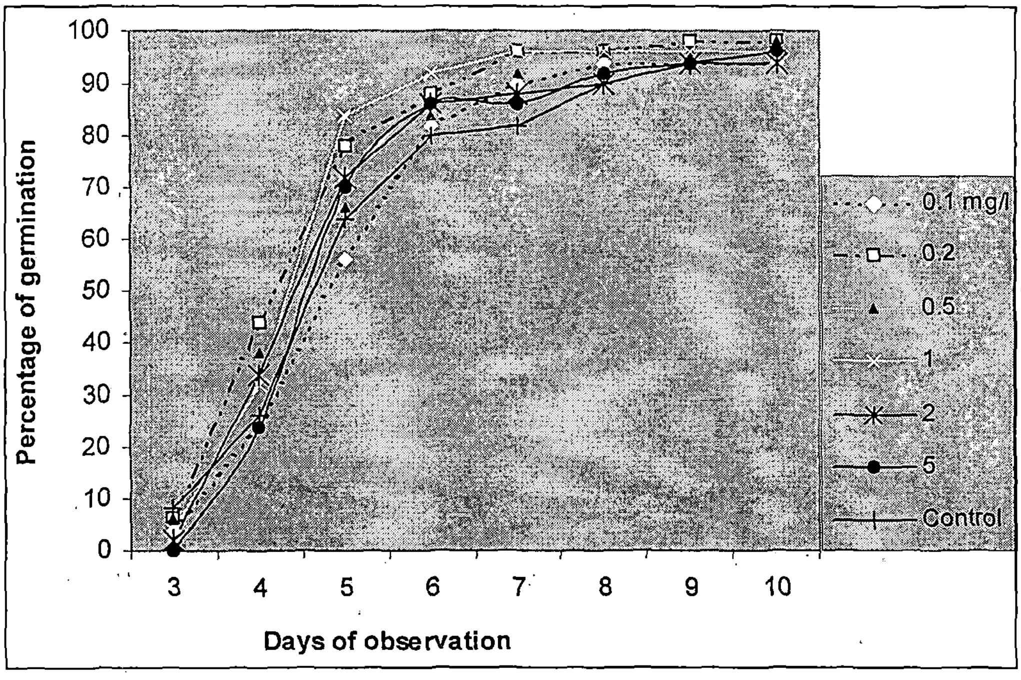


Fig-6.11 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different concentrations of GA_3.

and 65.09 % inhibition in root length, respectively, as compared to control. Lateral roots were formed in almost all concentrations except 5.0 mg/l GA_3 , and 1.0 mg/l solution produced highest number of lateral roots (3.20).

However, in comparison to the control (5.06 cm), the total length of seedling was observed to be longer in 0.5 and 1.0 mg/l GA_3 treatments (5.56 ± 1.13 and 5.52 ± 0.49 cm, respectively)and the seedling length was appreciable with 0.1 and 2.0 mg/l GA_3 solutions. Seedling vigour index was more at 0.5 and 1.0 mg/l GA_3 solutions (544.88 and 529.92, respectively) as against the control (485.76). In general, the shoot : root ratio was more in all concentrations, specially in higher concentration, this ratio was increased very much indicating more inhibition of root growth.

Gibberellic acid has been shown to stimulate seed germination and seedling growth by number of workers (Kahn *et al.* 1957; Wittwer & Bukovac, 1957; Brain et al.; 1962; Laloraya & Rai, 1962). It was also reported that, gibberellic acid, in fact, found to reverse the inhibitory effect of light and dark (Evenari et al. 1958; Phinney & West, 1960) Chawan & Sen (1970) observed that the presence of GA_3 compensated the requirement of light when the seeds of *Asteracantha longifolia* were germinated in total darkness although they were found to prefer light for germination. Kahn et al. (1956) and Lona (1956) indicated that gibberelic acid stimulated the germination of *Lactuca sativa* and *L. scariola* in the dark. However in the present investigation gibberellic acid showed slight stimulatory effect or remain ineffective in germination promotion of *S. sylvestre*.

Weaver (1972) expressed the opinion that gibberellic acid will increase the germination rate, stimulate seedling growth and overcome dwarfing of dormant epicotyles. In case of *S. sylvestre* gibberellic acid also increased the rate of germination and index of speed of germination in almost all concentrations under experiment. As far as the root and shoot growth are concerned, gibberellic acid enhanced the shoot length of *S. sylvestre* at some specific concentrations. Simultaneously, there was a corresponding decrease in root length. The increased shoot growth may be due to the enhanced enzymatic activity by different concentrations of gibberellic acid. Richardson (1958) reported a definite promotion of root growth in seedlings of *Pseudotsuga* by gibberellic acid, whereas the results of the present experiment do not corroborate the same, rather support the finding of Brain *et al.* (1955) and Key (1969). Brain *et al.* reported that gibberellic acid had no significant effect on root growth. Key also noted that gibberellins have a function in regulating nucleic acid and protein synthesis and may be suppressing root elongation by interfering with these processes.

6.2.12. EFFECT OF 6-BENZYLAMINO PURINE (BAP) ON SEED GERMINATION AND SEEDLING GROWTH OF *Streptocaulon sylvestre* WIGHT.

The present investigation was performed to study the role of 6-Benzylamino Purine (BAP) on seed germination and early growth of seedlings in *Streptocaulon sylvestre* Wight. Results are presented in Table-6.13 and Fig-6.12. From the perusal of the data it is apparent that the highest germination percentage of 98.00 ± 2.00 was obtained from seeds treated with 1.00, 2.00 and 5.00 mg/l BAP solutions caused, 2.08 % stimulation over control (96.00 ± 2.45 %). The lowest germination percentage of 92.00 ± 2.00 was achieved with 0.2 mg/l BAP solution which resulted in 4.16 % inhibition as against the control. Concentration of 0.1 mg/l BAP solution showed a similar rate of germination percentage (96.00) as observed under the control. In addition, concentration of 0.5 mg/l BAP solution obtained 94.00 ± 4.00 % seed germination. Thus BAP seems to affect the germination percentage differently depending on its concentration.

The ranges of average days for first emergence of radicle and to complete the process were 3.20 to 3.60 and 7.00 to 8.20 days, respectively. It required 3.20

Table 6.13 : Effect of 6-Benzylamino Purine (BAP) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight

BAP concentration mg/l	Germination %	Germination % Inhibition or stimulation	Average days required for 1st emergence of radicle	Average days required for complete germination	Index of speed of germination	Nonvaible %	Mean shoot length (cm) per seedling	Shoot length inhibition or stimulation %	Mean root length (cm) per seedling	Root length inhibition or stimulation %	Mean length (cm) per seedling	Seedling length inhibition or stimulation %	Mean number of lateral roots	Shoot vigour Index	Root vigour Index	Seedling vigour index	Shoot/ Root ratio
0.1	96.00 ± 4.00	00.00	3.60	7.80	19.42 ± 0.90	4.00	2.84 ± 0.35	-3.52	1.56 ± 0.26	-26.41	4.40 ± 0.47	-13.04	0.80	272.64	149.76	422.40	1.82
0.2	92.00 ± 2.00	-4.16	3.20	7.80	19.56 ± 0.75	8.00	2.52 ± 0.53	-14.28	2.10 ± 0.29	-0.94	4.62 ± 0.67	-8.69	2.00	231.84	193.20	425.04	1.20
0.5	94.00 ± 4.00	-2.08	3.60	8.20	20.17 ± 0.83	6.00	2.68 ± 0.28	-8.84	2.16 ± 0.66	+1.88	4.84 ± 0.81	-4.35	2.20	251.92	203.04	454.96	1.24
1.0	98.00 ± 2.00	+2.08	3.40	7.20	22.17 ± 0.31	2.00	2.16 ± 0.17	-26.53	1.04 ± 0.27	-50.94	3.20 ± 0.36	-36.76	1.60	211.68	101.92	313.60	2.07
2.0	98.00 ± 2.00	+2.08	3.40	7.00	22.18 ± 0.36	2.00	2.74 ± 0.35	-6.80	0.42 ± 0.04	-80.18	3.16 ± 0.38	-37.55	00.00	268.52	41.16	309.68	6.52
5.0	98.00 ± 2.00	+2.08	3.60	7.20	21.29 ± 0.45	2.00	2.18 ± 0.35	-25.85	0.24 ± 0.06	-88.68	2.42 ± 0.38	-52.17	00.00	213.64	23.52	237.16	9.08
Control	96.00 ± 2.45	00.00	3.40	8.80	19.35 ± 0.41	4.00	2.94 ± 0.32	00.00	2.12 ± 0.40	00.00	5.06 ± 0.67	00.00	00.60	282.24	203.52	485.76	1.38

+ / - indicates stimulation / inhibition of germination or seedling growth.

days for first emergence of radicle and 7.80 days for completing the germination at 0.2 mg/l BAP solution. At 1.0 and 2.0 mg/l BAP solutions, it took 3.40 days for first emergence of radicle and 7.20 and 7.00 days for completing the germination, respectively. Besides at 0.1, 0.5 and 5.0 mg/l BAP solutions 3.60 days were taken for first emergence of radicle and 7.80, 8.20 and 7.20 days were required for completing the germination, respectively.

It was seen that all BAP treatments showed better index of speed of germination over control. The highest index of speed of germination was obtained at 1.0 and 2.0 mg/l BAP solutions (22.17 ± 0.31 amd 22.18 ± 0.36, respectively). At 0.1, 0.2, 0.5 and 5.0 mg/l BAP solutions the index of speed of germination were 19.42 ± 0.90, 19.56 ± 0.75, 20.17 ± 0.83 and 21.29 ± 0.45, respectively.

In this investigation a comparison of dynamics of seed germination and index of speed of germination of different BAP solutions reveals that the rate of germination was faster in all these treatments, (Fig-6.12). Moreover at 1.0 and 2.0 mg/l BAP solutions the rate of germination were very quick, where germination was started on the third day and was completed on the ninth day. About 50.00 % seed germination was obtained there within four days and 80.00 % within five days after sowing. Futhermore, it was also observed that the rate of germination was

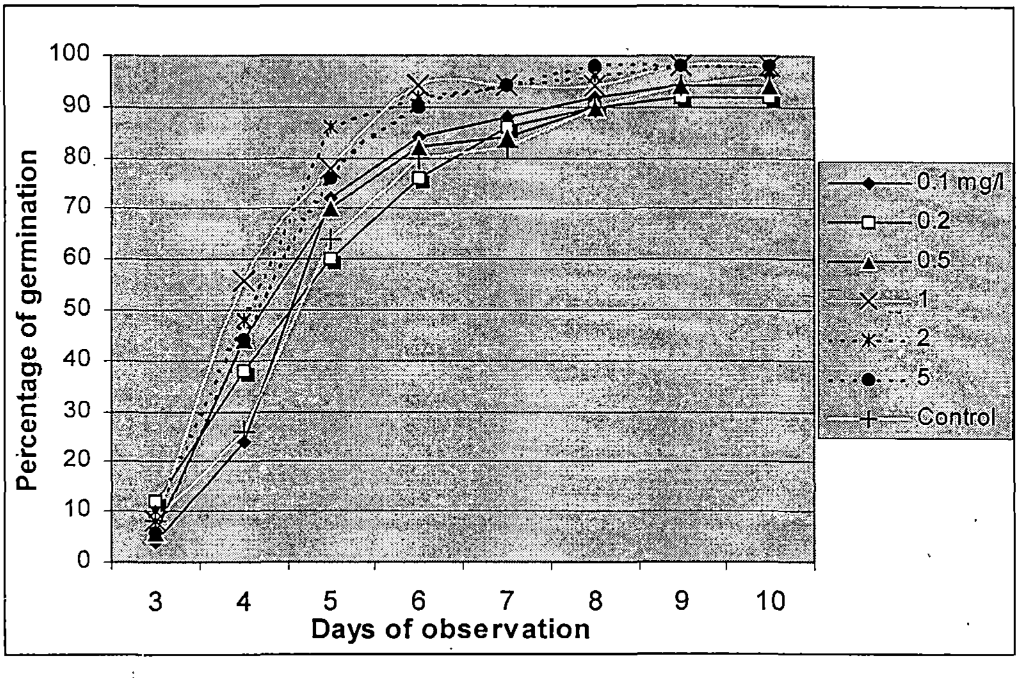


Fig-6.12 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different concentrations of BAP.

quickest at 5.0 mg/l BAP treatment, where germination was started on the third day and was completed on the eightth day after sowing and 44.00 % seeds were germinated within four days and 90.00 % within six days.

The effect of BAP on early growth parameters of seedling were different (Plate-V). BAP reduced the shoot length in all concentrations. Although there was no considerable difference in shoot length amongst the different concentrations of BAP. The maximum (2.84 ± 0.35 cm) and minimum (2.18 ± 0.35cm) shoot length were observed in 0.1 and 5.0 mg/l BAP concentrations. Application of BAP solutions, namely 0.1, 0.2, 0.5, 1.0, 2.0 and 5.0 mg/l showed 3.52, 14.28, 8.84, 26.53, 6.80 and 25.85 % inhibition in shoot length as against control. In this study healthy cotyledons were found to be observed at 1.0 mg/l BAP treatment. At 2.00 mg/l BAP treatment hyhocotyle and cotyledon of each seedling became thick and healthy. Besides heavy healthy cotyledon and thick hypocotyl was developed with 5.0 mg/l BAP treatment (Plate-V).

Marked inhibition of root growth was also observed in higher concentration of 1.0, 2.0 and 5.0 mg/l BAP solutions resulting in steady decline of 50.94, 80.18 and 88.68 % in root length as against control, respectively. While in lower concentrations of 0.2 and 0.5 mg/l, slight stimulatory effect in root length was observed (0.94 and 1.88 %, respectively). In addition lateral roots were also developed in all lower concentrations of BAP. In general, vigour index was less in all concentrations as compared to control. Moreover increased shoot : root ratio indicated high inhibition of root development than that of shoot at all higher concentrations. However BAP was observed to be inhibitory in seedling elongation of *Streptocaulon sylvestre* Wight.

6.2.13. EFFECT OF INDOLE ACETIC ACID ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF *Streptocaulon sylvestre* WIGHT.

This investigation was conducted to ascertain the effect of Indole acetic Acid (IAA) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight. The results obtained for different parameters are demonstrated in Table-6.14 and in Fig-6.13. Results indicate that the effect of IAA on the germination of seeds of *S. sylvestre* varied according to its concentration. In this study the concentrations of 0.5 and 1.0 mg/l IAA were observed to be stimulatory, showed highest amount of germination (98.00 ± 2.00 %). Minimum germination (92.00 ± 3.74 %) was obtained from 0.2 mg/l IAA solution caused 4.16 % inhibition in seed germination as compared to control. In addition concentrations of 0.1 and 2.00 mg/l were also showed inhibitory

Table 6.14 : Effect of Indole acetic acid (IAA) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight

IAA concentration mg/l	Germination %	Germination % Inhibition or stimulation	Average days required for 1st emergence of radicle	Average days required for complete germination	Index of speed of germination	Nonvaiable %	Mean shoot length (cm) per seedling	Shoot length inhibition or stimulation %	Mean root length (cm) per seedling	Root length inhibition or stimulation %	Mean length (cm) per seedling	Seedling length inhibition or stimulation %	Mean number of lateral roots	Shoot vigour Index	Root vigour Index	Seedling vigour index	Shoot/ Root ratio
0.1	94.00 ± 2.45	-2.08	3.60	7.80	18.80 ± 0.46	6.00	2.24 ± 0.26	-23.81	1.98 ± 0.35	-6.60	4.22 ± 0.46	-16.60	3.00	210.56	186.12	396.68	1.13
0.2	92.00 ± 3.74	-4.16	3.60	7.20	19.01 ± 0.83	8.00	2.00 ± 0.39	-31.97	3.36 ± 0.93	+58.49	5.36 ± 1.25	+5.92	1.40	184.00	309.12	493.12	0.59
0.5	98.00 ± 2.00	+2.08	3.20	8.20	22.31 ± 0.37	2.00	1.88 ± 0.40	-36.05	3.00 ± 0.52	+41.51	4.88 ± 0.76	-3.56	3.00	184.24	294.00	478.24	0.62
1.0	98.00 ± 2.00	+2.08	3.40	6.80	21.31 ± 0.85	2.00	1.94 ± 0.12	-34.01	3.16 ± 0.67	+49.05	5.10 ± 0.72	+0.79	2.60	190.12	309.68	499.80	0.61
2.0	94.00 ± 2.45	-2.08	3.40	7.40	19.38 ± 0.68	6.00	2.42 ± 0.31	-17.68	2.84 ± 0.38	+33.96	5.26 ± 0.45	+3.95	2.00	227.48	266.96	494.44	0.85
5.0	96.00 ± 2.45	00.00	3.60	7.60	19.69 ± 0.54	4.00	2.90 ± 0.40	-1.36	2.46 ± 0.21	+16.04	5.36 ± 0.51	+5.93	2.80	278.40	236.16	514.56	1.18
Control	96.00 ± 2.45	00.00	3.40	8.80	19.35 ± 0.41	4.00	2.94 ± 0.32	00.00	2.12 ± 0.40	00.00	5.06 ± 0.67	00.00	0.60	282.24	203.52	485.76	1.38

Number of '+' signs indicates stimulation and '-' signs indicates inhibition.

effect on seed germination. Application of 5.00 mg/l IAA caused equal (96.00 ± 2.45 %) amount of germination to that of the control.

With IAA treatments, the ranges of average days for the first emergence of radicle and for completing the germination were 3.20 to 3.60 days and 6.80 to 8.20 days, respectively, It required 3.20 days for the first emergence of radicle and 8.20 days for complete the germination at 0.5 mg/l IAA solution. At 1.0 and 2.0 mg/l IAA solutions 3.40 days were taken for first emergence of radicle and 6.80 and 7.40 days were required for completing the germination, respectively. Moreover, at 0.1, 0.2 and 5.0 mg/l levels of IAA it took 3.60 days for first emergence of radicle and average 7.8, 7.2 and 7.60 average days for completing the germination, respectively.

In this investigation, it was observed that the highest index of speed of germination (22.31 ± 0.37) was achieved at 0.5 mg/l IAA followed by 1.0 mg/l IAA (21.31 ± 0.85) treatment. In addition, the index of speed of germination of 18.80 ± 0.46, 19.01 ± 0.83, 19.38 ± 0.68 and 19.69 ± 0.54 were obtained at 0.1, 0.2, 2.0 and 5.0 mg/l IAA solutions, respectively.

A comparison of the dynamics of seed germination and the index of speed of germination of tested IAA solutions indicates that the rate of germination was faster at all IAA treatments in *S. sylvestre* (Fig-6.13). Although in 0.5 and 1.0 mg/l IAA solutions the rate of germination was very quick, where germination was started on the third day and was completed on the tenth and eighth day after sowing, respectively. 80.00 % seed germination was achieved there within five days and 90.00 % within seven days after sowing. Moreover the rate of germination was quick at 5.0 mg/l IAA. Germination initiated there on the third day and was completed on the ninth day after sowing. 72.00 and 92.00 % seed gerimination was obtained within five and seven days after sowing, respectively.

In this study seedling growth of *S. sylvestre* was affected variably under IAA treatments (Plate-IV & V). The shoot length was observed to be inhibited by all the concentrations of IAA used in the present experiment. The maximum (2.90 ± 0.40 cm) and minimum (1.88 ± 0.40 cm) shoot length were recorded under 5.0 and 0.5 mg/l IAA treatments, respectively. Different concentrations of IAA solutions, namely 0.1, 0.2, 0.5, 1.0, 2.0 and 5.0 mg/l caused 23.81, 31.97, 36.05, 34.01, 17.68 and 1.36 % inhibition in shoot length, respectively, as against the control.

The root length of seedlings were distinctly enhanced in almost all concentrations of IAA. Only the lowest concentration (i.e. 0.1 mg/l) was slightly inhibitory to root elongation. The maximum root length was obtained from 0.2 mg/l of IAA (3.36 ± 0.93 cm). Treatments with 0.2, 0.5, 1.0, 2.0 and 5.0 mg/l IAA solutions showed 58.49, 41.51, 49.05, 33.96 and 16.04 % stimulation in root length, respectively, over control. IAA also accelerated lateral root formation in all concentrations. 0.1 and 0.5 mg/l IAA initiated maximum number of lateral roots (3.00).

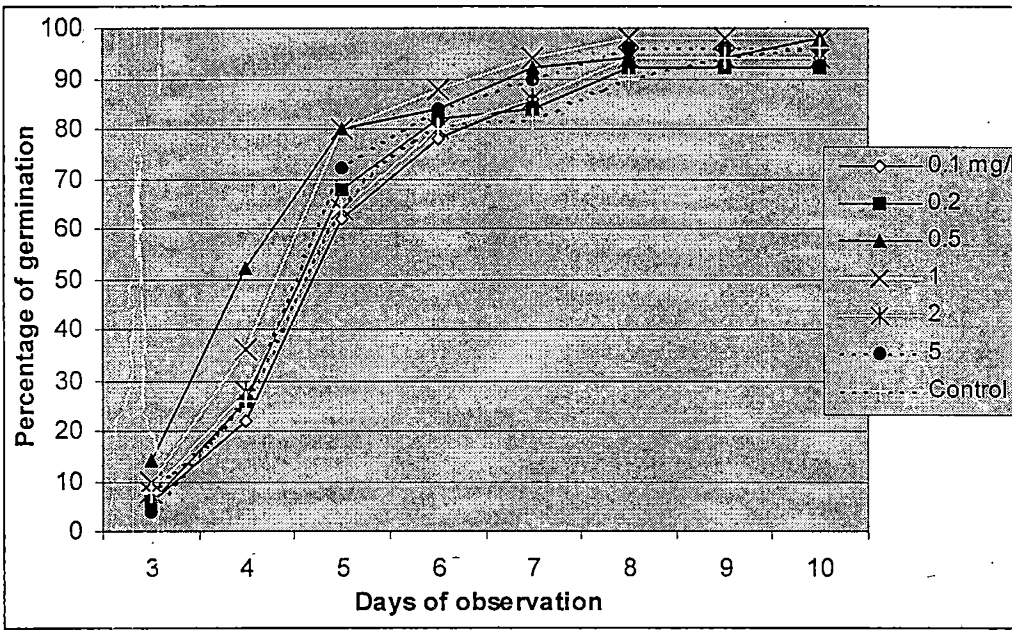


Fig-6.13 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different concentrations of IAA.

Moreover, total length of seedling of *S. sylvestre* was appeared to be promoted at almost all concentrations of IAA. It can be seen that there were 5.92, 0.79, 3.95 and 5.93 % stimulation in the linear growth of seedlings at 0.2, 1.0, 2.0 and 5.0 mg/l levels of IAA, respectively, as against the control. Only 0.1 and 0.5 mg/l concentrations showed 16.60 and 3.56 % inhibition, respectively. Root vigour index was more in almost all concentrations except 0.1 mg/l IAA. The shoot : root ratio followed the similar pattern of response as for the shoot and root growth which was generally lower than 1.00, indicating vigorous development of root system than that of the shoot. During investigation it was also seen that root and shoot, both, became healthy at 5.0 mg/l IAA treatment. In addition, vigorous root growth was observed at 0.2 and 0.5 mg/l IAA concentrations.

Mayer & Poljakoff-Mayber (1975) noted that Indole acetic acid (IAA) can, under very special conditions, stimulate germination, but normally it has little or no effect. They also mentioned that the effect of IAA on germination has long been in

EXPLANATIONS OF PHOTOGRAPHS

Plate V.
Germination of *Streptocaulon sylvestre* Wight:

Photo 1. Germination with different concentration of GA_3 [A= Control; B= 0.1 mg/l; C= 0.2 mg/l; D= 0.5 mg/l; E= 1.0 mg/l; F= 2.0 mg/l; G= 5.0 mg/l]

Photo 2. Germination with different concentration of BAP [A= Control; B= 0.1 mg/l; C= 0.2 mg/l; D= 0.5 mg/l; E= 1.0 mg/l; F= 2.0 mg/l; G= 5.0 mg/l]

Photo 3. Formation of giant seedlings along with the complete suppression of radicle development (under 2.0 & 5.0 mg/l concentration of BAP)

Photo 4. A naturally developed seedling with three cotyledons

Photo 5. A naturally developed seedling with four cotyledons

Photo 6. Germination with 0.1 mg/l concentration of BAP

Photo 7. Germination with 5.0 mg/l concentration of BAP

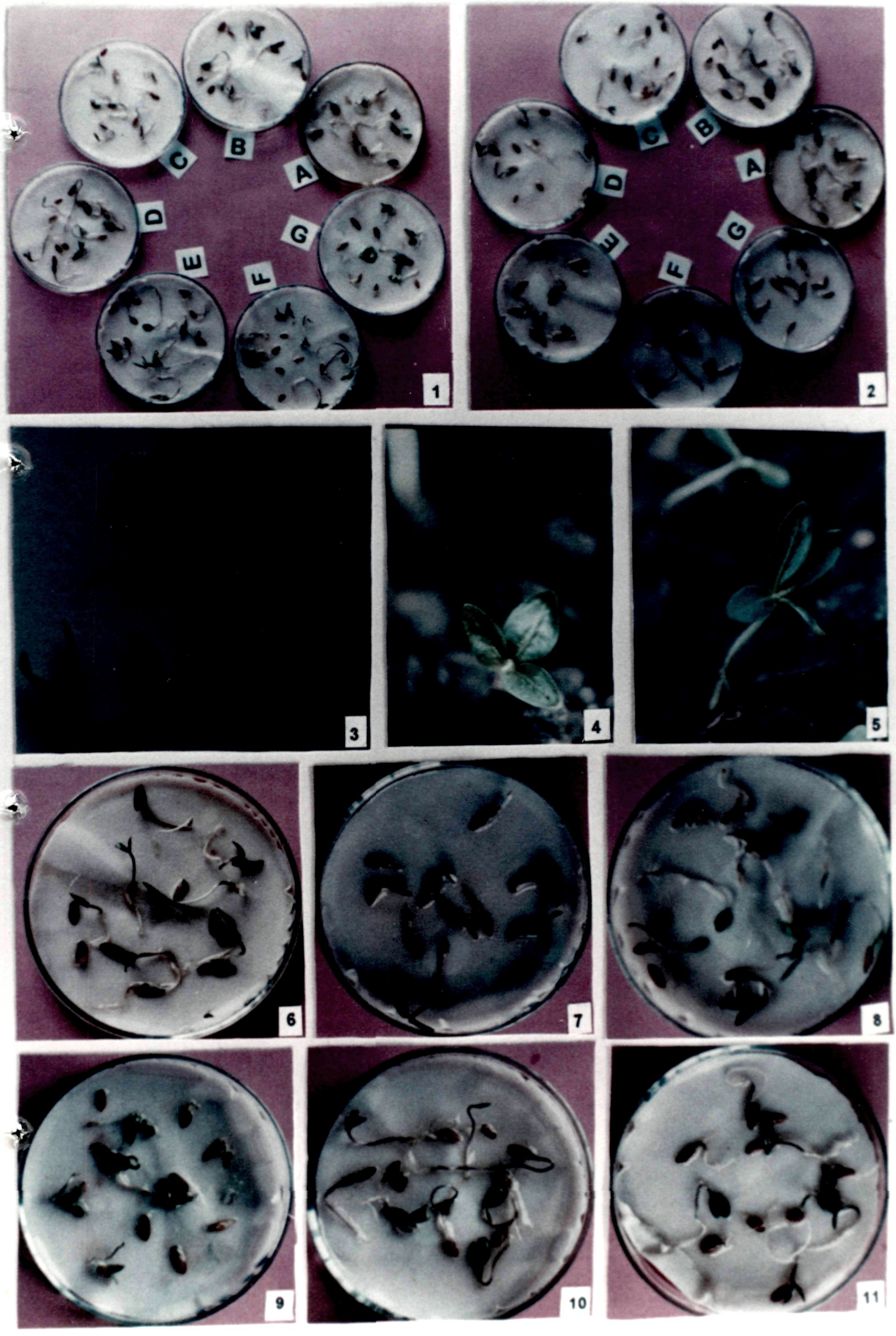
Photo 8. Germination with 1.0 mg/l concentration of GA3

Photo 9. Germination with 5.0 mg/l concentration of GA3

Photo 10. Germination with 1.0 mg/l concentration of IAA

Photo 11. Germination with 2.0 mg/l concentration of IAA

PLATE V



dispute. Numerous workers have investigated the effect of IAA on germination of a variety of seeds and have obtained conflicting results, stimulation or inhibition being obtained, depending on the concentration of IAA and the type of seed used. Kumar & Sinha (1992) reported that IAA was observed to be promotive on germination to limited extent under light and dark in *Indigofera linnaei*. In the present study, IAA was found to have both the stimulatory as well as the inhibitory effects on the germination of seeds of *S. sylvestre,* depending on the concentration.

It is well known that IAA enhances root formation in plant. Thimann & Went (1934) and Thimann & Koepfli (1935) observed that IAA was found to promote root growth and adventitious root formation. In this investigation IAA stimulated root elongation and enhanced lateral root formation of *S. sylvestre* which corroborates the above mentioned findings.

6.2.14. EFFECT OF 2,4- DICHLOROPHENOXYACETIC ACID ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF *Streptocaulon sylvestre* WIGHT.

The objective of this study was to examine the effect of 2,4-Dichlorophenoxyacetic acid (2,4- D) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight. Results of these experiments are shown in Table-6.15 and in Fig-6.14. Data on the amount of germination showed that highest percentage of (96.00 ± 4.00 %) seeds were germinated with minimum concentration of 0.1 mg/l 2,4- D solution. Thereafter number of germinating seeds started decreasing with increasing concentrations of 2,4- D. Lowest number of seed germination (80.00 ± 3.16 %) was observed at 5.00 mg/l 2,4-D solution resulting in 16.66 percent inhibition as compared to control (96.00 ± 2.45 %). Treatments with 0.2, 0.5, 1.0 and 2.0 mg/l 2,4- D solutions showed 2.08, 8.33, 10.41 and 12.50 % inhibition, respectively, in seed germination as against control. Thus in *S. sylvestre* 2,4-D was observed to be inhibitory on seed germination at almost all concentrations.

With 2,4-D treatments, the ranges of average days for the first emergence of radicle and for completing the germination were 4.00 to 4.40 days and 7.00 to 9.60 days, respectively. It required 4.00 and 7.00 days for the initiation and for completing the germination at lowest concentration of 0.1 mg/l 2,4-D. The same for 5.0 mg/l 2,4-D were 4.40 and 9.20 days, respectively. In addition at 0.2, 0.5, 1.0 and 2.0 mg/l 2,4-D solutions 4.00, 4.40, 4.00 and 4.20 days were taken for the first emergence of radicle and 8.20, 7.40, 9.00 and 9.60 days for completing the process, respectively.

Table 6.15 : Effect of 2,4-Dichlorophenoxy acetic acid (2,4-D) on seed germination and seedling growth of *Streptocaulon sylvestre* Wight

2,4-D concentration mg/l	Germination %	Germination % Inhibition or stimulation	Average days required for 1st emergence of radicle	Average days required for complete germination	Index of speed of germination	Nonvaiable %	Mean shoot length (cm) per seedling	Shoot length inhibition or stimulation %	Mean root length (cm) per seedling	Root length inhibition or stimulation %	Mean length (cm) per seedling	Seedling length inhibition or stimulation %	Mean number of lateral roots	Shoot vigour Index	Root vigour Index	Seedling vigour index	Shoot/ Root ratio
0.1	96.00 ± 4.00	00.00	4.00	7.00	19.00 ± 0.65	4.00	2.72 ± 0.11	-7.48	0.56 ± 0.02	-73.58	3.28 ± 0.11	-35.17	1.20	261.12	53.76	314.88	4.86
0.2	94.00 ± 2.45	-2.08	4.00	8.20	18.67 ± 0.26	6.00	1.72 ± 0.47	-41.49	0.40 ± 0.03	-81.13	2.12 ± 0.50	-58.10	0.80	165.12	38.40	203.52	4.30
0.5	88.00 ± 2.00	-8.33	4.40	7.40	15.86 ± 0.16	12.00	1.22 ± 0.20	-58.50	0.30 ± 0.04	-85.85	1.52 ± 0.23	-69.96	00.00	114.68	28.20	142.88	4.06
1.0	86.00 ± 2.45	-10.41	4.00	9.00	13.65 ± 0.42	14.00	0.42 ± 0.11	-85.71	0.16 ± 0.02	-92.45	0.58 ± 0.11	-88.54	00.00	38.64	14.72	53.36	2.62
2.0	84.00 ± 2.45	-12.50	4.20	9.60	13.11 ± 0.22	16.00	0.66 ±0.35	-77.55	0.16 ± 0.02	-92.45	0.82 ± 0.36	-83.79	00.00	59.40	14.40	73.80	4.12
5.0	80.00 ± 3.16	-16.66	4.40	9.20	11.96 ± 0.58	20.00	0.24 ± 0.02	-91.83	0.18 ± 0.02	-91.51	0.42 ± 0.04	-91.69	00.00	20.64	15.48	36.12	1.33
Control	96.00 ± 2.45	00.00	3.40	8.80	19.35 ± 0.41	4.00	2.94 ± 0.32	00.00	2.12 ± 0.40	00.00	5.06 ± 0.67	00.00	0.60	282.24	203.52	485.76	1.38

+ / - indicates stimulation / inhibition of germination or seedling growth.

In this study, it was seen that the index of speed of germination was inversely related to the concentrations of 2,4-D solutions. Treatment with lowest concentrations of 0.1 mg/l 2,4-D solution registered highest index of speed of germination (19.00 ± 0.65) followed by 0.2 mg/l 2,4-D solution (18.67 ± 0.26). Similarly at 0.5, 1.0, 2.0 and 5.0 mg/l levels of 2,4-D, the index of speed of germination were 15.86 ± 0.16, 13.65 ± 0.42, 13.11 ± 0.22 and 11.96 ± 0.58, respectively.

In this investigation, results of dynamics (Fig-6.14) and index of speed of germination of different 2,4-D solution indicate that the rate of germination of *S. sylvestre* was faster at lower concentrations and was slower at higher concentrations of 2,4-D treatments. At 0.1and 0.20 mg/l 2,4-D solutions, germination was started on the fourth day and was completed on the eighth and ninth days, respectively, after sowing. About 60.00 % seed germination was obtained within five days. On the other hand, at 5.0 mg/l 2,4-D treatment germination was started on the fourth day and was completed on the tenth day after sowing. Only 14.00 % germination was achieved there within five days and 62.00 % within eight days after sowing.

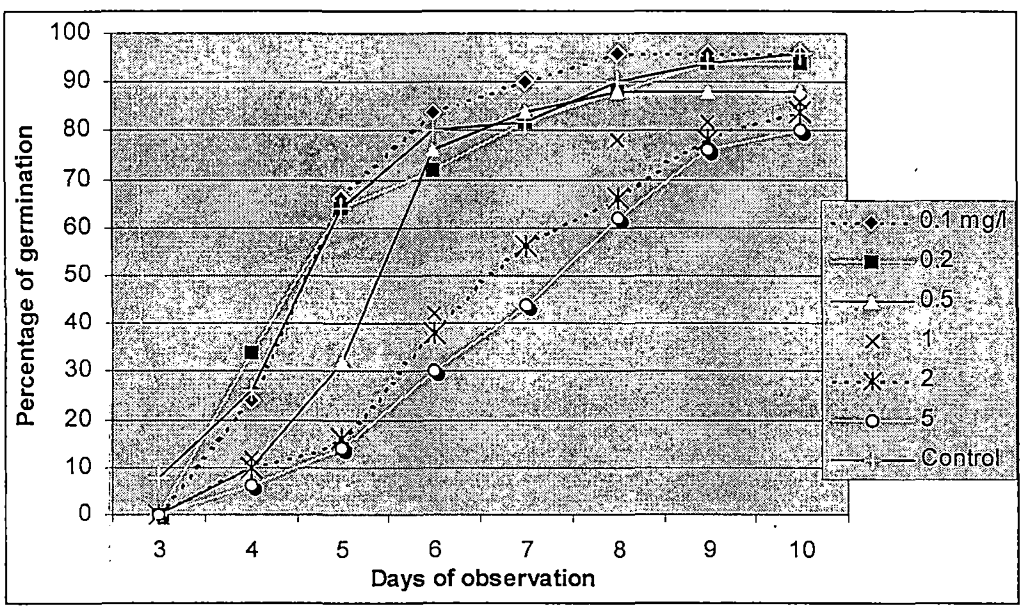


Fig-6.14 Dynamics of seed germination of *Streptocaulon sylvestre* Wight at different concentrations of 2,4-D.

During investigation, it was observed that 2,4-D treatments markedly retarded the seedling growth of *S. sylvestre* at all concentrations (Plate-IV). The degree of inhibition, from partial to complete, was dose dependent. The maximum seedling length was at 0.1 mg/l (3.28 ± 0.11 cm) whereas 5.0 mg/l resulted in the production of shortest tiny seedlings (0.42 ± 0.04 cm). For control this figure was 5.06 ± 0.67 cm.

As far as the shoot length is concerned, 2,4-D at 0.1, 0.2, 0.5, 1.0, 2.0 and 5.0 mg/l concentrations caused 7.48, 41.49, 58.50, 85.71, 77.55 and 91.83 % inhibition in shoot length, respectively, as against the control. The length of the hypocotyl and radicle also showed considerable dissimilarities on growth pattern in the same concentration of 2,4-D. Treatments with 0.1, 0.2, 0.5, 1.0, 2.0 and 5.0 mg/l 2,4-D showed 73.58, 81.13, 85.85, 92.45, 92.45 and 91.51 % inhibition in root length, respectively, as compared to control. The shoot : root ratio at all concentrations were also increased which indicated more inhibition of growth of root system than shoot. Inspite of that vigour indices were lower in all concentrations of 2,4-D.

The effect of 2,4-D on seedling growth pattern was very interesting. It was seen that at 0.2 mg/l 2,4-D treatment seedling showed healthy roots, whereas 0.5 mg/l exhibited heavy and healthy shoots and roots. Similarly at 1.0 and 2.0 mg/l treatments shoot base became very thick. Interestingly, shoot base of seedlings formed callus like tumour with small roots at 5.0 mg/l 2,4-D treatment. In all concentrations of 2,4-D, root tips turned gray and rotten.

Mayer & Poljakoff-Mayber (1975) mentioned that herbicides of various kinds inhibit germination to a greater or lesser extent. Many of the commonly used herbicides, such as 2,4-D, affect germination at comparatively low concentrations. In this study very low concentration of 2,4-D (0.1 mg/l) was considerably ineffective in seed germination of *Streptocaulon sylvestre* Wight whereas comparatively high concentrations inhibited and delayed germination inversely. Earlier many workers including Audus & Quastel (1947), Mayer & Evenari (1953), Isikawa (1955), Libbert (1957), Misra & Patnaik (1959) also reported inhibitory effect of 2,4-D on seed germination for other species.

Mayer & Poljakoff-Mayber (1975) noted that herbicides are frequently used to kill the freshly-emerging weed seedlings. He also mentioned that 2,4-D induces profound changes in the metabolism of treated plants. Sell *et al.* (1949) and Weller *et al.* (1950) obtained depletion of starch and sugar in red kidney bean with herbicidal doses of 2,4-D. Wort (1964) and Wort & Rathore (1967) obtained similar results in some other crop plants. Hitchcock & Zimmerman (1937, 1942) and Stoutemyer & O' Rourke (1945) observed that some of the phenoxy compounds having auxin activity promote root formation even at very low concentrations. Hartmann & Kester (1975) noted that the weed-killer, 2,4-D, is quite potent in inducing rooting of certain species, but it has the disadvantage of tending to inhibit the shoot development. Mayer & Poljakoff-Mayber (1975) mentioned that 2,4-D was found to change the carbohydrate metabolism of root tips of seedlings of a number of plants. In such root tips of intact seedling 2,4-D caused depressed glycolysis and increased metabolism via the pentose cycle. In the present experiment, seedling growth of *Streptocaulon sylvestre* was severely inhibited with treatments of 2,4-D and the degree of inhibition was concentration dependent. The root of the seedlings was more affected than the shoot and root tips turned gray and rotten. Callus like tumor formation occurred at the base of hypocotyle. This observation corroborates Hanson & Slife (1961), where they reported the tumer formation and abnormal growth with the application of 2,4-D.

6.2.15. REPRODUCTIVE CAPACITY AND SEEDLING SURVIVABILITY OF *Streptocaulon sylvestre* WIGHT.

The formation of flowers and then fruits, structure and number of fruits, number of seeds per fruit, the seasons of flower and fruit formation, reproductive capacity, etc are important aspects in the life cycle of a plant which greatly influence the success of a species among the members of the community in regeneration and establishment for generation after generation. Environment is greatly responsible for bringing about the initiation of flower and fruit formation. Even after effective pollination and fertilization the environment affects fruit formation to certain extent, especially certain disease causing fungi and insects damage flowers and fruits and thus affect fruit formation to a great extent. Thus the objective of this study was to examine the seed output, reproductive capacity, aggressive capacity and seedling survivability of *S. sylvestre*, aiming to clarify the possible regeneration problems of the species. The results of the investigation on different parameters are shown in Table-6.16.

Results reveal that the seed output of *S. sylvestre* was very low, although the average number of seeds per fruit was 30.64 ± 2.64. The average seed output of this plant was 13.35 ± 2.14. This was due to very low fruit producing capacity of the plant population. It was observed that 92.00 ± 3.74% plants produce flowers, but only 9.21 ± 0.97 % plants produce fruit. It flowered during March to February. Fruiting period was also ranged from March to February. Highest number of mature fruits were found during December and January. Average number of fruits per plant was 0.435 ± 0.06, although each fruit bearing plant produced average 4.73 ± 0.68 fruits. Average seed output of each fruit producing plant was 145.06 ± 23.23. This suffrutescent plant produce flowers and fruits once in a year and after ripening of fruits the aerial shoot died and underground part remain dormant for a short period of around one month. So, the reproductive capacity of *S. sylvestre* is very low. The reproductive capacity of the population was 7.209/ plant. However, the reproductive capacity of fruit producing plants was 78.33/ plant. This was due to very low seed output and low germination percentage in soil. Water content in soil might be the probable cause of low germination. This aspect discussed elaborately earlier in the germination aspects. Reproduction by vegetative parts (stems and roots) was tested but was not successful. The species never produce any adventitious root from nodes or internodes.

Table 6.16 : Reproductive capacity and seedling survivability of *Streptocaulon sylvestre* Wight.

Parameters	Results
Percentage of flower producing plants	92.00 ± 3.74
Percentage of fruit producing plants	9.21 ± 0.97
Average number of fruit per plant	0.435 ± 0.06
Average number of fruits per fruit producing plant	4.73 ± 0.68
Average number of seeds per fruit	30.64 ± 2.64
Average seed output per plant	13.35 ± 2.14
Average seed output per fruit producing plant	145.06 ± 23.23
Percentage of damage of seeds	8.52
Germination percentage of seeds in soil	54.00 ± 2.58
Reproductive capacity of plant	7.209
Reproductive capacity of fruit producing plant	78.33
Percentage of survivability of seedlings	40.46 ± 3.46
Percentage of mortality of seedlings	59.53 ± 3.46
Aggressive capacity of plants	2.916
Aggressive capacity of fruit producing plants	31.69

In this study it was also observed that the percentage of seedling mortality of *S. sylvestre* was higher than the percentage of seedling survivability which were 59.53 ± 3.46 % and 40.46 ± 3.46 %, respectively (Plate-IV).The aggressive capacity of this species was also lowest as both the reproduction capacity and seedling survivability was lower. The aggressive capacity of average population was 2.916 and fruit bearing plants was 31.69.

Salisbury (1942) mentioned that the seed output in a particular habitat may be an important factor in determining the occurrence as well as frequency or abudancy of a species in natural conditions. Ambasht & Ambasht (1996) noted that several environmental factors influence the seed output of an individual plant but, above all, biotic factors are the most important. In *S. sylvestre* it was observed that during fruit formation some unknown flower infecting fungi and insects damage the embryos at a very young stage leading to inhibition of fruits. Inspite of that herbivores mostly removed the top of grasslands plants giving little chance for the flower to developed fruit. Grazing animals, mostly cows and goats also trample these plants. Another probable cause of low fruit formation might be the pollination problem which was largely governed by the morphology of flower with regard to the position and time of maturity of the anthers and stigmas, season of flowering, wind movement and biotic agents of pollination (insects).

Salisbury (1942) noted that reproductive capacity indicates the potential for population growth. The reproductive capacity of a species is as much a characteristic as any other specific features and is of considerable ecological interest. It also has an importance in establishment of seedlings. In this case, low reproductive capacity of *S. sylvestre* indicates the lowest degree of abundance and frequency and also the lowest growth potential of this plant. A number of Indian weeds, grasses and forest trees have been investigated for their seed output and percentage germination which depicted their reproductive capacity. Nelivigi (1962) and Sant (1962) presented such values for a number of grasses and forbs. Paria & Sahoo (1981) reported the reproductive capacity of certain weed species growing in the vicinity of Calcutta.

Misra (1992) noted that frost, drought, grazing, trampling and fungal infections are some of the most important factors which influence seedling mortality. In *S. sylvestre* absence of early dormancy allowed rapid germination of dispersed seeds to a favourable condition which was uncongenial to seedling survivability. Shortly after germination the seedling might be exposed to extremes of many environmental factors. In April and May temporary rainfall favoured rapid germination of seeds which subsequently experience dryness or water stress around seedling roots causing permanent damage. On the other hand during June to September heavy rainfall washed off the seeds and young seedlings of this species which might be another important reason for seedling mortality. The influence of biota on seedling survivability might also be there. The soft and delicate young root needs to bear hard and granular soil through which it made its way. A large variety of unknown soil fauna and micro organism also damage soft roots. Moreover, grazing animals cause maximum damage to seedlings of *S. sylvestre* both by browsing and trampling in natural habitat. All the factors discussed above, together, lead to high rate of seedling mortality.