EFFECT OF SOME ENVIRONMENTAL FACTORS ON GERMINATION AND GROWTH OF *PLANTAGO OVATA* FORSSK

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Abstract

Germination and growth behaviour of *Plantago ovata* Forssk. was studied under different laboratory and field conditions. Maximum germination was observed in garden loam, followed by clayey soil at 20°C after 144 hours. Rate of germination decreased with increase in sodium chloride concentrations beyond 0.5%. Best growth and development of the plant was achieved under full light and on garden loam, followed by clayey soil.

Introduction

Plantago ovata Forssk. is much used as an Ayurvedic system medicine in the Indo-Pak sub-continent. Seeds with husk are known to be dimulcent, soothing and diuretic and so are used for various digestive and urinary diseases. Chopra (1958), based on his 15 years trials on *P. ovata*, has shown excellent results in chronic amoebic and bacillary dysentry, chronic constipation with auto-inoxication produced from other causes, hill diarrhea and chronic diarrhea in children. The seeds are also effective in cough, cold and sore-throat. With vinegar and oil, they are made into an emollient poultice which is applied to inflammatory swellings.

The chief constituent of the plant is the mucilage lying in the "husk", the epidermis of the seed-coat. While the mucilage yields two complex polysaccharides, the seeds proper contain a fixed oil, pentosins, aleuron and gelatins (Laidlaw and Percival, 1949 and 1950).

The plant is a small indigenous annual herb, found growing sparsely in the arid plains and low foothills but no where forming extensive crops for ready collection. As the arid plains are gradually being reclaimed and collection becoming difficult and collection changes heavy, the required supplies may no more be available. In order to make large supplies available on sustained yield basis, it would therefore, be desirable to raise it as a crop, but no information on its ecological behaviour is hither-to known. With a view to provide some data on optimal environmental conditions for germination and growth of the plant, the present study, involving temperature, light soil type and soil salinity conditions, was undertaken.

Review of Literature

Information on the ecological behaviour of the plant is hither-to not available. One pertinent reference of Vaichyunene (1973) states that 20–30°C is the optimum temperature for the best growth of the plant. The present investigation in Pakistan is, therefore, pioneer and original.

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Material and Methods

Seed germination and growth behaviour of *Plantago ovata* was studied, making many assays under laboratory and field conditions.

A. Investigations under lab conditions:

Germination was tested separately under different air temperatures and different salinities.

(a) *Germination at different temperature*: Seed was sown on moist Whattman No. 1 filter paper in sterilized air-tight petri dishes, each having 10 seeds and 5 replicates, and incubated at 20, 25 and 30°C for 144 hours to find out the optimum temperature to be maintained in the subsequent assays, examining and moistening them daily again wherever necessary. Emergence of radical was taken as the index of germination (Gulliver and Heydecker, 1975; Come and Tissani, 1973).

(b) *Germination under saline conditions*: Seeds were sown on filter paper moistered with distilled water (control) and solutions of NaCl at 0.5, 1.0, 1.5, 2.0, 2.5 and 3% by weight (gm) in distilled water (cc) and incubated at 20° for 144 hours.

B. Investigations under field conditions

(a) *Germination in different soil types*: 15 seeds were sown in each of the 5 equal-sized pots, filled with equal volumes of each of the four types of soils, viz. clayey, sandy, loamy, clay-loam and garden loam and pots watered with equal quantities of water and kept in the open for 144 hours. After this period, percentage germination was recorded for each soil type.

C. Growth and Development

Effect of light conditions and soil texture on plant growth and development was equally investigated, making two assays for the former and one for the latter aspect.

(a) *Effect of light*: This study was started on 6th March and concluded on 11th May, laying one experiment in the pot and another in the field.

(i) *Pot experiment*: Seeds were sown in 15 equal-sized pots, filled with garden loam. After germination, only two seedlings were left in each pot. The pots were then divided into 3 groups, each to receive a different light treatment, with 5 replicates each. One group was placed under complete shade (C.S.), the second in partial light (P.L.) and the third in full light (F.L.).

(ii) *Field experiment*: Field experiment was started simultaneously with the pot

experiment. For this, three 2.5′ x 6′ sized plots were prepared with the same type of soil as under (i) above. Seeds were sown and, after germination, 10 seedlings only were allowed to grow in each plot. Each plot was provided different light conditions, complete shade (C.S.) making use of wooden planks, partial shade (P.L.) making use of dry tree branches and full light (F.L.). Both pots and plots were regularly watered and hoed.

(b) *Effect of soil texture*: Five equal-sized pots were filled with one of the five types of soils, namely, clayey, sandy, loamy, clay-loam and garden loam for this investigation.

Seeds were sown on 10th March and experiment closed on 12th May. All the pots were placed in the open. Regular watering and hoeing was done as needed. After germination, two seedlings were left per pot. On the termination of the experiment, all the plants were carefully pulled out with roots.

At the end of the experiment data on the following parameters was recorded in all the studies laid above and plants oven-dried at 70°C.

(i) Height of shoot
(ii) Length of root
(iii) No. of leaves per plant
(iv) Leaf length and breadth
(v) No. and size of inflorescences per plant
(vi) Fresh weight of plants;
(vii) Dry weight of plants.

Results and Discussion

The various investigations yielded some useful information. The studies on germination at different temperatures reveal that seeds kept at a temperature of 20°C for 144 hours gave the highest percentage (94%) of germination. (Table 1) It was also observed that, with the increase in temperature beyond 20°C the rate of germination tends to drop, thereby showing an inverse linear relationship between rise in temperature and the rate of germination. This might have been due to the interference with O_2 uptake by the seed-coat. Under these conditions, the testa imbibes a large amount of water, due to mucilage in the seed coat, to act as a block as is opined by Heydecker (1972). This might have been also due to the fact that high temperatures decrease the solubility coefficient of O_2 as was also reported by Morinage (1926) and Come (1962).

The soil salinity investigation showed that the germination dropped with increase in salinity beyond 0.5% after 144 days, a level which the germinating seeds could stand, giving 88% germination. (Table 2) The decline in germination might have been primarily due to higher osmotic potentials of the solutions, fed to the plants as was reported by Meyer and Anderson (1952). It could also be that both Na^+ and Cl^- in higher concentrations might have caused specific injury to the seeds.

The study on germination in different soil types brought to light that there occurred a maximum of 93.33% germination in garden loam after 144 hours. Clayey soil yielded 80% and loamy soil 53.33% germination. (Table 3) The fact is that *Plantago ovata* requires relatively larger amounts of water for germination which is supplied by the water imbibed in the seed coat, since garden loam has ten-fold water-holding capacity (Daubenmire, 1974) and optimum capacity to supply O_2 to the germinating seed (Black, 1967). Nearly the same is true of clayey soils. Lowest germination in barren loamy soil might be due to the fact that garden loam contains some organic matter, while the barren loamy soil does not.

The study on effects of light and soil type on growth and development, too, yielded useful information. Plants grown in full light (F.L.), both in pots and in the field, gave the best over-all growth with higher values of almost all the plant parts/parameters as compared to other light conditions. (Table 4) These plants were healthy, dark green and erect while those grown under partial light (P.L.) were weak and pale green and still those grown under complete shade (C.S.) very weak, mostly dying subsequently. The weak plants observed in complete shade are primarily due to lack of light (Gowan and Williams, 1973). It might also be due to negative effect on temperature and humidity (Daubenmire, 1974). The shade produced an over-all adverse effect on the growth.

The occurrence of best growth under full light indicates that the plant has a higher saturation level (Daubenmire 1974). The results are in conformity with the findings of Visnon (1963). Full light conditions not only facilitate gaseous exchange in the plant but also favour the soil temperatures (Daubenmire, 1974). Full light conditions equally induce greater flowering and fruiting, as was also observed by Shirley (1929) and Dunlop (1943). More fruit means more produce per unit area.

Table 1. Germination at different temperatures.

Time (Hours)	Temperature (C°)	Germination (%)	Radical length (mm)
72	20	64	4.94
	25	56	4.12
	30	54	3.91
144	20	94	8.98
	25	76	6.74
	30	80	7.00

Table 2. Germination in different concentrations of Sodium Chloride at 20°C.

Time (No. of hours)	NaCl Concentration (%)	Total seeds (No.)	Germinated Seeds (No.)	Germination (%)	Average radical length (mm)
72	o (Control)	50	32	64	5.12
	0.5	50	29	58	4.00
	1.0	50	25	50	2.81
	1.5	50	19	38	1.44
	2.0	50	–	–	–
	2.5	50	–	–	–
	3.0	50	–	–	–
144	o (Control)	50	47	94	8.66
	0.5	50	44	88	6.68
	1.0	50	42	84	4.14
	1.5	50	34	68	2.84
	2.0	50	11	22	0.12
	2.5	50	–	–	–
	3.0	50	–	–	–

Table 3. Germination in different soils.

Soil type	Total seeds (No.)	Germinated seeds (No.)	Germination (%)
Garden-loam	15	14	93.33
Loamy-soil	15	8	53.33
Clayey-soil	15	12	80.00
Sandy-soil	15	9	60.00

Table 4. Average, Light effect on various parameters.

Exp.	Light Conditions	Plant height (cm)	Root length (cm)	Leave per Plant (No.)	Leaf length (cm)	Leaf Breadth (mm)	Inflore-scence per Plant (No.)	Fresh scence length (cm)	Fresh weight of plant (gm)	Dry weight of plant (gm)
Field	F L	19.75	5.94	37.40	12.12	3.34	13.00	2.16	6.6101	0.9394
	P L	14.19	3.76	13.70	10.21	2.43	2.80	0.63	0.7381	0.0479
	C S	7.55	2.43	6.40	9.62	1.60	–	–	0.2221	0.0311
Pot	F L	17.17	5.72	25.70	11.49	2.76	6.90	1.63	3.7677	0.2199
	P L	14.01	3.68	12.40	9.73	2.13	2.30	0.45	0.5465	0.0921
	C S	7.34	2.10	6.70	8.83	1.76	–	–	0.2403	0.0214

Table 5. Average, effect of soil texture on various parameters.

Soil type	Plant height (cm)	Root length (cm)	Leaves per Plant (No.)	Leaf length (cm)	Leaf Breadth (mm)	Inflore-scence per Plant (No.)	Inflore-scence length (cm)	Fresh weight of plant (gm)	Dry weight of Plant (gm)
Garden Loam	13.34	5.23	21.40	9.20	2.50	5.60	0.98	1.2587	0.2284
Loamy	8.17	5.12	8.70	6.91	1.95	2.80	0.78	0.5360	0.0889
Clayey	10.61	6.08	12.40	8.64	2.40	3.60	0.88	0.8327	0.1790
Sandy	9.66	5.27	9.70	8.20	2.04	3.40	0.82	0.7637	0.1076
Clayey-Loam	8.49	4.06	8.10	6.78	1.81	2.50	0.36	0.3118	0.0839
Sandy-Loam	7.32	3.89	7.30	6.28	1.68	2.10	0.48	0.2010	0.0794

The studies on the effect of soil texture show that plants grown in garden loam gave the best over-all growth in all parts, clayey soils too giving significant growth as compared to that in other soils, while poor growth was observed in sandy loam. (Table 5). This is because the garden loam is rich in organic colloids (Daubenmire, 1974).

Relatively good growth in clayey soils is due to their higher water-holding capacity (Daubenmire, 1974). This finding also confirms Stewar (1927) who observed that maize plant remained unwilted for a long time in the fine-textured soils as compared to the coarse-textured. The poor growth in coarse soils is due to rapid infiltration of water (Buckman and Brady, 1969).

Soil salinity studies show that all salt concentrations above 0.5% had an adverse effect on plant growth. (Table 6). All the plants survived at 0.5% concentration, while many plants died at higher concentrations and six out of ten at 2.0% concentration. Growth in all parts was seriously affected with the increasing salinity.

Soil salinity has more than one detrimental effects on the plants (Bernstein, 1964). The direct effect of salinity is due to increase in osmotic potential of the soil solution which subjects the plants to physiological drought (Meyer and Anderson, 1952). With the increase in salt concentration, the plant has to expend more energy to absorb water (Newton, 1925). Also the plants in saline soils face a decrease in photosynthesis (Gale et al., 1967). Similar observations were also made by Lapina and Popou (1970). Haffman and Phene (1971), working with sodium chloride and cotton plant, also obtained similar results.

While decrease of water within the plant, due to physiological drought, also slows down the translocation of nutrients, large quantities of NaCl in the soil also cause nutritional deficiencies of calcium, magnesium and other cations (Bower and Turk, 1946). The plants also suffer due to sodium chloride toxicity in the soil (Black, 1967). Ayers (1950) have also reported the same effects. Soil salinity also adversely affects soil structure (Dubenmire, 1974) and aeration, which is directly injurious to roots.

One or more of the unfavourable factors together not only reduce the vegetative growth but also affect flowering and fruiting and ultimate seed production–the much demanded drug part of the plant.

Table 6. Average, effect of Sodium Chloride (NaCl) concentrations on various parameters

NaCl (%)	Plant height (cm)	Root length (cm)	Leaves per Plant (No.)	Leaf Length (cm)	Leaf Breadth (mm)	Inflore-scence per Plant (No.)	Inflore-scence Length (cm)	Fresh weight of plant (gm)	Dry weight of plant (gm)
Control	18.13	5.72	18.40	13.05	3.80	4.20	1.40	2.7705	0.1024
0.5	13.73	4.88	15.60	10.65	3.50	2.30	0.90	2.3632	0.1012
1.0	10.03	3.65	6.00	8.75	2.50	0.70	0.30	1.4703	0.0753
1.5	8.85	2.98	6.00	6.93	2.10	–	–	0.8011	0.0576
2.0	7.00	2.30	5.00	5.30	2.00	–	–	0.5331	0.0426

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