

HETEROTROPHIC GROWTH DURING SEED GERMINATION IN *JUNIPERUS EXCELSA* M. Bieb.

by

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Summary. *Juniperus excelsa* M. Bieb has an extremely slow rate of autotrophic growth² (Troup, 1921), while nothing is reported about its heterotrophic mode of growth³—especially during seed germination. The present investigation was taken up to determine the rate of growth in the embryo after the germination is initiated and to establish the precise limits of heterotrophic growth in the radical, hypocotyle and cotyledons.

Material and Methods. Juniper seed was procured from Ziarat in November, 1974. This seed had been extracted manually from fresh berries collected from several trees growing around Ziarat about a week before. Empty seed were removed by blowing and part of the seed was stratified in moist sand at 5°C ($\pm 1^\circ\text{C}$) for about 90 days in an electrically operated incubator; part of it was sown on 13-11-74 on moist filter paper in a germinator in the Silviculture Branch to study germination.

From this latter ten seeds were selected the tips of whose radicals had just emerged out of their seed coats. This was done on December 13, 74 when about 20% of the 400 seed had started germination. These were numbered and placed separately in the same chamber under similar germination conditions which are stated below:

- (a) An alternating temperature regime of 30°C and 20°C maintained for 8 hours during day time and 16 hours during night time respectively per day.
- (b) Diffused day light as passed through the transparent plastic door of the germinator during day time.
- (c) Moisture in filter papers maintained by watering at 8 a.m., and 3 p.m., to the extent which did not form a film of water around the seedling. The humidity ranging from 90 to 95% maintained by filling water in the water-pocket of the standard germinator (CLELAND, USA).

Daily observations were recorded on the emergence and growth increment of the radical, hypocotyle and cotyledons for each seedling. Measurements were taken daily at 10 a.m. This was continued till the seedlings stopped growth. The data recorded is given in Appendix 1.

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1. The author is Plant Physiologist in the Pakistan Forest Institute, Peshawar.
 2. The diameter growth of the tree varies from 0.1 to 0.3 inches annually.
 3. The heterotrophic growth is defined as—growth for which CO₂ is not the carbon source. Spermatophytes pass through this stage as gametes gametophytes and embryos (HUTNER, 1953).

Out of the seed lot in stratification five germinating seeds were numbered and placed individually on top of moist filter paper in a closed petridish at room temperature on a lab table. Growth of radical, hypocotyle and cotyledons was measured in the same way as the first lot of ten seedlings. The data are given in Appendix 2.

Results and Discussion. *Growth under controlled conditions:* The average growth of radical, hypocotyle and cotyledons is given below:

No. of days	Radical (mm)	Hypocotyle (mm)	Cotyledons (mm)
1 (Dec. 13, 1974)	0	0	0
2	2	0	0
3	4	0	0
4	6	1	0
5	7	2	0
6	7	2	0
7	8	4	0
8	10	4	0
9	11	9	1
10	12	10	2
11	13	12	2
12	14	13	2
13	14	14	3
14	15	14	3
15	16	16	4
16	17	18	5
17	18	22	6
18	18	22	6
19	18	25	7
20	18	27	8
21	18	28	9
22	19	29	9
23	19	29	9
24 (Jan. 5, 1975)	19	29	9

The data have also been shown in Figure 1. From this it is evident that on the initiation of germination the radical is the first organ which grows and comes out from the seed coat. During first three days it grows quite fast (2mm/day) and on the fourth day, hypocotyle which is coaxial in growth, follows the radical carrying the mother seed at its top. The hypocotyle is olive green in colour and is clearly differentiated from the white radical by a diffused union line. Later the growth in radical and hypocotyle is independent and in opposite directions leading the hypocotyle upwards and radical downwards beyond the union line. By this time the cotyledons are enclosed within the seed coat. The further growth of each organ is described below:

- (a) *Radical.* The radical grows at an average rate of about 1 mm per day and attains the maximum average length of about 19 mm within a period of three

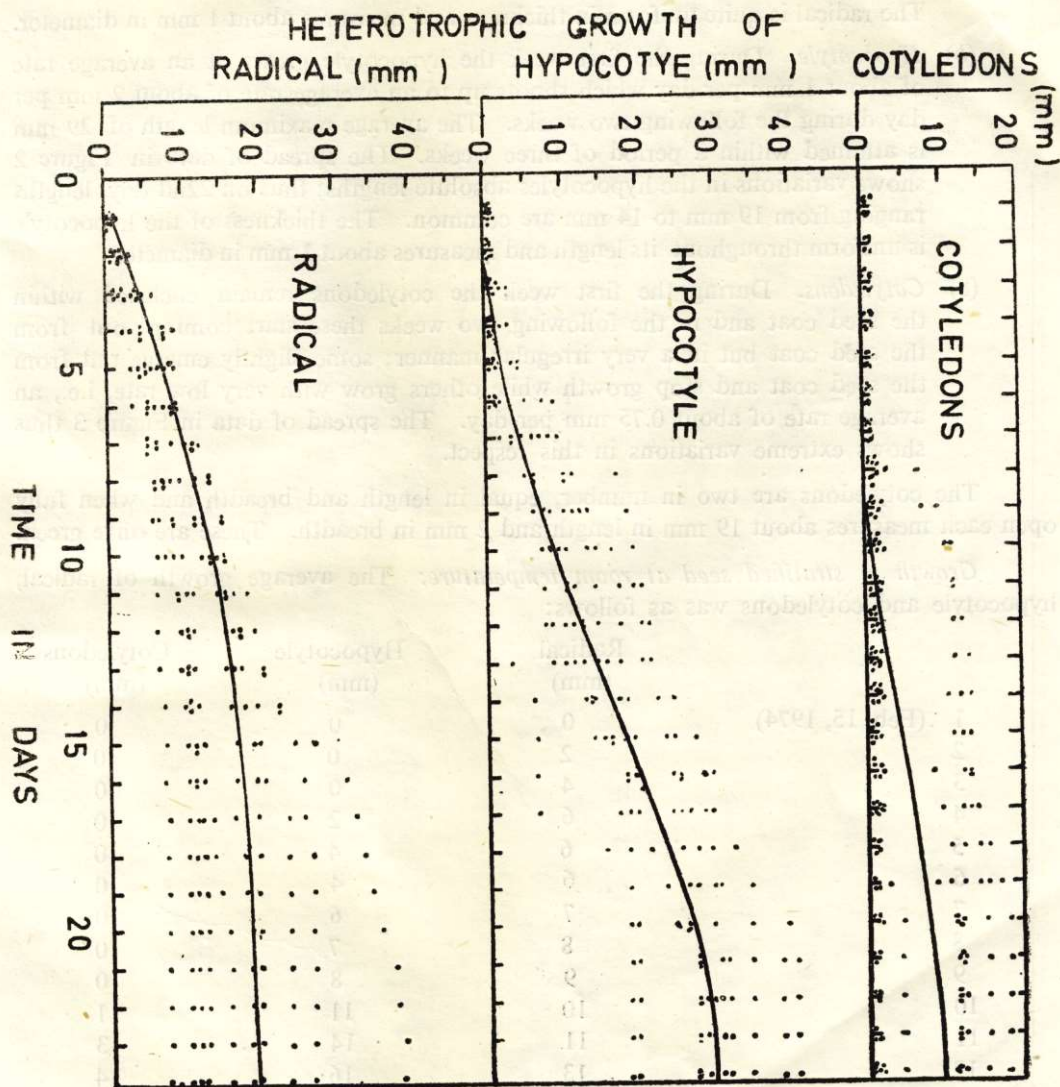


Figure 1. Heterotrophic growth of radical, hypocotyle and cotyledons in ten germinating seeds of *Juniperus excelsa* recorded daily for 24 days. The lines represent average values of growth.

weeks. The spread of data in Figure 1 indicates a wide amplitude of variation in the absolute length of the radical; for instance on the 22nd day, radicals ranging from 8 mm to 33 mm are represented.

The radical is quite uniform in thickness and measures about 1 mm in diameter.

- (b) *Hypocotyle*. During the first week the hypocotyle grows at an average rate of about 1 mm per day which shoots up to an average rate of about 2 mm per day during the following two weeks. The average maximum length of 29 mm is attained within a period of three weeks. The spread of data in Figure 2 shows variations in the hypocotyles absolute lengths: thus on 22nd day, lengths ranging from 19 mm to 14 mm are common. The thickness of the hypocotyle is uniform throughout its length and measures about 1 mm in diameter.
- (c) *Cotyledons*. During the first week the cotyledons remain enclosed within the seed coat and in the following two weeks these start coming out from the seed coat but in a very irregular manner; some slightly emerge out from the seed coat and stop growth while others grow with very low rate, i.e., an average rate of about 0.75 mm per day. The spread of data in Figure 3 thus shows extreme variations in this respect.

The cotyledons are two in number, equal in length and breadth and when fully open each measures about 19 mm in length and 2 mm in breadth. These are olive green.

Growth in stratified seed at room temperature: The average growth of radical, hypocotyle and cotyledons was as follows:

	Radical (mm)	Hypocotyle (mm)	Cotyledons (mm)
1 (Feb. 15, 1974)	0	0	0
2	2	0	0
3	4	0	0
4	6	2	0
5	6	4	0
6	6	4	0
7	7	6	0
8	8	7	0
9	9	8	0
10	10	11	1
11	11	14	3
12	13	16	4
13	15	16	5
14	17	22	7
15	19	22	8
16	21	23	9
17	21	27	9
18	21	27	9

Thus the growth of radical, hypocotyle and cotyledons is similar as described before for unsatisfied seed.

Conclusions. The study indicates the following points:

- (a) The heterotrophic growth is limited to about three weeks and is about 21 mm for the radical and 27 mm for the hypocotyle.
- (b) On the initiation of germination, it takes about three weeks to produce a complete seedling.
- (c) The seedlings vary in size of their radicals, hypocotyles and cotyledons at termination of heterotrophic growth and a well developed seedling measures over 20 mm of radical, over 30 mm of hypocotyle with two cotyledons each of which is about 20 mm in length.
- (d) Seed germination is epigeous.

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References

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Appendix I

Data showing growth of the radical, hypocotyle and cotyledons in each of the ten germinating seeds of *J. excoecsa* under controlled conditions

Days ¹	S ² -1		S-2		S-3		S-4		S-5		S-6		S-7		S-8		S-9		S-10	
	R ³	H ⁴	C ⁵	R	H	C	R	H	C	R	H	C	R	H	C	R	H	C	R	H
1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	0	0	4	1	0	2	0	0	1	0	0	2	0	0	3	0	0	2	0
3	5	1	0	6	1	0	3	0	0	2	0	0	3	0	0	5	0	0	4	0
4	8	3	0	8	2	0	4	0	0	3	0	0	5	0	0	8	0	0	6	0
5	9	4	0	9	4	0	5	0	0	4	0	0	6	0	0	8	0	0	6	0
6	10	5	0	10	5	0	6	0	0	4	0	0	6	0	0	9	2	0	6	0
7	13	10	0	12	8	0	7	2	0	6	0	0	8	0	0	9	3	0	6	0
8	14	10	0	12	9	0	9	3	0	8	4	0	7	0	0	10	4	0	7	0
9	16	11	0	12	12	8	13	6	0	12	9	0	7	0	9	7	0	12	7	0
10	16	14	8	12	13	10	15	8	0	14	11	0	8	7	0	10	9	0	14	8
11	16	17	11	12	15	12	19	10	0	16	12	0	10	8	0	11	11	0	17	9
12	16	20	12	12	18	12	20	11	0	16	12	0	10	8	0	11	13	0	17	11
13	16	22	12	12	18	13	21	12	0	16	13	0	10	9	0	11	13	0	17	11
14	16	22	12	12	18	14	23	12	0	18	13	0	10	9	0	12	15	0	18	11
15	17	23	13	13	19	14	28	14	11	21	14	7	12	14	0	12	18	0	20	14
16	17	24	13	13	28	14	32	20	12	23	16	10	12	17	0	12	19	0	21	15
17	17	26	14	13	29	14	33	26	13	25	20	10	14	19	0	12	25	0	24	18
18	18	28	15	13	30	16	34	30	13	26	24	11	14	22	0	12	26	0	24	22
19	18	29	15	13	31	18	35	35	13	26	26	12	15	24	0	12	27	0	24	26
20	19	30	16	13	32	19	36	40	13	27	28	12	16	25	0	12	27	0	24	27
21	19	32	16	13	35	19	38	41	13	27	31	12	16	28	0	12	28	0	24	29
22	19	32	16	13	35	19	38	41	13	27	31	12	16	28	0	12	28	0	24	29
23	19	33	16	13	35	19	39	43	13	27	32	12	16	28	0	12	28	0	24	29
24	19	33	16	13	35	19	39	43	13	27	32	12	16	28	0	12	28	0	24	29

¹No. of days counted from November 13, 1974.²S-1 is the number of seedling.³Radical.⁴Hypocotyle.⁵Cotyledon.

Appendix II

Data showing growth of the radical, hypocotyle and cotyledons in each of the five germinating seeds of *J. excelsa*. The seed have been stratified for about three months at 5°C.

Days ¹	S ² — 1			S — 2			S — 3			S — 4			S — 5		
	R ³	H ⁴	C ⁵	R	H	C	R	H	C	R	H	C	R	H	C
	mm														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0
3	4	2	0	6	1	0	0	0	0	2	0	0	1	0	0
4	6	4	0	10	4	0	1	2	0	3	0	0	3	1	0
5	6	7	0	15	7	0	2	4	0	3	0	0	4	3	0
6	6	8	0	17	8	0	2	5	0	3	0	0	4	4	0
7	7	9	0	18	9	0	3	7	0	4	0	0	5	4	0
8	9	10	0	20	10	0	3	9	0	5	0	0	6	5	0
9	10	11	0	21	11	0	4	10	0	6	0	0	7	6	0
10	13	16	6	21	15	0	4	10	1	6	6	0	7	9	0
11	18	20	8	22	20	6	4	11	2	6	7	0	7	12	0
12	25	26	10	25	24	8	4	11	3	7	7	0	7	14	0
13	28	29	11	27	28	12	4	14	4	9	8	0	7	18	0
14	31	34	14	30	31	14	7	15	5	9	9	0	8	21	0
15	37	39	19	34	35	16	9	17	7	10	10	0	9	23	0
16	40	42	20	36	38	18	10	18	8	11	11	0	10	26	0
17	40	43	20	36	38	18	10	18	8	11	11	0	10	27	0
18	40	43	20	36	38	18	10	18	8	11	11	0	10	27	0

¹No. of days counted from February 15, 1974.

²Number of seedling.

³Radical.

⁴Hypocotyle.

⁵Cotyledon.