CENTRO DI SPERIMENTAZIONE AGRICOLA E FORESTALE C.P. 9079 — ROMA
ISTITUTO DI SPERIMENTAZIONE PER LA PIOPPICOLTURA C.P. 24 — CASALE MONFERRATO

FACTORS AFFECTING THE DIFFICULT ROOTING OF CUTTINGS IN SOME POPLARS

RESEARCH FINAL REPORT

Grant No. : E. 15 FS. 3 Project No. : FG. It. 122

Principal investigator : Prof. A. DE PHILIPPIS

E. N. C. C. — Roma
1966

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III - TRIALS IN THE OPEN AND UNDER COVER TO STIMULATE THE ROOTING PROCESS

(Investigators: Dr. G. Frison - Prof. E. Giordano - Prof. G. Giulimondi - Dr. M. Sekawin)

INTRODUCTION

Various trials were performed in the field and in greenhouse to stimulate the rooting of cuttings. Firstly, efforts were made to determine soil influence by examining different types of substrata in the open. The research was pursued later on to establish the more suitable environment for the rooting process, placing the cuttings under controlled conditions both in the ground and in water.

To foster rooting, use was made of rhizogenous substances and fertilizers, and some practical methods, such as, for instance, soil covering with plastic sheets, were perfected to create in the nursery an environment similar to the more favourable one obtained in laboratory. The parent plant age and the best planting season of the cuttings were also experimented.

The results obtained are reported after the description of both the material and the methods adopted for each experience.

INFLUENCE OF SOIL IN THE FIELD

Observations were carried out on the rooting of cuttings as affected by main physical and chemical features, moisture content and soil tem perature.

The tests were performed in a nursery on the outskirts of Rome, in spring 1964, from April 8 to June 25.

During the experiments the minimum temperature dropped to - 1.5°C (April 9th) whereas the maximum temperature reached +37°C (June 7th).

The diurnal fluctuations of temperature were moderate during the month of May (15°-16°C) and reached 22°C in April and June.

Precipitations scarcely reached 82 mm and occurred mainly in April (77 mm), being almost negligible during the following months.

The trend of the mean temperature of the air, during the experimental period, is expressed in fig.1.

Materials and methods

In the experiments, use was made of 1,800 cuttings of *P.deltoides*, taken from non-selected clones and obtained through vegetative propagation from a group of seedlings, derived from seeds imported directly from the United States in 1958.

These clones, which in the nursery showed a different rooting capacity, were divided and classified as follows:

- well rooting clones (b);
- inconstantly rooting clones (i);
- poorly rooting clones (m).

A number of 600 cuttings, taken from each of these groups,were planted out in 4 different substrates, in the form of latin square. To determine the eventual influence of the genetic factor on rooting, 540 selected cuttings of *P.deltoides* ('77/51', '63/51', 'UAS 235') and 420 cuttings of two clones of *P.x euramericana* ('I 214', '45/51'), with a known rooting capacity, were employed as controls.

Four types of soil, often used for poplar cultivation in the Pontine Area, were choosen, i.e.:

- clay loam from alluvial deposit;
- sandy loam from mudbank deposit;
- sand from fluvial deposit;
- peat from Pontine Area.

Growth tanks, of 2x5x1 m, sunk in the soil, were used for the rooting experiments. The walls were covered by plastic sheets and a 50 cm gravel layer was employed for draining the bottom.

The cuttings, 25 cm long, were placed at a distance of 10x10 cm. During the experiments, the four substrates were irrigated every 8-10 days, to saturation of the first 30-40 cm of soil.

Physico-chemical properties. - The data relative to the physico-chemical properties of the different substrata employed in the trials are set down in table 1.

From the values of the field capacity, the wilting point and the bulk density, it is possible to calculate the maximum amount of available water for each cutting in the different substrata. In fact, in a soil block of 100x100x250 mm at the cutting's disposal 89.0 mm are available in clay loam, 101.0 mm in sandy loam, 56.0 mm in sand and 55.5 mm in peat. These values, however, do not actually represent the available water per cutt-

Table 1 - Physical properties of the substrates (% O.D. weight).

type of soil	sand	silt	clay	field capacity	wilting point	available water	bulk density	specific gravity	porosity
clay loam	37.5	31.5	31.0	52.2	17.57	34.63	1.027	2.600	60.5
sandy loam	84.4	4.5	7.1	43.1	8.96	34.14	1.192	2.658	55.2
sand	97.5	1.0	1.5	24.4	7.24	17.16	1.325	3.018	56.1
peat	-	-	-	106.2	63.38	42.86	0.518	2.014	74.3

Table 2 - Chemical properties of the substrates.

type of soil	pH	lime %	total N %	organic C %	humus %	avail. P_2O_5 ppm	exch. K_2O ppm
clay loam	7.8	25.2	0.12	1.42	2.44	20	500
sandy loam	7.8	28.3	0.11	1.33	2.29	20	870
sand	7.6	traces	0.007	0.10	0.17	10	520
peat	7.5	1.3	1.49	25.8	44.5	20	260

Table 3 - Moisture contents of the substrates (% O.D. weight).

date	clay loam	sandy loam	sand	peat
April 30	34.77	26.31	19.78	90.78
May 5	35.23	25.20	18.24	83.94
May 11	32.83	25.52	17.70	81.90
May 18	31.51	23.25	17.89	86.15
May 26	29.40	21.81	14.64	80.53
June 3	30.46	20.36	17.69	79.48

ing since they do not take into account swelling phenomena, whic may occur in both the clay particles and the humus, owing to water. For this reason, the available water only refers to the block of oven-dry soil.

It is interesting to note the marked difference in clay content of the various substrates: clay loam 31%, sandy loam 7.1%, sand 1.5% (table 1). The chemical characteristics are given in table 2. The pH reaction of the soil varies between a minimum of 7.5 in peat to a maximum of 7.8 in clay loam and it is, therefore, particularly favourable to poplar cultivation.

The content of silt, total nitrogen, organic carbon, humus and available phosphorus is almost identical in both the clay loam and sandy loam soils. The latter, however, has a higher quantity of exchangeable K_2O.

The sand is rather poor both in total nitrogen and organic carbon and has a content in available phosphates equal to half that of the other substrates. The peat belongs to the meso-trophic type, with a high content of nitrogenous substances and available phosphates.

Moisture content and temperature of the substrates. - The temperature and the moisture content of each substrate were controlled during the experiments, taking into account the quantity of water provided by both rain and irrigation.

Soil temperature was measured twice a day at a depth of 15 and 40 cm and the mean values are reported in fig. 2.

At a depth of 15 cm, the sand temperature was clearly higher than that of other soils, whereas the temperature of clay loam was the lowest and the closest to the air temperature. At 40 cm depth all substrata showed a temperature equal to or below that of the air, with the exception of the sand.

Fig. 3 compares the temperatures of sand and clay loam, from which were obtained the most diverse rooting results.

In sand the maximum temperature at 15 cm of depth reached 29°C and the minimum 18°C, while at 40 cm absolute maximum and minimum were 27.2°C and 15°C respectively.

In clay loam soil, at the first layer, the maximum temperature was 23.6°C and the minimum 16°C while, at the second depth, temperatures varied between a maximum of 22.5°C and a minimum of 16°C. It is interesting to note that the fluctuation in temperature in this substrate was limited to about half that in sand.

Results

The appearance of shoots on the cuttings occurred about a month from the beginning of the trials and was recorded every 8-10 days.

The shooting process, which was similar in all substrates, may be divided into 3 phases (fig. 4). In the first stage, which took about 30 days, the number of shoots produced by the cuttings increased up to the maximum, occurring in sandy loam and sand a week earlier than in peat and two weeks earlier than in clay loam. In the second stage, which lasted about 20 days in clay loam and peat and more than a month in sandy loam and sand, the number of shoots decreased gradually to a certain level at which it remained constant (third stage).

Table 4 - Number of surviving shoots.

date	cuttings	groups *	clay loam	sandy loam	sand	peat
5.5.1964	150	m	67	65	61	84
	150	i	67	63	59	77
	150	b	126	89	95	89
14.5.1964	150	m	74	60	55	86
	150	i	78	63	60	73
	150	b	123	92	86	92
21.5.1964	150	m	80	55	40	77
	150	i	87	57	45	54
	150	b	108	90	72	83
29.5.1964	150	m	70	48	25	47
	150	i	74	43	32	38
	150	b	93	75	55	63
9.6.1964	150	m	39	28	12	34
	150	i	48	28	13	27
	150	b	74	48	31	40
15.6.1964	150	m	39	27	11	34
	150	i	48	29	12	27
	150	b	74	48	30	38
25.6.1964	150	m	38	26	11	34
	150	i	48	29	11	27
	150	b	74	48	28	38

* Cuttings of *P. deltoides* : well rooting clones (b); inconstantly rooting clones (i); poorly rooting clones (m).

Table 5 - Average height of the cuttings.

date	cuttings	groups *	clay loam	sandy loam	sand	peat
5.5.1964	150	m	5.5	5.3	4.0	5.9
	150	i	5.2	5.3	3.8	5.5
	150	b	6.2	5.9	4.7	6.1
14.5.1964	150	m	5.6	5.8	4.3	6.2
	150	i	5.3	5.5	4.0	5.9
	150	b	6.6	6.4	5.2	6.6
21.5.1964	150	m	6.8	6.5	4.5	6.5
	150	i	7.0	6.1	4.3	6.2
	150	b	9.0	8.0	5.4	7.6
29.5.1964	150	m	12.0	14.0	5.2	11.3
	150	i	12.7	11.7	4.5	11.0
	150	b	17.0	16.0	5.7	12.0
9.6.1965	150	m	20.2	22.2	7.5	18.0
	150	i	21.5	19.8	6.5	18.0
	150	b	32.3	29.0	10.0	25.0
15.6.1964	150	m	33.0	36.0	14.0	31.0
	150	i	34.0	34.0	11.0	30.0
	150	b	40.0	38.0	14.0	39.0
25.6.1964	150	m	50.1	57.7	27.1	58.6
	150	i	52.7	54.1	19.8	58.3
	150	b	57.3	65.7	22.5	62.4

* Cuttings of *P. deltoides*: well rooting clones (b); inconstantly rooting clones (i); poorly rooting clones (m).

The maximum average development of buds (fig. 5 and table 5) was in peat and in sandy loam (60 cm).

In clay loam, which had similar chemical characteristics to sandy loam, shoot growth was slightly less (53 cm). The development of cuttings, however, was poor (23 cm).

Fig. 6 shows that there is a certain correlation between available water and shoot growth in the various soils, with the exception of peat, where, as noted previously, it is extremely difficult to determine the physical properties.

The rate of shoot growth is influenced by the type of substrate as well as by air temperature.

The best development of the cuttings, in fact, began in all soil types from the second week of June onwards (fig. 1 and 5).

Conclusions

The success of cuttings was recorded 2 months from the beginning of the experiments (table 6).

The non-selected clones of *P. deltoides* showed on the whole a rather moderate rooting capacity, namely 35.6% in clay loam, 22.8% in sandy loam 22.0% in peat and 11.1% in sand.

Considering separately the success of the cuttings of the 3 groups in which were divided the non-selected clones of *P. deltoides* (table 7), it appears evident that the cuttings obtained from well rooting clones gave better results than those of the other groups, independently of the substrate.

The behaviour of the cuttings obtained from inconstantly rooting clones (group i) did not differ considerably from that of poorly rooting clones (group m). In particular, in peat the cuttings of the latter group had a higher rooting percent than that of the previous ones.

The rooting of cuttings of selected clones of *P. deltoides* ('77/51', '63/51', 'UAS 235') and *P. x euramericana* ('I 214', '45/51'), taken for comparison, was much greater (table 6). On the whole, the rooting of selected clones of *P. deltoides* was two or three times higher than that of non-selected clones, i.e. 68.2% in clay loam, 76.3% in sandy loam 63.8% in peat and 31.9% in sand.

It is worth signaling that the clone 'UAS 235' showed a rooting percentage from 80% to 85%. These values are higher than the average for the three substrates of *Populus x euramericana* '45/51' and approach that of *Populus x euramericana* 'I 214' (87.5%), with the exception of sand. In the other 2 selected clones of *P. deltoides*, in all substrates, rooting was greater or equal to that of *Populus x euramericana* '45/51'.

The behaviour of *P. x euramericana* 'I 214' confirmed its considerable capacity for adaption. In fact, the differences in the rooting of this clone in the various substrates ranged from a minimum of 66.7% in sand to a maximum of 88.3% in sandy loam, being much greater in the clone '45/51' (28.9% in sand, 64.4% in sandy loam).

Clay loam proved to be more favourable to the rooting of non-selected clones of *P. deltoides*, but sandy loam to the selected clones and to *Populus x euramericana* 'I 214' and '45/51'.

Table 6 - Root success (%) and average height (h) of plants of different clones.

clones	clay loam		sandy loam		sand		peat	
	%	h	%	h	%	h	%	h
P.deltoides (non-selected cl.)	35.6	53.4	22.9	59.2	11.1	23.1	22.0	59.7
P.deltoides '77/51'	60.0	54.2	66.7	48.0	37.8	23.0	42.4	57.4
P.deltoides '63/51'	64.5	70.1	77.8	58.9	28.9	28.2	66.7	52.9
P.deltoides 'UAS 235'	80.0	72.1	84.4	51.4	28.9	30.4	82.2	69.7
P.x euramericana '45/51'	60.0	60.2	64.4	55.7	28.9	32.9	53.2	63.5
P.x euramericana cv. 'I 214'	87.0	88.9	88.3	93.4	66.7	59.1	87.0	90.2

Table 7 - Root success (%) of non- selected clones of *P. deltoides.*

groups	clay loam	sandy loam	sand	peat
well rooting clones (b)	49.3	32.0	18.7	25.3
inconstantly rooting clones (i)	32.0	19.3	7.3	18.0
poorly rooting clones (m)	25.3	17.3	7.3	22.7
average	*35.6*	22.9	*11.1*	*22.0*

In analysing the results, it is clear that soil texture exercises a considerable influence on rooting. This characteristic, in particular, represents the most important difference, from a physical point of view, between clay loam and sandy loam, which possesses, as noticed previously, a content in nutritional substances and a reaction very similar.

Taking into account these last two substrates, it may be seen that the clay percent is in the ratio 4:1 (table 1) in favour of the first, which also gives a greater average percentage of success of the cuttings of non-selected clones. Therefore, in this case, it seems that rooting may be favoured by a greater adhesion to the cutting of clay particles and colloids, forming around it a compact and saturated layer. Moreover, it is interesting to observe that in clay loam temperature remained more constant than in the other substrates.

The different requirements of selected and non-selected clones with respect to the substrate more suitable for the rooting of cuttings may also depend on genetic factors, as for example a more advanced stage in the formation and in the number of root primordia.

The two substrates more favourable to the rooting of cuttings, therefore, differ from the less favourable one in texture, water availability, aeration, percent of nutritional substances and temperature; the interaction of these factors determines the rooting conditions and establishes the most suitable means to facilitate the emergence of roots from the cuttings.

INFLUENCE OF TEMPERATURE, LIGHT AND MOISTURE

As it results from laboratory experiments, three factors seem to affect directly the rooting of poplar cuttings, namely: temperature, moisture and light.

With a view to studying the influence - either individual or combined - of these elements, five rooting trials were carried out over the spring 1965, employing water and soil as substrates.

TEMPERATURE INFLUENCE

The temperature influence was studied with two tests: in the first soil was used as a substratum for rooting, in the second water was employed.

Materials and methods

In the first test 70 cuttings were used, which had been distributed (7 per container) in 10 containers, each holding about 8 Kg of soil. Soil humidity was maintained at 28% and, for keeping it uniform, the containers were placed in polyethylene bags.

Table 8 - Temperature influence on rooting of poplar cuttings in pots.

temperature	treatments	cuttings	success %	days	development roots	callus	buds
27°C	containers placed in thermostat in the dark	35	100	12	++++	a + b +++++	++++
				34	-	-	-
				41	-	-	-
10-16°C	containers buried in the open	35	100	12	0	0	0
				34	++++	b ++	++++
				41	+++++	b ++	++++

\- = experiment ended after the first observation

a = callus forming at the top of the cutting; b = callus forming at the base of the cutting

Table 9 - Temperature influence on rooting of cuttings in beakers in light.

temperature	days	success %	development roots	callus	buds
21°C	12	20	+	b +	+
	15	36	++	b ++	++
	21	100	+++	b ++	+++
	34	-	+++	b ++	+++
10-16°C	12	-	-	-	-
	15		+	b ++	++
	21	36	++	b ++	++
	34	76	++	b ++	++++

\- = experiment ended after the first observation

a = callus forming at the top of the cutting; b = callus forming at the base of the cutting

Table 10 - Effect of light on rooting of poplar cuttings in polyethylene bags (groups of 25 cuttings).

treatments			cuttings %	development roots	callus	buds
dry cuttings at 20-21°C	not end-dipped in paraffin	dark	100	++++	++++	++
		light	60	+	+	+
	end-dipped in paraffin	dark	100	++++	+++	++
		light	0	0	0	+
soaked cuttings at room temperature	not end-dipped in paraffin	dark	100	++++	+	++
		light	60	+	0	+
	end-dipped in paraffin	dark	100	++++	++	++
		light	80	+	0	++

For observing the temperature effect on the rooting, five containers were buried in the open, subjecting therefore the cuttings to varying temperature, while the remaining ones were placed in the thermostat in darkness at a constant temperature of 27°C. In the first two weeks, the temperature in the open field oscillated between a minimum of 10°C during the night and a maximum of 15-16°C during the day; the temperature progressively increased in such a way that at the 5th week the minimum night temperature was at 14°C and the maximum day temperature at 20°C.

In the second test the rooting took place in beakers holding about 1 litre of water. This was done in light with 50 cuttings, subdivided into two groups of 25 cuttings each. The first group had been placed in the thermostat at a constant temperature of 21°C, the second in the open at varying temperatures of 10°C to 15-16°C.

Results

The results of the first test are shown in table 8. The influence of the thermal gradient on the roots is evident following a comparison of the difference in the timing of root development. When the cuttings are kept at a constant temperature of 27°C, there is a much faster root emergence and development than at varying temperatures of 10°C to 15-16°C. In the first case all the cuttings had rooted after only 12 days from the beginning of the experiment and had formed roots well polarized, 8 - 10 cm in length, and budding appeared simultaneously with the roots. Callus tissue was abundant, especially in correspondence to the apical cut of the cutting. But at varying temperatures of 10°C - 15/16°C, after the same period from the beginning of the test, the cuttings were still dormant and bud formation began much later but before rooting. At the second examination, performed 35 days from the beginning of the trial, all the cuttings kept at varying temperatures had developed some roots and buds, but their growth was merkedly inferior to those cuttings kept at a constant temperature. It is interesting to observe how the absolute humidity of 28% revealed itself as particularly favourable for the type of soil used, as far as rooting is concerned.

The possibility of accelerating the formation of roots and buds through rise in temperature up to 27°C is of considerable pratical interest, and warrants further study. In particular, various types of covering should be studied to obtain thermal conditions particularly favourable to rooting.

The results of the second test, conducted on cuttings immersed in water, are reported on table 9. Also when the cuttings are kept in water, the proportionately highest and constant temperature (21°C) accelerated the emergence and the development of the roots compared with the lower and varying temperature (10 - 15/16°C). In the light, there was 100% rooting under a constant temperature of 21°C and 76% rooting under varying temperatures of 10° - 15/16°C. Furthermore, varying temperatures considerably retarded root emergence and bud formation. From the results noted above the previous conclusions regarding the significance of temperature were confirmed.

LIGHT INFLUENCE

A study was undertaken on the light effect on cuttings placed in polyethylene bags to root.

Materials and methods

Two hundred cuttings, of which one hundred had been earlier soaked for 3 days in water, were placed at a constant temperature of 21°C in polyethylene bags to root. The cuttings were subdivided into 8 groups of 25 cuttings each. Four groups of cuttings were end-dipped into paraffin.

Results

The experiment proved the inhibitory effect of light on root emergence. Table 10 shows that in the dark 100% rooting was obtained for cuttings in polyethylene bags whether they had been end-dipped in paraffin or not. The roots were not polarized, and were found over the entire cutting uniformly distributed.

Under light, however, the dry cuttings which were not end-dipped in paraffin, gave 60% rooting, while those which had been end-dipped in paraffin showed no roots; the soaked cuttings which were not end-dipped in paraffin gave a rooting of 60%, while those end-dipped in paraffin gave a rooting of 80%. In each case, the few developed roots did not grow further under light and soon turned black.

Immersion of the cuttings (*) in water favoured the development of a greater number of roots.

The end-dipping of the cuttings into paraffin, however, exerted no significant influence on the rooting capacity.

LIGHT INFLUENCE ON ROOTING OF CUTTINGS PLACED IN WATER

Laboratory results previously reported demonstrated that darkness exerted a positive influence on the root emergence of *P.x euramericana* cv. 'I 214' cuttings, when placed to root in water.

It therefore appeared advisable to extend the experiments also to the two clones of *P.deltoides* for purpose of observing the possibility to influence rooting by the reduction of light intensity.

Materials and methods

The experiments were carried out in the greenhouse as well as out

(*) The effect of pre-immersing cuttings in water for 3 consecutive days was also examined in the field. Twenty-five untreated cuttings were studied against the same number of treated ones. The rooting resulted in 24% and 72% respectively.

Table 11 - Light intensity in lux (May 25,1965).

hours	outdoor light	outdoor dark	reduction %	greenhouse light	greenhouse dark	reduction %
9	4.000	200	95	900	40	96
15	2.500	120	95	800	40	95
18	1.000	50	95	500	40	92

Table 12 - Influence of light on the rooting of poplar cuttings in water.

clone	greenhouse						outdoor					
	dark			light			dark			light		
	cuttings	success		cuttings	success		cuttings	success		cuttings	success	
	No	No	%	No	No	%	No	No	%	No	No	%
'63/51'	50	48	96	50	41	82	150	104	69	150	92	61
'77/51'	100	66	66	100	22	22	125	69	55	50	26	52
'I 214'	100	90	90	100	44	44	150	89	59	150	74	49

Table 13 - Influence of light, temperature and humidity on the rooting of poplar cuttings in beakers.

treatments		temperature of 21°C.					temperature of 27°C.				
		days	success %	development roots	development callus	development buds	days	success %	development roots	development callus	development buds
beakers without polyethylene bags	dark				a ++++						
	light	12	100	+++	b -	++	12	100	++++	b ++++	++++
		15	-	-	-	-	15	-	+++++	b ++++	+++++
		25	-	-	-	-	25	-	-	-	-
polyethylene bags	light	12	20	+	b +	+	12				
		15	36	++	b ++	++	15				
		25	100	+++	b ++	++++	25				
breakers in polyethylene bags	dark	12	100	+++	a +++	++	12	75	+	a +++++	++++
		15	-	-	-	-	15	75	++	+++++	++
		25	-	-	-	-	25	75	+	+++++	+
	light	12	0	0	a +	0	12				
		15	0	0	a ++	+	15				
		25	10	+	a ++	++	25				

- = experiment ended after the first observation.
a = callus forming at the top of the cutting, b = callus forming at the base of the cutting.

door and began in the 9.4.65 and 15.4.65 respectively, for 60 days.

Middle and basal cuttings of *P.deltoides* '63/51' and '77/51' were used, obtained from S_1R_1 nursery plants of the Poplar Research Institute in Casale Monferrato, and for the parallel study cuttings of *P. x euramericana* cv. 'I 214' were obtained from plants of S_1R_1 of the 'Cesurny' nursery in Rome.

In the trials performed in the greenhouse, cuttings were placed to root in water into plastic basinets, 30x30x12 cm, and in the outdoor trials were arranged into a cement basin of 570x83x40 cm.

Water replacement in all recipients was effected every 48 hours.

To maintain a vertical position of the cuttings in the basinets, they were gathered in bundles of fifty and immersed in 20 cm of water.

The cuttings in the basin outdoor were threaded through 2.5x2.5 cm wire netting to assure a perpendicular position and to prevent their sliding to the bottom.

Part of the cuttings were shaded by three plastic nets, type 'Umbratex', fixed to wooden frames in order to reduce light intensity by about 95%, while the remaining ones were exposed to normal day-light in the outdoor test, and to reduced light in the greenhouse experiment.

Throughout the experiment it was necessary to keep down the greenhouse matting to avoid an excessive warming up of air.

Some light meter readings (Lange 203) resulted in table 11.

The maximum and minimum temperature recorded every 24 hours are summarized in fig. 7-10.

Root emergence of the cuttings was checked after 38 days in the outdoor basin, after 30 days in the greenhouse and at the conclusion of the experiment; relative data are shown in table 12.

Results

The response of rooting to different light intensity of the examined clones was evident. In fact, the cuttings shaded by the plastic nets presented a greater number of roots than those placed under full day light.

The difference are particularly clear in the greenhouse experiment, where under shading the cuttings of the clones of *P deltoides* '77/51' and *P x euramericana* cv. 'I 214' had rooted at 66% and 90% respectively, while only 22% and 44% under full day-light.

In *P.deltoides* '63/51' the differences between the two treatments are less evident than in the precious clones; nevertheless, 96% of the shaded cuttings rooted and 82% of those under full day-light did so.

The number of cuttings in the outdoor basin, which had taken root under shading, was smaller with regard to those of the analogous test in the greenhouse, namely: 69% in *P deltoides* '63/51', 55% in *P. deltoides* '77/51' and 59% in *P. x euramericana* cv. 'I 214'.

In spite of water replacement effected every second day, a presence of algae at the base of the cuttings exposed to full daylight was observed.

In the complex phenomenon which regulates the root building, an interaction of other factors is ascertained; in the first place that of tem

Table 14 - Measurement of light intensity in Lux in the plots A, B and C.

date	hours	weather	shading	light	reduction %
28.4.1965	7	clear	without	3000	-
			1 net	850	72
			2 nets	350	88
	14	clear	without	9500	-
			1 net	2400	75
			2 nets	950	90
13.5.1965	7	cloudy	without	2500	-
			1 net	500	80
			2 nets	220	91
27.5.1965	14	partly cloudy	without	6000	-
			1 net	1700	72
			2 nets	700	88
11.6.1965	14	clear	without	8500	-
			1 net	1500	82
			2 nets	800	90

Table 15 - Number of cuttings with buds after 23 days under shade.

clone	open plots	protected plots	
	without shade	one net	two nets
P. deltoides '63/51'	67	3	1
P. deltoides '77/51'	69	1	-
P. x euramericana cv. 'I 214'	51	9	1

perature.

The higher thermal gradient has been found positive on rooting as shown by a greater root emergence in the greenhouse, where higher temperature together with intense darkness has been obtained.

Future research will therefore be directed towards the possibility to stimulate rooting in controlled light and temperature conditions.

COMBINED EFFECT OF LIGHT, HUMIDITY AND TEMPERATURE ON CUTTINGS PLACED IN WATER

Materials and methods

One hundred and fifty cuttings, subdivided into 6 groups of 25 cuttings each, were placed to root in 1 litre beakers filled with water. Half of the amount of cuttings were enclosed in polyethylene bags.

Results

All the cuttings placed in beakers, in the dark, rooted after only 12 days; under light, however, the complete rooting process was delayed by 10 - 12 days.

In addition, under light, budding appeared earlier than root development, whereas in the dark the process was simultaneous.

The high moisture content in the beakers wrapped in polyethylene bags exerted a different influence on rooting according to the absence or presence of light.

It was noted that in the dark at a temperature of 21°C. in the polyethylene wrapped beakers the cuttings rooted throughout, including the portion outside the water, whereas in those without polyethylene, roots were formed only on those parts of the cuttings immersed in water.

In the dark, at a temperature of 27°C, 75% of the cuttings contained in polyethylene wrapped beakers formed roots, mainly on those parts outside the water; all cuttings showed a well developed callus in correspondence to the apical cut.

At the same temperature, in the dark, the cuttings in the beakers without polyethylene bags gave a remarkable amount of roots and callus tissue on the portion immersed in water.

Under light, and at temperature of 21°C., only 10% of the cuttings rooted in the polyethylene wrapped beakers, formed roots only on the immersed portion. The unrooted cuttings showed a remarkable rotting process.

FIELD STUDY ON EFFECT OF SHADING

Experimental results obtained in the laboratory gave evidence that on cuttings of *P. x euramericana* cv. 'I 214'; when rooting in full light conditions, the process of bud formation precedes that of root building.

If root formation did not occur within a short time, the buds would dry up and compromise the vitality of the cuttings.

It was verified, however, that, when cuttings were left in the dark, the process was reversed, and roots were formed before the buds.

Under normal planting conditions the entire cutting is introduced into the soil and only the upper tip remains exposed to light.

Since bud formation generally originates on the tip of the cutting and it is therefore directly influenced by light, a trial was conducted on the effect of shading until root formation begins, checking the formation of buds.

Materials and Methods

The cuttings used in the experiment were tqken from the middle and basal portion of one-year poplar belonging to the following clones: *P. deltoides* '63/51'; *P. deltoides* '77/51' and *P. x euramericana* cv. 'I 214'.

Before planting, the cuttings were immersed for 24 hours in water to assure an uniform state of humidity, and were then planted in three plots (A,B,C) of 5.75 m x 7.25 m, with a distance of 5.50 m between them.

To submit the cuttings to different shade conditions, two plots (A, B) were covered with plastic nets, type 'Umbratex', secured with wire on wooden frames, in such a way that the net was roughly 2 m above the ground. Lateral shading was obtained with frames placed along the perimeter of the plots at a distance of 1.50 m from cuttings to limit every possible marginal influence.

The first plot (A) was covered with a net that reduced the light intensity by 70 - 80%, while the second plot (B) was covered with two nets of the same material to obtain a more effective shade of 80 - 90%.

The light intensity in the plots was periodically measured with a lightmeter, model 'Lange' 203, and the relative data are given in table 14.

For every clone, 203 cuttings were taken and subdivided into 7 groups of 29 cuttings each and then planted at a distance of 25 x 25 cm.

The shading experiment began on the 5.4.1965 and was over after 70 days, i.e. on the 14.6.1965, with the elimination of the two protective nets.

During this period, the soil was cultivated with hoes three times to reduce weed competition, and was also irrigated until the soil was saturated. The cuttings were then allowed to develop in daylight for a further 78 days, during which time the soil was irrigated five times at intervals of 15 days and weeded twice.

Results

Root formation proceeded *normally and was examined* after 70 and 148 days, i.e. when the shades were removed and when the experiment concluded.

Bud formation was first noted on 20 April, or 15 days after the cuttings were placed in the open plot and 20 days after they were set out under shade.

It is interesting to observe that after 23 days, the number of cuttings showing bud formation in the open plot was appreciably greater than that of those in the protected plots, as shown in table 15.

Moreover in the two shaded plots, only a few cuttings had a well developed callus, on which minute buds grew after a short time.

Effect of shading on cutting success. - The influence of shading on the rooting of cuttings is shown in table 16.

In the first control made after 70 days, only the cuttings which appeared with shoots in normal vegetative conditions were considered as rooted.

In the shaded plots regular shoots were noted on 90% of *P. x euramericana* cv. 'I 214' cuttings, while on those of *P. deltoides* '63/51' a level of 82% was measured in plot A (protected by one net) and 81% in those of plot B (shaded with 2 nets).

P. deltoides '77/51' demonstrated a particular behaviour, since root formation was higher (84%) in the shaded plot with one frame by comparison to that covered with 2 frames (74%).

In the open plot, C, almost identical results on the root formation was noted for the clones of *P. deltoides* (80% for the clone '63/51' and 78% for the clone '73/51') and they differed little from those plots protected by nets.

However, in *P. x euramericana* 'I 214' root formation of the cuttings in the open was only 86%, or 13% less than that of the cuttings in the shaded plots.

At the conclusion of the experiment it was possible to detect those cuttings which had definitely taken roots, because cuttings with poor root formation dried up during the period of exposure to full light.

In the plot protected with one frame, the root formation of both, *P. deltoides* '63/51' and '77/51' was 62%, while for *P. x euramericana* 'I 214' it was 97%.

In the protected plot with two frames, root formation of *P. deltoides* '63/51' and *P. x euramericana* 'I 214' reached 67% and 96% respectively, while for *P. deltoides* '77/51' it was only 51%.

In the unprotected plot root formation of *P. deltoides* '63/51' and '77/51' was 66% and 70% respectively, while results for *P. x euramericana* 'I 214' were 81%.

Effect of shading on the development of shoots. - After 70 days of shading, the following number of cuttings had reached a height of 40-50 cm (table 17).

When the plastic nets were removed, the cuttings showed great difficulty in adapting to conditions of full light.

The height measurement of the plants at the end of the experiment or after 78 days of full light gave the results set down in table 18.

The shoot development of the cuttings which rooted in the open plot was greater than of the cuttings in the shaded plots. In particular, *P. deltoides* '63/51' reached an average height of 198 cm which proved superior by 48% and 36% respectively, compared with the cutt-

Table 16 - Cutting success after a 70 days-shading and at the conclusion of the experiment.

treatment	clone	70 days No	%	148 days No	%	difference No	%
one net	'63/51'	166	82	126	62	40	20
	'77/51'	171	84	126	62	45	22
	'I 214'	202	99	197	97	5	2
two nets	'63/51'	164	81	136	67	28	14
	'77/51'	150	74	103	51	47	23
	'I 214'	202	99	193	95	9	4
open light	'63/51'	162	80	134	66	28	14
	'77/51'	159	78	142	70	17	8
	'I 214'	175	86	164	81	11	5

Table 17 - Number of cuttings with shoots of 40 - 50 cm after a 70 days-shanding.

clone	without shade No	%	shaded one net No	%	two nets No	%
P. deltoides '63/51'	118	73	91	55	52	32
P. deltoides '77/51'	126	79	88	51	39	26
P. x euramericana cv. 'I 214'	130	74	82	41	56	28

Table 18 - Height of plants (in metres) at the end of the experiment.

clone	without shade	shaded one net	two nets
P. deltoides '63/51'	1.98	1.36	1.46
P. deltoides '67/51'	1.60	1.30	1.72
P. x euramericana cv. 'I 214'	1.96	1.28	1.35

ings protected with one or two nets.

These differences were more evident in *P. x euramericana* 'I 214', where the height of 196 cm was superior by 53% and 45% respectively to those reached in the shaded plots (one net 128 cm and two nets 135 cm).

Only in *P. deltoides* '77/51' the average height (cm 172) of cuttings grown in the plot protected with two nets was superior by 7%, compared with the cuttings in the open field.

This is probably due to the larger area available for each cutting, as result of the poor rooting occurred in the shaded plot. It is interesting to observe that the height of the shoots from cuttings protected with two nets was greater than that reached by those protected with one net only.

The experiments demonstrated that the cuttings of the tested clones found in the soil suitable conditions for root formation, and that overhead shading mainly affected the emission and development of buds rather than that of roots.

The overhead shading resulted, in fact, in a delay in the formation of shoots, and was insufficient to assure a better rooting of the cuttings.

Analysis of the cuttings in the various plots at the end of the test showed that shading had exerted a stimulating action on rooting only in *P. x euramericana* 'I 214', as previously observed in laboratory research.

Conclusions

The laboratory and field trials have shown that the three factors: temperature, light and moisture, exert a clear influence on the rooting of cuttings.

Temperature has particularly affected the promptness of root emergence and, as a consequence, the success of the cuttings.

The negative influence of light on rooting has been emphasized on cuttings placed in water, in laboratory and greenhouse, even in the clones of *P. deltoides* not tested during the previous years.

However, in the field trials, shading had no favourable influence, since in the ground the cuttings are placed in suitable conditions of darkness.

High moisture conditions are positive on rooting as shown by the trials of preimmersion of the cuttings in water and by the trials in polyethylene bags. Briefly, the most favourable rooting conditions occur in the darkness, at rather high temperature and with a considerable moisture.

COMBINED INFLUENCE OF SOIL AND MOISTURE IN GREENHOUSE

To better establish moisture influence on rooting, some trials were carried out in greenhouse, placing the cuttings in pots and adopting two different types of soil, each having seven different moisture contents.

The experiment was performed according to the factorial design.

Good rooting cuttings of *P. x euramericana* cv. 'I 214' were compared with poor rooting cuttings of *P. deltoides* '63/51' and '77/51'. The quantities of soil needed were taken from the upper layer of two fields (up to cm 30 depth) and dried at environmental temperature. The physicochemical characteristics of the two plots (indicated by A and B) are reported in table 19.

In the pots were placed double-polyethylene bags, filled with earth to keep moisture constant. The desidered water contents, equal to 15, 30, 45, 60, 80 and 100% of soil maximum water capacity were successively obtained by the addition of appropriate quantities of water. Polyethylene bags, supported over the upper part of the pot by a frame 20 cm high, were closed as soon as the cuttings were planted.

To these 6 treatments with a constant moisture content, a further one was added as control, with the earth put directly in the pot without the polyethylene bags, to establish to what extent the particular conditions created by the closed bags may affect shooting. Soil moisture was always kept near the saturation point.

The pots used for the test were 126 (i.e. 108 with polyethylene bags and 18 without), divided in two groups of 63 each (i.e. 54 with bags and 9 without). In order to obtain 7 different soil moisture levels, each group was then divided into 7 sub-groups of 9 pots (6 sub-groups with the bags and one without). Of the 9 pots of each sub-group, 5 contained cuttings of *P. deltoides* '63/51'; 3 cuttings of *P. deltoides* '77/51' and 1 cuttings of *P. x euramericana* cv. 'I 214'.

After 21-23 days from the beginning of the trials, the following observations were made: estimate of rooted cuttings; estimate and classification of roots according to their length; estimate of shoots and length measurement; estimate of the size of the callus formed on the upper and lower surface of the cuttings.

Results

Tables 20-26 give the results for each clone; they can be summarized as follows:

P. x euramericana cv. 'I 214'

- 100% rooting of cuttings was recorded for every treatment;
- the average number of roots did not show significant differences between the various treatments;
- the kind of soil was not responsible for significant differences in the average number of roots per cutting;
- a higher soil moisture did not improve length of roots appreciably;
- the shoots in pots without polyethylene bags were much longer that shoots

Table 19 - Analysis of soils submitted to the rooting test.

features	plot A	plot B
gravel	absent	absent
coarse sand %	4.48	0.70
fine sand %	64.97	86.68
silt %	21.45	7.20
clay %	9.10	5.42
water capacity %	37.00	35.00
pH %	7.80	7.80
lime %	absent	5.40
P_2O_5 total %	0.88	1.50
K_2O available ppm	6.00	24.00
Na_2O available ppm	25.00	25.00
humus %	1.25	1.03

Methods applied to the analyses: mechanical analysis: pipet method; pH: potentiometric method; ratio soil-water 40/100 (1:2.5); lime: volumetric method; humus : Walkley and Black method; P_2O_5 total: Ferrari methos; K_2O available: Dirks & Schefer method; soil water capacity: S.A. Wilde and G.K. Voigt method.

Table 20 - Soil and moisture influence on root success.

treatments	soil A			soil B		
	'63/51'	'77/51'	'I 214'	'63/51'	'77/51'	'I 214'
15% M.W.C.	57.5	41.7	100.0	95.0	50.0	100.0
30% "	90.0	66.7	100.0	100.0	62.5	100.0
45% "	100.0	70.8	100.0	100.0	100.0	100.0
60% "	97.5	87.5	100.0	100.0	100.0	100.0
80% "	100.0	100.0	100.0	100.0	100.0	100.0
100% "	100.0	100.0	100.0	100.0	100.0	100.0
control	100.0	100.0	100.0	100.0	100.0	100.0

M.W.C. = Maximum Water Capacity.

Table 21 - *P. x euramericana* cv. 'I 214': total number of roots and % distribution in length classes.

treatments	root total	length classes of the roots in cm						
		3	3.1-6	6.1-9	9.1-12	12.1-15	15.1-18	18.1-21
				s o i l A				
15% M.W.C.	174	51.73	12.07	14.37	14.94	6.32	0.57	0.00
30% "	251	25.90	21.11	27.49	12.75	12.35	0.40	0.00
45% "	205	19.51	18.54	24.88	20.98	13.66	1.46	0.97
60% "	178	20.22	22.48	24.16	16.85	14.04	1.13	1.12
80% "	217	18.89	20.74	25.34	17.51	10.61	6.45	0.46
100% "	224	19.64	19.20	26.34	23.21	6.70	4.91	0.00
control	256	3.91	14.84	19.22	25.00	19.14	14.06	3.13
				s o i l B				
15% M.W.C.	192	18.75	17.71	27.60	21.88	7.29	3.65	3.12
30% "	210	13.81	16.19	37.62	17.14	10.95	4.29	0.00
45% "	225	17.78	18.22	30.67	17.33	12.00	3.11	0.89
60% "	209	23.92	20.10	22.00	20.10	9.09	3.35	1.44
80% "	204	20.37	19.14	25.31	19.75	11.11	3.09	1.23
100% "	162	36.42	17.90	12.96	19.14	12.35	0.62	0.61
control	249	2.41	11.25	23.29	26.11	17.27	11.24	8.43

M.W.C. = Maximum Water Capacity

Table 22 - *P.x euramericana* 'I 214': average number and length of shoots; callus occurrence.

treatments	shoots		callus development	
	number per cutting	length cm	lower cut	upper cut
		soil A		
15% M.W.C.	3.00	5.4	2.7	2.7
30% "	2.25	8.5	3.3	3.2
45% "	2.60	8.6	3.2	1.8
60% "	2.70	8.6	2.9	2.1
80% "	2.52	7.5	2.0	2.3
100% "	2.60	6.7	0.0	3.7
control	1.55	14.0	1.2	0.0
		soil B		
15% M.W.C.	2.75	7.5	2.3	2.8
30% "	2.87	8.3	3.0	3.3
45% "	2.78	8.4	3.0	3.1
60% "	2.83	8.5	2.8	1.7
80% "	2.75	8.0	2.7	2.0
100% "	2.00	7.9	0.0	2.6
control	1.50	14.6	1.0	0.0

M.W.C. = Maximum Water Capacity.

Callus development: 0-1 slight; 1-2 average; 2-3 well; 3-4 high.

in the pots with the bags, and, in this last connection, no significant differences were recorded between the shoots;
- in the treatment with 100% maximum water capacity, the callus developed only on the upper surface of the cutting. In the others, it developed on both the lower and upper surface, without significant variations between the treatments; in cuttings from pots without polyethylene bags it formed just on the lower surface of the cutting.

P. deltoides '63/51'
- root success was more marked in soil B than in soil A;
- a higher soil moisture brought about a gradual increase in the root average number per cutting;
- the root average number was far higher in soil B than in soil A;
- longer roots were observed as soil moisture increased;
- as to shoots and callus, the same remarks as for *P. x euramericana* 'I 214' can be made.

P. deltoides '77/51'
- root success was slightly higher in soil B than in soil A;
- a higher soil moisture caused a gradual increase in the root average number per cutting;
- longer roots were observed as soil moisture increased;
- the shoots in the treatment with a higher moisture content are slightly longer than those of *P. deltoides* '63/51' but shorter than in *P. x euramericana* 'I 214';
- a better aeration was probably responsible for the greater increase of the shoots in pots without polyethylene bags; such growth was, however, recorded for all clones submitted to the same treatment.
- the callus increased more considerably than in the other clones.

The average number of roots per cutting is reported in table 27. Such data were statistically elaborated (tables 28-30). The following conclusions can be drawn:
- the differences due to the kind of soil, regardlessly of the clone, were not significant;
- the differences between the various clones were highly significant;
- the differences depending on varying soil moisture contents were highly significant;
the interactions between the soil type and the clone are significant. This means that, towards the soil, the clones do not behave in the same way. The rooting of *P. deltoides* '63/51' was in fact more significant in soil B than in soil A, while no substantial differences were recorded for the other two clones;
- the interaction between the soil type and the moisture content was not significant;
- the interaction between the clone and the different soil moisture content resulted highly significant; which involves that the clones do not react all in the same way against moisture variations. While the different moisture content did not bring about significant differences in the root average number per cutting in *P. x euramericana* 'I 214', it determined highly significant differences in the two clones of *P. deltoides*.

Table 23 - *P. deltoides* '63/51': total number of roots and % distribution in length classes.

treatments	root total	length classes of the roots in cm						
		3	3.1-6	6.1-9	9.1-12	12.1-15	15.1-18	18.1-21
				soil A				
15% M.W.C.	87	95.40	4.60	0.00	0.00	0.00	0.00	0.00
30% "	167	66.47	22.16	8.38	2.39	0.00	0.60	0.00
45% "	403	30.77	44.32	15.13	6.20	1.74	1.24	0.50
60% "	424	10.85	50.47	27.83	8.49	1.89	0.47	0.00
80% "	652	15.49	40.03	22.55	11.81	7.36	1.69	1.07
100% "	932	17.39	17.49	31.12	20.17	9.44	3.32	1.07
control	482	20.75	35.27	25.10	10.79	4.98	2.28	0.83
				soil B				
15% M.W.C.	370	65.40	17.57	13.51	2.43	1.09	0.00	0.00
30% "	288	14.96	61.07	19.06	2.25	1.64	0.61	4.41
45% "	589	14.43	29.54	33.28	14.77	6.11	0.85	1.02
60% "	627	15.94	24.40	33.81	20.10	4.63	0.80	0.32
80% "	1024	14.55	38.77	29.39	13.97	3.13	0.19	0.00
100% "	1043	21.76	15.92	29.73	21.09	9.01	2.21	0.38
control	519	19.46	43.55	17.53	12.52	4.63	1.54	0.77

M.W.C. = Maximum Water Capacity

Table 24 - *P. deltoides* '63/51': average number and length of shoots; callus occurrence.

treatments	shoots		callus development	
	number per cutting	length cm	lower cut	upper cut
	soil A			
15% M.W.C.	1.30	4.3	1.8	1.3
30% "	1.60	3.7	2.3	1.4
45% "	2.22	5.7	2.4	1.9
60% "	2.47	6.1	2.4	2.4
80% "	2.55	5.5	1.4	1.9
100% "	1.82	4.5	0.0	2.7
control	1.45	10.8	1.0	0.0
	soil B			
15% M.W.C.	2.35	3.8	3.0	1.5
30% "	2.40	5.7	2.6	1.5
45% "	3.00	5.7	2.9	2.4
60% "	3.00	4.5	2.1	1.8
80% "	2.90	4.6	1.7	1.4
100% "	1.72	4.4	0.0	1.5
control	1.55	11.2	1.2	0.0

M.W.C. = Maximum water capacity.

Callus development: 0-1 slight; 1-2 average; 2-3 well; 3-4 high.

Table 25 - *P.deltoides* '77/51': total number of roots and % distribution in length classes.

treatments	root total	length classes of the roots in cm						
		3	3.1-6	6.1-9	9.1-12	12.1-15	15.1-18	18.1-21
				soil A				
15% M.W.C.	24	100.00	0.00	0.00	0.00	0.00	0.00	0.00
30% "	71	78.87	16.90	4.23	0.00	0.00	0.00	0.00
45% "	42	30.95	38.10	14.29	4.76	7.14	4.76	0.00
60% "	145	46.90	16.55	20.00	6.90	3.45	5.52	0.68
80% "	364	54.40	15.11	10.99	13.74	4.40	0.54	0.82
100% "	564	45.92	17.20	14.54	11.70	4.26	3.55	2.83
control	245	35.10	24.90	15.10	11.84	6.12	4.90	2.04
				soil B				
15% M.W.C.	48	91.67	2.08	4.17	2.08	0.00	0.00	0.00
30% "	64	48.44	15.62	9.37	17.19	6.25	3.13	0.00
45% "	141	27.66	10.64	21.99	18.44	11.35	3.54	6.38
60% "	185	33.51	13.51	18.38	16.22	9.19	6.49	2.70
80% "	257	26.85	26.85	19.07	14.40	5.83	4.67	2.33
100% "	425	28.24	29.65	19.53	11.06	6.82	3.76	0.94
control	244	35.65	23.36	15.99	11.06	5.74	5.33	2.87

M.W.C. = Maximum Water Capacity

Table 26 - *P. deltoides* '77/51': average number and lengh of shoots; callus occurrence.

treatments	shoots		callus development	
	number per cutting	length cm	lower cut	upper cut
	s o i l A			
15% M.W.C.	1.41	2.2	3.6	3.0
30% "	2.25	2.7	4.0	2.8
45% "	2.16	4.4	4.0	2.0
60% "	2.41	4.8	3.5	3.0
80% "	2.20	5.8	3.4	3.3
100% "	1.45	6.7	0.0	3.6
control	1.45	11.0	2.0	0.0
	s o i l B			
15% M.W.C.	1.29	4.0	3.4	2.1
30% "	2.00	4.6	3.5	2.5
45% "	2.75	6.6	3.3	3.5
60% "	2.70	6.2	3.7	1.8
80% "	2.66	6.2	3.2	2.5
100% "	1.75	7.6	0.5	3.0
control	1.40	11.3	2.4	0.0

M.W.C. = Maximum Water Capacity.

Callus development: 0-1 slight; 1-2 average; 2-3 well; 3-4 high.

Table 27 - Soil moisture influence on rooting. Average number of roots per cutting.

clones	% soil moisture of M.W.C.							total
	15	30	45	60	80	100	control	clones
				s o i l A				
'I 214'	21.75	31.37	25.62	22.25	27.12	28.00	32.00	188.11
'63/51'	2.17	4.17	10.07	10.60	16.30	23.30	12.05	78.66
'77/51'	1.04	2.96	1.75	6.04	15.17	23.50	10.21	60.67
total	24.96	38.50	37.44	38.89	58.59	74.80	54.26	327.44
				s o i l B				
'I 214'	24.00	26.25	28.12	26.12	25.50	20.25	31.13	181.37
'63/51'	9.25	12.20	14.73	15.68	25.60	26.06	12.97	116.49
'77/51'	2.00	2.66	5.87	7.71	10.71	17.71	10.16	56.82
total	35.25	41.11	48.72	49.51	61.81	64.02	54.26	354.68
sums	*60.21*	*79.61*	*86.16*	*88.40*	*120.40*	*138.82*	*108.52*	*682.12*

Table 28 - Soil moisture influence on the average number of roots.

Interaction soil x clone

treatment	soil A	soil B	total
'I 214'	188.11	181.37	369.48
'63/51'	78.66	116.49	195.15
'77/51'	60.67	56.82	117.49
total	*327.44*	*354.68*	*682.12*

Interaction soil x moisture

treatment	soil A	soil B	total
15% moisture	24.96	35.25	60.21
30% "	38.50	41.11	79.61
45% "	37.44	48.72	86.16
60% "	38.89	49.51	88.40
80% "	58.59	61.81	120.40
100% "	74.80	64.02	138.82
control	54.26	54.26	106.52
total	*327.44*	*354.68*	*682.12*

Interaction clone x moisture

treatment	'I 214'	'63/51	'77/51'	total
15% moisture	45.75	11.42	3.04	60.21
30% "	57.62	16.37	5.62	79.61
45% "	53.74	24.80	7.62	86.16
60% "	48.37	26.28	13.75	88.40
80% "	52.62	41.90	25.88	120.40
100% "	48.25	49.36	41.21	138.82
control	63.13	25.02	20.37	108.52
total	*369.48*	*195.15*	*117.49*	*682.12*

Table 29 - Soil moisture influence on the average length of the roots per cutting.

clones	% soil moisture of M.W.C.							total
	15	30	45	60	80	100	control	clones
				soil A				
'I 214'	4.91	6.47	7.47	7.19	7.54	7.28	10.33	51.19
'63/51'	1.63	2.97	4.78	5.74	6.44	7.53	6.12	35.21
'77/51'	1.50	2.26	5.50	5.18	4.60	5.49	6.05	30.58
total	8.04	11.70	17.75	18.11	18.58	20.30	22.50	116.98
				soil B				
'I 214'	7.64	7.74	7.51	7.08	7.47	6.22	10.86	54.52
'63/51'	3.18	5.04	5.36	6.80	6.08	6.92	5.91	39.29
'77/51'	2.00	5.29	5.35	7.02	6.56	6.11	6.15	38.48
total	12.82	18.07	18.22	20.90	20.11	19.25	22.92	132.29
sums	*20.86*	*29.77*	*35.97*	*39.01*	*38.69*	*39.55*	*45.42*	*249.27*

Table 30 - Soil moisture influence on the average length of the roots.

Interaction soil x clone

treatment	soil A	soil B	total
'I 214'	51.19	54.52	105.71
'63/51'	35.21	39.29	74.50
'77/51'	30.58	38.48	69.06
total	*116.98*	*132.29*	*249.27*

Interaction soil x moisture

treatment	soil A	soil B	total
15% moisture	8.04	12.82	20.86
30% "	11.70	18.07	29.77
45% "	17.75	18.22	35.97
60% "	18.11	20.90	39.01
80% "	18.58	20.11	38.69
100% "	20.30	19.25	39.55
control	22.50	22.92	45.42
total	*116.98*	*132.29*	*249.27*

Interaction clone x moisture

treatment	'I 214'	'63/51'	'77/51'	total
15% moisture	12.55	4.81	3.50	20.86
30% "	14.21	8.01	7.55	29.77
45% "	14.98	10.14	10.85	35.97
60% "	14.27	12.54	12.20	39.01
80% "	15.01	12.52	11.16	38.69
100% "	13.50	14.45	11.60	39.55
control	21.19	12.03	12.20	45.42
total	*105.71*	*74.50*	*69.06*	*249.27*

Root average length is set down in table 4. The statistical working out of the results (table 28) allows the research to draw the following conclusions:

- the differences due to the soil, regardlessly of the clone, are highly significant. Longer roots were recorded in soil B than in A;
- the differences between the various clones are highly significant;
- the differences depending on various soil moisture contents are highly significant;
- the interactions between the soil type and the clone are not significant. All clones in fact showed longer roots in soil B than in A;
- the interactions between the soil type and the moisture content are not significant; actually, regardlessly of the clone, a higher moisture content favoured a greater root development.
- the interactions between the soil moisture content and the clone are highly significant; while the two clones of *P. deltoides* are greatly affected by the soil moisture content as concerns their root elongation, *P. x euramericana* 'I 214' is not influenced significantly, at least within the moisture contents experienced.

The poplar clones tested in this experiment revealed significant differences in their behaviour. A high soil moisture is no doubt responsible for the rooting of *P. deltoides* clones, both as regards the average number of roots and length.

INFLUENCE OF THE TREATMENTS WITH RHIZOGENOUS SUBSTANCES

Preliminary

Rhizogenous substances, to foster root emergence in poplar cuttings, were repeatedly employed in the experiments. Since their influence on poplars is little known, it was judged it suitable to carry out a preliminary test in 1963 on both the way and the time of uptake by cuttings.

Two series of trials were performed to compare the action either individual or combined of indole-3-acetic acid (IAA), indole-3-butyric acid (IBA) and naphtalene-1-acetic acid (NAA).

The contradictory results obtained from such trials made it necessary to repeat the experiments also in 1964 and to investigate on several other stimulatory substances.

The trials and the resulting conclusions are reported in paragraphs a, b and c.

Study of the absorption and diffusion of IAA and NAA by the cuttings

The literature on the application of rooting substances is abundant but the relevant data are somewhat contradictory.

There are two widely-used methods of application: treatment of the cuttings with solutions of the rooting substances at high concentration for a short time, or prolonged treatment at low concentration.

To gain a general idea of the absorption and diffusion of these substances, NAA and IAA labelled with H^3 and C^{14} respectively, were used on the cuttings of various clones of *P. deltoides*.

In the rapid treatment, 10 cuttings from each clone were immersed for 15 minutes in solutions of 250 and 500 ppm IAA or in solutions of 250 and 500 ppm NAA. In the prolonged treatment, the cuttings were immersed in the same solutions for 24 hours.

The cuttings were placed to root in the greenhouse, in boxes with sterile sand. Irrigation was performed by means of a spray mist in such a way as to maintain the moisture level of the substrate. The experiment lasted 51 days, from the 7th May to the 27th June 1963.

During this period the mean temperature of the glasshouse was 22°C (mean minimum 17°C, mean maximum 25°C) while the relative humidity of the air was 77% (mean minimum 63%, mean maximum 90%).

Diffusion of the labelled element in the cuttings was noted 8, 14, 28 and 50 days after treatment.

For periodic observations 4 sections were taken from each cutting, 2 from the basal region treated with the acids, and 2 from the mid region (approximately 12 cm from the base) respectively, the sections being subjected to radiography.

The number of rootlets emerging from the cutting, and their vegetative conditions were also noted.

The results of the experiment and those from the radiography may be thus summarized:

- 8 days after treatment: there was rapid absorption of labelled IAA and NAA in the cambial region of all cuttings, the diffusion having risen to the mid zone of the cutting.

No cutting showed emerging rootlets and there was no perceptile difference between the two treatments.

- 14 days after treatment: the absorption of IAA was greater than that of NAA. However, in the rapid treatment the cuttings treated with NAA at 250 ppm for 15 minutes showed about twice the number of rootlets present, in the cuttings treated with IAA.

In the slow treatment there was an appreciable thickening, in the form of a sheath, at the base of the cuttings treated with 250 and 500 ppm NAA for 24 hours.

There was no emergence of roots from the sheath, which extended to a height of 2-3 cm, but roots appeared above the thickening.

- 28 days after treatment: in the rapid tratment the diffusion of IAA and NAA within the cutting was more evident at 500 ppm than at the lower concentration, but there was no perceptible difference in rooting between the various clones.

In the slow treatment the absorption of IAA was greater than that of NAA.

The cuttings treated with 500 ppm NAA showed pronounced signs of disintegration, particularly in the region of the basal sheath.

The onset of the disintegration was also noted in several cuttings treated with 500 ppm IAA.

- 50 days after treatment: there was, in general, an increased rooting in cuttings treated with 250 ppm and 500 ppm IAA for 24 hours. However, there were signs of disintegration in many of the cuttings treated at higher concentration.

In the cuttings treated with NAA, at 250 ppm, and more especially at 500 ppm, the disintegration was widespread.

The cuttings submitted to rapid treatment showed poor rooting, but they were in better vegetative conditions.

The diffusion of auxin in cuttings which received the rapid treatment was evident at both levels of IAA, but to a lesser extent at 250 ppm than at 500 ppm.

With the slow treatment, the diffusion of IAA was also evident at both concentrations, but was less perceptible for NAA.

The experiment with labelled IAA and NAA demonstrated a marked difference in the absorption and diffusion of the two acids.

In general IAA appears strongly in all treatments, while NAA is absorbed to a lesser extent or otherwise is more labile.

In fact, already by the fiftieth day after treatment it is difficult to find NAA, except at the 500 ppm concentration, in cuttings subjected either the rapid or the slow treatment.

IAA causes increased rooting activity of the cuttings, particularly with the slow treatment, at both concentrations.

NAA also has a good rooting effect but cannot be used with the slow treatment, because in the poplar cuttings it caused visible malformation and serious disintegration.

Use of rhizogenous substances (1st series of trials, 1963)

Three substances widely used also in the agricultural field, were examined, i.e.: indole-3-acetic acid (IAA), indole-3-butyric acid(IBA), naphthalene-1-acetic acid (NAA).

The trials were made in the nurseries of Casale Monferrato and Rome on cuttings 25 cm long taken from different clones of *P. deltoides* and from *P. alba* '58/57'.

The number of the cuttings employed, the type of treatment as also the results obtained in the experiments are set down hereunder.

Treatment with IBA. - Cuttings of *P. deltoides* '77/51' and *P. alba* '58/57' were immersed for 24 hours in IBAsolutions at the following concentrations: 0, 5, 25, 50, 100 ppm. The control cuttings were immersed in water for the same period. For each treatment, four replications of 10 cuttings each were made, giving 400 cuttings, on the whole, per clone. With a view to investigating the influence of the substrate, the cuttings were subdivided and placed in boxes with sand or ordinary soil.

The results of the trial are reported in table 31.

The results are somewhat indefinite, but nevertheless indicate that in the case of *P. deltoides* an increase in concentration causes a decrease in rooting.

With *P. alba*, on the other hand, rooting is greater in the cuttings treated with IBA at concentrations above 25 ppm.

Table 31 - Success % of cuttings treated with IBA

clones	substrate	control	5 ppm	25 ppm	50 ppm	100 ppm
P. deltoides '77/51'	sand	85	57	47	42	40
	soil	60	60	42.5	37.5	25
P. alba '58/57'	sand	67.5	65	57.5	62.5	40
	soil	45	45	62.5	50	67.5

Table 32 - Success % of cuttings treated with IAA, IBA and IAA+IBA

clone	substrate	control	IBA 50 ppm	IAA 50 ppm	IAA + IBA 50 ppm + 50 ppm
P. deltoides 'UAS 235'	soil	52	74	80	78

Table 33 - Success % of cuttings treated with IAA and NAA at 250 ppm

clones	IAA	NAA	controls
P. deltoides '72/51'	65	65	75
" '79/51'	55	65	65
" '60/51'	65	75	75
" '63/51'	65	80	65
" '67/51'	80	75	65
" Rosedale 6	50	65	35
" Lake Beulah	60	35	20
" Indian Point	55	45	25
" Missouriensis	70	50	75
" Virginiana	60	80	65
P. x euramericana 'I 214'	95	95	100

Table 34 - Number of treatments and cuttings per clone.

clones	groups	treatments	cuttings
P. deltoides '63/51'	1 - 9	36	3240
" '77/51'	1 7	4	280
" '37'	1 - 5	1	100
P. alba '58/57'	1 - 9	12	1080
P. x euramericana cv. 'I 214'	1 - 10	13	1300

Treatment with IBA and IAA in combination. The combined action of these two acids causes, in many cases, an increased rooting of the cuttings and a reduction in toxicity.

In an experiment conducted on the clone *P. deltoides* 'UAS 235', the cuttings were treated with IAA and IBA at a concentration of 50 ppm separately and in combination.

For each treatment, 5 replications of 10 cuttings each, were made and planted out in the ground.

The results of this experiment proved that, as concerns *P. deltoides* 'UAS 235', the acids positively affect rooting.

Treatment with IAA and NAA. The trial was conducted on 10 clones of *P. deltoides* and on one clone of *P. x euramericana.* Forty cuttings subdivided into 4 replications were used for each treatment, with the same number of controls.

The treated cuttings were immersed in solutions of IAA and NAA at 250 ppm for one hour, while the control cuttings were immersed in water for the same period. The cuttings were then planted out.

The results of the trial may be thus summed up.:

The trials performed in nursery showed that the application of rooting substances to cuttings was effective only in certain clones of *P. deltoides* (Rosedale 6, Lake Beulah, Indian Point) and in one clone of *P. alba* ('58/57'), while the remaining clones examined gave no result or a negative one.

In any case it appears that climatic and edaphic conditions would have a considerable effect upon rooting.

Further investigations on the use of rhizogenous substances (2nd series of trials, 1964)

The treatments were repeated, employing this time a greater number of substances on three clones of *P. deltoides* ('63/51'; '77/51'; '37'), one clone of *P. alba* ('58/57') and on *P. x euramericana* 'I 214' as control.

The cuttings were obtained from one-year-old stems of poplars with two-year-old roots. The following compounds were used, i.e.: indole-3-acetic acid (IAA); indole-3-butyric acid (IBA); indole-3-pyruvic acid (IPYA); glucose; mineral salts ($ZnSO_4 . 7H_2O$, $CuSO_4 . 5H_2O$, $MnSO_4 . H_2O$ and K_2HPO_4); 2,4 - D.

The interaction between the mineral salts and IAA an IBA was also tested.

As regards *P. deltoides* '63/51', the stems, from which cuttings were obtained, were divided into 20 cm long parts, with the exception of the apical region (60-80 cm).

According to their position in the stem, the cuttings were collected in groups, which were numbered progressively, starting from the base. As to the other clones, owing to the scarce availability of the material, homogenous groups of cuttings were employed in each treatment, without taking into account their different position in the stem.

In table 34 the number of both the groups of cuttings and the treatments employed per each clone are reported. On the whole, 6,000 cuttings were used.

The cuttings of *P. deltoides* '63/51' were prepared on April 5th 1964, treated on April 6th, and planted out the following day. The cuttings of the other clones were prepared on April 8th 1964, treated on April 9th and planted out the next day, with the exception of *P. deltoides* '77/51'. In fact, the cuttings of this last clone were taken 10 days later from plants already in vegetation, from the basal and mid-regions of the stem, where the buds were still dormant.

Preparation of the solutions and treatments.- The weighed quantities of IAA and IPYA were solved in few cc of methyl alchool and diluted to volume with water in volumetric flask to obtain the required concentration.

Glucose was used in 2% aqueous solution. The mineral salts ($ZnSO_4 \cdot 7H_2O$, $FeSO_4 7H_2O$, $CuSO_4 \cdot 5H_2O$, $MnSO_4 \cdot H_2O$, K_2HPO_4) were employed in N/400 aqueous solution.

The cuttings were placed in containers where later on was added the solution; their basal region was immersed till a height of 5 cm. When IAA, IBA and IPYA were used, all operations were performed in the dark to avoid the photodecomposition of auxinic substances. All treatments lasted 24 hours; then, the cuttings were washed in running water and directly planted out.

Discussion and conclusions

The results of the trials are set down in tables 35-38. From their examination, it is evident that non-treated cuttings had a considerable success, as in the case of *P. deltoides* '63/51'. This confirms what was already observed in 1963, namely that the action of the rooting substances upon most of the examined clones is rather moderate. Also from this series of trials, it appears that rooting is greatly influenced by particular climatic and edaphic conditions. This might also explain the considerable differences which were recorded from year to year in the nursery.

Even though the action of the treatments did not prove to be efficacious, it is interesting to note that in 1964, in most of the experiments, the various substances showed to act differently on the several clones.

The treatments carried out on *P. alba* '58/57' with IBA at 50 ppm and on *P. deltoides* '63/51' with IAA combined with iron sulphate, copper sulphate, potassium phosphate and manganese sulphate gave significant differences, in the negative sense.

2,4-D used for the clone '63/51', at a concentration of 5, 25, 50 ppm in 9 replications of 10 cuttings, revealed to posses a high toxicity even at the lowest concentration (5 ppm). Its toxic effect was attenuated at a 0.25 ppm concentration, employed for *P. deltoides* '37' (table 39).

The behaviour of *P. deltoides* '77/51' and *P. x euramericana* 'I 214' did not present significant differences with respect to the control ones. The moderate rooting of *P. deltoides* '77/51', during the experiment (table 36) may be explained by the fact that the treatments were performed on cuttings taken from plants in vegetative conditions.

Table 35 - *P. deltoides* '63/51'.
Influence of various rhizogenous substances on rooting (groups of 90 cuttings).

treatments	number of rooted cuttings per each group									total	success
	I	II	III	IV	V	VI	VII	VIII	IX		%
test	10	10	10	10	10	9	8	10	8	85	94
distilled H_2O	10	10	9	10	6	10	10	8	8	81	90
IAA 10 ppm	10	9	10	8	9	9	9	9	7	80	89
" 25 ppm	10	7	9	9	10	7	9	9	8	78	87
" 50 ppm	10	9	9	8	9	9	9	8	7	78	87
" 100 ppm	9	10	10	10	8	8	7	9	9	80	89
IBA 10 ppm	10	9	10	8	9	8	10	10	7	81	90
" 25 ppm	8	10	10	8	10	9	7	8	10	80	89
" 50 ppm	9	9	7	8	8	9	10	7	7	74	82
IPYA 10 ppm	10	5	10	9	9	10	10	9	9	81	90
" 25 ppm	9	9	10	10	8	10	9	10	9	84	93
" 50 ppm	8	8	9	8	10	10	9	9	10	81	90
" 100 ppm	10	8	9	10	10	10	10	10	9	86	95
glucose 2%	10	8	9	8	10	10	9	10	10	84	93
$ZnSO_4 \cdot 7H_2O$ N/400	9	8	8	10	10	8	8	7	9	77	86
$FeSO_4 \cdot 7H_2O$ N/400	10	10	8	10	10	6	10	7	10	81	90
$CuSO_4 \cdot 5H_2O$ N/400	10	10	9	6	9	8	9	10	10	81	90
K_2HPO_4 N/400	9	9	10	10	10	9	5	7	9	78	87
$MnSO_4 \cdot H_2O$ N/400	10	9	10	7	10	9	8	7	10	80	89
IAA 20 ppm + glucose 2%	10	10	9	9	10	8	10	9	8	83	92
" + $ZnSO_4 \cdot 7H_2O$ N/400	9	10	8	9	10	8	8	8	8	78	87
" + $FeSO_4 \cdot 7H_2O$ N/400	7	8	7	9	6	5	4	5	4	55	61
" + $CuSO_4 \cdot 5H_2O$ N/400	10	9	10	9	10	10	10	8	9	85	94
" + K_2HPO_4 N/400	9	10	10	10	9	9	8	7	7	79	88
" + $MnSO_4 \cdot H_2O$ N/400	10	9	10	10	10	9	6	8	9	81	90
IBA 25 ppm + glucose 2%	9	10	9	9	8	6	9	9	8	77	86
" + $ZnSO_4 \cdot 7H_2O$ N/400	9	8	9	10	10	10	8	7	9	80	89
" + $FeSO_4 \cdot 7H_2O$ N/400	8	8	8	10	9	8	8	5	8	72	80
" + $CuSO_4 \cdot 5H_2O$ N/400	7	9	9	7	10	8	6	8	7	71	79
" + K_2HPO_4 N/400	10	8	8	8	10	8	10	8	5	75	83
" + $MnSO_4 \cdot H_2O$ N/400	10	10	9	10	8	10	7	6	5	75	83
IPYA 25 ppm + glucose 2%	10	10	8	10	9	8	9	10	10	84	93
IAA 25 ppm+IBA 25 ppm+IPYA 25 ppm	10	9	10	8	9	9	8	8	9	80	89
total	309	295	300	295	303	284	277	270	272	2605	
average	*9.36*	*8.93*	*9.09*	*8.93*	*9.18*	*8.60*	*8.39*	*8.18*	*8.24*		

L.S.D. per treatment: P 0.05 = 1.04; P 0.01 = 1.37
L.S.D. per replication: P 0.05 = 0.54; P 0.01 = 0.71

Table 36 - *P. deltoides* '77/51'.
Influence of IBA on rooting (groups of 70 cuttings)

treatments	number of rooted cuttings per each group							total	success
	I	II	III	IV	V	VI	VII		%
test	5	4	5	3	4	3	4	28	40
IBA 25 ppm	3	7	2	5	7	7	1	32	45
" 50 ppm	4	4	8	4	2	2	4	28	40
IBA 25 ppm + glucose 2%	5	5	3	4	6	5	7	35	50
total	17	20	18	16	19	17	16	123	

Table 37 - *P. x euramericana* cv. 'I 214'.
Influence of IAA, IBA, IPYA on rooting (groups of 100 cuttings).

treatments	number of rooted cuttings per each group										success
	I	II	III	IV	V	VI	VII	VIII	IX	X	%
test	9	9	10	9	6	8	9	9	9	7	84
IAA 10 ppm	10	6	9	8	8	9	9	8	10	9	86
" 25 ppm	10	9	8	10	9	10	10	6	7	8	87
" 50 ppm	8	9	10	10	8	10	9	10	10	10	94
" 100 ppm	10	10	7	9	10	10	10	10	7	10	93
IBA 10 ppm	7	10	9	8	8	9	10	9	8	7	85
" 25 ppm	10	10	9	9	10	10	8	8	10	10	94
" 50 ppm	9	5	9	9	9	8	10	10	10	10	89
" 100 ppm	9	9	8	10	9	9	5	6	7	6	78
IPYA 10 ppm	6	8	10	8	9	9	9	7	7	9	82
" 25 ppm	7	10	10	10	9	10	9	10	8	8	91
" 50 ppm	9	10	8	9	10	10	9	10	10	10	95
" 100 ppm	10	9	10	10	9	9	8	8	8	10	91
total	113	114	117	119	114	121	115	111	111	111	

Table 38 - *P. alba* '58/57'.
Influence of IAA, IBA, IPYA on rooting (groups of 90 cuttings).

treatments	number of rooted cuttings per each group									total	success
	I	II	III	IV	V	VI	VII	VIII	IX		%
test	10	9	9	10	5	8	9	10	4	74	82
IAA 10 ppm	9	10	9	10	10	7	8	8	6	77	85
" 25 ppm	9	8	9	9	10	10	9	9	6	79	87
" 50 ppm	10	9	9	9	6	9	8	10	6	76	84
" 100 ppm	10	9	10	10	9	8	10	10	10	86	95
IBA 10 ppm	10	8	7	10	8	9	5	5	4	66	73
" 25 ppm	10	7	9	9	8	6	5	9	4	67	74
" 50 ppm	7	6	9	6	6	6	9	8	4	61	68
IPYA 10 ppm	10	9	7	9	7	10	10	10	8	80	89
" 25 ppm	10	10	10	7	10	10	9	9	10	85	94
" 50 ppm	10	9	9	10	6	9	8	9	10	80	88
" 100 ppm	7	10	9	8	8	9	9	10	8	78	87
total	112	104	106	107	93	101	99	107	80	999	

L.S.D. per treatment: P 0.05 = 1.07; P 0.01 = 1.42.

Table 39 - *P. deltoides* '37'.
Influence of 2,4-D on rooting (groups of 50 cuttings).

treatments	number of rooted cuttings per each group					total	success
	I	II	III	IV	V		%
test	5	7	7	8	9	36	72
2,4-D 0.25 ppm	5	5	6	7	5	28	56
total	10	12	13	15	14	64	

On the whole, trials proved that IPYA and IAA solutions seem to possess a more favourable action than that of the other substances and therefore will be further studied. Conversely, the treatment with IBA gave no positive results, confirming what was already observed during the previous investigations.

INFLUENCE OF FERTILIZERS

A study was undertaken in 1964 to establish the direct effect of the mineral fertilization on the rooting of cuttings as also the indirect effect of the parent plants' nutritional conditions on it.

The trials were made on cuttings of *P. deltoides* '63/51'.

A factorial experiment was carried out by comparing four levels of phosphatic fertilizers with three levels of potassio fertilizers (both distributed once only) and with nitrogen. This last element was used whether in two levels, to study fertilization direct influence on rooting, or in three levels, to investigate its indirect effect on it.

The levels of fertilizers employed are expressed in Kgs/ha of P_2O_5, K_2O and N; distribution periods are set down in table 40.

Having adopted three different sets of factors in the experiment, the split plot arrangement was preferred.

Fertilization direct influence on rooting

The entire area was divided into five blocks (I-V) corresponding to the number of replications of the different treatments; each block was then subdivided into four main plots where the four levels of phosphatic fertilizers (A_0, A_1, A_2, A_3) were randomized in only one distribution. In its turn, each main plot was split into three sub-plots in which were randomized, always in only one distribution, the three levels of potassic fertilizers (B_0, B_1, B_2). Finally, every sub-plot was cut into 3 portions in which ware randomized the three levels of nitrogenous fertilizers by distribution carried out in different times (C_0, $C_{0.5} + C_{0.5}$, $C_{0.5} + C_{0.5} + C_1$).

On the whole, 180 portions of 7x6,25 sq.m were set up, leaving inside each portion a surface of 7.50 sq.m (3 x 2,50) planted with 50 cuttings of *P. deltoides* '63/51', arranged in two rows distant 1,25 m the one from the other. The remaining area of the portions was planted with cuttings of *P. x euramericana* cv. 'I 214' at the same distance as above, to avoid that the cuttings of *P. deltoides* '63/51' -under observation- were influenced by the fertilizers given to the surrounding portions.

The cuttings, obtained from the basal and middle tract of S_1R_1 * and S_1R_2 plants, were divided into five groups, according to the level of the parent plant, taking ten of them from each group.

* S = Stem; R = Root; S_1R_1 = means one-year-old stem with one-year-old root.

The plantation, established in April 1965, presented sandy loam soil fairly provided with phosphorus and potassium, at least in the upper layer; the phisico-chemical characteristics are illustrated in table 41.

In springtime, rainfalls were rather low. Cultivation practice consisted of ordinaty weedings and two irrigations.

The results of fertilization direct influence on rooting were observed after some two months from the plantation. It should be mentioned that at that time two of the three portions of each sub-plot were given 36.8 Kg of nitrogen, leaving the third one as control.

For the statistical working out of the results, therefore, account was taken of the average rooting of *P. deltoides* '63/51' cuttings, as recorded in the two portions ($C_{0.5}$ + $C_{0.5}$) and in the control.

Conclusions.- The results are given in table 42. The statistical elaboration of the data proves that there are no significant differences between the various factors, which means that the mineral fertilizers applied both separately and in combination did not affect rooting.

It should be borne in mind that the conditions of soil fertility were good enough and that perhaps cuttings' requirements during the the first stages of development are not such as to take advantage of eventual additions of fertilizers.

Fertilization indirect influence on rooting

The material employed was taken from S_1R_1 plants planted out in the 180 portions of the previous experiment.

A number of 250 cuttings of equal dimensions were obtained from the plants of each treatment and thus, considering that the treatments were 36 and repeated 5 times, 9,000 cuttings were finally collected on the whole. In spring 1966, these latter were planted out in the split plot arrangement, keeping the ones apart from the others according to the treatment adopted for their parent plant. Also in this trial were performed 36 treatments, repeated 5 times.

Rainfall attained 103 mm in April, 53 mm in May and 40 mm in June. Cultural practice consisted of ordinary manuring, irrigations and weedings. Root successes were recorded 90 days from the plantation.

Results.- Results are set down in table 45. Their statistical working out demonstrates that the phosphatic fertilization adopted for the cuttings from S_1R_1 and S_1R_2 plants significantly affect the success of the cuttings derived from them.
The interaction between P_2O_5 and K_2O resulted highly significant, while that between K_2O and N proved significant just at 0.05.

However, it is important to stress that, as table 47 shows, the two interactions phosphorus-potassium and potassium-nitrogen are unsignificant as against the control.

Conclusions.- The trials performed to establish the influence of mineral fertilization on cuttings' rooting allowed the researchers to highlight that nitrogen, phosphorus and potassium, either kept separately or combined at various levels, did not exert any positive action when applied directly to the soil.

Table 40 - Distribution period and Kg/ha of P_2O_5, K_2O and N.

P_2O_5	K_2O	N			total N
1st April	1st April	1st April	7th June	3rd July	
A_0 0	B_0 0	C_0 0	C_0 0	C_0 0	C_0 0
A_1 76.0	B_1 61.5	$C_{0.5}$ 36.8	$C_{0.5}$ 36.8	-	C_1 73.6
A_2 152.0	B_2 123.0	$C_{0.5}$ 36.8	$C_{0.5}$ 36.8	C_1 73.6	C_2 147.2
A_3 304.0	-	-	-	-	-

Table 41 - Chemical and physical features of the soil.

depth	sand		silt	clay	pH	lime	total	available	humus
cm	coarse	fine				%	P_2O_5	K_2O ppm	%
5 - 30	9.00	76.60	11.00	3.40	7.9	2.5	1.45	15	0.90
30 - 70	3.00	92.50	3.00	1.50	8.0	2.8	1.20	7	0.40
70 - 100	6.00	85.10	7.90	1.00	8.0	3.2	1.20	8	0.30
100 - 120	1.70	94.00	3.00	1.30	8.0	3.7	1.00	7	0.30

Table 42 - Direct effect of the mineral fertilization on the rooting of poplar cuttings(rooted cuttings for each plot).

levels	replications I	II	III	IV	V	total	average	success %
$A_0B_0C_0$	37	22	37	18	35	149	29.80	59.60
$A_0B_0C_{0.5}$	42	26	38	37	36	179	35,80	71,60
$A_0B_0C_{0.5}$	32	15	40	37	35	159	31,80	63,60
$A_0B_1C_0$	37	21	34	39	40	171	34,20	68,40
$A_0B_1C_{0.5}$	36	28	24	38	36	162	32,40	64,80
$A_0B_1C_{0.5}$	35	14	27	38	30	144	28,80	57,60
$A_0B_2C_0$	35	23	28	39	32	157	31,40	62,80
$A_0B_2C_{0.5}$	35	24	25	31	37	152	30,40	60,80
$A_0B_2C_{0.5}$	28	19	32	39	34	152	30,40	60,80
$A_1B_0C_0$	36	33	29	26	21	145	29,00	58,00
$A_1B_0C_{0.5}$	42	36	21	37	29	165	33,00	66,00
$A_1B_0C_{0.5}$	37	31	23	35	36	162	32,40	64,80
$A_1B_1C_0$	41	40	22	40	38	181	36,20	72,40
$A_1B_1C_{0.5}$	37	29	23	21	19	129	25,80	51,60
$A_1B_1C_{0.5}$	34	24	17	43	34	152	30,40	60,80
$A_1B_2C_0$	21	30	38	40	34	163	32,60	65,20
$A_1B_2C_{0.5}$	35	23	28	41	32	159	31,80	63,80
$A_1B_2C_{0.5}$	28	29	23	45	28	153	30,60	61,20
$A_2B_0C_0$	32	29	34	16	40	151	30,20	60,40
$A_2B_0C_{0.5}$	35	34	24	28	39	160	32,00	64,00
$A_2B_0C_{0.5}$	36	37	38	37	38	186	37,20	74,40
$A_2B_1C_0$	34	36	34	32	31	167	33,40	66,80
$A_2B_1C_{0.5}$	37	39	31	29	38	174	34,80	69,60
$A_2B_1C_{0.5}$	43	23	27	29	31	153	30,60	61,20
$A_2B_2C_0$	33	31	29	35	39	167	33,40	66,80
$A_2B_2C_{0.5}$	29	24	26	24	34	137	27,40	54,80
$A_2B_2C_{0.5}$	32	27	19	27	37	142	28,40	56,80
$A_3B_0C_0$	31	37	24	25	30	147	29,40	58,80
$A_3B_0C_{0.5}$	27	32	27	34	28	148	29,60	59,20
$A_3B_0C_{0.5}$	22	30	32	35	23	142	28,40	56,80
$A_3B_1C_0$	28	31	26	39	20	144	28,80	57,60
$A_3B_1C_{0.5}$	32	37	30	31	21	151	30,20	60,40
$A_3B_1C_{0.5}$	28	32	22	41	27	150	30,00	60,00
$A_3B_2C_0$	20	32	24	37	20	133	26,60	53,20
$A_3B_2C_{0.5}$	29	31	26	34	22	142	28,40	56,80
$A_3B_2C_{0.5}$	22	31	25	39	15	132	26,40	52,80
total	1178	1040	1007	1216	1119	5560	-	-
average	*32,72*	*28,88*	*27,97*	*34,05*	*31,08*	-	*30,88*	*61,78*
%	65,44	57,76	55,94	68,10	62,16	-	61,78	-

Table 43 - Influence of fertilizers on the rooting of poplar cuttings (250 cuttings for each treatment).

Interaction P_2O_5 x K_2O

levels	A_0	A_1	A_2	A_3	total
B_0	317	308	322	290	1237
B_1	323	320	330	294	1267
B_2	307	318	304	268	1197
total	947	946	956	852	3701

Interaction P_2O_5 x N

levels	A_0	A_1	A_2	A_3	total
C_0	477	489	485	424	1875
$C_{0.5} + C_{0.5}$: 2	470	457	471	428	1826
total	947	946	956	852	3701

Interaction K_2O x N

levels	B_0	B_1	B_2	total
C_0	592	663	620	1875
$C_{0.5} + C_{0.5}$: 2	645	604	577	1826
total	1237	1267	1197	3701

Table 44 - Analysis of variance of rooted cuttings.

source of variation	df	sum of squares	mean squares	F
effects : P_2O_5	3	240.00	80,000	1,950 n.s.
K_2O	2	73.36	36,680	< 1
N	1	20.01	20,010	< 1
interaction:				
$P_2O_5 \times K_2O$	6	23.14	3,856	< 1
$P_2O_5 \times N$	3	23.32	7,773	< 1
$K_2O \times N$	2	171.78	85,890	2,094 n.s.
$P_2O_5 \times K_2O \times N$	6	214.39	35,731	< 1
error	96	3,938.00	41,020	-
total	119	4,704.00		

n.s. = non significant differences.

Table 45 - Influence of mineral fertilization on parent plants (rooted cuttings per plot).

levels	replications I	II	III	IV	V	total	average	success %
$A_0B_0C_0$	37	37	41	32	42	189	37,80	75,60
$A_0B_0C_1$	33	41	25	32	33	164	32,80	65,60
$A_0B_0C_2$	36	37	33	40	26	172	34,40	68,80
$A_0B_1C_0$	39	24	36	38	39	176	35,20	70,40
$A_0B_1C_1$	42	36	35	41	43	197	39,40	78,80
$A_0B_1C_2$	38	34	41	28	32	173	34,60	69,20
$A_0B_2C_0$	31	33	33	44	35	176	35,20	70,40
$A_0B_2C_1$	39	42	34	33	38	186	37,20	74,40
$A_0B_2C_2$	34	37	37	39	33	180	36,00	72,00
$A_1B_0C_0$	35	42	35	36	33	181	36,20	72,40
$A_1B_0C_1$	34	46	31	42	32	185	37,00	74,00
$A_1B_0C_2$	36	40	36	24	39	175	35,00	70,00
$A_1B_1C_0$	28	36	37	32	30	163	32,60	65,20
$A_1B_1C_1$	32	36	35	42	31	176	35,20	70,40
$A_1B_1C_2$	39	35	43	33	37	187	37,40	74,80
$A_1B_2C_0$	25	38	34	31	35	163	32,60	65,20
$A_1B_2C_1$	32	35	36	38	34	175	35,00	70,00
$A_1B_2C_2$	44	38	38	34	33	187	37,40	74,80
$A_2B_0C_0$	36	39	39	36	36	186	37,20	74,40
$A_2B_0C_1$	35	35	37	40	33	180	36,00	72,00
$A_2B_0C_2$	42	43	33	36	39	193	38,60	77,20
$A_2B_1C_0$	34	41	35	44	39	193	38,60	77,20
$A_2B_1C_1$	34	37	45	40	39	195	39,00	78,00
$A_2B_1C_2$	27	35	36	37	37	172	34,40	68,80
$A_2B_2C_0$	41	37	38	33	36	185	37,00	74,00
$A_2B_2C_1$	33	40	40	37	38	188	37,60	75,20
$A_2B_2C_2$	46	49	39	41	37	212	42,40	84,80
$A_3B_0C_0$	41	42	36	34	50	203	40,60	81,20
$A_3B_0C_1$	28	42	39	32	36	177	35,40	70,80
$A_3B_0C_2$	36	36	35	41	38	186	37,20	74,40
$A_3B_1C_0$	38	42	45	43	47	215	43,00	86,00
$A_3B_1C_1$	30	42	39	43	40	194	38,80	77,60
$A_3B_1C_2$	37	38	31	43	34	183	36,60	73,20
$A_3B_2C_0$	32	31	28	33	33	157	31,40	62,80
$A_3B_2C_1$	31	32	30	27	40	160	32,00	64,00
$A_3B_2C_2$	39	34	29	31	25	158	31,60	63,20
total	1274	1362	1294	1310	1302	6542	36,34	72,68

Table 46 - Calculation of the interaction.

Interaction P_2O_5 x K_2O

levels	A_0	A_1	A_2	A_3	total
B_0	525	541	559	566	2191
B_1	546	526	560	592	2224
B_2	542	525	585	475	2127
total	1613	1592	1704	1633	6542

Interaction P_2O_5 x N

levels	A_0	A_1	A_2	A_3	total
C_0	541	507	564	575	2187
C_1	547	536	563	531	2177
C_2	525	549	577	527	2178
total	1613	1592	1704	1633	6542

Interaction K_2O x N

levels	B_0	B_1	B_2	total
C_0	759	747	681	2187
C_1	706	762	709	2177
C_2	726	715	737	2178
total	2191	2224	2127	6542

Table 47 - Comparison between the averages.

Interaction P_2O_5 x K_2O

levels	A_0	A_1	A_2	A_3	average
B_0	35.00	36.06	37.26	37.73	36.51
B_1	36.40	35.06	37.33	39.46	37.06
B_2	36.13	35.00	39.00	31.66	35.45
average	35.84	35.37	37.86	36.28	36.34

Interaction P_2O_5 x N

levels	A_0	A_1	A_2	A_3	average
C_0	36.06	33.80	37.60	38.33	36.45
C_1	36.46	35.73	37.53	35.40	36.28
C_2	35.00	36.60	38.46	35.13	36.30
average	35.84	35.37	37.86	36.28	36.34

Interaction K_2O x N

levels	B_0	B_1	B_2	average
C_0	37.95	37.35	34.05	36.45
C_1	35.30	38.10	35.45	36.28
C_2	36.30	35.75	36.85	36.30
average	36.51	37.06	35.45	36.34

LSD: between the averages for P_2O_5 P 0.05 = 1.83 P 0.01 = 2.40

LSD: between the averages for interaction P 0.05 = 5.48 P 0.01 = 7.20

Fertilization experiments on parent plants revealed, on the contrary, phosphorus marked influence on cuttings' rooting, while potassium and nitrogen did not seem to affect it. All this is outstandingly important from a practical point of view, whereby particular attention and cares must be devoted to phospatic fertilization.

INFLUENCE OF THE IMMERSION OF CUTTINGS IN WATER

This trial was carried out to establish the influence of immersion in water on the rooting of cutting before their planting out.

In the experiments were employed the following poplar clones, all with a poor rooting capacity:

P. deltoides '63/51'.- Use was made of 2,400 cuttings obtained from S_1R_2 plants as also of 2,400 cuttings from S_1R_1 plants. Each of these two types of cutting was submitted to three different treatments, making for each of them four replications of 200 cuttings. The treatments were the following:

- control (no treatment);
- cuttings in water for 3 days;
- cuttings in water for 5 days.

P. deltoides '77/51'.- Use was made of 800 cuttings, from S_1R_1 plants, submitted to four different. For every treatment, four replications were made, of 50 cuttings each.

P. alba '58/57'.- Use was made of 1,600 cuttings from S_1R_2 plants and of 800 from S_1R_1 plants. The cuttings were submitted to six different treatments, making for each of them four replications of 100 cuttings. The treatments were as follows:

- untreated cuttings from S_1R_1 plants, as control;
- cuttings from S_1R_1 plants kept in water for 2 days;
- cuttings from S_1R_2 plants, as control;
- cuttings from S_1R_2 plants kept in water for 2 days;
- cuttings from S_1R_2 plants kept in water for 4 days;
- cuttings from S_1R_2 plants kept in water for 6 days.

For both types of cuttings, the plantation was established on March 24, 1966, in a plot of sandy loam texture and mean fertility.

The split plot arrangement was adopted for *P. deltoides* '63/51' while the randomized groups were used for the other two clones.

Over the spring 1966, the following rainfall was recorded: 103 mm in April, 53 mm in May and 40 mm in June.

Cultivation works consisted of ordinary manuring, irrigation and weeding.

Results

Root success was observed 100 days from the planting out of the cuttings.

P. deltoides '63/51'.- The statistical working out of the data in table 48

Table 48 - Root success of cuttings from *P. deltoides* '63/51', immersed in water (200 cuttings per replication).

replications	days	success S_1R_2	success S_1R_1	total	sums
I	3	124	137	261	
	5	138	155	293	
	control	123	111	234	788
II	3	114	155	269	
	5	138	178	316	
	control	116	132	248	833
III	3	117	153	270	
	5	131	156	287	
	control	102	130	232	789
IV	3	121	149	270	
	5	142	159	301	
	control	97	124	221	792
sums		1463	1739		3202

Table 49 - Influence of the treatments on the root success of cuttings of *P. deltoides* '63/51'.

days	S_1R_2	$\bar{x}$	S_1R_2	$\bar{x}$	total	$\bar{x}$
3	476	119.00	594	148.50	1070	133.75
5	549	137.25	648	162.00	1197	149.62
control	438	109.10	497	124.25	935	116.87
total (TS)	1463		1739		3202	
average		*121.91*		*144.91*		*133.41*

LSD for the immersion in water: P 0.05 = 7.30; P 0.01 = 10,06
LSD for the age influence: P 0.05 = 9.35; P 0.01 = 13.43

Table 50 - Root success of cuttings of *P. deltoides* '77/51' immersed in water (50 cuttings per replication).

days	replications I	II	III	IV	total	average	%
2	41	32	36	33	142	*35.50*	71.00
4	36	37	39	30	142	*35.50*	71.00
6	35	42	36	38	151	*37.75*	75.50
control	25	25	27	30	107	*26.75*	53.50
total	173	136	138	131	542		

LSD: P 0.05 = 6.13; P 0.01 = 8.81.

Table 51 - Root success of cuttings of *P. alba* '58/57' immersed in water.

cuttings	days	replications I	II	III	IV	total	%
S_1R_1	0	78	45	62	53	238	59.50
S_1R_1	2	85	90	78	86	339	84.75
S_1R_2	0	53	63	59	52	227	56.75
S_1R_2	2	81	85	77	69	312	78.00
S_1R_2	4	71	90	73	81	315	78.75
S_1R_2	6	82	80	81	76	319	79.75
total		451	453	430	417	1750	72.91

LSD: P 0.05 = 12.27; P 0.01 = 16.97.

reveals that cuttings' immersion in water before planting greatly fostered root success (table 49). The best results were given by the longest immersion period, i.e. 5 days and, in particular, by the cuttings from S_1R_1 plants.

P. deltoides '77/51'.- The trial carried out on the cuttings of this clone proved that the immersion in water fostered root success and that a statistically significant improvement was obtained with a 2-days'-immersion (table 50). The same result was given by a 4-days-immersion, while after a 6-days'-immersion the cuttings showed a further slight progress, yet statistically non significant, as against those submitted to the first two treatments.

P. alba '58/57.- The immersion in water considerably favoured the rooting of cuttings from both S_1R_2 and S_1R_1 plants (table 51). It did not give significantly different result when increasing the number of days, whereby two days of immersion would seem sufficient to get good results.

Conclusions

The immersion in water always fostered cuttings' rooting, but while for *P. deltoides* '63/51 the extension of the immersion period up to 5 days led to a gradual rooting improvement, this did not occur as concerns the other 2 clones.

In the near future researches will be carried out to determine the reasons governing the different behaviour of *P. deltoides* '63/51'.

Considering, however, that the cuttings easily dehydrate during the preparation, their immersion in water is always advisable because of the extreme simplicity of this method.

INFLUENCE OF SOIL COVERING WITH PLASTIC SHEETS

Preliminary laboratory tests showed that temperatures between 20° and 27°C connected with high moisture considerably hasten root emergence in cuttings of some poor rooting poplar clones.

On the ground of these results, a method intended to modify soil temperature and moisture, which are generally too low during the plantation period, was experienced.

The test was carried out on cuttings of *P. deltoides* '63/51', '77/51' and *P. alba* '58/57', which were compared with well rooting clones of *P. x euramericana* cv. 'I 214'.

Two rectangular plots of 120 sq.m were chosen and planted on March 1966, with 200 cuttings from each clone, divided into 4 replications. The day after the plots were watered. From March 20th to April 7th, 1966, one of the plots was covered with a plastic sheet supported by a wooden frame, maintaining the sheet at a height of 40 cm laterally and of 80 cm at the centre. The other plot, used as control, was not covered.

Geothermoigrographs were used to control variations of temperature and relative moisture in the two plots. The most sensitive parts of this

Table 52 - Soil temperature in ^{o}C at 15 cm depth.

period	covered plot					uncovered plot					difference between av. temp.
	Max.	Min.	8a.m.	6p.m.	av.	Max.	Min.	8a.m.	6p.m.	av.	
20.3.66	-	-	-	-	-	-	-	-	-	-	-
21.3.66	-	-	-	-	-	-	-	-	-	-	-
22.3.66	-	-	-	-	-	-	-	-	-	-	-
23.3.66	-	-	-	-	-	12.5	4.5	4.5	11.0	*8.1*	-
24.3.66	-	-	-	-	-	13.5	5.5	5.5	13.0	*9.3*	-
25.3.66	-	-	-	-	-	9.5	4.0	5.0	7.0	*6.3*	-
26.3.66	19.5	8.5	9.0	19.0	*14.0*	10.0	1.0	2.5	10.0	*5.8*	8.2
27.3.66	20.5	11.0	11.0	20.0	*15.6*	12.0	2.5	3.0	11.5	*7.2*	8.4
28.3.66	22.5	12.5	13.0	22.5	*17.6*	13.0	4.0	6.0	12.5	*8.8*	8.8
29.3.66	23.0	13.0	13.0	23.5	*18.1*	11.5	2.5	6.0	12.0	*8.0*	10.1
30.3.66	22.5	13.0	13.5	22.5	*17.8*	12.0	2.5	3.0	11.0	*7.1*	10.7
31.3.66	22.5	13.5	13.5	22.5	*18.0*	11.5	5.0	3.0	11.0	*7.6*	10.4
1.4.66	20.0	15.0	15.0	20.0	*17.5*	14.0	5.5	5.0	10.5	*8.7*	8.8
2.4.66	23.0	14.0	14.0	23.0	*18.5*	14.0	5.5	5.5	12.5	*9.3*	9.2
3.4.66	23.5	14.5	14.5	23.5	*19.0*	14.5	6.5	5.5	13.5	*10.0*	9.0
4.4.66	24.0	15.0	15.0	23.5	*19.3*	14.5	7.5	7.5	12.5	*10.5*	8.8
5.4.66	24.0	16.0	16.0	23.5	*19.8*	16.0	7.5	9.0	12.5	*11.2*	8.6
6.4.66	25.0	17.0	17.0	25.0	*21.0*	16.0	9.0	8.5	13.5	*12.0*	9.0

Table 53 - Influence of the plastic cover on rooting.

treatment	clones	replications				total	average
		I	II	III	IV		
plastic	'I 214'	47	47	48	50	192	*96.0*
	'63/51'	38	38	48	46	170	*85.0*
	'77/51'	38	35	41	36	150	*75.0*
	'58/57'	45	40	47	46	178	*89.0*
	total	168	160	184	178	690	
control	'I 214'	48	49	50	48	195	*97.5*
	'63/51'	29	28	30	32	119	*59.5*
	'77/51'	22	21	38	29	110	*55.0*
	'58/57'	31	26	39	23	119	*59.5*
	total	130	124	157	132	543	

Table 54 - Average success of cuttings.

treatment	'I 214'	'63/51'	'77/51'	'58/57'	average
plastic	48.00	42.50	37.50	44.50	*43.12*
control	48.75	29.75	27.50	29.75	*33.93*
average	*48.37*	*36.12*	*32.50*	*37.12*	*38.53*

LSD: between the plots: P 0.05 = 3.11; P 0.01 = 5.72.

LSD between the clones: P 0.05 = 5.44; P 0.01 = 7.45.

Table 55 - Influence of the plastic cover on the average height of the shoots (after 95 days).

treatment	clones	replications I	II	III	IV	total
plastic	'I 214'	125.3	125.8	118.1	111.9	481.1
	'63/51'	117.0	110.8	102.1	99.0	428.9
	'77/51'	95.0	95.1	104.5	94.6	389.2
	'58/57'	125.9	111.6	105.3	104.2	447.0
	total	463.2	443.3	430.0	409.7	1746.2
control	'I 214'	113.2	98.1	104.7	103.9	419.9
	'63/51'	63.3	65.8	55.8	62.7	247.6
	'77/51'	48.0	58.6	63.8	51.6	222.0
	'58/57'	89.7	81.5	87.6	83.6	342.4
	total	314.2	304.0	311.9	301.8	1231.9

Table 56 - Shoot average heights.

treatment	'I 214'	'63/51'	'77/51'	'58/57'	average
plastic	120.27	107.22	97.30	111.75	*109.14*
control	104.97	61.9	55.50	85.60	*76.99*
average	*112.62*	*84.56*	*76.40*	*98.67*	*93.06*

LSD between the plots: P 0.05 = 7.51; P 0.01 = 13.78.

LSD between the clones: P 0.05 = 6.34; P 0.01 = 8.69.

LSD interaction treatment x clone: P 0.05 = 8.97; P 0.01 = 12.29.

device were earthed up at 15 cm depth. Temperature variations are set down in table 52, where it appears that the mean temperature of the covered plot exceeded that of the control by 8-10°C. A higher relative moisture was also recorded in the covered plot, where it kept near the saturation point.

Rainfalls occurred as follows: April, mm 103; May, mm 53 and June, mm 40.

The test was performed on a sandy loam soil, of midium fertility. At the moment the sheet was taken off, the cuttings in the covered plot presented shoots 15-20 cm long whereas those of the control had just started sprouting.

On June 21st, 1966, i.e. 95 days from the beginning of the test, the root success was controlled, and the height of the shoots measured.

The cuttings of *P. x euramericana* cv. 'I 214' were almost always successful even in the control plot, thus proving that their rooting was not affected by the plastic cover. The cuttings of *P. deltoides* '63/51' and '77/51', and *P. alba* '58/57' covered with the plastic sheet recorded a higher success than control ones, with highly significant differences (table 53).

The shoots in the covered plot were also higher than those in the control, with highly significant differences (table 54).

This field trial fully confirmed laboratory observations on the influence of soil temperature and moisture on cuttings' root success; it also proved to be of very practical application.

INFLUENCE OF THE TREATMENT WITH PLASTIC SUBSTANCES

To avoid moisture losses from wood tissues, it was judged it more suitable to apply to the stem of the poplars - from which the cuttings were taken - a plastic substance diluted in water (Vitaplast) for creating a protective cover over the bark.

This experiment was performed on March 11th, 1966 on 10 two-year-old poplars of each of the following clones: *P. deltoides* '74/51', *P. deltoides* '67/51' and *P. x euramericana* cv. 'I 214'.

The cuttings were prepared two days after the treatment and Vitaplast was applied also to the cut surface, i.e. at boths ends of the cuttings. Then, they were stored a week and later on, on March 21st, 1966, namely after 8 days of conservation, planted out in the ground. Cuttings success is set down in table 57.

Observations

The treatment with plastic substances did not provoke any inconvenience to the cuttings rooting after some 2 months, in fact, the rooted cuttings presented a regular development. Therefore, Vitaplast seems having exerted a positive influence on rooting since fairly marked differences were recorded for *P. deltoides* '74/51' and *P. x euramericana* cv.

Table 57 - Success % of cuttings from parent plants treated with Vitaplast.

clones	cuttings treated	cuttings control
P. x euramericana cv. 'I 214'	97	88
P. deltoides '74/51'	86	72
P. deltoides '67/51'	89	86

Table 58 - Influence of the age of the plants from which the cuttings are obtained on their rooting.

clones	plant age	cuttings	success No	success %
P. x euramericana cv. 'I 214'	S_1R_1	105	56	53.33
	S_1R_2	105	80	76.19
	S_2R_3	105	56	53.33
P. deltoides '63/51'	S_1R_1	105	26	24.76
	S_1R_2	105	56	53.33
	S_2R_3	105	17	16.19
P. deltoides '77/51'	S_1R_1	105	8	7.62
	S_1R_2	105	18	17.14
	S_2R_2	105	42	40.00
	S_2R_3	105	15	14.28

'I214'. As concerns these two clones, the cuttings treated with Vitaplast showed a higher success than the control ones (i.e. by 14% and 11% respectively). Also the cuttings of *P. deltoides* '67/51' presented a higher success (3%).

These results appear to be satisfactory, whereby further investigation will be devoted to the use of this coating substance.

INFLUENCE OF THE PARENT PLANT AGE

The conditions of the plant, from which the cuttings are obtained, can affect the rooting of these latter. It was, therefore, judged it suitable to perform some trials on cuttings from plants of different age.

Ist SERIES OF TRIALS

In these investigations, use was made of cuttings taken from the year's shoots of the following types of plants:

- S_1R_1 = one year old stem with one year old root
- S_1R_2 = one year old stem with two years old root
- S_2R_2 = two years old stem with years old root
- S_2R_3 = two years old stem with three years old root

The clones were the following: *P. x euramericana* cv. 'I 214', *P. deltoides* '63/51', *P. deltoides* '77/51', employing 105 cuttings of each one.

For the first two clones use was made of cuttings obtained from S_1R_2 and S_2R_3 plants, while for *P. deltoides* '77/51' cuttings from S_1R_2, S_2R_2, S_2R_3 were used. Cuttings were taken from the stem portion lying between 20 cm and 120 cm of plants S_1R_2 and from an one meter long portion of the year's shoots of S_2R_2 and S_2R_3 plants.

For all types of cuttings, with the exception of those from S_2R_2 *P. deltoides* '77/51', studies were carried out to determine the mineral contents (N, ashes, P, Na, K, Ca) and the organic nitrogen present in the bark. For each type of cutting five replications were used, each replication was formed by an average sample of the bark obtained from five plants.

Results

In the field trials, the highest success was obtained with cuttings from plants S_1R_2 of both *P. x euramericana* cv. 'I 214' and *P. deltoides* '63/51', which attained a rooting percentage of 76% and 53% respectively (table 58). The rooting values were considerably higher than those from other types of cuttings, viz. as regards *P. x euramericana* cv. 'I 214' which exceeded by some 23% those obtained with cuttings from plants S_1R_1 and S_2R_3 and, as to *P. deltoides* '63/51' by about 28% visà-vis the cuttings S_1R_1 and by 36% with respect to cuttings S_2R_3.

In the trials performed with *P. deltoides* '77/51', relatively good results were obtained (40%) only with cuttings taken from plants S_2R_2 and almost negligeable for other types of cuttings. It would therefore appear that the age of the plant, from which the cuttings are obtained, may influence their rooting.

The examination of the chemical analyses carried out on the barks of the different types of cutting (table 59) proved that there are significant differences between the various clones and also between the various types of cuttings, mainly regarding N content. However there is not an evident correlation between nitrogen content and rooting, since the S_2R_3 cuttings have a greater nitrogen concentration than the S_1R_1 cuttings, but have not had a better rooting. When considering the chemical composition of the cuttings, which indicates the nutritional condition of the plants from which they have been taken, it is interesting to note that the cuttings of *P. x euramericana* cv. 'I 214' have a greater capacity for utilising phosphorous and potassium to form a proteinorganic synthesis, than cuttings of other clones.

2nd SERIES OF TRIALS

These investigations were carried out on material purposely prepared since spring 1964, when a certain number of cuttings were planted out at close distance.

In spring 1965, the plantation was coppiced, leaving the roots in the ground and utilizing for the production of cuttings the aerial part only. The cuttings were planted out in the same spring, in proximity of the plantation. In spring 1966, the new shoots of the coppiced plantation and the cuttings directly planted in the soil the previous year provided the material for this second series of trials. The clones employed were: *P. deltoides* '63/51'; '77/51'; 'UAS 235'; *P. alba* '58/57'.

For the two types of cuttings from each clone four replications were made, employing 600 cuttings for *P. deltoides* '63/51', 100 cuttings for *P. deltoides* 'UAS 235' and *P. alba* '58/57', and 50 cuttings for *P. deltoides* '77/51'.

The plantation was established on March 1966 in a plot with sandy loam soil and medium fertility.

During the experiments, the following rainfall was recorded, namely: 103 mm in April, 53 mm in May and 40 mm in June.

Cultivation works consisted of ordinary manuring, irrigation and weeding.

Results

Root successes, as observed 100 days from the plantation, are set down in table 60.

Since during the experiments, for all clones, a different number of cuttings was used, it was necessary to express root success in percentages, working out these latter afterwards.

Table 59 - Mineral content (in %) of dry matter in the bark of cuttings of three different clones.

clones	cuttings from S_1R_1 plants						cuttings from S_1R_2 plants						cuttings from S_2R_3 plants					
	N	ashes	P	Na^+	K^+	Ca^{++}	N	ashes	P	Na^+	K^+	Ca^{++}	N	ashes	P	Na^+	K^+	Ca^{++}
'63/51'	2.05	8.13	0.575	0.0188	1.51	1.44	2.62	7.77	0.571	0.0198	1.59	1.26	2.38	8.11	0.578	0.0324	1.66	1.41
	2.01	8.46	0.588	0.0282	1.77	1.76	2.56	8.34	0.530	0.0321	1.61	1.44	2.38	7.96	0.557	0.0321	1.56	1.43
	1.90	7.82	0.553	0.0258	1.57	1.62	2.57	8.15	0.546	0.0259	1.65	1.57	2.29	7.88	0.594	0.0318	1.71	1.46
	1.81	8.23	0.557	0.0282	1.44	1.47	2.59	8.20	0.541	0.0258	1.53	1.43	2.26	7.73	0.552	0.0306	1.57	1.35
	1.95	8.28	0.559	0.0268	1.70	1.68	2.57	7.70	0.530	0.0187	1.72	1.44	2.32	7.87	0.653	0.0270	1.75	1.47
average	*1.94*	*8.18*	*0.556*	*0.0256*	*1.60*	*1.59*	*2.58*	*8.03*	*0.543*	*0.0245*	*1.62*	*1.43*	*2.33*	*7.91*	*0.586*	*0.0308*	*1.65*	*1.42*
'77/51'	1.81	7.63	0.472	0.0234	1.41	1.36	2.38	8.85	0.500	0.0280	1.71	1.54	2.17	7.30	0.450	0.0282	1.28	1.35
	1.90	7.89	0.440	0.0259	1.78	1.55	2.31	8.56	0.489	0.0321	1.88	1.43	2.22	7.02	0.423	0.0233	1.27	1.28
	1.55	7.73	0.446	0.0235	1.47	1.44	2.27	8.59	0.510	0.0284	1.71	1.77	2.16	7.26	0.448	0.0284	1.29	1.31
	1.78	7.43	0.417	0.0258	1.38	1.35	2.32	8.49	0.382	0.0281	1.77	1.45	2.14	7.33	0.430	0.0282	1.34	1.39
	1.80	7.67	0.469	0.0212	1.67	1.47	2.30	8.83	0.496	0.0282	1.99	1.63	2.26	7.34	0.470	0.0234	1.40	1.53
average	*1.77*	*7.67*	*0.448*	*0.0240*	*1.54*	*1.43*	*2.32*	*8.66*	*0.475*	*0.0290*	*1.81*	*1.56*	*2.19*	*7.25*	*0.444*	*0.0263*	*1.32*	*1.37*
'I 214'	1.60	6.67	0.430	0.0235	1.08	1.37	1.88	6.66	0.345	0.0128	0.97	1.41	1.86	6.65	0.365	0.0187	0.99	1.52
	1.72	6.70	0.438	0.0188	1.21	1.54	1.90	7.09	0.362	0.0187	1.03	1.81	1.98	6.88	0.400	0.0222	0.97	1.60
	1.54	6.99	0.426	0.0260	1.27	1.65	1.88	6.84	0.364	0.0235	1.02	1.64	1.97	6.88	0.383	0.0199	1.16	1.68
	1.74	7.10	0.460	0.0200	1.12	1.52	1.88	6.87	0.379	0.0199	0.96	1.59	1.89	6.86	0.396	0.0237	1.09	1.51
	1.65	7.12	0.452	0.0180	1.20	1.64	1.90	6.80	0.349	0.0188	1.02	1.70	1.92	6.87	0.415	0.0187	1.18	1.59
average	*1.65*	*6.92*	*0.441*	*0.0214*	*1.18*	*1.54*	*1.89*	*6.85*	*0.359*	*0.0187*	*1.00*	*1.63*	*1.92*	*6.83*	*0.391*	*0.0206*	*1.08*	*1.58*

Table 60 - Influence of the parent plant age on the root success of cuttings.

clone	plants age	cuttings per replication	I success No	I success %	II success No	II success %	III success No	III success %	IV success No	IV success %	total success No	total success %
'63/51'	S_1R_2	600	385	64.2	368	61.5	350	58.3	360	60.0	1463	60.90
'77/51'	S_1R_2	50	19	38.0	24	48.0	18	36.0	15	30.0	76	38.00
'UAS 235'	S_1R_2	100	43	43.0	44	44.0	38	38.0	36	36.0	161	40.25
'58/57'	S_1R_2	100	63	63.0	53	53.0	59	59.0	52	52.0	227	56.75
'63/51'	S_1R_1	600	403	67.2	465	77.5	439	73.2	432	72.0	1739	72.40
'77/51'	S_1R_1	50	25	50.0	25	50.0	27	54.0	30	60.0	107	53.54
'UAS 235'	S_1R_1	100	72	72.0	64	64.0	57	57.0	68	68.0	261	65.25
'58/57'	S_1R_1	100	78	78.0	45	45.0	62	62.0	53	53.0	238	59.50

The first line of table 60 gives absolute successes and the second per cent ones.

From the calculation of the analysis of variance, the following conclusions may be drawn (table 61);

- in considering the results obtained with cutting from S_1R_1 and S_1R_2 plants, regardlessly of the clone, highly significant differences can be noticed as concerns the root success of the cuttings from S_1R_1 plants;
- the differences observed in the root success of the different clones, regardlessly of the type of cuttings, are greatly significant;
- the interactions between the type of cutting and the clone are significant for P = 0.05. Examining table 2, it can be noted that for *P. alba* '58/57' the differences between the averages of success of the two types of cuttings are quite modest and therefore non significant.

As to *P. deltoides* '77/51' and 'UAS 235', the differences between the averages of success of the two types of cutting are highly significant while, for *P. deltoides* '63/51', they are such only at 0.05.

In conclusion, as concerns the three experimented clones of *P. deltoides* ('63/51', '77/51', 'UAS 235'), the cuttings from shoots of S_1R_1 plants present better results than those from shoots of coppiced plants, whereas for *P. alba* '58/57' significant differences cannot be pointed out between the two types of cutting.

Taking into consideration also the results obtained in the previous series of trials, it is impossible to draw final conclusions on the influence of the parent plant age on cuttings' rooting.

INFLUENCE OF THE PLANTING SEASON

The experiments were carried out to establish the differences between autumn and spring plantation. In these trials were used two poor rooting clones of *P. deltoides* '63/51' and '77/51'; and, as control, *P. x euramericana* cv. 'I 214' and *Salix alba* 'SI 4/59', both with high rooting capacity.

Two types of cuttings were employed for each clone, namely: cuttings from S_1R_1 plants; cuttings from the lateral branches of 2-year-old plants.

The autumn plantation was established on December 1965 and the spring one on March 1966.

Use was made of 200 cuttings from each clone, being 20-25 cm long and divided into 4 replications of 50. The plantation was set up on sandy loam soil, of medium fertility. Cultivation practice consisted of ordinary manuring, irrigations and weedings.

The factorial design was adopted, this trial presenting three variances, i.e.: plantation period, type of cutting and clone.

Results

The results are illustrated in table 62. The working out of the da

Table 61 - Comparison of the significance between average percent successes.

plants age	'63/51'	'77/51'	'UAS 235'	'58/57'	average
S_1R_2	60.90	38.00	40.25	56.75	*48.99*
S_1R_1	72.40	53.50	65.25	59.50	*62.68*
average	*66.71*	*45.75*	*52.75*	*58.12*	*55.83*

LSD between the averages: P 0.05 = 7.37; P 0.01 = 13.54.
LSD between the clones: P 0.05 = 7.35; P 0.01 = 10.08.
LSD interaction type of cutting x clone: P 0.05 = 10.39; P 0.01 = 14.25.

Table 62 - Influence of the planting season on the rooting of poplar and willow cuttings.

planting season	cuttings	clones	success of cuttings per replication I	II	III	IV	total	sum
autumn	from S_1R_2	'I 214'	50	50	50	50	200	
		'63/51'	20	17	13	18	68	
		'77/51'	24	17	15	20	76	
		SI 4/59	50	50	44	44	188	
							532	
	from lateral branches of 2-year-old plants	'I 214'	29	36	25	38	128	
		'63/51'	8	12	9	11	40	
		'77/51'	1	4	3	2	10	
		SI 4/59	46	42	50	50	188	
							366	898
spring	from S_1R_2	'I 214'	49	48	48	50	195	
		'63/51'	28	30	29	32	119	
		'77/51'	22	21	38	29	110	
		SI 4/59	50	50	50	49	199	
							623	
	from lateral branches of 2-year-old plants	'I 214'	50	50	50	47	197	
		'63/51	7	10	9	8	34	
		'77/51'	5	13	1	7	26	
		SI 4/59	48	41	50	39	178	
							435	1058

Table 63 - Influence of the interaction: period x type of cutting x clone on rooting.

period	cuttings	'I 214'	'63/51'	'77/51'	SI 4/59
autumn	from S_1R_2	50.00 48.75	17.00 29.75	19.00 27.50	47.00 49.75
spring	from lateral branches of 2-years-old plants	32.00 49.25	10.00 8.50	2.50 6.50	47.00 44.50

LSD: P 0.05 = 5.08; P 0.01 = 6.68.

ta, carried out according to the method of the variance analysis, proved that the differences due to plantation period, type of cutting and clone are highly significant. The calculation of the first -and second-order interactions was also performed.

A short account on the behaviour of the different clones is reported hereunder:

P. x euramericana cv. 'I 214':

- cuttings from S_1R_1 plants when planted in autumn give the same results as those planted in spring;
- cuttings from the lateral branches of 2-year-old poplars when planted in spring give better results than those planted in autumn, recording highly significant differences.

P. deltoides '63/51' and *P. deltoides* '77/51':

- cuttings obtained from S_1R_1 plants give better results if planted out in spring than in autumn; even in this instance, highly significant differences are observed;
- cuttings from lateral branches attain very modest results, not differing significantly in the two plantation periods;
- cuttings from S_1R_2 plants, in both spring and autumn plantations, give better results than those by cuttings from lateral branches of 2-year-old poplars.

The differences are highly significant.

Salix alba 'SI 4/59':

The cuttings of both types give very good results in either plantation period.

Conclusions

The various experimented clones behaved differently, according to the plantation period and the type of cutting.

As to poplars, for *P. x euramericana* 'I 214' the plantation period did not affect rooting, at least as far as the cuttings from S_1R_2 plants are concerned, while for the two *P. deltoides* clones the spring plantation of cuttings from S_1R_2 plants must be preferred.

For *Salix alba* 'SI 4/59' the plantation period had no influence at all, either resorting to cuttings from S_1R_2 plants or to willow lateral branches.

In the near future, these trials will be repeated on a greater number of clones for both *Populus* and *Salix*.

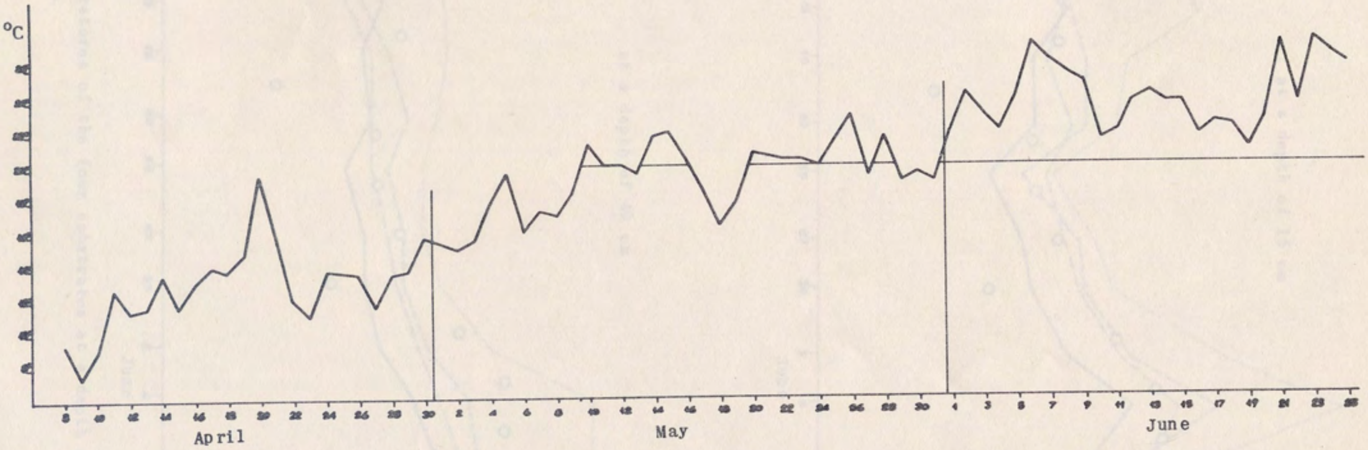

Fig. 1 - Trend of mean temperature.

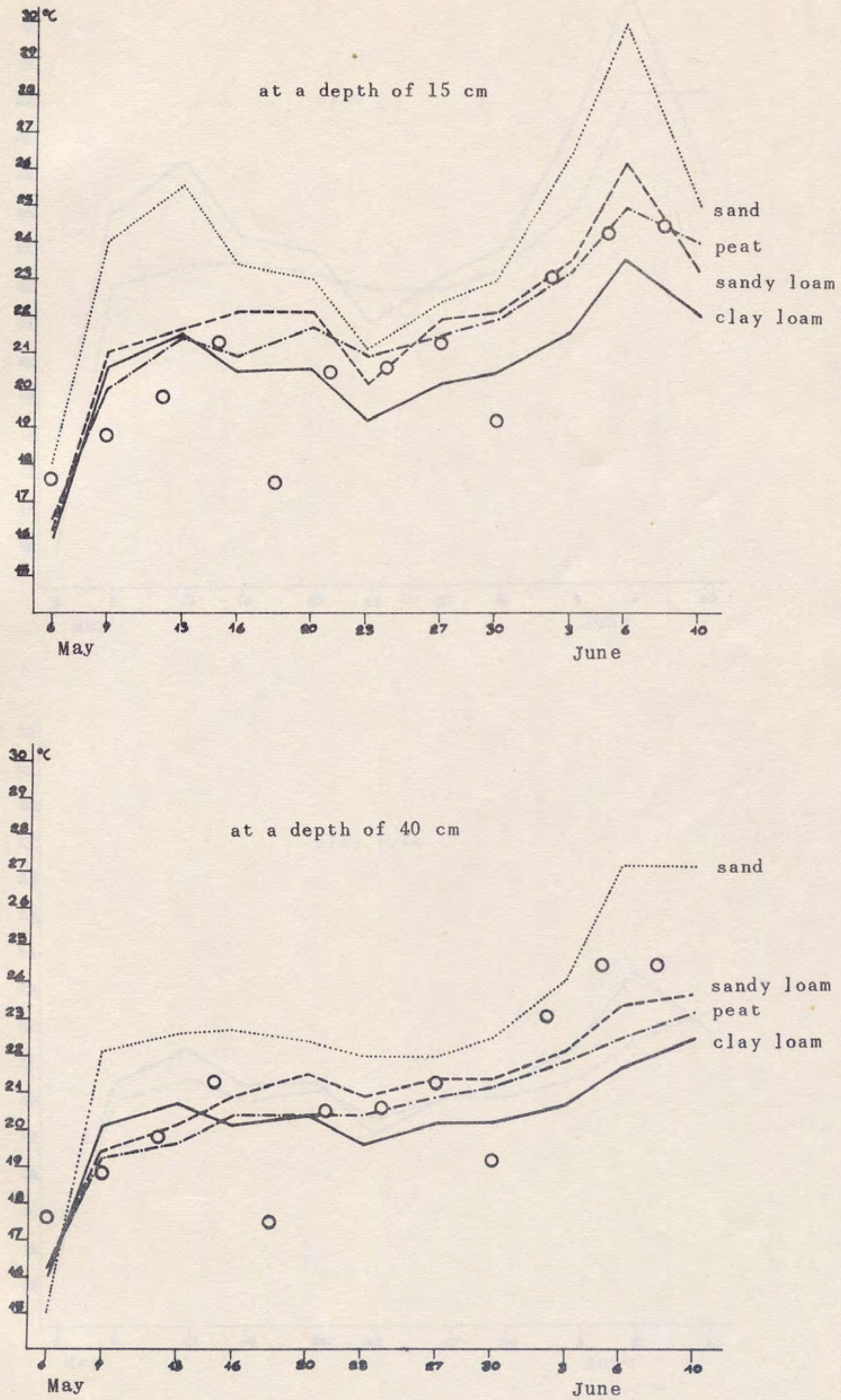

Fig. 2 - Temperatures of the four substrates at a depth of 15 cm and 40 cm and air temperature (O).

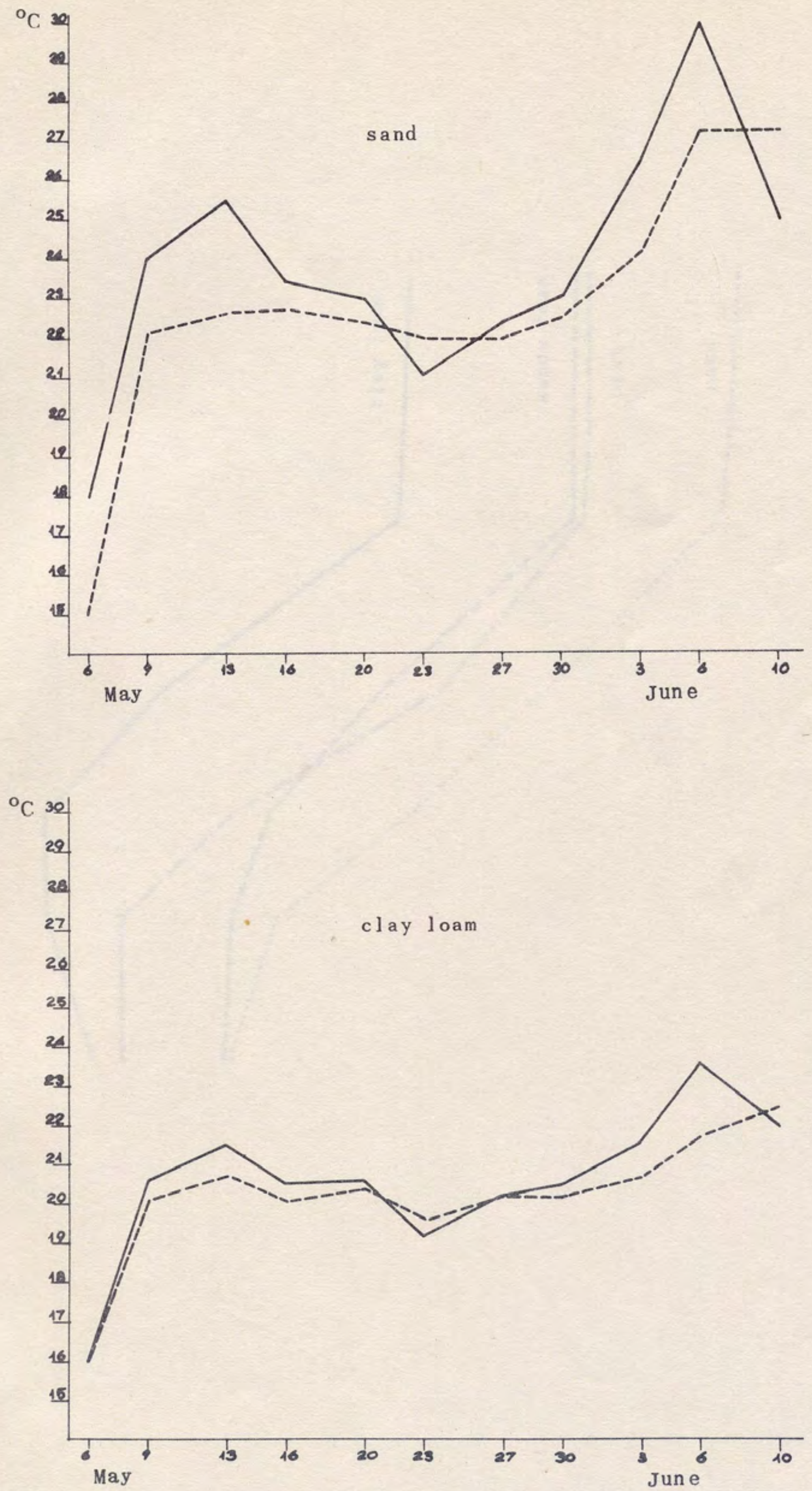

Fig. 3 - Temperatures of sand and clay loam at a depth of 15 cm (——) and 40 cm (---).

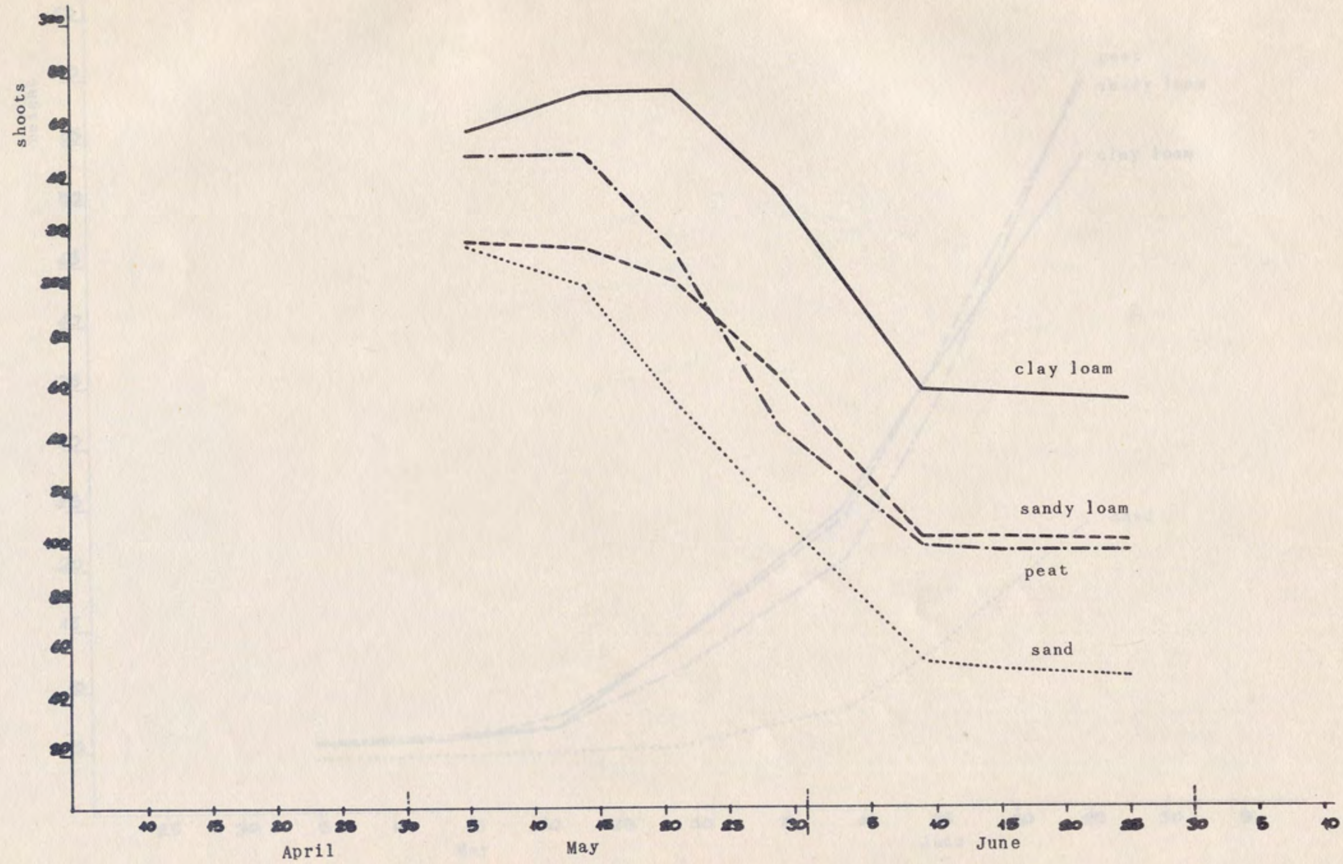

Fig. 4 - Variation in the number of the surwiving shoots.

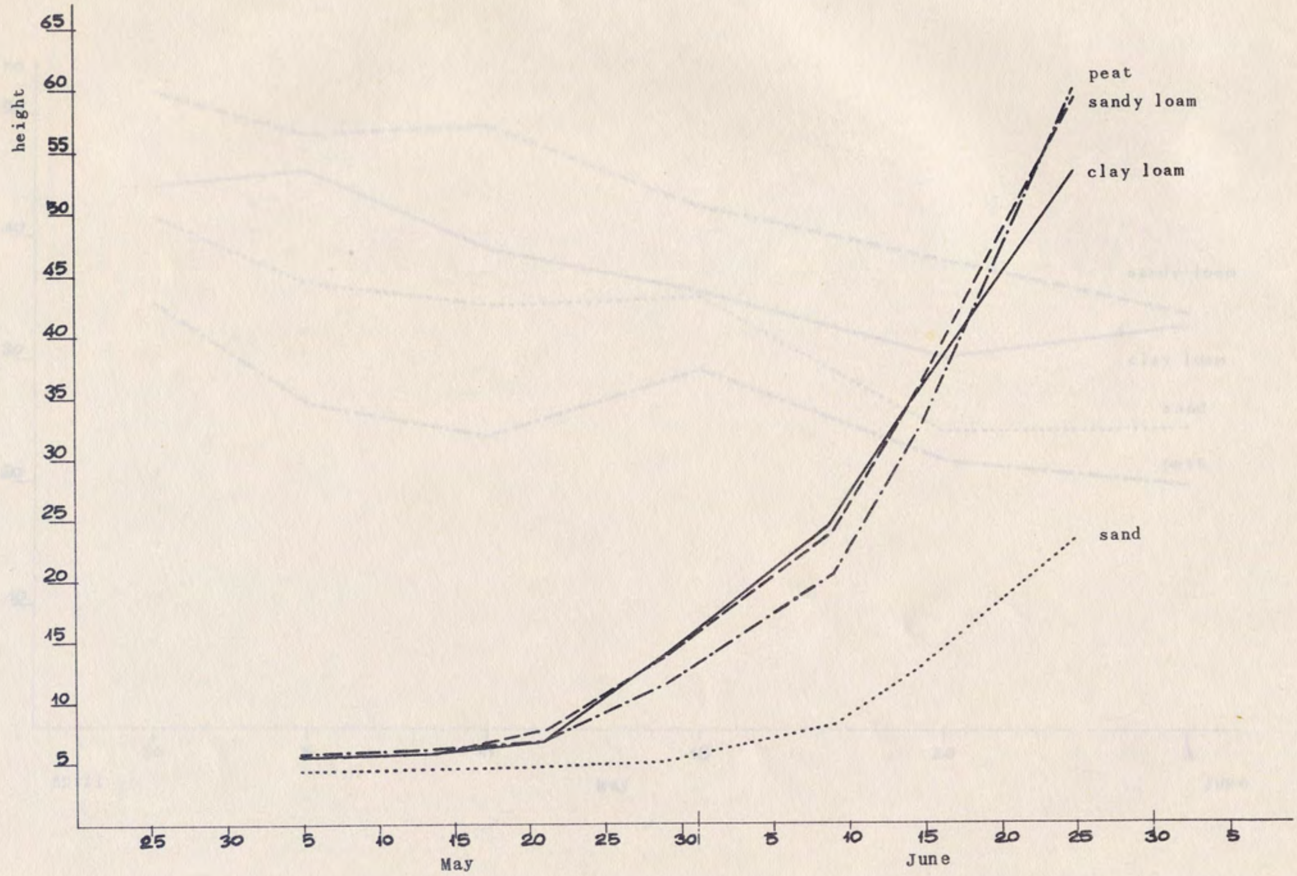

Fig. 5 - Average height of the shoots.

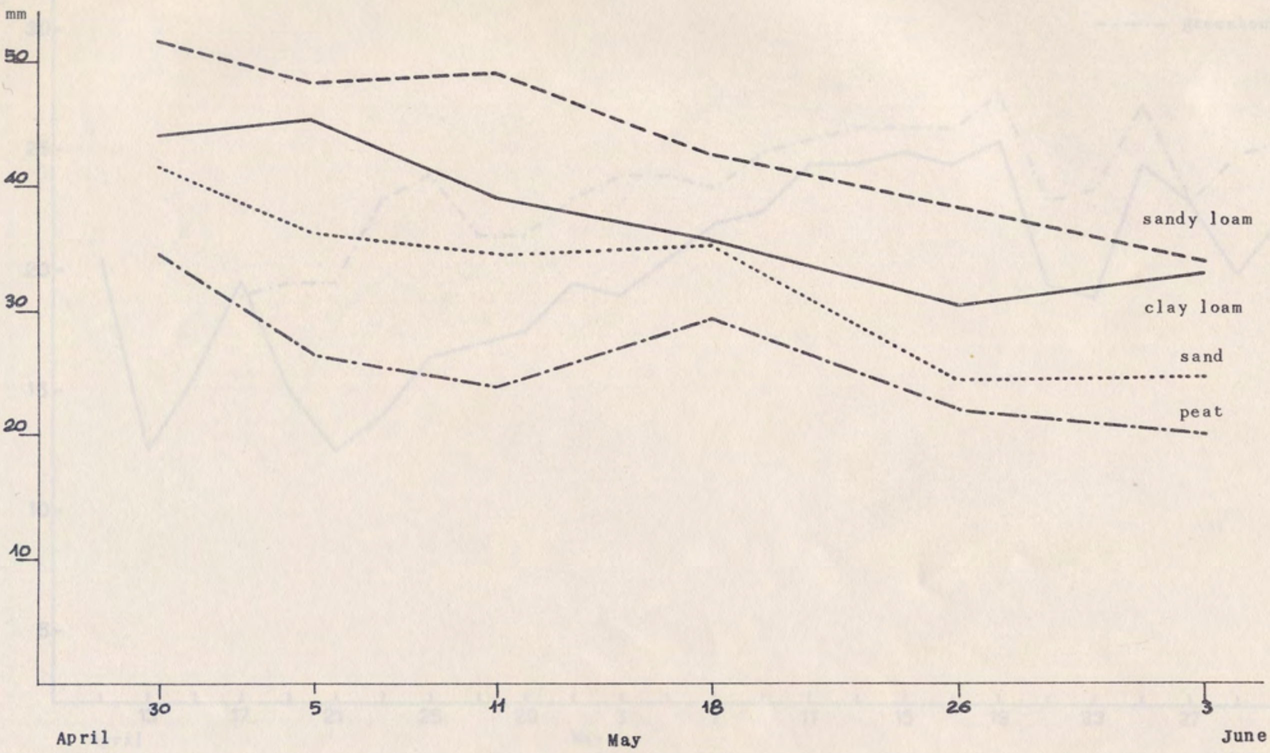

Fig. 6 - Available water per cutting.

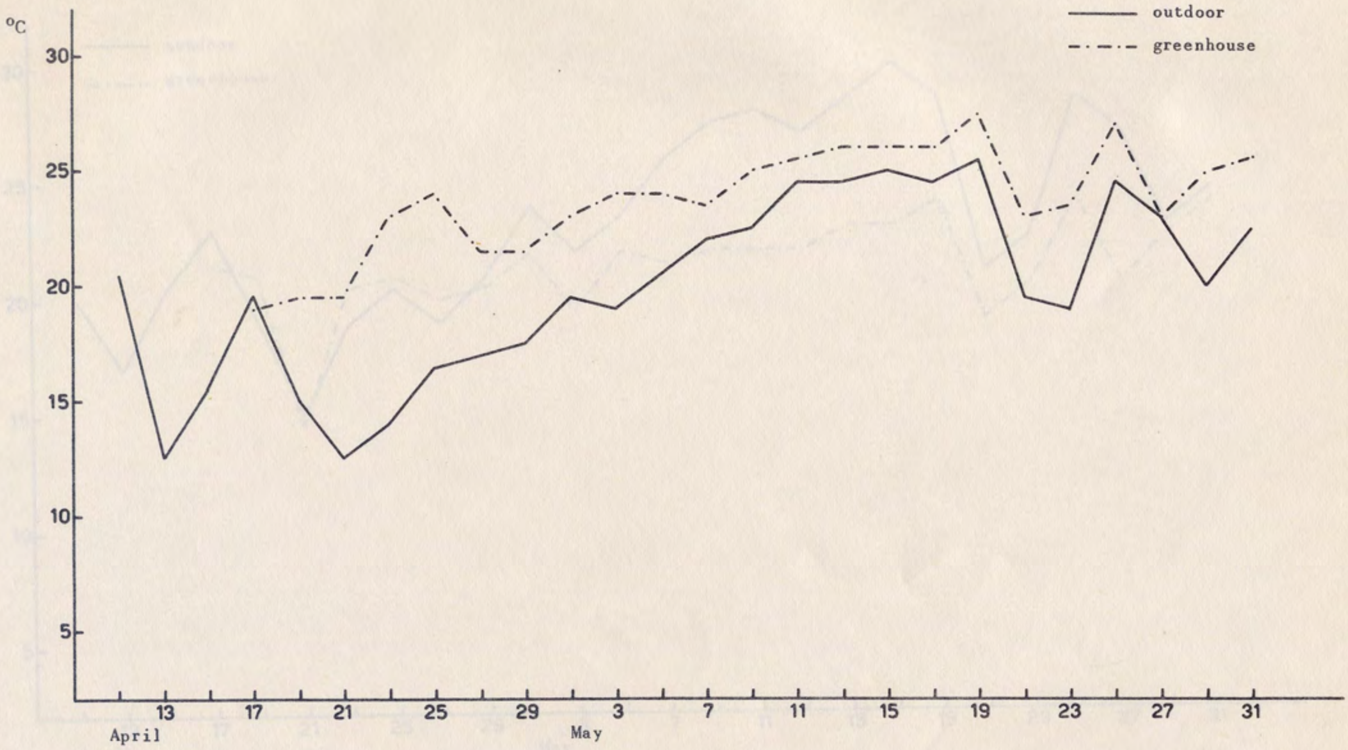

Fig. 7 - Variation of maximum temperature in the darkness.

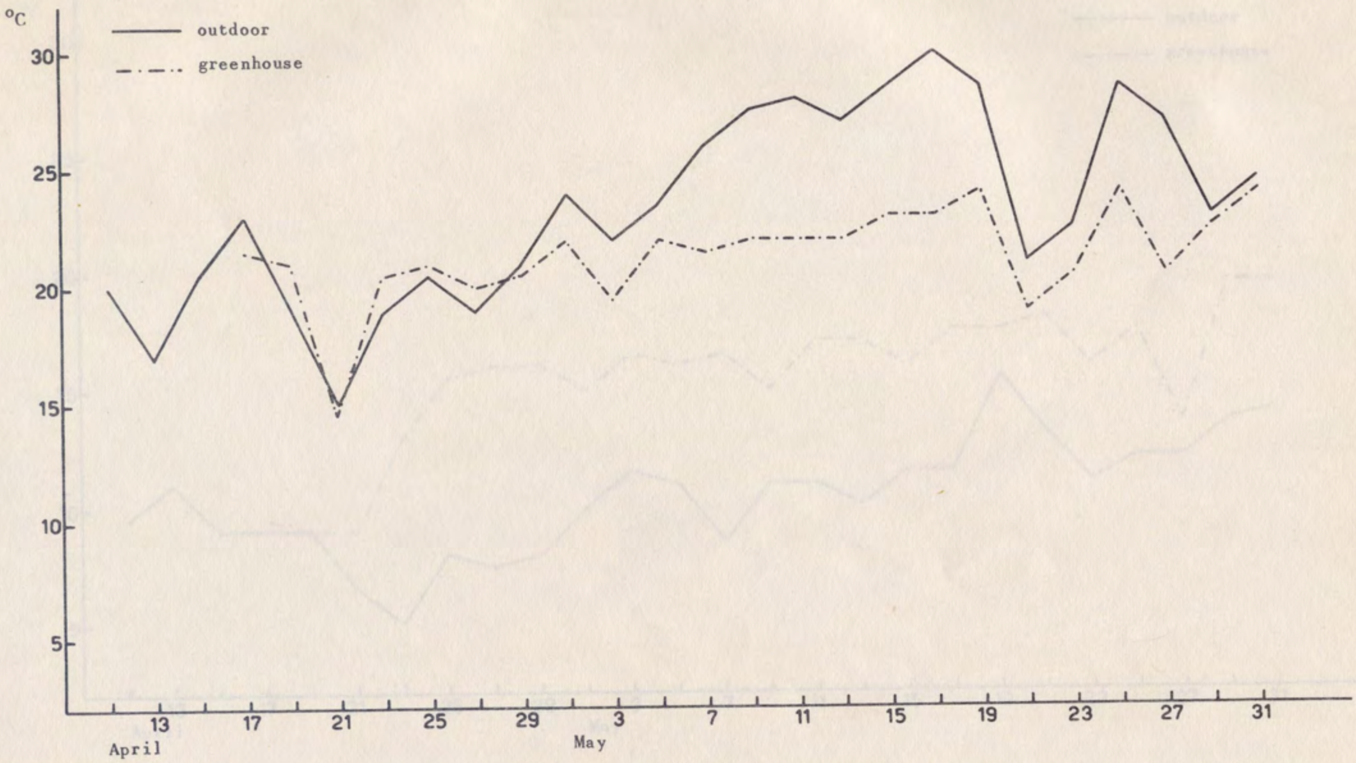

Fig. 8 - Variation of maximum temperature in the light.

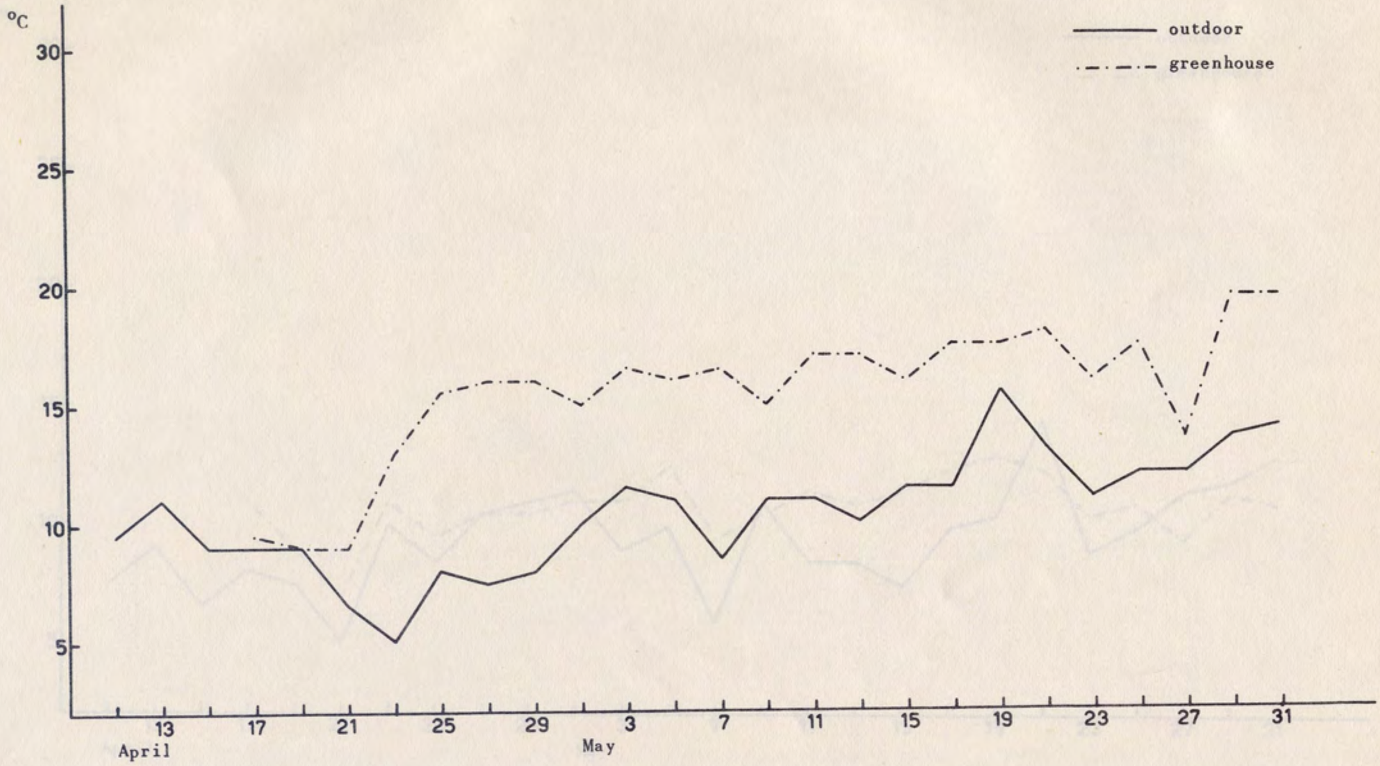

Fig. 9 - Variation of minimum temperature in the darkness.

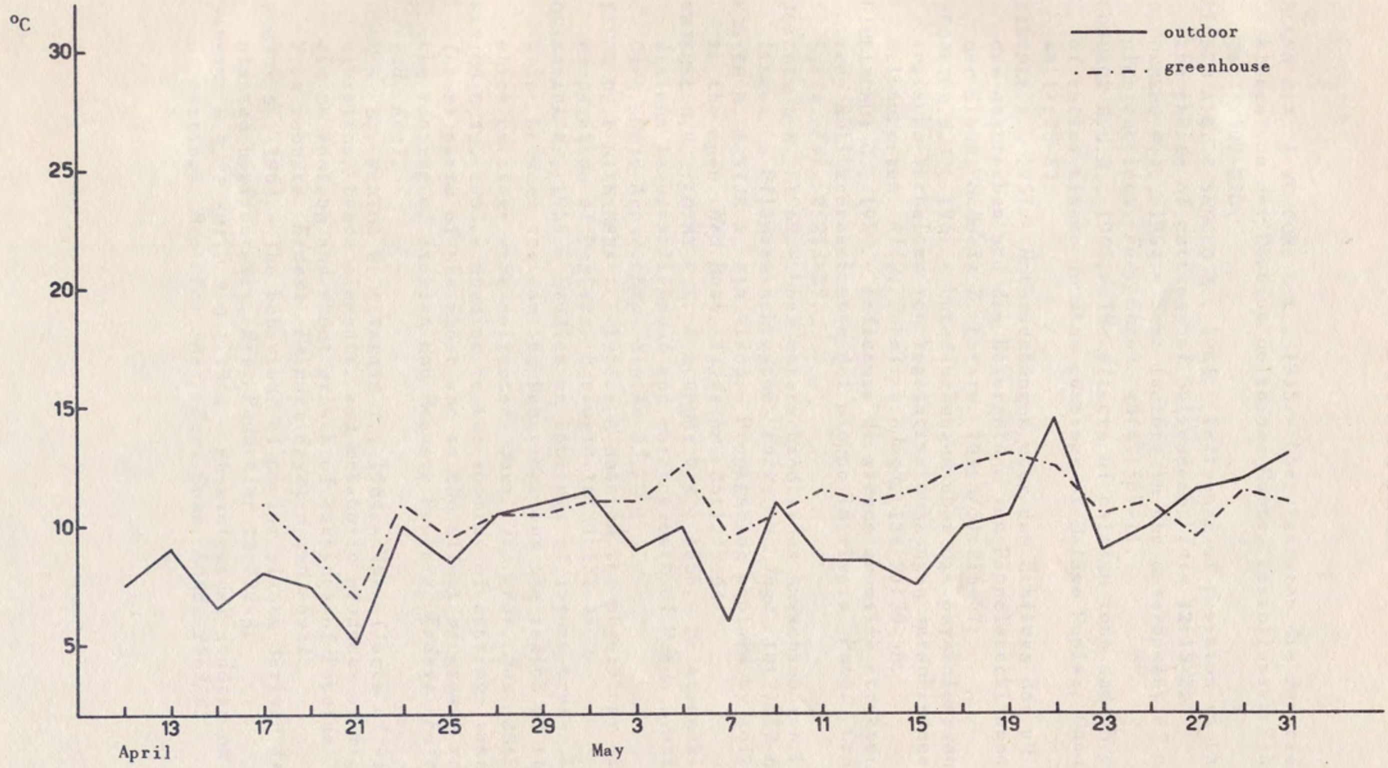

Fig. 10 - Variation of minimum temperature in the light.

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CONCLUSIONS

The factors affecting the rooting of poplar cutting are numerous but they can be grouped into two main classes: factors depending on both the species and the clone, such as the biochemical and anatomical ones, and environmental factors, like soil, moisture, light, temperature and so on. The investigations carried out in this respect, either separately or on the whole, aimed at establishing whether it is possible to influence rooting, acting directly on the cuttings with suitable treatments or properly modifying the conditions of the environment where the cuttings are placed to root.

The results, obtained in the trials performed in laboratory, in greenhouse and in the field on thousands of cuttings from poplar clones with different rooting capacity, give a fairly complete picture of this phenomenon and allow the research to draw some conclusions of great importance for normal nursery practice.

The biochemical investigations highlighted the complexity of all those phenomena occurring in rooting. During the experiments, in fact, it was possible to detect in the cuttings the presence of auxinic substances, like indole-3-acetic acid, which usually foster rooting, as also of inhibitory substances, not yet identified.

Rooting, therefore, is likely to be affected by the antagonistic action of these substances as also by their equilibrium, governed by external factors like temperature, light and moisture. The experiments proved, in fact, that there exists a seasonal variation in the presence of such substances in the cuttings. It is also probable that some other activators of auxins, like amino acids, play an outstanding role in rooting, but so far the trials performed did not succeed in determining their behaviour.

The anatomical research proved that there exist marked differences between the various species and clones as concerns the number of root primordia in the cuttings.

The differentiation of primordia occurs more rapidly in well rooting clones, such as, for instance, *P.x euramericana* cv. 'I 214', and more slowly in the examined poorly rooting clones of *P.deltoides*. Furthermore, it was observed that rooting greatly depends on bud opening, that, when considerably precedes root emergence, gives place to a critical period on which depends cuttings' survival.

It is, therefore, very important, from a practical point of view, to stimulate the formation and the development of root primordia. The experiments performed in this respect revealed that rooting is mainly influenced by 3 factors, i.e.: light, temperature and moisture.

Light exercises an inhibitory action on root emergence; as it was observed, in fact, the cuttings placed to root in the dark have a greater number of roots than those rooting in full light.

A temperature of 20-27°C hastens the rooting process, thus shortening the critical period of the cuttings, and guarantees a higher root success.

Moreover, a high moisture content in the substrate is indispensable to the success of poorly rooting clones, like *P.deltoides* '63/51 and '77/51', being less necessary in the case of well rooting clones, such as *P.x euramericana* 'I 214'.

The treatment of the cutting with rhizogenous substances, regarded in literature as very promising, actually gave very poor results.

In the trials, use was made of several substances like IBA, IAA, NAA, IPYA at different concentrations as also of mineral salts of Zn, Fe, Cu, Mn, K. Such treatments, however, did not provoke a significant increase in the number of rooted cuttings, in comparison with the control ones, and in some cases they affected rooting negatively.

Among the substances more favourable to rooting, indole-3-acetic acid and indole-3-pyruvic acid deserve further experiences. Also the direct application to the soil of phosphatic, potassic and nitrogenous fertilizers did not give positive results as concerns cuttings' rooting. Conversely, it is interesting to point out that phosphatic fertilization to parent plants seems to influence the nutritional state of the cuttings, thus facilitating root emergence.

Therefore, the methods which in practice proved to stimulate the rooting process more markedly consist in both rising the cuttings' moisture content and creating in the substrate appropriate conditions of moisture and temperature.

The trials in the field showed that high root successes can be obtained for the tested clones of *P.deltoides* just immersing the cuttings in water for a minimum of 48 hours, before the planting out.

Moreover, to create at least in the first stage those conditions particularly favourable to root emergence, it was sufficient to cover the ground with plastic sheets kept by a wooden frame at a distance of some 40 cm from the soil. In fact, the increased temperature (8°C-10°C) and, above all, a higher moisture degree markedly affected the rooting of *P.deltoides* '63/51', '77/51' and *P.alba* '58/57'.

Finally, a factor which must not be neglected and is likely to influence rooting is represented by the parent plant's age. The experiments performed did not manage to detect the type of cutting more suitable to rooting, as it is probable that phenomena, imputable to both topophys and seasonal trend, can intervene in this process.

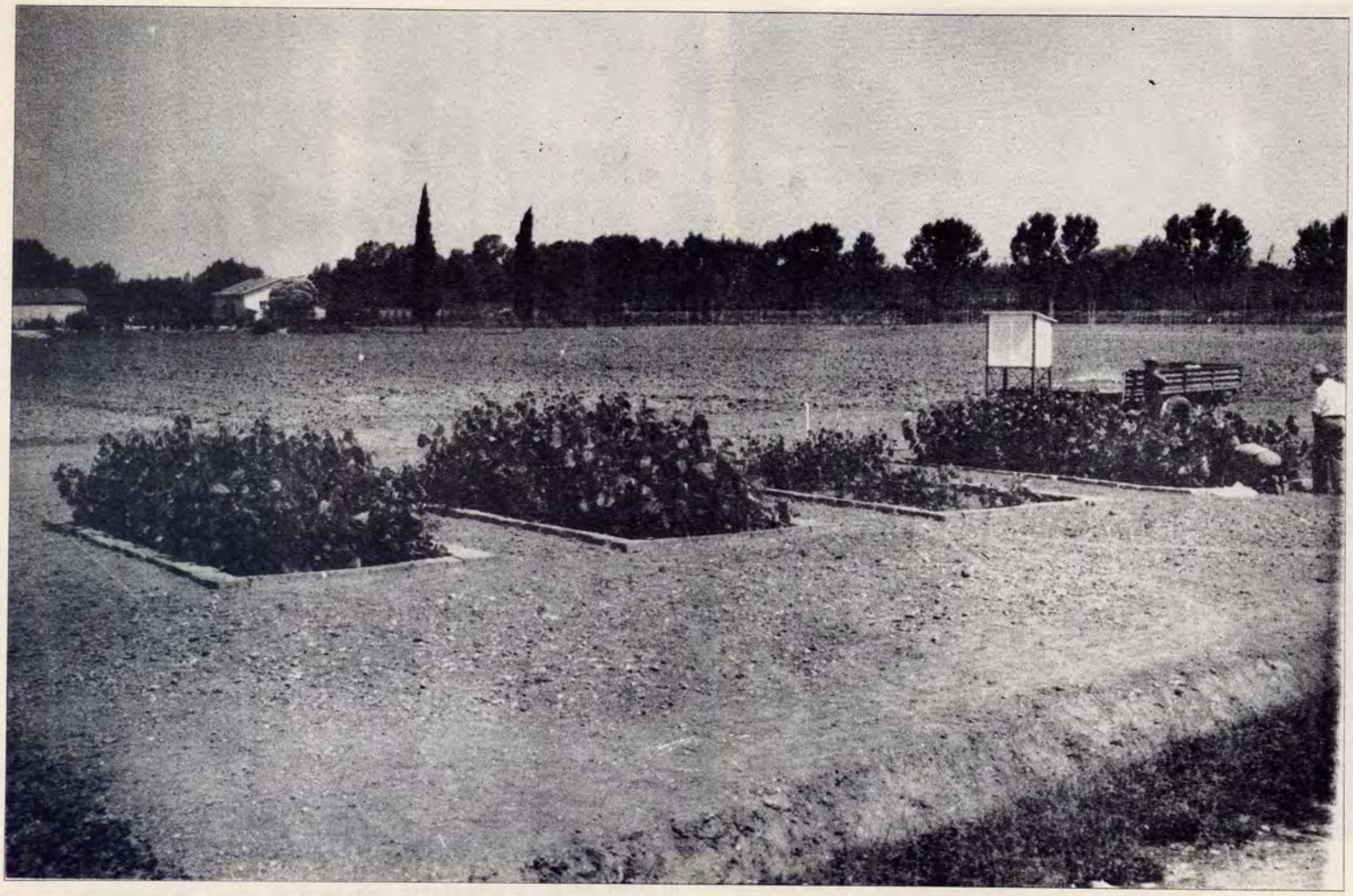
The research will be carried on in the near future to determine also this important aspect of the problem, but a marked improvement in root success can be obtained since now if the above-mentioned methods will be adopted for poorly rooting cuttings.

NEED FOR ADDITIONAL RESEARCH

Over the four years devoted to these experiments, an exceptional event has occurred, giving the research a greater interest.

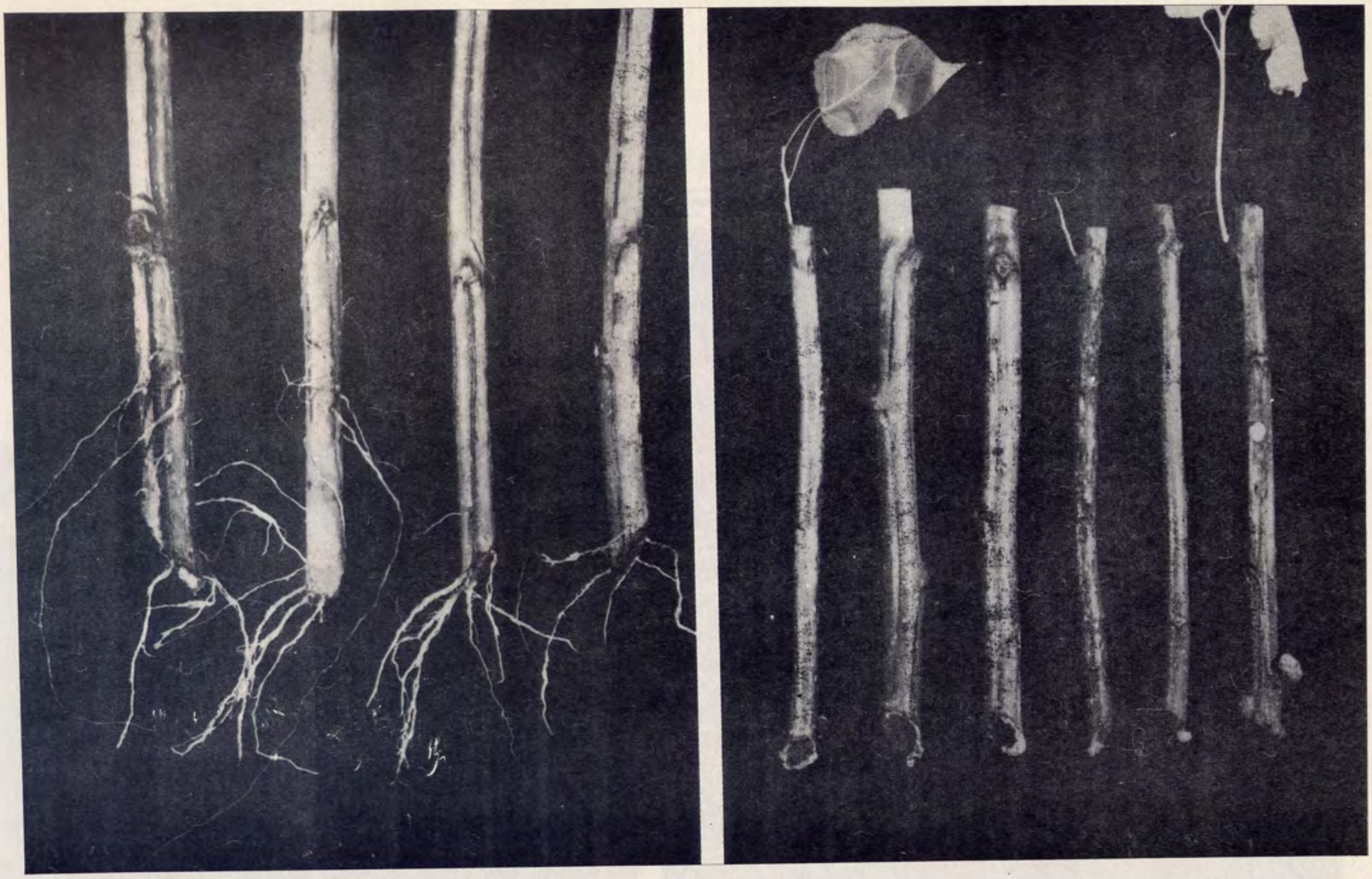
In fact, a disease caused by a fungus, *Marssonina brunnea* (Ell. et Ev.) P. Magn.; has at present spread in our country, mainly in northern Italy, provoking the defoliation of trees, with serious consequences for their production. Luckily, most of the clones of *P. deltoides* present in Italy showed to be well resistant to this fungus, whereby they will be ever more widely employed in poplar cultivation, though *P. deltoides* is a species with great requirements as regards the soil.

The present rooting trials will be, therefore, pursued on the clones of *P. deltoides*, trying in particular to fill the scarce knowledge on the influence of both the position and the parent plant age on the rooting of cuttings. Moreover, the best attention will be devoted to the substances governing root emergence, since the present shortage of information in this connection does not allow the research to draw definite conclusions.



Influence of soil in the field on the rooting of poplar cuttings. From the left: clay loam, sandy loam, sand, peat.

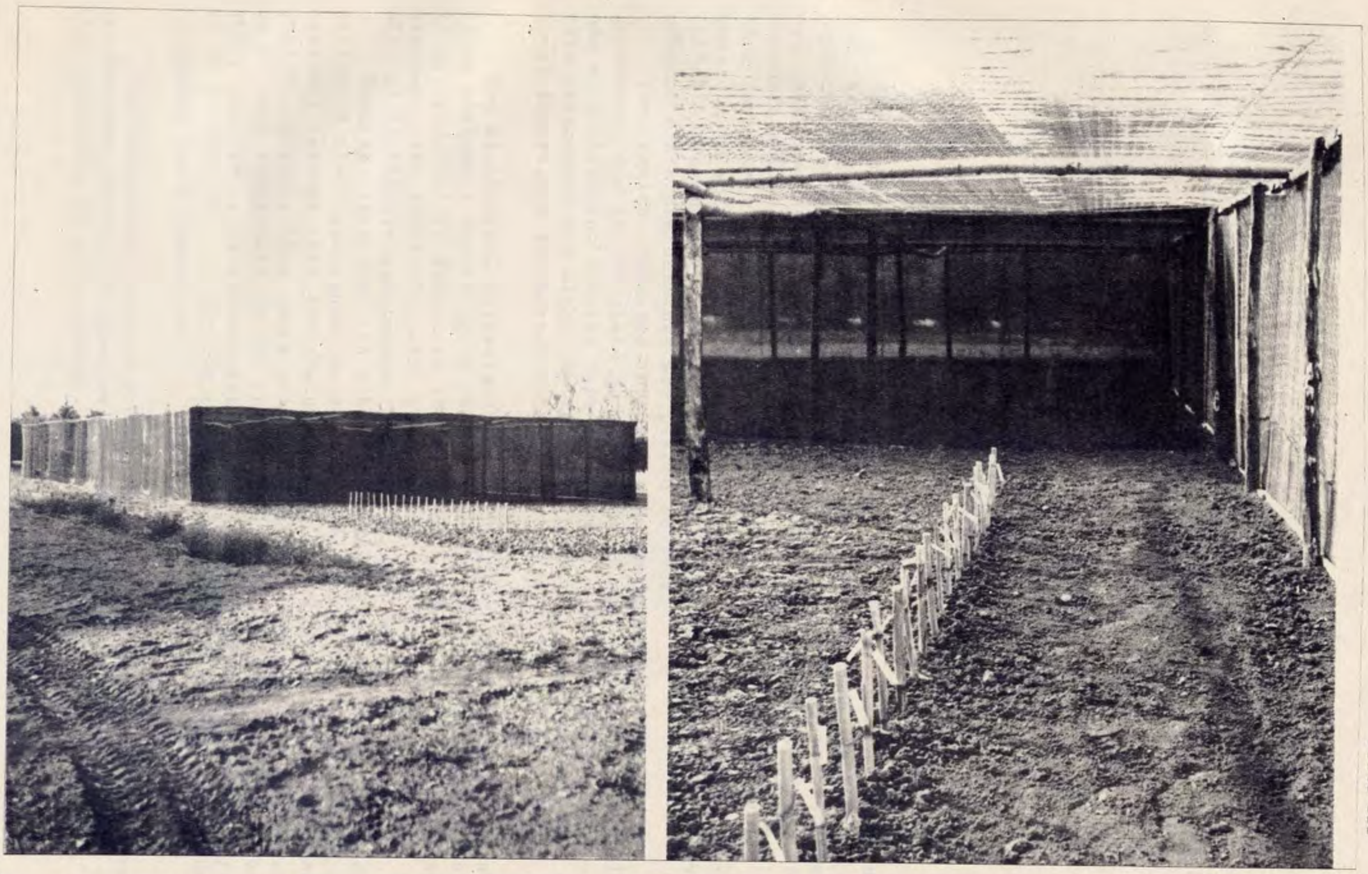
Plate I



Influence of light on rooting: cuttings placed to root in the dark (on the left) and in the light (on the right).

Plate II

Plate III



Trials of shading in the field with 'Umbrayex' nets.