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RESULTS OF POPLAR FERTILIZATION TRIALS ON SANDY SOILS

Giuseppe FRISON

Ente Nazionale per la Cellulosa e per la Carta
Poplar Research Institute
Casale Monferrato - Italy

ABSTRACT

From the results obtained in the three trials carried out in poplar plantations established on sandy soils poor in nitrogen and in organic matter, it emerged that in two experiments the growth of the trees was increased by nitrogen fertilizing. The phosphorus did not significantly influence the production, expressed in fresh weight of timber or in basal area of the trees. The effect of potassium proved to be absolutely insignificant, exception made for wood density (weight, ovendry ; volume, green) which was increased by this nutrient added to fertilization with nitrogen and phosphorus.

INTRODUCTION

Mineral fertilizing is certainly an effective means of increasing the productivity of cultivation, both agricultural crops and fruiting trees. Naturally this statement is valid also for the poplar, especially in soils critically deficient in nutrient elements which can be corrected by the application of fertilizers particularly if the rest of the physical environment properties are adequate.

The Poplar Research Institute has for several years been carrying out intense research activity both in investigation directed to the study of the tree, of its contents in nutrient elements (Frison, 1967, 1968 and 1969) of the rhythm of absorption of nutrients in relation to production (Frison, 1975), etc., and with experiment in pots (Frison, 1976) or in the open field (Frison, 1974 and 1976) with the aim of studying, on the basis of timber production and of the nutrient contents of dry matter, the response of the trees to the application of fertilizers.

This is done in order to increase knowledge concerning the nutritional requirements of the poplar and to indicate eventual correlations between nutritive disponibility of the soil and nutrient contents of the trees, between nutrient contents of the various organs of the tree and timber production, correlations which can supply information extremely useful for choice of type of fertilizer.

Some interesting results have already been obtained, as can be seen from the literature mentioned, others can be glimpsed in research still being carried out and will be made public as soon as possible.

However the information so far obtained by the experiments have not always been sufficient to give indications answering to precise economic criteria concerning fertilization of the poplar in the differing climatic and edaphic environments of the Po valley, as many doubts and perplexities still exist regarding the effectiveness of the various elements of fertility in increasing the growth of the trees, with particular attention to the production of timber which constitutes the aim of poplar culture. It results that the formulae adopted are occasionally grossly empirical above all with regard to the doses and relationships

among the nutritive substances with the inevitable outcome both of waste of certain elements (potassium and also phosphorus, for example) and of insufficient applications of others (nitrogen, for example) in relation to their concentration in the soil and to the requirements of the tree.

Under these circumstances, urged on by the necessity of a better understanding of the problem of the fertilization of the poplar, with particular attention to its more practical aspects, suitable trials have been carried out in order to try to give, in a short space of time, guidelines to cultivators of poplars who, also as a consequence of the rise in costs of chemical fertilizers, ask us more and more frequently if and how it is profitable to fertilize the poplars on their land.

In order to meet the above-mentioned requirements, we present the results of three trials in this paper. Two of them (the first and the third) have been carried out in sandy soil formed from alluvial deposits with slight differences in the level of fertility, as shown by the data in Table 1.

The other (the second) has been carried out on sandy soil, still poorer, situated in the zone of the Po delta which represents a vast area of Italian poplar culture with particular characteristics.

The first and third experiments concern poplar plantations of dense spacing (3 m x 2 m and 2 m x 2 m), destined for the production of timber for paper, while the second was carried out in a plantation of average density (7 m x 4 m) destined to produce timber for the ply-wood and paper industries.

EXPERIMENTAL PART

Trial N° 1

Site : Casale Monferrato (AL)

Soil : sandy soil of subalkaline reaction, poor in total carbonate (limestone), organic matter and nitrogen, less than average in total phosphorus and rich in available potassium. The poplar stand had never been fertilized before and the soil had not undergone fertilization for at least three years. The ground water level varied from about 2.40 m to 4.60 m from the soil surface (see Table 2).

Climate : annual precipitation : 854.4 mm in 1968 ; 837.2 mm in 1969 ; 780.2 mm in 1970 ; 1226 mm in 1971 ; rainfall in the growing period respectively : 476.8 mm ; 496 mm ; 379.4 mm ; 813 mm. Annual mean temperature : 12.2°C in 1968 ; 11.6°C in 1969 ; 11.9°C in 1970 and 8.9°C in 1971.

Clone : Populus x euramericana (Dode) Guinier, 'I-214'.

Type of propagation material : two-year-old nursery saplings (S_2R_2), belonging to the commercial class of 14.5-17 cm in circumference at 1.00 m above ground level.

Method of planting : saplings (with the root section) placed in holes 90-100 cm deep and 50 cm in diameter.

Spacing : distribution of 3 m x 2 m (3 m between each row and 2 m along the row), equal to 1666 trees per hectare.

Date of establishment : Spring 1968.

Date of beginning of fertilization trial : Spring 1969.

Factors studied : nitrogen treatments, nitrogen-phosphate treatment and nitrogen-phosphate-potash treatment.

Experimental design : randomized blocks with seven replications.

Experimental unit : plot of 900 m^2 (square of 30 m per side) containing n° 150 trees of which 54, situated in the central part of the plot, had their measurements taken. To avoid edge effects a 6 m

Table 1.- Physical and chemical characteristics of the soils

Trial N°	Depth of sampling in cm	Sand % 2-0.2 mm	Sand % 0.2-0.02 mm	Silt % 0.02 - 0.002 mm	Clay % 0.002 mm	pH	Total % Carbonate (Scheibler)	Organic matter % C (Walkley & Black)	Organic matter % Cx1.724	N_2% (Kjeldahl)	Total P_2O_5% (Ferrari)	Available K_2O ppm (Dirks & Scheffer)
1	1 - 40	1.97	83.53	12.55	1.95	7.85	5.02	0.785	1.353	0.105	1.708	14
	41 - 75	0.75	82.17	14.75	2.33	7.90	6.20	0.655	1.129	0.088	1.263	9
	76 - 100	0.52	89.03	9.30	1.15	8.00	6.00	0.660	1.138	0.073	1.349	3
2	1 - 50	0.53	96.84	1.85	1.12	7.87	9.05	0.183	0.315	0.035	0.645	-
	51 - 100	0.37	97.35	1.66	0.62	7.92	8.37	0.176	0.303	0.028	0.879	-
	101 - 150	0.28	97.92	1.20	0.60	7.83	9.58	0.110	0.190	0.025	0.852	-
3	1 - 50	1.25	88.75	7.25	2.75	8.00	4.65	0.665	1.146	0.095	1.798	15
	51 - 80	4.47	92.23	1.60	1.70	7.50	4.90	0.320	0.552	0.055	1.942	10
	81 - 110	3.07	94.48	1.45	1.00	7.50	4.85	0.240	0.414	0.052	1.200	5
	111 - 150	0.25	93.40	4.75	1.60	8.00	4.86	0.300	0.517	0.030	1.567	4

Table 2.- Depth of water table (in m from soil surface)

Month	Depth	Trial N° 1 Year 1968	1969	1970	1971	Trial N° 3 Year 1968	1969
January	Max.	4.53	3.82	4.54	4.59	5.58	4.93
	Min.	4.44	3.53	4.39	4.50	5.49	4.63
February	Max.	4.67	4.16	4.48	4.27	5.67	5.13
	Min.	4.56	4.04	4.39	4.05	5.39	4.63
March	Max.	4.51	3.86	4.36	4.13	5.43	4.46
	Min.	4.19	3.27	4.11	3.43	4.73	3.95
April	Max.	4.54	3.30	4.48	3.71	6.01	4.68
	Min.	4.10	2.86	4.18	3.11	5.49	3.04
May	Max.	3.21	2.61	3.66	3.02	4.77	3.60
	Min.	2.78	2.27	3.11	2.56	3.96	2.46
June	Max.	2.85	2.69	2.86	2.78	4.35	4.12
	Min.	2.82	2.61	2.75	2.61	3.70	3.84
July	Max.	3.31	2.48	3.08	3.11	5.36	3.56
	Min.	2.89	2.43	2.95	2.80	4.48	3.53
August	Max.	3.44	3.15	3.43	3.29	5.41	4.84
	Min.	3.31	2.60	3.16	3.18	5.09	3.65
September	Max.	3.15	3.31	3.25	3.35	4.56	5.18
	Min.	3.02	3.13	3.00	3.33	4.02	4.48
October	Max.	3.38	3.52	3.36	3.51	4.47	4.75
	Min.	3.26	3.21	3.23	3.11	4.30	4.26
November	Max.	2.97	3.96	3.87	3.90	3.89	5.43
	Min.	2.27	3.71	3.57	3.61	1.85	4.86
December	Max.	3.28	4.36	4.56	4.39	4.46	5.53
	Min.	3.08	4.11	3.70	3.97	3.50	5.40

wide band was excluded from consideration all around the plot.

Times of distribution and fertilizer treatments : the total quantities of pure nutrients supplied per tree were as follows :

Year 1969 : a) Nitrogen (N_2) : 17th April : 61.2 g/tree
3rd June : 61.2 g/tree
17th July : 61.2 g/tree
b) Phosphate (P_2O_5):17th April: 174 g/tree
c) Potash (K_2O) : 17th April : 168 g/tree

Year 1970 : a) Nitrogen (N_2) : 17th April : 61.2 g/tree
10th June : 61.2 g/tree
6th July : 61.2 g/tree
b) Phosphate (P_2O_5):17th April: 87 g/tree
c) Potash (K_2O) : 17th April : 84 g/tree.

Application of fertilizer treatment : broadcast distribution over the whole area of the plots and incorporation of the fertilizers by disking (20 cm).

The following fertilizers were applied :
N as Urea with 46 % N_2 ;
P as Mineral superphosphate with 18-20 % P_2O_5 ;
K as Potash salt with 42 % K_2O.

Cultural care : 3 disking per annum, some spraying and control treatments for parasites (especially for Cryptorhynchus lapathi). The irrigation was always carried out by controlled flooding using quantities of water sufficient to saturate the soil to a depth of 25-30 cm on the dates shown below :
1969 : July 16th-22nd
1970 : July 31st - August 4th ; September 21st
1971 : August 6th-10th.

Felling of the trees : November 1971.

Surveys : a) Basal area, calculated on the basis of the girth measured at the end of every vegetative season at 1.30 m above ground level ;
b) Height, measured at tree-felling ;
c) Volume, calculated using the HEYER formula for stumps of 2 m of trunk ;
d) Specific weight and density of the wood determined on the basis of trunk samples taken at 2 m above ground level ;
e) Fresh weight of wood assortments destined for paper industries and fiber production.

Statistical Analysis of the data : analysis of variance of the data observed and orthogonal comparisons between the treatments made subdividing the respective deviance of the analysis of variance.

Economic Balance : the economic advantage of the use of the fertilizers in relation to the increase in production that they determine has been calculated.

Results

The experiment has begun in very homogenous conditions (given that before starting application of the fertilizers (at the end of 1968) the mean basal areas of the trees relative to the various treatments (Tab. 3) did not prove to be statistically different on analysis of variance (Tab. 4).

No significant difference in basal area was encountered during the two following years (1969 and 1970) in which the fertilizing was carried out. In the third year (1971), instead, significant differences were observed, always in the basal area, in favour of the fertilized trees, with respect to those of the control. The treatments of fertilizers with NP and with NPK, although showing, at the felling of the trees (1971), parameter values superior to those of the treatment with only N, did not result statistically different from this last. The same results were confirmed also in favour of volume, of specific weight (weight, fresh ; volume, green) for the trunk and of fresh weight of timber per tree, limited to that destined for paper use. On the other hand no significant difference was observed as far as fresh weight of timber destined for wood-shavings was concerned (until 3 cm in diameter).

From the data relative to height no significant differences emerged between the trees of the control and those fertilized, while those fertilized with NP or NPK resulted significantly higher than those fertilized only with N.

The density (weight, oven-dry ; volume, green) was influenced positively by fertilization and the highest values were recorded among

Table 3. - Trial N° 1. Basal area, Total height, Volume, Specific weight, Density and Fresh weight of trees

Parameters	Treatments				General mean
	Test	N	NP	NPK	
Basal area (cm^2/tree)					
1968	23.4957	23.3800	23.4114	23.8214	23.5271
1969	52.8529	54.3900	58.5000	56.8186	55.6404
1970	90.8043	94.0271	106.9568	101.9000	98.4225
1971	115.1743	120.0914	135.2114	127.7843	124.5654
Total height (m)	14.7643	14.8514	15.5029	15.1686	15.0718
Volume (dm^3/tree)	79.3899	83.5114	95.4457	89.6186	86.9914
Specific weight(kg/dm^3)	0.5418	0.6269	0.5618	0.6041	0.5836
Density (kg/dm^3)	0.2595	0.2715	0.2691	0.2936	0.2734
Fresh weight (kg/tree)					
a) Wood for paper industries (till 10 cm in diameter)	28.1471	37.8914	39.3586	39.9400	36.3343
b) Wood for fiber production (till 3 cm in diameter)	18.3957	18.5457	18.4871	18.7171	18.5364
c) Total wood	46.5428	56.4371	57.8457	58.6571	54.8707

Table 4.- Trial N° 1. Results of analysis of variance of the data shown in table 3 and orthogonal comparisons

Parameters	Treatments	Orthogonal comparisons		
		Test vs N+NP+NPK	N vs NP+NPK	NP vs NPK
Basal area (cm^2/tree)				
1968	n.s.(+)	n.s.	n.s.	n.s.
1969	n.s.	n.s.	n.s.	n.s.
1970	n.s.	n.s.	n.s.	n.s.
1971	n.s.	*	n.s.	n.s.
Total height (m)	*	n.s.	*	n.s.
Volume (dm^3/tree)	n.s.	*	n.s.	n.s.
Specific weight (kg/dm^3)	*	*	n.s.	n.s.
Density (kg/dm^3)	*	*	n.s.	*
Fresh weight (kg/tree)				
a) Wood for paper industries (till 10 cm in diamter)	*	**	n.s.	n.s.
b) Wood for fiber production (till 3 cm in diameter)	n.s.	n.s.	n.s.	n.s.
c) Total wood	*	**	n.s.	n.s.

(+) Significant at 1 % (**) and 5 % (*) level or not significant (n.s.)

the trees which received all three elements (NPK).

As timber is sold by weight in Italy, it is to this parameter that we refer in order to make some observations of economic character on the use of the fertilizers.

In the case of fertilization with only nitrogen, the increase of timber production in fresh condition, compared with the control, was of 10 kg per tree for paper (1). The increased return (about 275 It. L. per tree) besides compensating for the cost of the urea (about 85 It.L. per tree, excluding interest which is not calculated because of the remarkable instability of the financial market) and that regarding its distribution (very modest if carried out with mechanical means) consents a margin of profit which is not negligible but which is not as yet sufficient to make the cultivation of dense poplar plantations, notoriously negative in the present situation of the market in Italy, profitable. Nitrogen phosphatic, and, worse still, nitrogen-phosphate-potassic fertilization proved to be absolutely anti-economic.

Trial N° 2

Site : Goro (FE)

Soil : very sandy soil of subalkaline reaction, average limestone, poor in organic matter, nitrogen and total phosphorus. During the course of the vegetative season the ground water level was kept to a depth of about 2 m from the surface of the soil by infiltration through lateral infiltration by deep ditches. This was possible in practice given the high permeability of the soil and made the water of the water table accessible to the roots.

Climate : annual precipitation : 509.9 mm in 1963 ; 764.8 mm in 1964 ; 579 mm in 1965 and 870.4 in 1966 ; rainfall in the growing period respectively : 335.7 mm, 484.6 mm, 358 mm, 460.4 mm. Annual mean temperature : 12.4°C in 1963, 12.9°C in 1964, 11.9°C in 1965 and 12.7°C in 1966.

Clone: Populus x euramericana (Dode) Guinier, 'I-214'.

Type of propagation material : two-year-old nursery saplings.

Method of planting : planting "in water" (at a depth of about 2 m).

Spacing : distribution of 7 m x 4 m (7 m between each row and 4 m along the row), equal to 357 trees per hectare.

Date of Establishment : end of February 1963.

Start of experiment : Spring 1963.

Factors studied : nitrogen, phosphorus and potassium, each at two levels and relative combinations (2 x 2 x 2, Factorial Experiment), with ratios of N_2, P_2O_5 and K_2O of 1 : 1.5 : 1.5.

Experimental design : randomized blocks with three replications.

Experimental unit : plot of about 600 m^2 containing n° 21 trees of which the inside five were used for survey.

Time of distribution and fertilizer treatments : the total quantities of pure nutrients supplied per tree as annual dressing at the beginning of spring were as follows :

(1) At the end of December 1975 timber for paper was quoted at prices varying between 2,500 and 3,000 It.L. per quintal, the price of the fertilizers (VAT included) was 10,600 It.L. per quintal for Urea, It.L. 7,250 per quintal for Mineral superphosphate and L. 6,600 per quintal for Potassic salt.

1963 : Nitrogen (N_2) : 0.270 kg/tree ; Phosphate (P_2O_5) : 0.405 kg/tree ; Potash (K_2O) : 0.405 kg/tree ;
1964 : N_2 : 0.285 kg/tree ; P_2O_5 : 0.430 kg/tree ; K_2O : 0.430 kg/tree ;
1965 : N_2 : 0.325 kg/tree ; P_2O_5 : 0.490 kg/tree ; K_2O : 0.490 kg/tree ;
1966 : N_2 : 0.400 kg/tree ; P_2O_5 : 0.600 kg/tree ; K_2O : 0.600 kg/tree.

Application of fertilizer treatments : the phosphatic and potassic fertilizers were spread by means of broadcasting over all the area of the plot while the nitrogenous one in the first two years was applied in a drip line placement. The fertilizers were incorporated by means of disking (15-20 cm in depth).

The following fertilizers were applied :

N as Ammonium sulphate with 20-21 % N
P as Mineral superphosphate with 19-21 % P_2O_5
K as Sulphate of Potash with 48-50 % K_2O

Culture Care : 3 disking per annum and some spraying and control treatment for parasites.

Surveys : Basal area, calculated on the basis of the girth measured at the end of the vegetative season at 1.30 m above ground level.

Statistical analysis of the data : analysis of variance of the data relative to the basal area.

Results :

From the results obtained (Tab. 5) it emerged that only nitrogenous fertilization showed itself effective on the growth of the trees. The positive effect appeared significant beginning from the end of the 2nd year from the first application (Tab. 6). In the following years surveys were not carried out due to factors beyond our control. In the period considered no significant difference was encountered in the growth of the trees for the effect of the phosphorus and the potassium. The interactions of first and second order never resulted significant, even at the level of significance of 10 %. However, the trees treated with NP showed a basal area superior to that of the trees which reveived either one on the other of the two elements.

On the basis of the data collected (Tab. 5) it appears evident that the trees grew in a rather modest way attaining, on average, a basal area of hardly 94.5 cm at the end of the fourth year of vegetation. It is sufficient to bear in mind that, in more fertile areas, in four years from installation, the basal area per tree has attained 300 cm^2 (Frison, 1973).

The low productivity can without doubt be attributed to the mediocre fertility of the area, intending with this term the complex of factors which determines its aptitude for production. Among these factors, chief importance is attributed to the soil, to its physical, chemical and microbiological properties, to its composition in nutrient elements, organic substance, water etc. No less importance has the climate, with particular regard to rainfall, temperatures, hygrometrical state of the air etc. Finally of equal importance are the preparation of the ground, the careful carrying out of antiparasitical work and treatments etc. It thus emerges clearly that in order to increase the aptitude to produce it is not always sufficient to supply chemical fertilizers, as many other factors may play the role of limiting factor. In a specific case, treating of soil represented almost exclusively by

Table 5.- Trial N° 2. Mean Basal area (cm^2/tree) at 1.30 m above ground level

Treatments	Year 1963 at planting	1963 at the end of the year	1964	1965	1966
Test	6.0567	16.4933	44.2100	63.5533	85.4533
K	6.2700	14.2467	39.2380	59.7667	83.1967
P	6.2267	14.8333	36.4443	56.5800	84.5133
PK	6.0700	15.0133	39.6133	54.8833	75.8200
N	6.2967	14.7900	43.9023	61.0567	88.2133
NK	6.1900	17.6900	55.5517	76.3600	108.7933
NP	6.0633	18.9600	60.7657	83.8133	121.9733
NPK	6.0900	17.4633	52.9233	71.4967	106.4200
General mean	6.1579	16.1863	46.5811	65.9388	94.2979

Table 6.- Trial N°2. Results of analysis of variance of the data shown in table 5

Treatments	Year 1963 at planting	1963 at the end of the year	1964	1965	1966
Treatments	n.s.(+)	n.s.	*	n.s.	n.s.
N	n.s.	n.s.	**	**	**
P	n.s.	n.s.	n.s.	n.s.	n.s.
K	n.s.	n.s.	n.s.	n.s.	n.s.
NP	n.s.	n.s.	n.s.	n.s.	n.s.
NK	n.s.	n.s.	n.s.	n.s.	n.s.
PK	n.s.	n.s.	n.s.	n.s.	n.s.
NPK	n.s.	n.s.	n.s.	n.s.	n.s.

(+) significant at 1 % (**) and 5 % (*) level or not significant (n.s.)

sand (Tab.1) and extremely poor in organic matter, its modest fertility may be attributed, apart from its scarce endowment in nutrient elements, to scarcities in its physical, chemical and microbiological properties. In such soil, the disponibility of a water-table, accessible to the roots during the vegetative season, although playing a determining positive rôle in the growth of the trees, is not sufficient to increase the aptitude of the soil to produce in a more evident way. Nevertheless the water-table besides having supplied water, could have put at the disposition of the roots a not negligible quantity of nutritive element among which, probably phosphorus, which would explain the lack of results in the application of this element on the growth of the trees.

Trial N° 3.

Site : Casale Monferrato (AL)
Soil : sandy soil, of subalkaline reaction, poor in limestone, organic matter and nitrogen, averagely supplied in phosphorus and rich in potassium. The ground water level varied from about 2 m to 6 m (See Table 2).
Climate : annual precipitation : 854.4 mm in 1968 ; 837.2 mm in 1969 ; rainfall in the growing period respectively 476.8 mm ; 496 mm. Annual mean temperature : 12.2°C in 1968 and 11.6°C in 1969.
Clone: 'Harvard' (Populus deltoides Bartr. va. deltoides).
Type of planting material : young poplars of one-year-old stem and two-year-old root (S_1R_2) with total height of 4.5 m.
Method of planting : in holes 70 cm deep and 50 cm in diameter.
Spacing : 2 m x 2 m.
Date of Establishment : March 1967.
Start of Experiment : December 1967.
Factors studied : phosphatic-nitrogen fertilizing.
Experimental design : single block divided into two plots each of about 1,000 m² (one for the control and the other for the treatment with NP). The two plots were separated by a special embankment.
Time of distribution : the total quantities of pure nutrients supplied per tree were as follows :
09.12.67 : Phosphate (P_2O_5) : 152 g/tree
27.03.68 : Nitrogen (N_2) : 46 g/tree
17.05.68 : Nitrogen (N_2) : 36.8g/tree
Application of fertilizer treatments : the fertilizers were distributed by means of broadcasting over all the surface and incorporated by means of disk harrow (15-20 cm in deep).
The following fertilizers were applied :
N as Urea with 46 % N_2
P as Mineral superphosphate with 18-20 % P_2O_5
Cultural Care : 3 annual diskings of the ground and antiparasitic treatments (especially for Cryptorhynchus lapathi). Irrigation was carried out by controlled flooding on the dates 2 July and 22 July 1968. In the last ten days of September 1968 trees of alternate transversal rows were felled.
Felling of the trees : the first ten days of October, 1969.
Surveys : a) Basal area, calculated on the basis of the circumference surveyed at 1.30 m above ground level at the end of 1967, 1968 and 1969 ;
b) Total height of the trunk, surveyed on trees felled in 1968 and 1969 ;

c) Fresh weight of wood divided in trunk and lateral branches : surveyed at the end of 1968 and 1969 on felled trees ;
d) Fresh weight and number of leaves per tree : surveyed at the end of 1968 on felled trees;
e) Water content of the trunk : surveyed on trees felled at the end of 1969 (first ten days of October).

Statistical analysis of the data : analysis of variance for the comparison between the two treatments.

Results :

The results have shown (Tab. 7) that the nitrogen phosphate fertilizing did not have a positive outcome either on the growth of the trees (basal area and height of trunk, fresh weight of timber) or on the number and on the fresh weight of the leaves. It had a positive influence, instead, on the water content of the timber.

As far as water nutrition is concerned, given the profile of the soil on the one hand appearing sandy and without skeleton as far as 1.50 m and rich in skeleton in the deeper strata and thus practically without possibility of a developed capillary fringe and on the other the movement of the ground water level (Tab. 2) in the course of the vegetative season oscillating between a minimum of 3.70 m and a maximum of 6 m in 1968 and between a minimum of 2.46 m and a maximum of 5.18 m in 1969, it can be deduced that the water resources of the trees were always represented by the rainfall (854.4 mm in 1968 and 837.2 mm in 1969 of which 423.2 mm and 492 mm respectively from April to September included), and by irrigation. On the basis of this data one cannot say that the moisture of the soil was always excellent but neither can one say that the trees suffered drought for long periods. In spite of this, the trees did not respond to fertilization.

As during the course of the trial a yellowing of the leaves was observed only in the fertilized plot quite marked on numerous trees, one could be led to think that the application of 0.8 kg per tree of 18-20 % P_2O_5 mineral superphosphate might have represented an excessive dose of P_2O_5, causing the above-mentioned phenomenon of chlorosis and at the same time impeding the tree from taking advantage of the nitrogen application.

CONCLUSIONS

From the results obtained in the three trials it has emerged that in two of them the growth of the trees was increased by nitrogen fertilizing. The effect of the element showed itself in a significant way at the end of the second (Trial N° 2) or the third year (Trial N° 1) from the first distribution. The positive effect can, however, be taken as existing in both trials a year before, considering as valid the level of probability of 10 % which is acceptable in trials in the open ground where the variability due to uncontrolled sources is always very high.

The effectiveness of nitrogen was not confirmed in the third trial and that seemed to be in relation with the abundant application of phosphorus (20 q/ha of 19/21 % mineral superphosphate) in a soil already sufficiently supplied in this element. The yellowing of the leaves observed in the trees fertilized would confirm this hypothesis.

Table 7.- Trial N° 3. Mean, Variance and F-Test concerning the data observed on each tree of each treatment (Test and Fertilized)

Year	Parameter	Treatment	Mean	Variance	F (*)
1967	Girth (cm/tree)	Test	16.84	4.69	0.0043n.s.
		Fert.	16.89	4.74	
	Basal area (cm^2/tree)	Test	22.94	35.14	0.0048n.s.
		Fert.	23.04	35.76	
1968	Girth (cm/tree)	Test	26.80	14.05	0.5207n.s.
		Fert.	27.49	14.98	
	Basal area (cm^2/tree)	Test	58.25	257.02	0.5972n.s.
		Fert.	61.28	234.61	
	Total height (m)	Test	10.26	0.70	1.3754n.s.
		Fert.	9.92	2.00	
	Fresh weight (kg/tree)				
	a) Trunk (T_r)	Test	24.32	64.33	0.0629n.s.
		Fert.	24.82	61.70	
	b) Lateral branches (L_b) ($\emptyset$ > cm 3)	Test	7.02	4.65	1.5243n.s.
		Fert.	7.76	7.04	
	c) $T_r + L_b$	Test	31.34	96.59	0.2617n.s.
		Fert.	32.58	90.82	
	d) Leaves	Test	7.63	5.85	0.0047n.s.
		Fert.	7.59	5.82	
	Number of leaves per tree	Test	1406.12	263527.56	0.1039n.s.
		Fert.	1445.10	198267.89	
1969	Girth (cm/tree)	Test	33.99	36.07	0.0966n.s.
		Fert.	33.69	32.48	
	Basal area (cm^2/tree)	Test	94.76	1097.54	0.1353n.s.
		Fert.	92.85	962.73	
	Total height (m)	Test	12.31	1.10	0.7309n.s.
		Fert.	12.16	1.29	
	Fresh weight (kg/tree)				
	a) Trunk (T_r)	Test	37.92	209.50	0.1991n.s.
		Fert.	36.89	197.37	
	b) Lateral branches (L_b) ($\emptyset$ > cm 3)	Test	5.09	11.00	0.0096n.s.
		Fert.	5.14	9.53	
	c) $T_r + L_b$	Test	43.05	299.02	0.2730n.s.
		Fert.	41.59	294.69	
	Moisture content of the wood (% fresh weight)	Test	56.52	1.38	4.3269 +
		Fert.	54.95	4.35	

(*) Significant at 5 % (+) level or not significant (n.s.).

In the other trials the phosphorus did not significantly influence the production, expressed in fresh weight of timber (trial N° 1) or in basal area of the trees (trial N° 2).

The effect of potassium proved to be absolutely insignificant, exception made for density (Trial N° 1) which was increased by this element added to fertilization with nitrogen and phosphorus. The lack of positive effect of potassium can be explained by the fact that the alluvial sands of the Po plain are often sufficiently supplied with this element.

From the results obtained in these and in other trials, a practical orientation which, while waiting for further experimental details, could be suggested to the poplar tree growers of the relative areas is the following : to carry out before establishment, even as a precautionary measure, a basal dressing of phosphate-potassic fertilizers on soils considered insufficiently supplied and then control with special attention the integration with nitrogenous fertilizers, more or less conspicuous according to the conditions of the soil and the tree.

RESUME

Résultats d'essais de fertilisation du peuplier sur des sols sableux

On expose les résultats de trois essais de fertilisation qui ont été faits en trois peupleraies dont deux (essais n° 1 et n° 3) à espacement serré (m 3 x m 2 et m 2 x m 2) réalisées à Casale Monferrato sur des terrains sablonneux, pauvres en matière organique et azote, et une (essai n° 2) à espacement moyen (m 7 x m 4) effectuée à Goro sur des sables pauvres du delta du Pô.

Dans le premier essai on a mis en comparaison les quatre traitements suivants : Témoin, N, NP, NPK et dans le troisième deux seulement : Témoin et NP. L'essai n° 2 a été effectué avec N, P, K, en employant deux niveaux (0 et 1) de chacun des trois éléments en combinaison factorielle.

Il ressort des résultats qu'en deux essais les engrais azotés ont déterminé un plus fort accroissement en surface terrière des plantes et dans les autres paramètres considérés. L'effet de l'azote s'est manifesté d'une manière significative à la fin de la deuxième (essai n° 2) ou de la troisième année (essai n° 1) dès la première distribution. L'efficacité de l'azote n'a pas été confirmée dans le troisième essai et cela a semblé être en relation avec l'abondant apport de phosphore (20 q/ha de phosphate minéral 18-20 % P_2O_5) dans un terrain déjà moyennement doué en cet élément. Le jaunissement des feuilles qu'on a remarqué dans les plantes fertilisées par engrais consoliderait cette hypothèse.

Dans les trois essais le phosphore n'a eu d'influence significative ni sur la production exprimée en poids vert du bois (essai n° 1 et n° 3) ni sur la surface terrière des plantes (essai n° 2).

Absolument insignifiant a été l'effet de la potasse, à l'exception de la densité basale (essai n° 1) qui a été augmentée à l'aide de cet élément ajouté aux engrais azotés et au phosphore. On peut expliquer le manque d'un effet positif de la potasse sur l'accroissement en tenant compte que les sables alluviaux de la plaine du Pô souvent contiennent une quantité suffisante de cet élément.

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