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RESEARCH ON MODERN TECHNIQUES OF POPLAR CULTIVATION

by

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SUMMARY

RESEARCH ON MODERN TECHNIQUES OF POPLAR CULTIVATION

The research carried out on certain modern techniques of poplar cultivation permits one to affirm that:

-poplar saplings more developed in nursery, that is to say dominant after transplantation offer higher productivity than smaller, that is, dominated ones;

-deep planting may permit a higher growth rate in those sites with a water-table accessible to the roots for sufficiently long periods during the vegetative season. If the water-table is only available during the spring months and for short periods, the effec on growth is either very small or lacking altogether, while it may be significant for the rooting. In soils subjected to trench ploughing the diameter of the hole has no effect on production. Not all clones react in the same way to depth of planting : in some the effect is more marked than in others. The production of wood is greatly influenced by the physical characteristics of the soil and becomes proportionately lower as the percentage of sand and gravel becomes higher;

-coppicing may give high production of wood for chipboard industries in very short rotation (from 1 to 3 years) and for paper with short rotation (from 4 to 6 years) but there remains the problem of choice of suitable clones, which must be specially selected.

RESUME

RECHERCHES SUR QUELQUES MODERNES TECHNIQUES DE CULTURE DU PEUPLIER

Les recherches faites sur quelques modernes techniques de culture du peuplier permettent d'affirmer que:

-les jeunes peupliers les plus développés en pépinière c'est-à-dire dominants donnent des productions plus élévées que ceux qui sont plus petits, c'est-à-dire dominés;

-la profondeur de plantation peut permettre des accroissements plus élevés dans les sols avec une nappe phréatique accessible aux racines pour des périodes assez longues pendant la saison végétative. Si l'eau de nappe n'est disponible qu'au cours des mois du printemps ou pour des périodes courtes l'effet sur la croissance est très pauvre ou inexistant, tandis qu'il peut être significatif pour l'enracinement. Dans les terrains préparés avec défoncement le diamètre du trou n'a aucun effet sur la production. Pas tous les clônes réagissent de la même façon à la profondeur de plantation: pour quelques-uns l'effet est plus marqué que pour d'autres. La production du bois est très influencée par les caractéristiques physiques du sol et est plus basse à mesure que le pourcentage de sable et de gravier est plus haut;

-le taillis de peuplier peut donner des productions du bois élevées pour panneaux avec des révolutions très brèves (de 1 à 3 ans) et pour papier avec des révolutions brèves(de 4 à 6 ans) mais il reste le problème du choix des clônes convenables qui doivent être selectionnés à ce propos.

RESEARCH ON MODERN TECHNIQUES OF POPLAR CULTIVATION

I. INTRODUCTION

Techniques of planting and cultivation of poplar stands have by now attained a good degree of improvement, although concerning certain of these, such as irrigation and fertilizing, there are still some aspects in need of clarification to render possible an exact evalutation of their effectiveness in differing environment conditions and the giving of advice for rational utilization on the basis of the requirements of the differing clones as they become chosen. As for others, which may be considered of recent introducti such as, for example, deep planting, or completely new, such as coppicing, the field is open to research and experiment for the solution of several problems which concern them. Literature concerning the choice of planting material is also somewhat short of data and at a practical level opinions are still often rather confused.

Aware of the gaps that remain to be filled, the Research Institutes of the S.A.F. - E.N.C.C. - that is, Istituto di Sperimentazione per la Pioppicoltura di Casale Monferrato (I.S.P.) and the Centro di Sperimentazione Agricola Forestale di Roma (C.S.A.F.) have for years been carrying out intensive research work in an attempt to improve certain aspects of cultural techniques already partially established, to gain more knowledge concerning others introduced more recently and to perfect still others newly conceive

With the proposal of reporting the results of research on subjects of more specialized interest in other notes, we limit ourselves in this paper to a brief exposition of the results of experiments concerning the more recent techniques of wider interest, in particular:

a) the choice of propagation material for establishment of poplar stands;

b) depth of planting in differing environments;

c) short rotation coppicing.

Research on points a) and b) have been carried out by the I.S.P. and of that on point c) by the I.S.P. together with the C.S.A.F.

EXPERIMENTAL PART

1. CHOICE OF TWO-YEAR-OLD NURSERY SAPLINGS FOR ESTABLISHMENT

For some time the "Istituto di Sperimentazione per la Pioppicoltura di Casale Monferrato" has been carrying out a series of trials to study the influence of the characteristics of planting material (two-year-old nursery saplings) on poplar stand production. In a preceding paper (Frison, 1978) the results obtained during the first five years after establishment in poplar stands made up of saplings of poplar ('I-214') belonging to the following commercial diametric categories: 3.03-3.82 cm; 3.83-4.61 cm; 4.62-5.41 cm; over 5.41 cm were published. As in the meantime one of the poplar stands part of this research has already been felled (at Lagosanto, in the province of Ferrara), we have considered it opportune to report the definitive results in this paper.

For all information concerning guidelines followed during research and the way they have been observed, we refer those interested to the paper already mentioned, limiting ourselves here to the presentation of definitive data and a brief comment on these.

From these data (Tab. 1), it is clear that production is considerably increased with increase in diameter of the saplings planted. The fresh weight of utilizable wood mass (calculated from ground level to the point where the overall bark diameter of the stem is 10 cm) has passed from an average of 4.25 q (q = 100 Kg) per tree for specimens obtained from saplings of the first category of diameter to an average of 5.20 q per tree for those obtained from saplings of the fourth.

The entity of the difference is considerable and demonstrates the clear superiority of dominant saplings over dominated saplings regarding their productivity in poplar stands, which is consonant with the results obtained by Avanzo (1975).

Table 1. - BREAST HEIGHT GIRTH, HEIGHT, VOLUME AND FRESH WEIGHT (expressed in mean per tree and calculated from ground level to the point where the over bark diameter of the stem is 10 cm) MEASURED AT THE FELLING OF THE TREES (8 year old)

Diametric class of the saplings (cm at 1 m above ground level)	Breast height girth (cm)	Height (h_{10}) (m)	Volume (V_{10}) (m^3)	Fresh weight (W_{10}) (q = 100 Kg)
3.03 - 3.82	84.04	18.65	0.608	4.25 a(*)
3.83 - 4.61	86.76	19.00	0.656	4.60 a b
4.62 - 5.41	89.17	19.22	0.697	4.90 b c
> 5.41	91.51	19.40	0.737	5.20 c

(*) Means followed by different letters are different (P = 0.05).

2. DEEP PLANTING

In two preceding studies (Frison, 1972 and 1973) we have examined the influence of the diameter and depth of holes on rooting and on growth during the first year of trees of certain clones ('I-214', LUX) in differing periods in 1971 and 1972. In this paper we are considering the growth of these same trees during the following years, limiting ourselves, for the sake of brevity, only to data collected up to the end of 1978.

The research, on the basis of the type of drill used and on factors studied, may be grouped in three series. In the first (trials n°1,2 and 3) the holes were made not only with the traditional auger (50 cm Ø, depth 100 cm), but also with the 'Castelbajac' drill (16 cm Ø, depth from 1 m to 3 m) and the factors of clone and depth of planting were studied; in the second the holes were made with 'Ellettari' auger (12 cm Ø, depth from 1 m to 3 m) and the time of planting and depth of planting were taken into consideration (trials n° 4 and 5) and in the third series (Ellettari auger, trials n°6, 7, 8, 9, 10, 11, 12, 13 and 14) the diameter of the holes (9 or 12 cm) , depth of planting and clone, taking factors concerning these together or separately, were examined.

Growth was evaluated on the basis of trunk circumference at 1.30 m above ground level and of the corresponding basal area, taking into consideration both average per tree and average per installation area, this latter making possible a more accurate evalutation of real productivity.

Data were also collected concerning height of trees of different treatments but as no significant differences in results were observed, we consider that a evalutation of productivity may be arrived at with sufficient precision on the basis of basal area referred to the spacing.

2.1 First series of research (trials n° 1,2,3)

Factors studied:

a) depth of planting

b) clone

Experimental design: Split-plots, assigning the plots to the clone and the sub-plots to the depth, with 3 or 4 repetitions.

Experimental unit: plot containing 16 or 25 trees.

The tests were carried out in sandy soil with skeleton (Casale Monferrato), in sandy soil (Pieve del Cairo) and in clay loam soil (Fossadello di Caorso). The water table remained at levels of around 3 metres during the spring period and fell to levels inaccessible to even the deepest roots during the summer and autumn periods.

At the end of the year 1978, after 8 years of vegetation, a period of time sufficient to allow the trees to complete their rotation at Fossadello or to approach the end of it at Casale, the data relative to the circumference showed that no signicant differences existed between the treatments (Tab. 2).

The data relative to average basal area per tree (Tab. 2) lead to the same conclusions while those referring to average basal area per spacing (m^2 16 at Casale Monferrato, 36 m^2 at Pieve del Cairo, 12 m^2 at Fossadello di Caorso) show the clearly positive effect of depth in these last two sites (Tab. 3). This is explained by the fact that in these localities the soil was characterized, even if only during the spring period, by a more favourable humidity in the deeper strata reached by the roots.

2.2 <u>Second series of research</u> (test n° 4 and 5)

- Factors studied

  a) time of planting (4 in the period from November, 1971 to March, 1972)

  b) depth of holes (Ø 12 cm): 1 m; 1.70 m; 2.30 m; 3.00 m.

- Experimental design: randomized blocks with 5 repetitions;
- Experimental unit: lot of 25 trees.

Trial n° 4

. Soil: sandy, subalkaline reaction with an average amount of total limestone and poor in organic matter,

. Water table: during the vegetative period the water surface varied between 2 m and 4 m of depth.

TABLE 2. - BREAST HEIGHT GIRTH (mean per tree in cm) MEASURED AT THE END OF 1978 IN CASALE MONFERRATO (AL), PIEVE DEL CAIRO (PV) AND FOSSADELLO DI CAORSO (PC) (under the name of each site the spacings and the date of plantation are indicated)

Clone	Depth of planting (m)	Trial 1 Casale M. 4 x 4 III/71	Trial 2 Pieve del Cairo 6 x 5 III/71	Trial 3 Fossadello di C. 4 x 3 III/71
LUX	1.00(oa,wr)			69.73
	1.00(oa,rl)	64.22	63.98	65.89
	1.00(dm,rl)	71.44	68.82	62.68
	1.50 " "	71.02	63.21	67.81
	2.00 " "	67.51	72.64	69.86
	3.00 " "	70.92	69.79	
'I-214'	1.00(oa,wr)			66.21
	1.00(oa,rl)	68.21	65.52	67.55
	1.00(dm,rl)	69.34	64.87	65.29
	1.50(" ")	69.54	64.96	68.87
	2.00	70.93	66.91	69.54
	3.00	67.45	67.90	
Mean (clone)				
LUX		69.05 a	67.69 a	67.20 a
'I-214'		69.10 a	66.03 a	67.49 a
Mean (Depth of planting)				
	1.00(oa,wr)			67.97 a
	1.00(oa,rl)	66.21 a	64.75 a	66.72 a
	1.00(dm,rl)	70.39	66.84 a	63.99 a
	1.50(" ")	70.28 a	64.09 a	68.34 a
	2.00(" ")	69.22 a	69.78 a	69.70 a
	3.00(" ")	69.19 a	68.85 a	
General mean		69.06	66.86	67.34

oa = ordinary auger ; dm = drilling-machine Castelbajac
wr = saplings with root ; rl = saplings rootless.

TABLE 3. - BREAST HEIGHT BASAL AREA (mean in cm^2 per tree and per area covered by each tree according to the spacing) MEASURED TO THE END OF 1978 IN CASALE MONF., PIEVE DEL CAIRO AND FOSSADELLO DI CAORSO (under the name of each site the spacings and the dates of plantation are indicated)

Clone	Depth of planting (m)	Mean per tree: Trial 1 Casale M. 4 x 4 III/71	Trial 2 Pieve C. 6 x 5 III/71	Trial 3 Fossadello 4 x 3 III/71	Mean per area covered by each tree: Trial 1 Casale M. 4 x 4 III/71	Trial 2 Pieve C. 6 x 5 III/71	Trial 3 Fossadello 4 x 3 III/71
LUX	1.00(oa,wr)			393.19			344.37
	1.00(oa,rl)	350.77	340.79	351.96	251.78	310.82	319.73
	1.00(dm,rl)	424.50	388.61	319.44	268.23	303.34	290.70
	1.50(" ")	424.45	336.83	372.01	268.52	305.29	324.83
	2.00(" ")	381.55	435.09	394.34	260.52	421.69	385.82
	3.00(" ")	417.07	400.75		322.63	380.14	
'I-214'	1.00(oa,wr)			353.91			311.81
	1.00(oa,rl)	379.55	343.21	366.49	327.59	315.31	303.56
	1.00(dm,rl)	391.65	340.36	343.91	331.31	332.70	331.18
	1.50(" ")	392.05	337.60	382.11	322.91	297.86	356.95
	2.00(" ")	408.88	361.19	391.88	349.18	330.61	337.20
	3.00(" ")	371.42	367.34		332.95	356.59	
Mean (clone)							
LUX		399.67 a	380.41 a	366.19 a	274.33 a	344.25 a	333.09 a
'I-214'		388.71 a	349.94 a	367.66 a	332.79 a	326.64 a	328.14 a
Mean (Depth of planting)							
	1.00(oa,wr)			373.55 a			328.09 a b
	1.00(oa,rl)	365.16 a	342.00 a	359.23 a	289.69 a	313.07 a	311.65 a
	1.00(dm,rl)	408.07 a	364.48 a	331.67 a	299.77 a	318.02 a	310.94 a
	1.50(" ")	408.25 a	337.21 a	377.06 a	295.72 a	301.58 a	340.89 b
	2.00(" ")	395.21 a	398.14 a	393.11 a	304.85 a	376.15 b	361.51 b
	3.00(" ")	394.25 a	384.04 a		327.79 a	368.41 b	
General mean		394.19	365.18	366.92	303.56	335.45	330.61

oa = ordinary auger ; dm = drilling-machine Castelbajac
wr = saplings with root ; rl = saplings rootless.

Trial n° 5

. Soil: on the surface sandy, subalkaline reaction, with an average amount of limestone and poor in organic matter and, in depth, strata with sandy loam texture.

. Water-table: it remained at a depth of around 3 m only during the spring period and dropped to even more than 5 m during summer and autumn.

Results

Circumference and average basal area per tree (tab. 4) were affected by neither time nor depth of planting in either site Also considering basal area in relation to the spacing (24 m^2 at Gussola and 30 m^2 at Monticelli Pavese) the differences between the treatments were not significant. It can, however, be noted that at Gussola trees planted at 3 m showed a greater basal area than those planted less deeply and the differences could become significant by the end of the rotation. Already, however, productivity in the site of Monticelli is proving to be clearly superior to that in the site of Gussola, the former being much more fertile on account of its being characterized by the presence in the composition of its soil of sandy loam strata.

2.3 Third series of research (tests n° 6,7,8,9,10,11,12,13 and 14)

- Factors studied

a) diameter of holes
b) depth of holes
c) clone.

The depth of hole factor was combined with the diameter of hole factor in trials n° 6,7,8,10,11, with the clone factor in trial n° 14 and was studied alone in trials n° 9,12 and 13.

- Experimental plan:

. split-plots, assigning the plots to the diameter of the holes and the sub-plots to the depth, with 3-7 replications (tests n° 6,7,8,10,11);

. Randomized blocks with 3-5 repetitions (tests n° 9,12,13 and 14).

TABLE 4. - BREAST HEIGHT GIRTH (mean per tree in cm) AND BASAL AREA (mean in cm^2 per tree and per area covered by each tree according to the spacing) MEASURED AT THE END OF 1978 IN GUSSOLA (CR) AND IN MONTICELLI PAVESE (PV).

Date of planting	Depth of planting (m)	Trial 4 Gussola (6 x 4) Girth $\bar{x}$/tree	Basal area $\bar{x}$/tree	Basal area $\bar{x}$/area	Trial 5 Monticelli P.(6 x 5) Girth $\bar{x}$/tree	Basal area $\bar{x}$/tree	Basal area $\bar{x}$/area
21/11/71(*)	1.00	62.67	318.01	309.79	80.34	515.67	468.74
and	1.70	58.45	285.26	279.15	81.62	531.91	505.40
	2.30	60.20	292.57	277.11	82.24	540.59	505.49
18/12/71	3.00	66.30	353.71	353.71	81.21	526.06	489.32
19/ 1/72	1.00	57.44	267.68	255.12	80.49	516.15	516.15
and	1.70	64.62	338.62	338.62	82.58	544.01	506.71
	2.30	60.90	300.51	280.81	82.50	543.42	482.09
13/ 1/72	3.00	68.67	380.90	380.90	81.53	527.60	515.52
24/ 2/72	1.00	66.54	358.00	318.66	81.02	523.52	523.52
and	1.70	65.93	353.49	299.76	80.78	521.43	521.43
	2.30	63.99	332.27	293.02	80.21	513.41	479.11
26/ 2/72	3.00	68.89	380.39	371.41	81.20	526.31	526.31
24/ 3/72	1.00	59.69	289.20	255.84	79.77	511.93	477.18
and	1.70	61.01	301.77	301.77	80.71	519.98	497.20
	2.30	63.25	325.79	270.37	79.15	500.11	489.43
23/ 3/72	3.00	60.61	298.83	259.71	79.01	500.66	445.16
Mean (date of planting)							
1st		61.90 a	312.38 a	304.94 a	81.35 a	528.56 a	492.24 a
2nd		62.91 a	321.93 a	313.86 a	81.77 a	532.80 a	505.12 a
3rd		66.34 a	356.04 a	320.71 a	80.81 a	521.17 a	512.59 a
4th		61.14 a	303.90 a	271.92 a	79.66 a	508.17 a	477.24 a
Mean (depth of planting)							
	1.00	61.58 a	308.22 a	284.85 a	80.40 a	516.82 a	496.40 a
	1.70	62.50 a	319.78 a	304.82 a	81.42 a	529.33 a	507.69 a
	2.30	62.09 a	312.78 a	280.33 a	81.02 a	524.38 a	489.03 a
	3.00	66.11 a	353.46 a	341.43 a	80.74 a	520.16 a	494.08 a
General mean		63.07	323.56	302.86	80.90	522.67	496.80

(*) The first date is referred to Gussola and the second to Monticelli P.

- Experimental unit: plot of 25 trees.

. Soil: sandy with 'skeleton' (Breme and Casale Monferrato), sandy (Zerbolò, Gussola, Zeme, Roncaglia); sandy loam (Soarza and Solero); clay loam (Torremenapace); with neutral reaction (Zerbolò, Zeme), subalkaline (Breme, Gussola, Roncaglia, Solero, Soarza, Torremenapace and Casale Monferrato), without total limestone (Zerbolò), or very poor (Breme and Zeme) or with average amounts (Gussola, Roncaglia, Soarza, Solero, Torremenapace, Casale Monferrato) and poor in organic matter in almost all sites.

. Water-table. The water-table proved fluctuating with the passing of time, also with very considerable variations both from one year to another and during the course of the vegetative period, according to precipitations and water-level of rivers. In particular, while during the spring-summer period of 1976 it proved to be extremely deep in all sites, in the corresponding period of 1977 it appeared decidedly nearer to the surface, bringing itself to levels accessible to the roots. In the other years taken into consideration it fluctuated, during the course of the vegetative season, registering minimum depths during the spring period and maximum depths during the summer-autumn period, descending to levels practically inaccessible to all roots.

Results

On the basis of circumference (Tab. 5) and of average basal area per tree and per installation area (Tabs. 6 and 7), no significant difference can be attributed to the diameter of the hole except in the case of one test, at Gussola, where a higher value was noted for 9 cm holes compared with those of 12 cm. This result is somewhat difficult to explain, also because, if anything, one would expect the opposite.

Neither does any significant difference emerge in the depths of planting although it may be noted that values of average basal area per installation area increase with the depth of the holes at Breme, for example, and decrease with these same at Torremenapace. The differences, which at the moment do not appear significant, could become so by the end of the cycle if the level of the water-table were still to influence the moisture of the deep strata of the soil positively at Breme

TABLE 5. - BREAST HEIGHT GIRTH (mean per tree in cm) MEASURED AT THE END OF 1978 IN BREME LOMELLINA (PV), ZERBOLO' (PV), GUSSOLA (CR), ZEME (PV), RONCAGLIA (PC), SOARZA (CR), SOLERO (AL), TORREMENAPACE (PV). (Under the name of each site the spacings and the dates of planting are indicated).

ø auger (cm)	Depth of planting (m)	Trial 6 Breme L. 4 x 4 III/72	Trial 7 Zerbolò 5 x 5 I/72	Trial 8 Gussola 6 x 4 XI/71	Trial 9 Zeme 6 x 5 II/73	Trial 10 Roncaglia 6 x 5 XII/71	Trial 11 Soarza 6 x 5 XII/71	Trial 12 Solero 6 x 6 II/73	Trial 13 Torremenapac 5 x 5 II/72
9	1.00	54.93	65.68	70.48		79.98	92.09		75.21
	1.70	50.44	61.32	69.30		80.48	89.83		72.75
	2.30	51.84	56.32	69.00		79.48	92.27		73.51
	3.00	56.25	65.24	71.83		78.78	90.30		70.83
12	1.00	51.22	66.23	60.64		79.35	92.06		
	1.70	53.05	67.84	60.53	74.49	79.30	92.07	66.69	
	2.30	54.22	61.66	52.08		77.79	88.66	67.46	
	3.00	55.33	60.38	65.50	75.44	77.34	89.14	66.39	
Mean (diameter of the auger)									
9		53.36 a	62.14 a	70.15 a		79.68 a	91.12 a		73.07
12		53.45 a	64.03 a	59.69 a	74.83	78.45 a	90.48 a	66.85	
Mean (depth of planting)									
	1.00	53.07 a	65.95 a	65.56 a		79.67 a	92.07 a		75.21 a
	1.70	51.74 a	64.58 a	64.92 a	74.49 a	79.89 a	90.95 a	66.69 a	72.75 a
	2.30	53.03 a	58.99 a	60.54 a		78.63 a	90.46 a	67.46 a	73.51 a
	3.00	55.79 a	62.81 a	68.66 a	75.44 a	78.06 a	89.72 a	66.39 a	70.83 a
General mean		53.41	63.08	64.92	74.83	79.06	90.80	66.85	73.07

TABLE 6. – BREAST HEIGHT BASAL AREA (mean per tree in cm^2) MEASURED AT THE END OF 1978 IN BREME LOMELLINA (PV), ZERBOLO' (PV), GUSSOLA (CR), ZEME (PV), RONCAGLIA (PC), SOARZA (CR), SOLERO (AL), TORREMENAPACE (PV). (Under the name of each site the spacings and the dates of planting are indicated).

Ø auger (cm)	Depth of planting (m)	Trial 6 Breme L. 4 x 4 III/72	Trial 7 Zerbolò 5 x 5 I/72	Trial 8 Gussola 6 x 4 XI/71	Trial 9 Zeme 6 x 5 II/73	Trial 10 Roncaglia 6 x 5 XII/71	Trial 11 Soarza 6 x 5 XII/71	Trial 12 Solero 6 x 6 II/73	Trial 5 Torremenapace 5 x 5 II/72
9	1.00	248.19	354.68	412.41		512.69	680.62		454.79
	1.70	219.53	309.17	400.23		518.53	646.03		425.57
	2.30	224.33	262.08	409.72		505.57	662.59		433.33
	3.00	258.50	350.09	430.52		494.31	655.74		403.65
12	1.00	219.21	357.62	304.45		505.92	677.50		
	1.70	237.09	378.39	317.90	443.65	502.88	678.19	354.95	
	2.30	243.80	311.09	227.92		483.73	633.28	363.23	
	3.00	256.72	294.98	358.51	454.85	479.32	653.39	352.14	
Mean (diameter of auger)									
9		237.64 a	319.00 a	413.22 a		507.78 a	661.24 a		429.34
12		239.20 a	335.52 a	302.20 b	449.25	492.96 a	656.09 a	356.77	
Mean (depth of planting)									
	1.00	233.70 a	356.15 a	358.43 a		509.31 a	679.06 a		454.79 a
	1.70	228.31 a	343.78 a	359.07 a	443.65 a	510.71 a	662.11 a	354.95 a	425.57 a
	2.30	234.07 a	286.59 a	318.82 a		494.65 a	547.93 a	363.23 a	433.33 a
	3.00	257.61 a	322.54 a	394.51 a	454.85 a	486.82 a	645.56 a	352.14 a	403.65 a
General Mean									
		238.42	327.26	357.71	449.25	500.37	658.67	356.77	429.34

TABLE 7. - BREAST HEIGHT BASAL AREA (mean in cm^2 per area covered by each tree according to the spacing) MEASURED AT THE END OF 1978 IN BREME LOMELLINA (PV), ZERBOLO' (PV), GUSSOLA (CR), ZEME (PV), RONCAGLIA (PC), SOARZA (CR), SOLERO (AL), TORREMENAPACE (PV). (Under the name of each site the spacings and the dates of planting are indicated).

Ø auger (cm)	Depth of planting (m)	Trial 6 Breme L. 4 x 4 III/72	Trial 7 Zerbolò 5 x 5 I/72	Trial 8 Gussola 6 x 4 XI/71	Trial 9 Zeme 6 x 5 II/73	Trial 10 Roncaglia 6 x 5 XII/71	Trial 11 Soarza 6 x 5 XII/71	Trial 12 Solero 6 x 6 II/73	Trial 5 Torremenapace 5 x 5 II/72
9	1.00	221.31	279.41	412.41		482.70	651.75		363.27
	1.70	220.36	289.77	400.23		417.00	631.52		356.12
	2.30	204.47	250.36	397.39		450.14	617.86		323.50
	3.00	246.23	331.88	407.14		465.94	611.38		311.82
12	1.00	171.00	344.02	297.64		462.30	662.98		
	1.70	215.35	335.86	300.27	404.27	444.54	618.65	345.72	
	2.30	220.35	276.16	227.92		470.62	588.04	336.49	
	3.00	234.95	274.82	346.43	427.96	399.08	621.48	352.14	
Mean (diameter of auger)									
9		218.01 a	287.85 a	404.29 a		453.95 a	628.13 a		338.68
12		210.41 a	307.72 a	293.06 b	416.11	444.14 a	622.79 a	344.78	
Mean (depth of planting)									
	1.00	196.16 a	311.72 a	356.02 a		472.50 a	657.37 a		363.27 a
	1.70	207.86 a	312.82 a	350.25 a	404.27 a	430.77 a	625.08 a	345.72 a	356.12 a
	2.30	212.41 a	263.26 a	312.65 a		460.38 a	602.95 a	336.49 a	323.50 a
	3.00	240.59 a	303.35 a	376.78 a	427.96 a	432.51 a	616.43 a	352.14 a	311.82 a
General mean		214.25	297.79	348.68	416.11	449.51	625.46	344.78	338.68

(sandy soil with gravel) and negatively at Torremenapace (clay loam).

Of greater interest appear to be the results (Tab. 8) of depth of planting in relation to the clone (test nº 14). For 4 of these (92/40, 3B, MC and PE-36/67) in fact, a depth of 3 m compared with that of 1.50 m, increased average basal area per area per tree to a significant extent. In reality a great part of the difference is to be attributed to the greater number of trees surviving with deep planting; this has, that is, had more influence of rooting than on subsequent growth of the trees.

Considerations

The tests as a whole have demonstrated as follows:

- time of installation.

As had already been shown during the course of the first year after planting (Frison, 1973), of the 4 periods taken into consideration, the spring one seems the least advantageous also for purposes of growth in basal area (mean per area per tree).

- diameter of holes.

No clear influence on basal area (average per area per tree) was exercised by the diameter of the hole, whether made with a traditional auger (Ø 50 cm) or Castelbajac drill (Ø 16 cm) or Ellettari auger (Ø 9 cm against Ø 12 cm), excepts in the case of the Gussola test where a 9 cm diameter achieved better results that a 12 cm one.

It must be borne in mind, however, that all the soils were ploughed deeply (60-100 cm) before installation which may explain the lack of effect of hole diameter on growth.

- depth of holes

On the basis of average basal area per area per tree, we may say that while depth of holes has had no greatly significant effects, results of a certain interest have been obtained in the sites (Pieve del Cairo, Gussola, Fossadello, Breme, Casale Monferrato) where the water-table during the spring periods has remained longer at levels accessible to the deepest roots. No positive effect has been seen in

TABLE 8. - BREAST HEIGHT GIRTH (mean per tree) AND BASAL AREA (mean per tre and per m^2 33) MEASURED AT THE END OF 1978 IN CASALE MONFERRATO (AL).(spacing m 6 x 5.50; Date of planting: Feb. 1974).

Clone	Depth of planting (m)	Breast height girth (cm)	Basal area mean per tree (m^2)	mean per m^2 33 (m^2)
35/64	1.50	52.86	226.02	208.69
	3.00	51.75	216.16	199.30
PE 4/68	1.50	55.12	246.42	209.17
	3.00	53.69	231.95	207.89
92/40	1.50	39.12	134.96	76.60
	3.00	48.74	192.29	157.08
3B	1.50	49.34	198.07	144.49
	3.00	48.01	186.63	177.81
MC	1.50	48.43	202.38	159.89
	3.00	51.88	218.24	195.18
PE/36/67	1.50	45.02	164.56	140.10
	3.00	46.93	180.60	170.95
Mean (depth of planting)				
	1.50	48.31 a	195.40 a	156.49 a
	3.00	50.17 a	204.31 a	184.70 b
Mean (clone)				
35/64		52.30	221.09	203.99
PE 4/68		54.41	239.18	208.53
92/40		43.93	163.63	116.84
3B		48.68	192.35	161.15
MC		50.16	210.31	177.54
PE 36/67		45.98	172.58	155.53
General mean		49.24	199.86	170.60

any of the other sites and there has been, as was indeed expected, even a negative effect in the site of Torremenapace on account of the presence of a water-table near the surface in clay loam soil.

From what has been observed above it seems clear that in a soil of high permeability and small capacity for retaining water, the presence of a water-table at levels accessible to the roots only during the spring months may exert influence on the moisture of the soil for a period of time which, while it may be considered sufficient for the purposes of taking root, is to be reckoned too short in order to be able to determine significant effects on the growth of trees planted more deeply; this in consideration of the fact that in spring there is usually sufficient rainfall, so that also less deeply planted trees rarely suffer from drought.

There have been various confirmations in this sense during the summer when during the driest periods suffering from drought was observed in all trees, including those planted at a depth of 3 m, so much so that it was necessary to intervene on all the field subject to the test with measure of irrigation assistance. But for the purposes of growth this intervention too was merely a palliative because in such pedological conditions it is only by means of irrigation for regulating the water-table that one can constantly maintain the surface of the water at levels accessible to the roots and influence the growth of the trees in any decisive way, as happens in the Po Delta, which is the classic zone of deep planting.

- clone.

While the clone LUX, the 35/64 and the PE 4/68 showed reaction analogous to that of the 214, other clones, in particular the MC, the 3B and the 92/40 proved to be more sensitive to deep planting.

growth in relation to the nature of the soil

Even without making a very accurate analysis, it appears evident that the growth of trees depends greatly on the composition of the soil and of all the other characteristics which it determines therein (structure, porosity, water capacity, etc.). It results that in a soil of sandy texture and with

skeleton, as compared with another of sand loam texture, productivity is certainly inferior.

3. SHORT ROTATION COPPICE

3.1 Annual rotation

The test was carried out at Casale Monferrato in a plantation of the clone 'I-214' by means of the planting of cuttings (20 cm long), with a spacing of 1.30 m x 0.20 m.

The soil of the area involved proved sandy, of sub alkaline reaction, with not particularly large amounts of total limestone or nutritive elements and poor in organic matter.

Every year cultural cares consisting in 2 or 3 harrowings, 3 or 4 operations of irrigation and maintenance fertilizing.

Coppicing was carried out every year between the end of February and the first days of March 'at stump level', that is, close to the ground.

Data collected concerned diameter and height of the shoots, mortality rate of the stumps and mass obtained. The percentage of wood and of bark on separate samples was also calculated.

These data are reported in tab. 9.

The shoots were of average height and diameter of respectively 2.50-3.00 m and of 1.40-1.76 cm and of a bark percentage of about 28-30%.

Wood mass, which was of 180 q/ha fresh weight in the first cycle, increased progressively and to a considerable extent in successive rotations, touching a ceiling of 328 q/ha at the fourth coppicing and then falling off until it returned to the levels of the first coppicing at the ninth or tenth rotation.

Mortality rate of the stumps increased progressively until it reached a point of 84% of the original number of stumps by the end of the tenth year. This is a rather high value which may be partly attributed to the very dense spacing and frequency of coppicing. In spite of this, productivity is maintained at quite high values.

TABLE 9. - PRODUCTION IN q (= 100 Kg) PER HECTARE OF A STAND OF POPLAR ('I-214') COPPICE IN AN ANNUAL ROTATION

Parameters	Year of plantation 1969	Annual rotation								
		1970	1971	1972	1973	1974	1975	1976	1977	1978
Fresh weight (q/ha)	180.07	257.96	297.48	327.85	245.18	230.80	287.63	216.32	182.37	172.81
Wood %	68.82	70.68	73.25	71.97	71.00	70.00	71.00	70.00	69.00	68.00
Bark %	31.18	29.36	28.75	28.03	29.00	30.00	29.00	30.00	31.00	32.00
Height (mean in m)	2.54	2.91	3.22	2.99	2.65	-	-	-	-	-
Diameter (mean in cm)	1.39	1.56	1.76	1.54	1.45	-	-	-	-	-
Tree stump per m^2	5.18	4.44	3.70	3.15	2.59	2.22	1.48	1.20	0.93	0.82
Mortality in each year (%)	-	14.28	16.67	14.86	17.77	14.28	33.33	18.92	22.50	11.83
Mortality in respect to the initial number of the stumps (%)	-	14.30	28.60	39.25	50.05	57.19	71.46	76.79	82.14	84.11

3.2 Two-yearly rotation

A comparative plantation was carried out with cuttings (30 cm long) of 25 clones some of which are already inscribed in the National Register of Clones (I-214, BL, PAN, TRIPLO, CAPPA BIGLIONA, BRANAGESI) and others still in experiment. Several of these latter were selected by the 'Centro di Sperimentazione Agricola e Forestale di Roma' (E.N.C.C.). As these are clones selected for classic poplar cultivation, the aim of the test is that of sampling - apart from production capacity in coppiced plantations - in particular the faculty of producing shoots, stump mortality rate, etc.

The cuttings were planted at a distance of 50 cm one from the other in rows distanced at 200 cm, adopting an experimental design of randomized blocks with 5 repetitions.

The characteristics of the soil were analogous to those of the soil described in the preceding test. Cultural cares were reduced to a minimum: only some working of the soil.

In the first rotation, of two years, only one shoot per scion was grown while in the second, which is still in course, all the shoots which have developed from each stump are being grown. Coppicing was carried out 'at stump level'.

The observations made have regarded the rooting ability of the cuttings, the diameter of the shoots and the weight of wood mass produced in the first rotation. In the course of the second rotation observations are also being made in order to estimate shoot-producing capacity and branching of the shoots. The percentage of bark has been determined on separate samples.

The data gathered during the course of the first cycle are shown in Tab. 10.

The frequency of the shoots in the various diametric classes taken into consideration (2.50-3.0 cm; 3.0-3.8 cm; 3.8-4.6 cm; 4.6-5.1 cm; above 5.1 cm shows a considerable variability between clones, which is confirmed also by the data concerning the fresh weight of wood mass produced during the two years, considering only the trunks, which fluctuates from a minimum of 113 q/ha for the 35/64 clone (poor in rooting) to a maximum of 505 q/ha for the Bellotto clone (almost total in rooting). Taking into consideration also the branches, production increases by about 20%.

TABLE 10. - FREQUENCY DISTRIBUTION OF DIAMETERSAND FRESH WEIGHT OF THE SHOOTS OF 25 CLONES OF POPLARS

Clone	Frequency distribution of diameters of the shoots class in cm					Survival	Mean Fresh Weight Per plot	Per hectare
	2.5-3.0	3.0-3.8	3.8-4.6	4.6-5.1	>5.1	%	(Kg)	(q=100 Kg)
35/54	3	16	18	31	20	35.20	89.42a	178.84
BOCCALARI 2	37	59	53	14	-	65.20	98,92ab	197.84
PE 35/57	24	72	69	23	-	75.20	121.96abc	243.92
130/51	19	76	71	23	-	75.60	123.44abc	246.88
ECO 28	4	10	18	34	41	42.80	124.56abc	249.12
PADOVANINO	13	39	64	41	6	65.20	127.00abc	254.00
NE 222	25	66	80	23	3	78.80	132.42 bc	264.84
CARPACCIO	16	42	45	42	17	64.80	134.78 bc	269.56
BRANAGESI	64	72	56	30	-	88.80	136.04 bc	272.08
TIEPOLO	19	52	70	50	3	77.60	145.30 cd	290.60
'I-214'	7	48	58	51	12	70.40	145.50 cd	291.00
TRIPLO	19	38	68	58	6	75.60	150.56 cde	301.12
PACHER	10	38	74	46	17	74.00	156.24 cde	312.48
ALTICHIERO	11	46	69	59	9	77.60	158.12 cde	316.24
CAPPA BIGLIONA	13	39	115	45	-	84.80	159.30 cde	318.60
PAN	27	47	88	46	7	86.00	161.50 cde	323.00
BL COSTANZO	22	57	87	52	3	88.40	163.80 cdef	327.60
6/67	6	12	29	59	54	64.00	183.32 defg	366.64
VENEZIANO	7	22	62	70	34	78.00	192.44 efgh	384.88
GUARDI	9	31	56	74	37	82.40	202.62 fghi	405.24
PE 3/70	3	27	45	75	44	77.60	202.66 fghi	405.32
CIMA	3	34	76	72	30	86.00	208.84 ghi	417.68
GIORGIONE	6	20	51	82	54	85.20	228.90 hil	457.80
PE 458	4	24	44	74	68	85.60	239.08 il	478.16
BELLOTTO	5	20	55	100	55	94.00	252.90 l	505.80

Apart from productivity and rooting ability, also shoot-producing capacity and branching have proved extremely variable. The percentage of bark, which increases with the diminuition in diameter of trunk or branches, represents about 20% of the fresh weight.

On the basis of these first observations some clones seem much more interesting than the 'I-214' which has given disappointing results; this, however, is understandable if we bear in mind that it was selected for classic poplar cultivation. This confirms that clones for coppicing, carried out with different criteria and reducing cultural cares to a minimum, must be specially selected. In the next years research will be widened, introducing above all such specially selected clones.

3.3 3-6 yearly rotation

Here are briefly illustrated the results obtained (Tab. 11) in five 'I-214' clone plantations, established with the aim of producing material for chipboard and paper industries in areas distributed in Northern Italy (Casale Monferrato) and in Central Italy (Bagni di Tivoli in the province of Rome) and Spello (in the province of Perugia).

Two plantations, the first with a spacing of 3 x 2 m and the second of 2 x 2 m, were created at Casale Monferrato, in the farm 'Mezzi' of the "Istituto di Sperimentazione per la Pioppicoltura", utilizing 2-year-old nursery poplars. Installation was carried out in sandy soil, of subalkaline reaction, averagely rich in nutritive elements and poor in organic matter. Cultural cares consisted of two or three workings of the soil yearly, operations of irrigation assistance and maintenance fertilization.

In the 3 x 2 m plantation the first coppicing was carried out at the end of the fourth year and yielded a wood mass of 130 m^3/ha, equal to an average annual increase of 32-50 m^3/ha. The second coppicing was carried out after 6 years and yielded a wood mass of 223 m^3/ha with only one shoot per stump and of 217 m^3/ha with two, equal respectively to an average annual increase of 37.17 and 36.16 m^3/ha.

TABLE 11. – PRODUCTION OF THE POPLAR clone 'I-214' IN VARIOUS COPPICED STANDS WITH 3-6 YEARS ROTATION

Characteristics	Casale Monferrato Trial 1 3 x 2	Casale Monferrato Trial 2 2 x 2	Bagni di T. Trial 3 1 x 1.50	Spello Trial 4 3 x 2		Spello Trial 5 3 x 1
Type of propagation material	2-year old saplings		Cattings	2-year old saplings		Cattings
1st Coppicing						
Rotation in years	4	1	3	3		4
Wood production (m^3/ha)	130.50	–	63.00	39.90		52.40
Mean increment (m^3/ha/year)	32.50	–	21.00	13.30		13.10
Density (Kg/dm^3)	0.27		–	0.307		–
Survival (%)	88.23	90.00	–	94.00		88.80
2nd Coppicing						
Rotation in years	6	3	5	3	5	5
Wood production (m^3/ha)						
1 shoot per stump	223.00	130.00				
2 shoot per stump	217.55	–	–	–	–	–
>2 shoot per stump			178.00	60.75	126.50	118.50
Mean increment (m^3/ha/year)						
1 shoot per stump	37.16	43.33				
2 shoot per stump	36.26	–	–	–	–	–
> 2 shoot per stump			35.60	20.25	25.30	23.70
Mortality of the stump (%)	20.0	10.0	7.25	–	13.78	7.31
3rd Coppicing						
rotation in years	–	–	–	5	3	–
Wood production (m^3/ha)	–	–	–	129.50	26.40	–
Mean increment (m^3/ha/year)	–	–	–	25.90	8.80	–

In the 2 x 2 m plantation, the first coppicing was carried out, for unforeseen motives, immediately after one year and the wood mass has not been held in account as it was, naturally, extremely small. The second coppicing was carried out after three years and yielded a wood mass of 130 m^3/ha, equal to an average annual increase of 43.33 m^3/ha.

At Bagni di Tivoli (Cf. Giordano E., 1974), in the farm 'Cesurni' in the zone of Golena, direct installation with 40 cm cattings at a distance of 1 x 0.50 m was carried out. Subsequently the trees were thinned out and the average distance increased to 1 x 1.25 m. The first coppicing, for the production of material for panelling, was carried out the third year and yielded an average annual increase of 21 m^3/ha.

The second coppicing was carried out, for the production of material for paper, after 5 years and the average annual increase proved to be of 35.60 m^3/ha.

At Spello (Perugia), in the farm 'Feccioli', an installation was established (1968) with two-year-old poplars, set at a distance of 3 x 2 m. The first coppicing, carried out at the end of the third year (1971), yielded an average annual increase of 13.3 m^3/ha. The second coppicing was carried out on one part of the plantation after three years (1974) and on one part after five years (1976). In the first case it yielded a wood increase of 20-25 m^3/ha/year and in the second of 25-30. The third coppicing on all the plantation was carried out in 1979, that is, the first part after 5 years and the second after 3, yielding, respectively, an average annual increase of 25.90 and 8.80 m^3/ha (observations made on only 1 lot in 4).

Finally, again at Spello (Perugia), on the farm 'Feccioli', a plantation was established directly with 40 cm long cuttings set at a distance of 3 x 1 m. In the first rotation, lasting 4 years, the average annual increase was of 13.10 m^3/ha and in the second, lasting 5 years, of 23.70 m^3/ha.

From these data taken as a whole, we note that productivity always proves higher in the second turn as compared with the first and, in general, in Northern as compared with Central Italy. Viceversa, the mortality rate of the stumps is higher in Northern Italy.

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