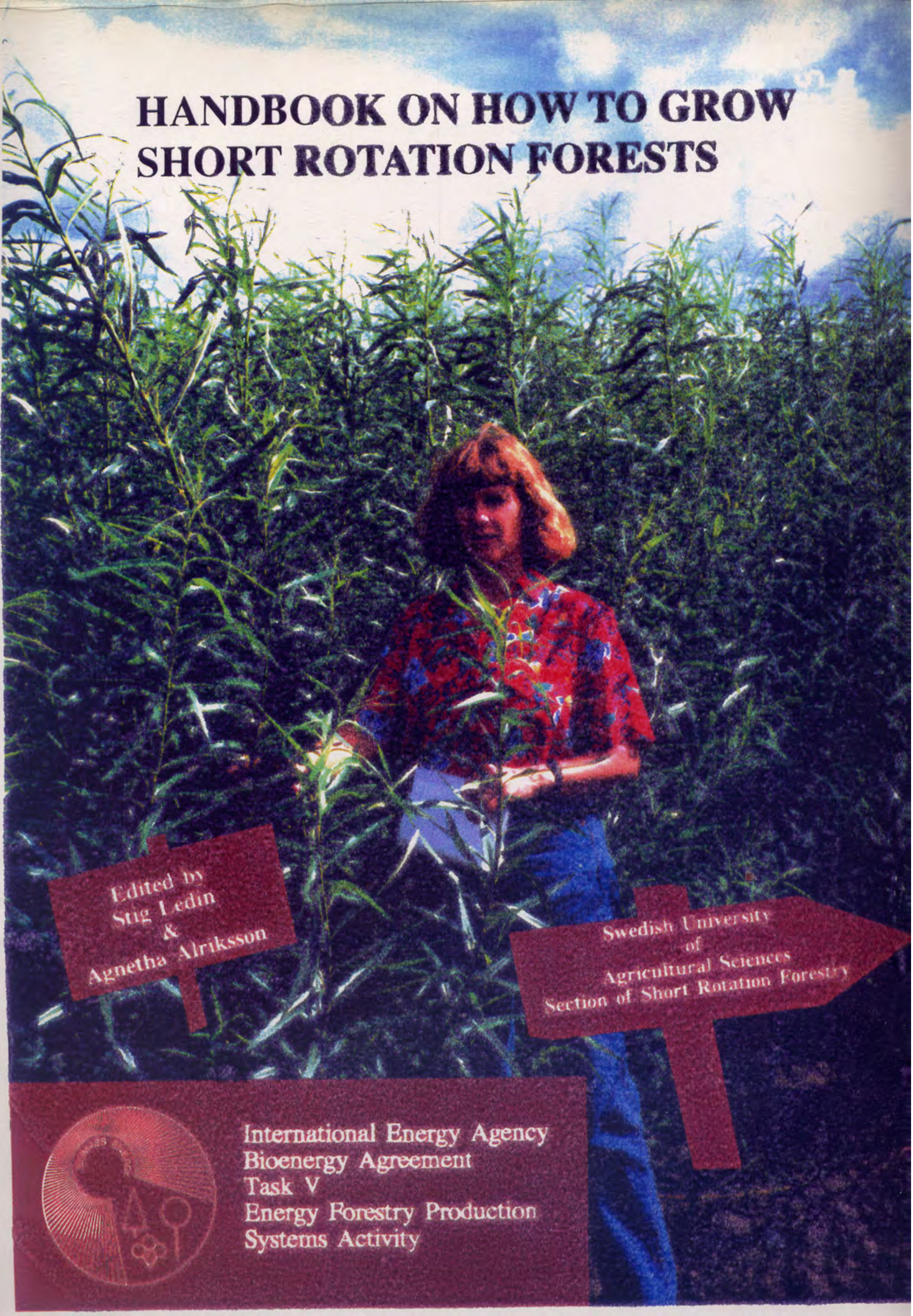
HANDBOOK ON HOW TO GROW SHORT ROTATION FORESTS



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International Energy Agency
Bioenergy Agreement
Task V
Energy Forestry Production
Systems Activity

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Contents

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FOREWORD

In April, 1978, several countries, members of International Energy Agency (IEA), decided to sign an Implementing Agreement (IA) for a programme of research, development and demonstration on forestry energy. The work was initially implemented via Programme Groups and Cooperative Projects. In 1986, a new Bioenergy Agreement (BA) was signed extending the work under the broader mandate of biomass energy. Research and development was organized into Tasks and Activities. Additional countries joined the agreement, for a total of 15 countries.

Biomass growth and production technology in short rotation forestry has been an important task of IEA/BA. During the 1986/89 period a Manual on Production Technology for Short Rotation Forestry (IEA Information Report 89:1) was produced and published by the activity concerned with this topic. Some of the results of the follow-up 1989/92 activity on production systems in Energy Forestry are in this **Handbook on How to Grow Short Rotation Forests.**

This publication is one in a series reporting on activities of Task V. Support for Task V was provided by the governments of Austria, Belgium, Canada, Denmark, Finland, Italy, Norway, Sweden, United Kingdom, United States of America and the Commission of the European Communities.

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PLANTING STOCK SELECTION

Giuseppe Frison

Cuttings of variable lengths, one-year-old and two-year-old plants are the type of planting stock commonly used in Italy for SRIC forestry.

A test carried out in Pomposa (FE) (FRISON, 1984), on a sandy soil of low fertility with the clone I-214, adopting spacing of 2.50 x 1.60 m, showed that, at the end of the fifth year, the cuttings (approx. 50 cm long) yielded 370 q/ha, one-year-old plants 807 q/ha and the two-year-old ones 1.008 q/ha, taking into consideration both the stems and the branches topped at a diameter of 4 cm. Production expressed in biomass is approx. 3.5, 7.5 and 9 ODT/ha/year for cuttings, one-year-old plants and two-year-old plants respectively.

On the basis of the practical experience acquired so far, we can state that in fertile soils the production differences among the three types of planting stock material tend to decrease; however, one-year-old plants are always better than cuttings, owing to the fact that the short cycle does not allow the smaller starting stock to recover, unless making rotation longer. On the contrary, the productive differences between one-year-old and two-year-old plants drastically decrease and often disappear.

There is no doubt that, for technical reasons, SRIC plantations request the use of cuttings, but for plantations having a density ranging from 1.000 to 2.500 plants per ha, it is often better to use one-year-old plants or, in alternative, unrooted shoots of the same age from coppice nursery. With this type of material, in addition to a higher production, an easier weed control is also achieved.

The two-year-old plants are decidedly less suitable for this kind of plantation, especially in view of their high production costs and of the considerable planting expenses.

The care needed for production, preparation and preservation of unrooted cuttings and of plants (or shoots) is the same to be devoted to the material for nurseries and conventional poplar plantations respectively.

The subject of this chapter is the cultivation of a special nursery, in Italian "barbatellaio", for the rearing of one-year-old stems to be used for the production of cuttings. With the cuttings obtained it is possible to establish biomass plantations, but they are essentially used for the establishment of nurseries.

HOW TO GROW CUTTINGS

Giuseppe Frison

The soil preparation should start by ploughing 40-50 cm deep when the soil has a stable crumb structure, preferably in summer, in order to allow both the elimination of weeds and the physico-chemical transformation of the soil.

When cuttings are being planted, the soil should be disk harrowed to prepare a good planting-bed.

The selection of cuttings should be done carefully, as the aim is the production of good propagation material.

The cuttings diameter varies according to the clone and usually between 10 and 30 mm. For *P. deltoides* the minimum is 15 mm as the pith is very thick.

A good criterion is to obtain cuttings that do not bend easily during the insertion into the soil. It is important to keep a dormant bud in good conditions near the upper cut of the cutting.

The planting of cuttings is carried out with best results using a machine built some years ago. The cutting is wholly inserted into the soil, thus sticking perfectly to it. Only in small farms and in case of limited quantities the cuttings are planted by hand.

The density in a nursery for cuttings production is about 70.000 plants per ha using single or double rows. The spacing used is 1.30 x 0.10 m for a single row and (2.20+0.40):2 x 0.10 m for double rows, equal in both cases to 76.920 plants per ha. Normal production is about 5 or 6 cuttings per stem, that is 350.000-400.000 cuttings per ha, or even 500.000 cuttings per ha in the best situations.

The choice of spacing depends on the dimensions of available machinery: single rows for small tractors and double rows for big ones.

The nutrition level of the one-year-old plants from which the cuttings will be obtained plays a leading role. Therefore, these plants should be cultivated in a deep soil with a sandy texture and a pH in the range of 6.5 to 7.5, rich in nitrogen, phosphorus and potassium. A good manuring will also be useful and it should be done directly for the culture of poplar or, even better, for the crop which preceeds it, for the positive influence of the organic matter on the physical caracteristics of the soil.

The mineral nutrition of these plants has been studied. The absorption rhythm during the vegetative season and the entity of mineral removal at the end of the annual cycle have been considered. Relatively more nutrients are absorbed in early growing season. It has been pointed out that at the beginning of August at a biomass production equivalent to the 45 per cent of the annual total production, the nitrogen absorption had already reached 72 per cent, that of phoshorus 66 per cent and that of potassium 85 per cent of the total amount. Nitrogen, phosphorus and potassium are absorbed early due to a particularly intense utilization of these elements by the young plants.

The quantity of nutritive substances taken from the soil is fairly high and is roughly like that of a wheat culture.

If we adjust the maintenance fertilization to removals, the quantities of fertilizing units to provide (taking also into account the washing away and immobilization phenomena of the elements) should be about 100 kg/ha of P_2O_5, K_2O and N. The nitrogen quantity could seem unsufficient but its limitation is aimed at favouring a better C/N ration in the tissues: this should not be too low because of the high concentration of N2; otherwise, it would negatively affect lignification. After coppicing, as the production of dry matter is increasing, the quantity of fertilizing elements to give should increase by 20-25 per cent.

Young plants in stool-bed need continuous cares. Weed control, fertilization, irrigation and pesticide treatments are very important.

Weed control is done both using chemical products and conventional cultivating equipments such as clod breakers and rotary tillers.

Chemical weed control is done in pre-emergency using products based on trifluralin + linuron (Nemifest or Trinulan) with doses of 0.8 + 0.4 kg of p.a./ha added to other products based on alachlor (Lasso) or metalachlor (Dual) with doses of 1.4 or 1.0 kg of p.a./ha respectively (e.g. 3.5 kg of Trinulan + 4.0 kg of Lasso per hectar or 3.5 kg of Trinulan + 2.5 kg of Dual per hectar of surface actually treated).

Once the herbicides effect is over, about one month later, the weeds growing along the rows are removed through hoeing and the weeds growing between the rows through mechanical work of the soil; that means frequent diskings, or tillages in the soft soils, two or three times during the vegetative season, depending on the infestation degree.

Insects controlled are the Gypsonoma, the Dusky Clearwing Moth (*Parenthrene tabaniformis*) and the Poplar Weevil (*Cryptorhynchus lapathi*); as concerns diseases, only *Marssonina brunnea* for the sensible clones. For treatments instructions see the specific chapter.

The top dressed fertilization is done by applying the nitrogenous fertilizer (ammonic sulphate, ammonium nitrate or urea) in the total quantity indicated (100 kg/ha of N) at two different times: the first time the fertilizer is spread beside the row (when the little stems are 30-40 cm high) and the second time on the whole surface (when they are about 1 m high).

The water quantity equivalent to the dry matter produced during the vegetative season (from April to September) varies from 500 to 600 mm. For example, as in the Po valley the average rainfall is 300 mm, irrigations should provide at least 200 mm, distributing them regularly during the vegetative season according to needs. Sprinkler irrigation and flooding are the methods used.

The stool-bed produces shoots of uniform dimensions, with no or few sylleptic branches, suitable for the production of cuttings with good sprouting and rooting abilities.

It is advisable to re-establish the stool-bed every year in order to obtain shoots with uniform development, with many dormant buds, healthy and in good physiological conditions.

Coppicing and the following growth of shoots from the stump can be done for some years only for the clones producing a stem with no or few sylleptic branches. Generally speaking, clones of *P. deltoides* produce many sylleptic branches, while some *P.* x *euramericana* clones produce only a few.

After leaf fall, the harvesting of shoots or branches can take place. However, it should not be done too early, unless a cool room, or any other well protected room is available where the material can be stored for several months. Actually, a decrease of the rooting ability and the survival percentage of the cuttings obtained from the material collected in December and then stored in open air has been observed.

The collection of whips in the stool-bed proceeds mechanically. They are cut with a circular blade at 5 cm from the soil level. After removing the dominant and the super-dominant (diameter at 50 cm from the soil less than 1 cm or more than 4 cm respectively) whips are roughly classified according to the height and then put together in bundles for the transportation to the farm. There they can be immediately reduced to cuttings or stored awaiting this operation.

The optimal mean diameter of cuttings is 18-20 mm but cuttings with a diameter of 15-17 mm are frequently prepared with good results, as well as 21-23 mm thick ones. Cuttings having these measures can be planted by machine. Cuttings with a diameter below 15 mm (and down to 10 mm) or above 23 mm, are used with good results but they should be planted by hand. The cuttings dimensions are not completely independent from the clone and from the techniques used in the production of planting stock material. As it will be explained afterwards, *P. nigra* clones supply fairly thin whips; while *P. deltoides* clones very big ones, particularly if coppiced. With our machine it is possible to plant cuttings up to a maximum of 25 cm.

The cutting can be cut by hand scissors or pneumatic or hydraulic scissors, or, as at the S.A.F. farms or in big nurseries, with a specific machine. Cuttings should be prepared with a clean cut and therefore the tools should always be very sharp. The top cut should be done preferably 1-2 cm above a dormant bud in good conditions and should be horizontal; the cut on the bottom should be a slanting one in order to make the insertion into the soil easier.

The preparation of cuttings usually begins at the end of February and planting in March. Cuttings can be cut and then immediately planted: however, it is often advisable to separate the two operations. In order to benefit at the same time the good soil preparation effects and the choice of the right moment for plantation, the practical solution is to store them in a cool room between -2 and +2°C. The cuttings can be stored also at +4°, but just until the end of March. Cuttings of the clone ERIDANO begin to sprout much earlier than those of the euramerican clones, at a temperature of about 4-5° C and so do those of the balsam poplars in general. These genotypes should be kept at lower temperatures.

It is advisable to take the material out of the cool room about one week before planting and to check the hydratation condition. Dehydrated cuttings are always unlikely to recover, particularly in case the soil in which they are being planted is not ideally humid. Immersion in water for at least one week can be a good remedy, as it would stimulate rooting. Balsamic poplars, however, are more sensible to asphyxia. Therefore, it is necessary to conveniently check the immersion in water and to avoid to let the cuttings in water for a too long time (3-4 days are sufficient).

It is usually not necessary to disinfect cuttings before planting, but each one should be checked once more while being planted.

CHOICE OF SITE AND ESTABLISHING SHORT ROTATION FORESTS

ITALY

Giuseppe Frison

SITE SELECTION AND PREPARATION

To evaluate the site it is necessary to consider soil texture, depth, availability of water and nutrients and pH reaction.

For short rotation intensive culture (SRIC) it is necessary to select a deep, medium texture soil with a high fertility and a pH in the range of 5.5 to 7.5. The soil should be well drained and have good water reserves (water table accessible to roots) or be easy to irrigate during the growing season.

Cultivated land and bottom land are suitable, while easy flooded lands are to be avoided because of the damage water could cause to the culture the first year after planting or coppicing.

Cultivated lands are normally cleared and reasonably well drained and for their preparation they need only to be ploughed at the end of summer or even just before planting, physical soil conditions and weather permitting.

Fertilizing should correct any possible lack of nutrients, almost always concerning nitrogen, but often also phosphorus and less frequently potassium. These last two nutrients are to be spread before ploughing, followed by disk harrowing to prevent weeds from growing again and to obtain a well-aired and finely crumbled soil, in order to improve the development of roots from cuttings or plants.

PLANTING

In the Po valley the most suitable season to plant cuttings is mid-February to March, but this period can be extended to the whole month of April if the material is stocked in cold storage at a temperature of -2 to 2°C. To plant one-year-old sets, both the period from the end of November to the end of December and that from mid-February to mid-March are suitable to plant clones with a good rooting ability, while the latter is to be preferred for clones with any rooting difficulties (e.g. *P. deltoides*).

The one-year-old plants are inserted into holes 60 to 80 cm deep and 15 to 20 cm in diameter, dug by an auger driven by a tractor.

Cuttings of normal length (20 to 25 cm) are planted by hand or with machines used to plant cuttings in nurseries while the longest ones (50 cm) are inserted into holes dug by an auger driven by a tractor.

REMOVAL OF NUTRIENTS FROM THE SOIL

On the basis of tests carried out in plantations of the clone I-214 we can state that the quantity of nutrients removed from the soil depends essentially on the percentage of bark and therefore varies according to the dimensions of the stems which, in turn, depend on the densities and rotations adopted.

For example, a tonne of leafless biomass can contain the following quantities of nutrients as presented in Table 1.

Table 1. Content of nutrients (kg/tonne DM) in leafless biomass.

Density (trees/ha)	Rotation (years)	N	P_2O_5	K_2O	CaO
75.000	1	6.9	3.1	5.2	9.0
10.000	2	5.6	2.1	4.2	7.5
277	13	1.6	0.7	2.4	5.7

We can reasonably expect that for a density of 1.000-2.500 trees per ha and rotations of 5-6 years, the quantities of nutrients removed are immediate among those given in the above tables for densities of 10.000 and 277 trees per ha. This means that for these plantations a tonne of woody biomass (oven dry) should contain approx. 3.5 kg of nitrogen, 1.5 kg of P_2O_5 , 3.5 kg of K_2O and 6.5 kg of CaO.

These data can be of help for an approximate definition of the maintenance fertilization needed by SRIC plantations. Obviously, it is necessary to verify them because the quantities of nutrients removed from the soil can vary as a function of soil fertility and of clone requirements.

Considering a yield of 20 DM/ha/yr of leafless biomass, it could be assumed that the needs in nutrients are fairly small.

Apart from the basic fertilization before planting, a maintenance fertilization is useful to return to the soil the elements contained in the biomass removed. This can be carried out once a year or every two years spreading about 50 to 60 kg/ha/yr of N, P_2O_5 and K_2O. Soils with a low nitrogen percentage can be spread with larger quantities of these elements.

IRRIGATION

As far as irrigation is concerned, in the Po valley there usually are long dry periods in July and August when, if the water table is not within root distance, it is necessary to irrigate the plantation with a total volume of about 150 mm water distributed two or three times. How to distribute water will obviously depend on the site, on the available equipment and sources.

Irrigation is often an expensive operation, particularly if we consider that the wood material produced has a small economic value. Unfortunately in Italy there are few pieces of land which could be cultivated with poplars without irrigation and this represents a limit to the expansion of biomass plantations.

SPACING

Comparisons made on poplar plantations of clone I-214 (PREVOSTO, 1974), with decreasing densities from 10.000 plants per ha (1.60 x 0.60 m spacing) to 4.500 (1.50 x 1.50 m), 2.500 (2 x 2 m), 1.600 (3 x 2 m), 1.100 (3 x 3 m), 830 (4 x 3 m), 550 (6 x 3 m), 410 (6 x 4) and, finally, to 330 plants per ha (6 x 5 m), showed that the yearly usable wood mass produced decreases when spacing is increased but, at the same time, the percentages of utilizable wood mass in the most valued assortments increases.

The results of a series of spacing tests carried out in plantations where cuttings were set at 18 increasing distances, on divergent rows, following the Nelder scheme, represent a proof of the above as regards the yields. The available area for each tree ranged from 0.807 to 30.75 sqm. With a six-year rotation the production, including stem and branches topped at 4 cm diameter, sharply decreased when density was reduced. With a density of 6.500 trees per ha production totalled 19.65 kg/sqm, equal to 196.5 t/ha, and lowered to 12.7 kg/sqm, equal to 127 t/ha, with a density of 2.770 trees per ha. Production expressed in biomass is of approx. 14.5 and 9.5 DM/ha/yr respectively.

It is interesting to note that production changes moderately from the density of 2.770 trees per ha (3.61 sqm/tree) to the density of 1.176 trees per ha (8.50 sqm/tree). This result is quite important from the practical point of view as it allows to operate in a sufficiently wide spacing range. For example, the density of 2.770 trees per ha can be obtained with 3 x 1.20 m spacing and that of 1.176 tree/ha with 3 x 2.80 m spacing. It is not by chance the choice of 3 m spacing within the rows, which allows, among other things, to employ the most common cultivating machinery. The possibility of changing the spacing within the rows from 1.20 to 2.80 m without significant production losses, allows to use clones with different requirements or to achieve production of logs with various diameters, increasing when spacing becomes greater. In fact, going from the first to the second distance the mean diameter per tree at breast height, six years after plantation, ranges, on average, from approx. 10 to approx. 15 cm, with an increase from 20 to 70 per cent of wood suitable for the paper industry.

In the conditions of the Po valley, with this density the first rotation lasts 5-6 years as well as the following ones realized with coppicing also do.

After coppicing it is necessary to remove all the coppice shoots except one kept for the development of the stem. The trimming should be made before the second vegetative season after coppicing.

Two coppice shoots can be left instead of one, but the dimensions they will reach during the rotation will be proportionally smaller. The choice of leaving one or two coppice shoots depends on how the material is used.

TENDING OF SHORT ROTATION FORESTS

ITALY

Giuseppe Frison

WEED CONTROL

Weed control is very important. It includes herbicides and mechanical cultivation practices with conventional cultivating equipment.

As to coppice with 5 or 6 years rotations, the moments in which weed control is most required are the first and the second year after planting and/or after coppicing. The years after, a thicker canopy can shade out any serious competition from weeds.

Herbicides are used in pre-emergency, right after planting cuttings or after coppicing but before flushing. Good results are obtained with products made of trifularin + linuron (0.8 + 0.4 kg/ha) in most soft soils or pendimethalin + linuron in more compacted soils against dicotyledons, adding other products made of alachlor (1.4 kg/ha) or metolachlor (1 kg/ha) against graminaceous plants. The herbicide is usually active 30 to 40 days. Afterwards, only methods for mechanical weed control are used.

In one-year old plantations only a small area around the tree is treated. Where a normal harrow can not manage, chemical treatments are done with good results, that is:

1 annual weeds are treated with products made of paraquat (0.9 - 1 kg) or diquat (1-1.2 kg/ha) mixed with other products made of trifluralin + linuron or pendimethalin + linuron in the dosis already mentioned;

2 in case of perennial and mixed species a first treatment is done using paraquat when weeds are growing and a second treatment containing:

- 2.4 d in little volatile formulae (0.15 kg/hl) mixed with white oil in those soils where there are mainly wide-leaved weeds maybe adding clopyralid (0.005 kg/hl) if there is any Cirsium;

- dalapon + oxyfluorfen (0.65 0 0.21 kg/hl) in case of perennial graminaceous plants;

- glyfosate (0.25 - 0.4 kg/hl) for an almost total and rather long lasting cleaning, particularly with largely diffused Artemisia, Solidago or any other weeds which are hard to control if the other herbicides are used;

3 in case of infesting bushes (Rubus, Amorpha, Robinia, Clematis, etc) a suspension of fosamine ammonium (0.48 kg/hl) can be sprayed at the end of August.

As a precaution it is recommended to avoid any contact of the sprayed treatment with the green parts of the plant, particularly when hormon products are being used.

To destroy weeds between the rows, disk harrows are used two or three times during the growing season according to the extent of the infestation and of the ability of weeds to recover.

Chemical weeding should be limited to the first two years and to a narrow stripe along the row, while mechanical weeding should be extended to all years and to all areas between rows.

During the second half of the first rotation and particularly during the rotations following coppicing, it would be useful to compare the usual harrowing with mowing, a much simpler operation. A thick layer of leaves and other vegetable material on the ground should make it harder for weeds to sprout, thus contributing to reduce the problem of weed control.

It is important to make sure that the above mentioned herbicides are suitable for the newly selected clones and to find out new chemical products in order to widen the range of products suitable for weed control in short rotation intensive culture.

PLANT MATERIAL FOR SHORT ROTATION FORESTRY

ITALY

Stefano Bisoffi

BACKGROUND

Poplar culture in Italy is intensive and rotations are short compared with other countries. Therefore many of the characteristics that make a clone suitable for wide spaced commercial plantations are the same that are sought after for very short rotation forestry oriented at the production of high quantities of biomass usually without strict requirements as far as quality is concerned.

As a consequence, breeding and selection for conventional culture can, to a large extent share the same goals as for biomass production. However, there are some remarkable differences.

Stem form, which is a point of major concern when selecting clones that should be suitable for veneer peeling, has a very limited importance if the wood will be reduced to chips. A monocormic habit is important in both situation. Good resprouting ability and the natural tendency to have only one shoot taking the lead after coppicing have no importance whatsoever in conventional culture, where stumps are extracted from the ground before replanting, but is a positive characteristic for biomass plantations.

Fast juvenile growth is certainly required in both cases, although in narrow-spaced plantations for biomass, its importance is taken to the extreme.

As far as resistance to diseases is concerned, the goal of clonal selection largely coincides in the two situations. Leaf diseases such as *Marssonina brunnea* (Ell. et Ev.) P. Magn., *Venturia populina* (Vuill.) Fabr. and *Melampsorae spp.* can severely reduce production and can open the road to weakness parasites such as the bark disease *Dothichiza populea* Sacc. et Br. One should also bear in mind that the micro-climate of a narrow-spaced plantation certainly favours the propagation of leaf diseases. Practical resistance, that is no need for chemical protection even if economically and technically feasible, is an absolute necessity.

Poplar Mosaic Virus (PMV) is also more dangerous in biomass plantations than in conventional culture. Diffusion of the disease is most likely carried out in part by infected cutting devices and coppicing would spread it. As a consequence of above, breeding and clonal selection for biomass have been and will most certainly continue to be minor branches of the main line of research dedicated to conventional culture.

Some very interesting results come from progeny trials recently performed with hybrid (*P. deltoides* Bartr. x *P. nigra* L.) families:

- additive components of genetic variances are much larger than non additive ones; that means that breeding strategies exploiting general combining ability are needed;

- resistance to *M. brunnea* depends more on the *P. nigra* than the *P. deltoides* parent, whereas growth-related traits are mainly under the influence of this species;

- the interaction between genetic components and the environment is negligible: no need to have separate breeding programmes for different ecological zones;

- much is to be expected from breeding for resistance to *M. brunnea* (and possibly to other leaf diseases); better results will be obtained by clonal selection for growth traits.

The choice of a clone within those already available is still a matter of research. Only sixty clones have been tested in narrow-spaced stands. About twenty of them displayed a yielding ability which was significantly higher than I-214, used as a control in all the trials. They are LUISA-AVANZO, CIMA, GUARDI, BELLOTTO, FLEVO, SAN-MARTINO, BL-COSTANZO, PAN, NE-222, PI70-001 (all *P.x euramericana* (Dode) Guinier), FIEROLO, LUX, DVINA, NL-1454 (=PE68-004), PE70-003, 2-KEN-8, S7C2, 14-9, 6-67 (*P. deltoides*) and the Belgian interamerican clone 69.042/2.

Some of the above-mentioned clones, however should be excluded from commercial SRIC plantations due to sanitary problems. For example, CIMA is very susceptible to leaf rusts (LUISA-AVANZO is now susceptible to the new race E3 of *Melampsora allii-populina* Kleb.); BL-COSTANZO and PAN can be severely damaged by *M. brunnea*, *Melampsorae spp.* and *Phloeomyzus passerinii* Sign. LUISA-AVANZO and BELLOTTO are very susceptible to water stress which probably favours attacks by *D. populea* and is probably the cause of a physiopathological phenomenon commonly called 'brown bark spots'.

Clones of *P. deltoides* are generally resistant to leaf diseases other than PMV and to bark diseases. However, a generally poorer rooting ability with respect to euramericans discourages attempts to establish stands by means of cuttings (as would be expected in SRIC plantations).

The interamerican clone 69.042/2 is practically resistant to all relevant diseases and has a very high growth rate in the first rotation; however, after coppicing, it displays a singular plagiotropic habit which would prevent any mechanical operation in a stand.

Even though early results are only moderately encouraging, there is certainly a very high potential for selection in the tens of thousands of new genotypes that annually enter the selection flow. Several clones, which have never been tested in SRIC plantations but display a very high growth rate in the nursery (two years from cutting with 1 m^2/plant) and good resistance to diseases. Among them some euramerican clones (CERVO, ORBA, PANARO, 80-084), some *P.deltoides* (S7C8, 1-13-13-2), some even *P. nigra* (BRISIGHELLA, N369). They could be probably available for large scale trials in a near future.

Some clones of *P. alba* L. have also showed very encouraging early results: they seem to be well suited to the drier environments of southern Italy.

Willow too is a dark horse. Various clones of *Salix* have been already selected for their rapid growth and excellent rooting and sprouting ability. At present their limit is represented by a rather high susceptibility to active lime in the soil (a very common occurrence in Italy), worsening after coppicing. However the effort put in willow breeding has been negligible as compared to poplars and a very quick progress can be expected in the next few years.

PESTS, DISEASES AND OTHER INJURIES IN SHORT ROTATION FORESTRY

ITALY

Achille Giorcelli, Gianni Allegro

ENTOMOLOGICAL AND PATHOLOGICAL RISKS

Productivity of plantations for biomass production can be affected in a remarkable measure by several biotic adversities. Their harmful effect is strictly connected to the peculiar characteristics of cultivation and to the microclimatic conditions of plantations, as well as to the destination of the wood material produced.

High density of plantations and the resulting humid microclimate are favourable to parasites proliferation, such as the Woolly Poplar Aphid (*Phloeomyzus passerinii*) and the scales (*Diaspis pentagona*, *Chionaspis salicis*, *Quadraspidiotus* spp.), which are able to compromise the vitality of cortical tissues and therefore the survival of young shoots. Humid environment is also suitable to defoliators such as *Phyllodecta vitellinae* and to foliar fungi such as *Melampsora* spp., the attacks of which will result in important production losses.

Coppicing allows the establishment on stumps of a great population of harmful bark and wood boring insects among which the most important ones are the European Goat Moth (*Cossus cossus*) and Poplar Clearwing Borer (*Paranthrene tabaniformis*), that are attracted by the healing tissues and cause a remarkable weakening of the tree, the Large Poplar Borer (*Saperda carcharias*), that causes a similar damage, and the Poplar and Willow Borer (*Cryptorhynchus lapathi*), that is to be considered the most fearful one for the gravity of damages on young stems. The delicate shoots developping after coppicing are moreover the favourite food by *Melasoma populi*, the defoliations of which can be important enough in consideration of the delicate vegetative phase of the tree.

If the culture is aimed at the production of material of adequate dimensions to be used in the paper industry, also the Poplar Shoot Borer (*Gypsonoma aceriana*), which is constantly present at high population levels, can cause appreciable damages, preventing development of the leader where a bitches broom, formed by smaller twigs, will take its place.

Finally, there are various parasites able to damage the poplar independently from the final use of the crop. Among these we can mention the bark and wood boring insects *Agrilus suvorovi populneus* and *Melanophila picta*, frequently found on trees suffering from water stress, and the defoliators *Hyphantria cunea* and *Byctiscus* spp. Also *Marssonina brunnea* and *Venturia populina* fungi, in the climate conditions of the Po valley, can cause repeated defoliations on the most sensitive clones.

Phytosanitary control in plantations for biomass production causes a number of problems (not only for economic reasons) mainly due to the culture characteristics themselves. The high density prevents an easy operation of machines and a satisfactory distribution of chemical products both on the stem and on the crown. In addition, bark and wood boring insects living in the stumps are unlikely to be reached by the insecticides and are therefore able to reinfest the crop itself as well as the adjacent poplar plantations grown as high forest, where they can seriously damage their quality.

It is advisable to control *C. lapathi* on account of its high injuriousness by a chemical spraying of the stems at the sprouting. Measures against the other parasites are economically and technically impossible; their damages can be limited by carefully choosing the planting site and by carrying out, where possible, adequate tending in order to maintain the trees in a sufficiently vigorous condition, so that they can better endure the attacks.

The use of resistant poplar species and clones can be of great help to control abiotic adversities. To this purpose, *Populus alba*, among indigenous poplars, shows a very high resistance to the Woolly Poplar Aphid and to several foliar diseases, as well as a good tolerance against bark and wood boring insects (DELPLANQUE *et al.*, 1986); among exotic species, *Populus deltoides* is generally resistant to the Aphid and to *Marssonina brunnea*. Among the hybrids, those of *P. deltoides x Populus trichocarpa* and x *Populus ciliata* give higher guaranties of resistance against *Ph. passerinii* and *M. brunnea* with respect to the hybrids *P. deltoides* x *P. nigra*, among which it is still possible to select some interesting clones.

MACHINERY FOR SHORT ROTATION FORESTRY

ITALY

Giuseppe Frison

EQUIPMENT FOR THE DRESSING OF CUTTINGS

With this machine it is possible to obtain cuttings with a slanting cut on the bottom and a clean cut on the top. The cuts are made using two opposite blades at adjustable distance. The machine works electrically and makes 27 cuts per minute. It is driven by two operators and its work capacity is 2.500 cuttings per hour.

PLANTING

A semi-automatic equipment is used for the planting of cuttings. The basic element is a track chain, with track shoes having a 10 cm pitch. The track chain can also be provided with 35 or 36 track shoes.

The track chain is made of flat track shoes and track shoes with a cylindric box containing cuttings expelled by a piston.

The track chain is stretched by the idle wheels driving the track and they are held by the machine frame.

As it is possible to vary the chain composition, the establishment distance on the row can be varied at will: 20,30,40,50,60,70 and 90 cm.

These compositions are used for nursery establishment. For the establishment of biomass plantations, once one has chosen the distance between cuttings on the row, e.g. 120 cm, only the boxes at this distance will be filled up. If the chain with boxes at a distance of 60 cm is used, it is enough to take one out of two.

The machine works as follows:

Along the track chain (1) the track shoes with a cylindric box (2), in which cuttings will be inserted, are put at fixed intervals; the operator takes the cutting from a case (4) and introduces it by hand into the upper hole (3) of the cylindric box.

The track shoe with the cylindric box (2) keeps still once in contact with the soil, restrained to the soil by the grip tooth, while the tractor proceeds and drags the machine frame, causing the flowing of the expelling piston rollers on the inclined track (7). In this way the cutting is pushed downwards and is enterely inserted into the soil (8). The machines are equipped with a cutting shield (6) to hold cuttings inside the cylindric box. The equipment can be supplied with one or two tracks and two operators are necessary for each unit. The machine is dragged and lifted (5) by a tractor with a power between 50 and 100 HP. The output is about 1200 cuttings per hour per each track.

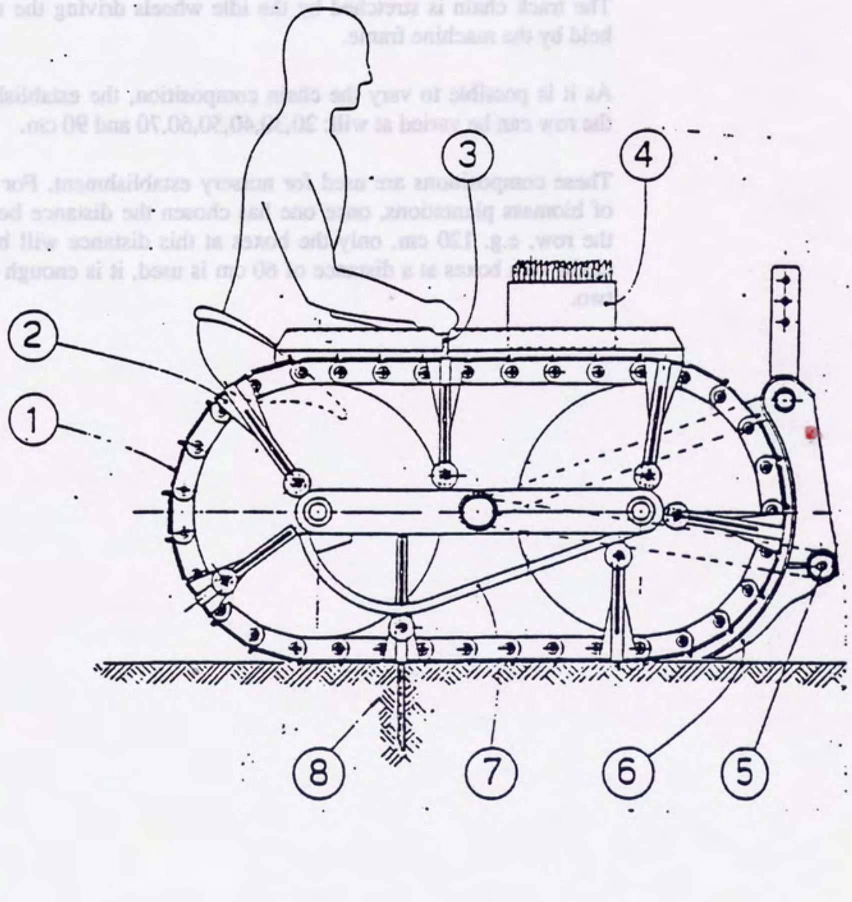

Figure 1. Semi-automatic planting machine.

ONE-YEAR-OLD PLANTS ESTABLISHMENT

One-year-old plants, or coppice shoots, with a normal heigth between 2.50 and 4.50 m, are put into holes with a diameter of 15-20 cm and 60-80 cm deep, opened with an auger driven by a tractor.

In this case the equipment is the one used for poplar plantations establishment in Italy. As it is well known, it is not necessary to describe it here.

MACHINES FOR INSECTS CONTROL

There are two main types of equipments used in poplar plantations for weed control and they are known as "dusters" and "sprayers".

Dusters

The most common duster (pression dusters with oriented jet) are made up of a tank, a liquid circuit, nozzles. The tank is provided with a filter, a level gauge, an agitator, a discharge outlet. From the tank the liquid is drained away by a pump preceeded and followed by filters compressing it in a pipe leading to the nozzles and having side branches on which it is possible to insert a pressure gauge (measuring pressure in the circuit) and a return pipe for the liquid in excess, on which a pressure regulator is installed. The suspension returning to the tanks can substitute the agitator. The most common nozzle is made up by a body on which a head is screwed on a mobile plate and by a device (small ring or spreader) causing a turbulence in the out liquid and thus producing droplets.

The pumps (with pistons, with membranes, with rollers, with gears, centrifuge, etc.) set on the dusters have an average flow between 20 and 60 l/min and the resulting pressure varies between 5 and 50 kg/cm^2.

In the dusters the antiparasitic suspension pressed by the pump flows from the nozzle and the droplets are ejected and broken up by the liquid pressure itself. It is necessary to use dusters for the control of the Poplar Weevil (*Cryptorhyncus lapathi L.*), the Large Poplar Borer (*Saperda carcharias L.*) and the Wolly Aphid (*Phloeomyzus passerinii Sign.*) and in general against parasites attacking the trunk of poplars. Dusters are used in case of limited surfaces or trees of small dimensions (1 to 3 years at most) or when localized treatments are required. In the first months in a one-year nursery, for example, from the flush, that is until plants do not reach the height of 0.8-1.2 m, it is possible to dust 4 rows at the same time using a lever 8 m wide with nozzles located at the same distance of interrows.

Sprayers

While dusters only have a liquid circuit, sprayers also have an air circuit. They are very similar to dusters but, instead of ejecting the antiparasitic droplets directly on the plant they supply air through a fan (axial, centrifuge etc) and it will transport them onto the plant. The sprayers commonly used are of two types:

1 pneumatic spraying: the nozzle, set in the point of maximum speed of the air, ejects with low pressure (0.5-5 kg/cm^2) the liquid that is then broken into small drops by the air current itself which is then causing the dispersion;

2 mechanical spraying: the pump ejects the liquid at a pressure of 15-25 kg/cm^2, providing in this way the formation of drops, while the fan air is just conveying them.

Sprayers are preferably used in case extended lands are to be treated against insects and leaves and branches diseases , both in poplar plantations (after the second or third year) and in nurseries (from the half of the first year on). They are not suited for treatments on trunks or small plants or in widely-spaced plantations because of the waste of antiparasitic suspension.

In biomass plantations these machines can be used where the plant density is high. It is therefore necessary to study possible adaptations for a better efficiency in biomass plantations.

SPRAYING EQUIPMENT FOR WEED CONTROL

After the establishment of cuttings and before their flushing the whole soil surface is treated with normal spray equipment. The work capacity is about 1/ha/h. The herbicides treatment effect lasts about one month, at most 40 days. Mechanical weed control is then made with normal disk harrows.

At the beginning of the second vegetative season and in the following ones only a land stripe beside the row is treated, using a band spraying equipment. The work capacity of these equipments is about 1.0 ha/h. After the treatment with herbicides mechanical operations are made.

MACHINES FOR THE CUTTING OF SETS IN NURSERIES AND FOR EXTIRPATION OF ONE- OR TWO-YEAR-OLD PLANTS

Stems of one- or two-year-old plants are cut with hydraulic scissors put on a oleodinamic station set on a lifter arm of the tractor with cardan joint transmission. 2 to 4 scissors can be used.

For the extirpation of one-year-old plants, row by row, a special plough is used.

MACHINE FOR THE SOIL DISKING

In the widely-spaced plantations, 3 x 3 m for example, disk harrows can be used. This machine allows the disking of the total surface, also between plants on the row and in this way a second transversal disking is not required.

MACHINES FOR STUMPS EXTRACTION

The machines used in Italy are of two types:

a) half-destroying cylinder. Once put on the stump it extracts the inner part of the stump with no earth. This part can be used by wood industries. The remaining part of the stump (roots included) is then broken into pieces and the rubbles are left on the place. The half-destroying cylinder has an internal working diameter of 350 mm, while the external breaking is done for a diameter of 1200-1300 mm.

b) auger. Once put on the center of the stump it breakes it into pieces and the rubbles are then left on the place. This machine has a working diameter from 900 mm to 1500 mm.

The technical features of the equipments are the following ones:

power absorbed:	100-110 HP
weight:	2950 kg
mean hour extraction:	70-80
mean hour breaking:	60-80

MACHINES FOR THE HARVESTING OPERATIONS

Considering densities between 1.000 and 2.500 trees per ha and the dimensions reached by trees with a 5-6 years rotation, for the felling of trees and the transportation of logs the same equipments adopted for conventional plantations are used, that is the chain saw for cutting down, buckets for the loading of logs and pitchforks for the amassing of branches.

In Italy the mechanization is not very advanced; an improvement of efficiency and a reduction of costs are therefore necessary.

ECOLOGICAL CONSIDERATIONS IN SHORT ROTATION FORESTRY

ITALY

Giuseppe Frison

Poplar plantations with high density and short rotations give high production results. After coppicing, that is in the rotations following the first one, the production often increases because the stumps have a well-developed root system. The combination of high density, e.g. 1 000 plants/ha, with regeneration via coppicing allows to obtain, in suitable sites and with rotations of 5 to 6 years, a production of 10 to 20 tonnes/ha/yr of oven-dry woody biomass.

Coppicing is carried out in order to avoid replanting (always very expensive), making profit of the resprouting ability of the stumps. Vigour and longevity of stumps are very important for the adoption of this technique.

Nevertheless, coppicing has some negative aspects, among which we can mention:

- a larger insects diffusion, such as the Poplar Weevil (*Cryptorhyncus lapathi L.*) and the Large Poplar Borer (*Saperda carcharias*) on stumps;

- onset of physiological unbalances for the greater competition among plants, which, in the conditions of the Po valley, makes them more sensible to water stresses;

- diffusion of the infection of PMV, particularly among the *Populus deltoides* clones;

- the exalting of the phenomen of iron carency in calcareous soils, particularly for the clones most sensible to this physiopathy.

In order to avoid or reduce these inconvenients it is advisable to choose the most suitable clones and soils. Very calcareous, permeable soils and soils with drainage problems should be avoided. Acid soils (pH 4-5) in which the growth of poplars is limited are not suitable either. Soil limings for correcting the acidity are very expensive and previuos experiences have shown their limited efficacy.

Also the correction of iron carency with reference to the low value of biomass yielded is too expensive.

In biomass plantations it is advisable to set up monoclonal plantations in order to increase production as it allows to obtain lots of homogeneous material as to both the size of the trees and the physical and technological characteristics of the wood produced. This aspect is very important for pulpwood industry material and is not negligible for chipboards (just think for instance of the percentage of bark, which varies according to the trunk diameter), while it is not so important for fuel wood.

Keeping a large range of species and clones is necessary to allow the establishment of a mosaic of monoclonal plantations of limited extension with the aim of reducing phytopathological risks which are always very high in the Italian environmental conditions.

ECONOMICS OF SHORT ROTATION FORESTRY

ITALY

Marco Borelli

INTRODUCTION

For the time being it is rather complex in Italy to evaluate the economic chances of a poplar culture aimed at producing material of small dimensions in short rotations. It is in fact difficult to foresee what reaction is expected from the industrial converting system against a material that would be offered to the market in a substantially different way from what has been made so far. On the basis of the most commonly adopted cultivation models, that are strictly answering the requirements of the market, the assortments destined to manufacture of pulp for paper production or chipboard can be considered as "by-products" of an activity aimed mainly at the production of timber suitable for veneer industry (BORELLI, 1989). The economic features of these materials would presumably be different in case they were placed on the market as real "products": in this case remuneration chances of poplar tree growers would probably change as a result of an activity specifically aimed at the production of small-size material.

It is obviously difficult to estimate, in absence of a similar reference system, the real importance of these aspects; however, it is worth trying to examine at least the market possibilities to absorb these products, on the basis of available data (R.E.S.S., 1984) concerning the wood consumption of industries manufacturing paper pulp and chipboard.

If we take into account only industries producing mechanical pulp, where poplar wood consumption reaches significant values, we can observe how strongly we are depending upon foreign supply: in fact, we import 204,000 tonnes out of the approx. 416,000 tonnes used. The most important reason for these industries to import timber is the unsufficient level of home production and not the price competitions and therefore we are likely to have sufficiently large chances to place suitable poplar material of internal production.

The situation of chipboard industries is completely different: in this case poplar wood, representing a little more than 50 per cent (924,000 tonnes) of the total consumption, comes almost exclusively (869,000 tonnes) from home supply. However, it is interesting to observe that round wood represents 55 per cent of this value, while the remaining quota comes, as discard of manufacture, from other converting industries. It is probably within this consumption quota that it will be possible to sell round material produced for the purpose, provided the price is competitive.

If we examine Table 1, drawn on the basis of the above mentioned research made by R.E.S.S., it is possible to observe a substantial homogeneity in the way poplar wood assortments are distributed according to classes of purchase price. The use of chips and residues could be explained by an unsufficient quantity of logs rather than by an economic convenience.

Taking the above considerations into account, we believe that there are real chances to place poplar material of low dimensions coming from SRF cultivations on the market; 500-600,000 tonnes per year could be the maximum quantity. Assuming an average production at end of rotation of approx. 150 tonnes/ha, this means, in terms of areas, that we need approx. 3,600 ha to be yearly felled and therefore, should the production planning be set in rotations of 6 years, the total area covered should be of at least 21,000 ha.

These are enormous figures for the Italian poplar cultivation reality, especially if we consider the present unfavourable conjuncture that caused, in the last ten years, a continous contraction of plantations. It is therefore evident that only a high profit of these crops can give impulse to important investments, especially with respect to competing of offer which, due to their need of irrigated soils of good fertility, would necessarily arise a competitive situation. Moreover, these conditions make it economically impractical to destine the plantations to the production of fuel wood.

It is therefore necessary to examine the cost-benefit ratio of this particular cultivation model. This is particularly complex in absence of reference points as regards not only the intensity of tending to be carried out but also the choice of the rate of interest as well as the sale price of the final product that would have to answer different expectations compared with those of a traditional offer system.

The values used in the following balance scheme (Table 2) are referred to well known situations of poplar farms in the Po Valley; therefore, the results obtained thereof have to be considered as merely indicative.

The table clearly shows that the economic results obtained with a poplar plantation destined to produce in a short period material of low dimensions are highly negative, especially because of the high planting costs. Even if these costs were drastically reduced in the successive cycles as a result of coppicing, poplar tree growers would have to support a heavy liability, difficult to be covered. The use of cuttings would certainly reduce the costs, but a similar reduction would also occur to production.

Only in the best sites, with a yield of approx. 270 tonnes/ha, will it be possible to have positive annual land revenues that can be estimated around 500,000 and 1,000,000 thousand lire per ha at the end of the first and second rotation respectively.

These economic estimates, although only indicative, do not allow to reach an optimistic conclusion on the possibilities of developping the proposed cultivation models on a large scale. In fact, against a substantially favourable expectation as regards the placing of the final product there is a reduced or even more likely a negative profitability of these productive systems; they are therefore practically unproposable in the present market situation of poplar wood. A possible overcoming of the unfavourable conjuncture that brought to a remarkable decrease of the price level, although expected for the next years, will be destined to rapidly exhaust unless the structure of the offer system and the relations between this system and the compartment of enterprises for the first converting are modified at the same time. To this purpose the establishment of inter-professional agreements between producers and users could guarantee to the former the product placing and a minimum level of sale prices; such level would have to be, on one hand, sufficiently high to guarantee an income that can be compared to that of other primary activities and, on the other hand, to the income of similar raw materials, but produced with different systems, in order to be competitive on the marketplace. For the time being, the margin separating these two values is so high to make it very hard to foresee a positive future for the development of SRF models on large areas.

Table 1. Market price of wood in Italy in 1981 by type, assortment and price class. Case frequency in census of chipboard industries.

Case Frequency	Conifers			Poplars			Other broadleaved trees			Total
Price Class	L	C	R	L	C	R	L	C	R	
Lire/tonne	n.	n.	n.	n.	n.	n.	n.	n.	n.	n.
40,000	1	1		1	-	1	2	1	-	8
40-50,000	3	-	3	9	3	6	4	1	3	32
50-60,000	5	5	9	14	10	9	5	5	3	65
60,000	-	-	3	4	3	2	2	-	1	15
Total	9	6	16	28	16	18	13	7	7	120

Table 2. Cultivation costs (in thousand lire) of one hectare of narrow-spaced poplar plantation.

LIST OF COST	YEARS 1th	2th	3th	4th	5th	6th
Site preparation	300					
Lay-out and holedigging	500					
Stock purchace (£ 2.200 each)	2,860					
Delivery and planting	800					
Mechanical weed control	270	270	270	270	270	270
Chemical weed control	70	70				
Irrigation	450	300	300	300	300	300
Pest and disease control	50	130	130			
Fertilization	150		120		120	
TOTAL	5,540	770	820	570	690	570
CAPITAL AND COMPOUND INTEREST (r = 0.07)	7,644	1,009	1,004	653	738	570

TOTAL COST:	£ 11,618,000
TOTAL PRODUCTION:	150 tonnes
AVERAGE VALUE:	50,000 £/tonne
TOTAL INCOME:	7,500,000