TECHNICAL NOTE 4/98

Forest Research
An agency of the Forestry Commission
TECHNICAL DEVELOPMENT BRANCH

NEW PLANTING OF FARM WOODLANDS: OUTPUT GUIDANCE

Summary

New planting operations were studied on a selection of agricultural sites to identify outputs and cost.

The output when planting bare root transplants, at a spacing of 2 m x 2 m on ploughed ground, was c 0.056 ha/shr at a cost of £143/ha. On weedy stubble requiring screefing, an output of 0.041 ha/shr was obtained at a cost of £195/ha.

The quality of weeding can reduce beating-up costs by >40%.

The use of a planting bag was found to improve output. This is less likely to damage trees than dragging them along the ground in a co-extruded bag.

Introduction

Technical Development Branch (TDB) holds data to assist forest managers predict output for restock planting in a woodland. However, no information was available to estimate the labour required for new planting on ex-arable or grassland.

TDB was commissioned jointly by Tilhill Economic Forestry and The Forestry Authority to provide general guidance for predicting work output for new planting schemes on farm land (Plate 1). As data were collected from a limited range of site types, this is not a comprehensive guide.

Health & Safety

The FASCO Guide 103 Planting should be followed. In particular the following protective clothing and equipment is required.

- Gloves (when planting sitka apruce or similar species).
- Non-snag outer clothing.
- Safety boots or safety wellingtons-good grip.
- Keep trees bagged for more than 3 weeks after delivery.

Plate 1

New Planting on Farm Land

- First Aid Kit (see Safety Guide No 802).
- Hand cleaning materials.
- Suitable planting tools.
- Waterproofed planting bag or container.
- Suitable file with handle.

Plant Handling

The success of any planting scheme is enhanced by careful plant handling during lifting and packing at the nursery, transportation to site and planting. Bad handling damages plants, causes losses and increases establishment costs.

Many nurseries now deliver plants in co-extruded bags, which are designed to reduce the risk of overheating.

When handling bagged plants it is important not to:

- Throw, drop or handle bags roughly.
- Stack bags upon each other.
- Sit or stand on bagged plants.

- Leave bagged plants in direct sunlight or exposed to frost.

Plants should be inspected when delivered. Insecticide dipped trees should be ventilated by loosening the bag seal.

At planting, plants should be transferred to a forest planting bag. Workers sometimes drag the opened co-extruded bag along as they work. This may add to the risk of plant damage and also increase working time and overall cost.

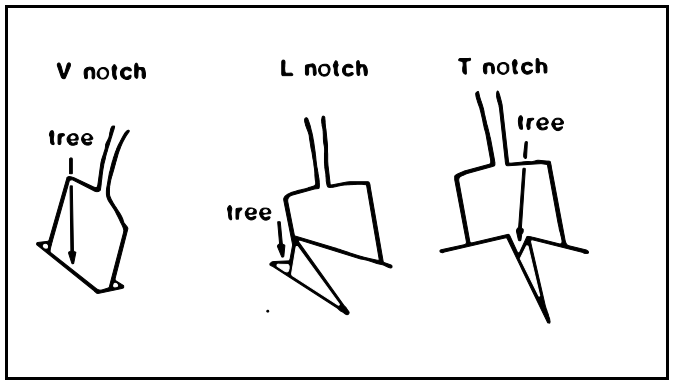
Planting Method

Planting may be by one of 3 methods, the choice being dictated by the size of the root and the soil condition:

- A Single (or 'V') notch, (Figure 1).
- A Double notch, 'L' or 'T', (Figure 1).
- Pit planting.

Figure 1

Notch Planting Methods (Dobson & Moffat 1993)



It is important that the plant roots are distributed evenly (Figure 2).

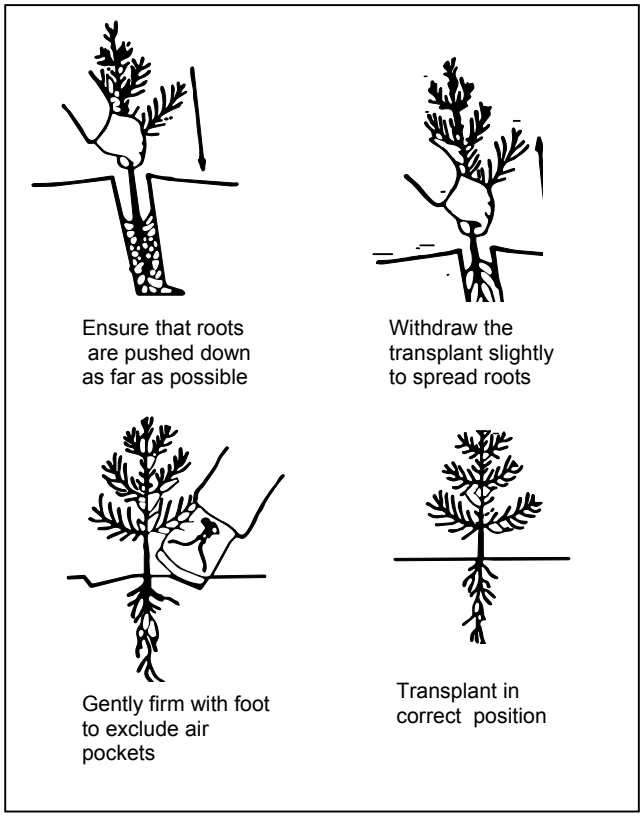
Single notch planting is acceptable on light soils for plants with small root systems.

If the soil is too heavy to open adequately with a single notch, or the roots are too big for the notch, the root system will be compressed and bent into the slit. This will affect early survival rates and future growth, form and stability and it will be more appropriate to use a double 'L' or 'T' notch.

If the root system is too big for a double notch, the plant must be pit planted.

Figure 2

Tree Insertion



The Trial and Working Methods Studied

Planting studies were collected from a limited range of agricultural site types, mostly in the Midlands and the National Forest area.

The majority of the sites were clayed brown earths on level ground. The exception was a sandy loam field.

There were 3 broad categories:

- **Ploughed arable**: Bare soft earth, wet and very sticky after rainfall.
- **Arable stubble**: Firm soil, stubble and light grass and broadleaved weed growth. Very sticky after rainfall.
- **Grassland**: Firm soil, heavy, low grass sward. One site was very stony.

Trial work concentrated on 2 working methods;

- **Single notch planting**: A single slot is made with a suitable planting spade. The spade is inserted to the required depth and rocked backwards and forwards to open a slot so that the roots can be inserted. The spade is withdrawn and the slot closed using the ball of the foot.

- **Double notch planting**: A double slot is made using a suitable planting spade. The slots can either be 'L' or 'T' shaped. The purpose of a double slot is to lift up the soil and create space to allow the roots to be distributed evenly. Once the tree has been positioned in the slot, the spade is removed and the soil is firmed with the ball of the foot.

A third method using Japanese Paper Pots (JPP) was also studied. The plants are grown in bio-degradable paper cells which remain with the plant all the way to planting. The plants are planted using a tubular tool called a Pottiputki (Plate 2). This system is ideally suited to small, slender planting stock, up to 15 cm in height. Pit planting was not studied during these trials.

Plate 2

Pottiputki Planting

Screefing may be required to:

- Mark the planting spot for a follow-up weeding.
- Remove a heavy humus layer to ensure that trees are planted to the correct depth in the soil.
- Level the planting position and bare the soil so that if a treeshelter is fitted, it can be properly sealed to the ground.

Screefing was not undertaken on all the grassland sites visited.

The planting methods varied by the manner in which the plants were carried. The use of both a forest planting bag and unsupported co-extruded bags was observed.

The plant stock used is summarised in Table 1.

Table 1

Plant Stock & Spacings Studied

Species	Plant Sizes (m)	Plant Spacing (m)
Mixed Broadleaves; Oak, Birch, Sweet Chestnut, Cherry, Sycamore, Rowan, Whitebeam.	30 - 45 60 - 90 Bare Root and Container Grown Stock	2 x 2 2.1 x 2.1 2.3 x 2.3 2.5 x 2.5 3 x 3
Corsican & Scots Pine, Serbian Spruce, Grand Fir,	15 - 20 20 - 30 Bare Root & JPP	1 x 1 2 x 2 1.7 x 2.2

The types of planting studied were:

- Intimate mixtures of broadleaves.
- Set pattern planting of oak groups in a matrix of other broadleaved species.
- Pure conifers.

The equipment used during the trials included:

- Garden spade.
- Schlich spade.
- Planting bag.
- Co-Extruded bag.
- Pottiputki Planter.
- Sighting Rods.

Two pairs of sighting rods gave the planter a line to follow. Two rods were placed c 15 m apart at the farthest end of each row so that the planter was always working towards them. As each rod was reached, the planter stopped working and moved it across 2 rows, to the next row up the field. When the top of the first row was reached and the last rod had been moved, the planter realigned to the next 2 rods at the bottom of the field. The rods used in the trials were 2 m surveying rods, marked at 50 cm intervals.

Beating-up is the replacement of dead trees in the second and third growing seasons. The planter walks the rows looking for missing or dead trees. A new tree is planted in each space without a live tree which is screefed if required. Studies were made to identify typical times for walking and searching in specified conditions.

Results

Output is quoted in hectares per Standard Hour[1] (ha/shr).

A labour charge of □8.00/shr is assumed. The cost of plants is not included.

The results of individual studies are given in Tables 2 to Table 8.

Spacing: Plant spacing has the greatest affect on output and costs irrespective of other factors. Output when planting at 2 m x 2 m is c 0.05 ha/shr compared to c. 0.12 ha/shr at a spacing of 3 m x 3 m. Where plants are spaced at 1 m x 1 m an output of c 0.01 ha/shr can be expected.

Planting Bags: The possible advantage for work output of carrying plants in a planting bag (Plate 3) instead of dragging them in a co-extruded bag is shown in Table 2.

A planting bag is ergonomically better as it reduces the amount of bending involved in planting. With the co-extruded bag, the worker has an additional bend to pick up the bag to move forward to the next planting position. It also reduces damage to the plants from the shock of being bumped along the ground

Note: FASCO Guide 103 Planting specifies the use of a waterproofed planting bag or container. Use of the co-extruded bag for carrying plants during planting is not recommended.

Table 2

Planting Bag Compared to Co-Extruded Bag

Plant Spacing (m)	Planting Method	Output (ha/shr)	Cost (□/ha)
2 x 2	Bare Root Mixed Blvds, 30 - 40 cm, in **Planting Bag**, Screefing & Double Notch on Weedy Stubble	0.041	195.12
2 x 2	Bare Root, Mixed Blvds, 30 - 40 cm, in **Co-Extruded Bag**, Screefing & Double Notch on Weedy Stubble	0.038	210.53

[1] A Standard Hour includes allowances of 18% for Rest and 23% for Other Work, such as refilling a planting bag or cleaning a spade.

Plate 3

Carrying Plants in a Planting Bag

Plant Comparison: Planting bare rooted plants compared to container grown plants is shown in Table 3.

The data collected did not show a consistent difference between planting container grown plants using a single notch method or bare rooted plants using a double notch method. In the majority of cases, a double notch planting method should be preferred to ensure good root distribution of bare rooted stock.

Table 3

Bare Rooted Stock Compared to Container Grown Planting Stock

Plant Spacing (m)	Planting Method	Output (ha/shr)	Cost (□/ha)
2 x 2 3 x 3	**Bare Root**, Mixed Blvds, 30 - 40 cm, in Planting Bag, **Double Notch**, on ploughed ground	0.056 0.122	142.86 65.57
2 x 2 3 x 3	**Cell Grown** Plants, Mixed Blvds, 30 - 40 cm, in Planting Bag, **Single Notch** on Ploughed Ground	0.05 0.13	160.00 61.54

Planting Site Comparison: Planting on agricultural ground which had been completely ploughed and harrowed compared to planting in weedy conditions requiring screefing increased work output by c 36%, saving c □53/ha (Table 4). Where screefing is necessary, output will fall as the weed mat becomes more dense and more effort is required to clear it.

The need to plough will depend upon soil conditions and the presence or absence of a plough pan.[2] Complete ploughing and harrowing may cost c £63/ha[3]. The savings from planting on ploughed ground may not be sufficient to justify ploughing for planting alone.

Table 4

Planting on Ploughed Ground Compared to Planting on Weedy Ground with Screefing

Plant Spacing (m)	Planting Method	Output (ha/shr)	Cost (£/ha)
2 x 2	Bare Root, Mixed Blvds, 30 - 40 cm, **Ploughed Ground**, Double Notch	0.056	142.86
2 x 2	Bare Root, Mixed Blvds, 30 - 40 cm, **Weedy Stubble**, **Screefing**, Double Notch	0.041	195.12

Japanese Paper Pot Planting System: The JPP system demonstrates the potential of a cell grown plant system to improve planting efficiency (Table 5). Plants are delivered to site in their growing trays. The paper cells are separated out by the operator and loaded into a carrying tray which holds c 200 plants. The planting hole is dug and opened by the Pottiputki, a planting tool specifically designed for cell grown stock. The JPP is dropped down the tube of the planter into the hole and firmed into place by foot. No bending is required and the planter can work up a very quick rhythm.

Table 5

Output using Japanese Paper Pot Planting System

Plant Spacing (m)	Planting Method	Output (ha/shr)	Cost (£/ha)
1.7 x 2.2 (2673/ha)	JPP Corsican Pine, planted on turf ploughing using Pottiputki planter	0.15	53.33

Plant Size Comparison: A comparison in output when using 2 different plant sizes is shown in Table 6. The data showed that there was no consistent disadvantage to using a larger plant stock for the planting aspect.

Other work could be significantly increased as considerably fewer large trees can be carried in the planting bag. This results in more walking to replenish the bag. Insufficient studies were undertaken to identify the extra work required.

The principal factor which influences outputs when using big plants is plant type. Plants with slender, single stems and light roots will give higher outputs than branchy, heavy rooted plants.

Table 6

Effect on Output of Different Sized Plant Stock

Plant Type	Spacing (m)	Output by Plant Size (ha/shr)		Variation on Output (%)
		30 - 40 cm	60 - 90 cm	
Cell Grown	2 x 2	0.05	0.07	+ 40
Cell Grown	3 x 3	0.13	0.12	- 8
Bare Root	2 x 2	0.056	0.049	- 13
Bare Root	3 x 3	0.122	0.117	- 4

Sighting Rods: Sighting rods help maintain regular lines. This is especially important if future management operations, such as weeding and cleaning are to be mechanised. However, there is a cost penalty attached to using them (Table 7).

The effect is greater on the wider spacing because the time is spread over a fewer number of trees.

Table 7

Time/ha Using Sighting Rods

Spacing Between Rows (m)	Standard Minutes/ha for Mean Row Lengths (m)				
	50	75	100	150	200
2	75.54	52.67	40.89	43.66	35.34
3	70.20	48.47	37.61	40.47	33.31

Beating Up: The results of the beating-up studies are presented in Table 8.

Site conditions, in particular the density of weed growth, influences the time to identify vacant planting positions.

[2] Willoughby and Moffat 1996, Cultivation of Lowland Sites for New Woodland Establishment, Forestry Commission RIN 288.

[3] Farm Management Pocket Book, J Nix, Wye College University of London, 1994.

Table 8

Component Times for Beating-up on Specified Site Conditions

Ground Conditions		Walk & Search (SM/100 m)	Plant New Tree	
			Specification	SM/Tree
I	Flat ground, bare earth, lines & trees visible	1.43	Single notch, Scots pine, 15 cm height	0.22
II	Flat ground, uneven weed growth, light, patchy low grasses, old thistle growth standing, lines and trees visible	3.53	Screefing & double notch, mixed blvds, 30 - 40 cm height	0.42
III	Flat ground, even moderate grass growth up to 20 cm height, weeding not evident, taller trees visible	4.39	Screefing & double notch, mixed blvds, 30 - 40 cm height	0.42
IV	Flat ground, heavy weed growth up to 1 m, trees and line not visible	11.11	Screefing & double notch, mixed blvds, 30 - 40 cm height	0.52

Discussion

This project has given ***indicative*** outputs for new planting on farmland on:

- Complete ploughing.
- Weedy stubble and grassland.

The number of study opportunities available during the project was limited. It was not possible to carry out detailed analysis of the effects of different site types, plant types and work methods on work output.

The principal factor which influences outputs when using large bare rooted plants is plant type. Plants with slender, single stems and light roots will give higher outputs than branchy, heavy rooted plants.

Container grown plant stock is thought to be less prone to shock than bare rooted transplants. This should increase the chance of survival in the first season but there is no clear research evidence to support this.

The need to plough a planting site depends upon whether there is a plough pan to break. Ploughing can greatly increase the growth of weeds on fertile ex-agricultural sites.

It will be easier and cheaper in the long term to manage a grass sward which will inhibit the development of noxious weeds, such as thistle and ragwort. It will also require less herbicide as weed control will be a band or spot application, rather than an overall application.

Estimation of Cost and Output for Beating Up

When beating up, site conditions, in particular the density of weed growth, can influence the time to identify vacant planting positions. The walk and search time in Table 8 and the distance walked for different row spacings in Table 9 allows indicative outputs and costs for beating up to be calculated.

The time to walk 100 m while searching and identifying planting spots should be taken. This time applied to the distance/ha will give the total walking time/ha.

Table 9

Distance to Walk/ha at Different Row Spacings

Distance Between Rows (m)	Distance Walked (m)
1.0	10 100
1.8	5 656
2.0	5 100
2.1	4 862
2.2	4 645
2.3	4 448
2.4	4 267
3.0	3 433

The worked examples (Table 10) show how this information can be used to estimate work output for beating up an area with a known quantity of plant losses. The time to replant (0.42 SM/tree) assumes screefing and double notch planting a 30 cm to 40 cm broadleaved tree. The ground condition categories are as given in Table 8.

Table 10

Outputs and Costs for Beating-up Broadleaves

Ground Conditions	I	III	III	IV
Row Spacing (m)	2 x 2	2 x 2	3 x 3	3 x 3
% Losses	15	15	10	10
No Trees	375	375	110	110
SM/Tree to Replant	0.42	0.42	0.42	0.42
Total SM to Replant	157.50	157.50	46.20	46.20
SM/100 m Walk & Search	1.43	4.39	4.39	11.11
Number of 100 m/ha	51	51	34.33	34.33
SM/ha Walk & Search	72.93	223.89	150.71	381.41
Total SM/ha	230.43	381.64	196.91	427.61
Work Output (ha/shr)	0.26	0.16	0.30	0.14
Cost (□/ha)	30.77	50.00	26.67	57.14

Note: When trees and rows are bvery visible (eg conditions 1 & 11) walk and search times can be reduced by beating up 2 rows at a time. No studies however were carried out with this method and the amount of saving cannot be calculated. Should the 'search' element be minimal the maximum saving would be up to 50% of walk and search time.

The quality of weeding influences the cost of replacing losses. The more visible the line and the living trees in it, the easier it is to identify vacant planting spaces. For the 2 m x 2 m example, where the vacant positions can be identified easily (Ground Conditions I) the cost of beating-up is c 40% lower than for a site which received no weeding and where gaps are difficult to find (Ground Conditions III).

Conclusions

Studies of new planting operations broaden the database available and allow more detailed analysis of the effects of:

- plant spacing,
- soil and site type,
- plant size,
- plant type (bare root/container grown) and
- method of planting.

Planting on ground which has had complete ploughing and harrowing can increase outputs by c 36% compared to planting into unprepared grassland.

The use of a planting bag is ergonomically better, helps optimise output and maintain the quality of the plants and their chances to successfully establish in the first season.

Cost savings were not identified when using a single notch
to plant container grown stock compared to a double notch when planting bare rooted stock in the soil types studied and with the planting stock used. A single notch should only be used in loose soil and with plants having small root systems. A double planting slit ensures good root distribution in heavier soils.

The JPP system indicated that significant labour cost savings are possible with certain types of cell grown stock.

A method for estimating the cost of beating-up has been identified. The quality of weed control influences the plant survival rate and also has a strong effect on the cost of beating-up. Weeding can reduce costs by c 40%.

Recommendations

Double slit planting notches should be used to ensure good quality planting.

Plants should be carried in a planting bag as it is beneficial ergonomically, optimises output and safeguards plant quality.

Further studies should be undertaken to broaden the database for new planting.

Further evaluation should be carried out to assess planting tools for cell grown stock.

Good quality weeding operations should be carried out, to enhance plant survival and to allow identification of planting positions which will reduce beating-up costs.

Acknowledgements

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