Developing of a Prototype for Short Rotation Forestry Tillage

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ABSTRACT

In Italy, at the moment, the poplar SRF harvesting affects only areas characterized by favourable pedoclimatic conditions. Based upon previous experiments conducted in central Italy in 2007, CRA-ING have pointed out technical and economical limits. To this end CRA-ING has developed a new system (tillage system) in order to reduce these limits (reduction of the costs of soil preparation at the poplar plantations). The trials, compared two different soil preparation techniques: the low input method (superficial plowing) and the high input method (deep cracking, plowing and harrowing). It was underscored the considerable influence of the degrees of both soil cracking and soil thinning in survival of the plantation during the drought summer period if not irrigation was supplied. CRA-ING designed and developed a machine able to execute in a single operation both deep cracking of the soil and superficial thinning of the area where the cutting rows will grow. The interesting results of the first experiments allowed the implementation of the new solutions with the harvesting techniques already in use.

Keywords: Short rotation forestry poplar, rollover plow, drought summer, Italy.

1. INTRODUCTION

Based upon experiments conducted in the centre of Italy in 2007 (Agricoltura n. 4/2008), CRA-ING has developed modifications to the “Falc Land 1500 rollover plow” in order to reduce the costs of soil preparation at the poplar plantations allowing a rapid root development of the cuttings. In these trials, two different soil preparation techniques were also compared: the low input method, involving working on strips of land with one superficial ploughing and deep ripping, and the high input method, characterized by deep ripping, plowing and harrowing. The tests results underscored the considerable influence of the degrees of both soil ripping and soil thinning on the roots deepening and on cutting/field adhesion in the first stage after transplanting, respectively.
The deep ripping also affects the reduction of the roots competition (by roots deep cut) of the existing plants on developing of the small one.
At last, the importance of deep working of the soil was pointed out by the positive impact on cuttings rooting and their subsequent drought resistance.

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Due to the economic disadvantages of the high input technique cause of the machines and operations required, CRA-ING's aim was to develop a machine with similar capacity but lower cost.
To this end, CRA-ING designed and charge the developing of some modifications to a machine already known for its main working: the rotary plow. The carried out changes allowed to execute in a single operation both deep ripping of the soil and superficial thinning of the only band of terrain where, in the centre, the cutting rows will grow.

2. DESCRIPTION OF THE MACHINE

The developing of the prototype is based on the first Falc Land 1500 model produced through a collaboration between CRA-ING with the Falc society in Faenza (RA) for experimental proof conducted in the 1990s, where they performed the necessary modifications to tune up the machine.
The original Falc Land 1500 was formed by a rollover plow supplied with 12 spears mounted on a horizontal axis in three fields, each of them made up of four axes. The sections were spaced 0.35 m from one to another, allowing for work on an area of 1.5 m. Two lateral parts allowed for a depth of 0.45, whereas the central section was 0.55 m deep (Fig. 1).

Figure 1. Rear view of the Machine Components

The CRA-ING modifications included the application of a vertical blade device on the machine that permit a deeper pre-breakthrough of the worked area of over 0.8 m (Fig. 2).

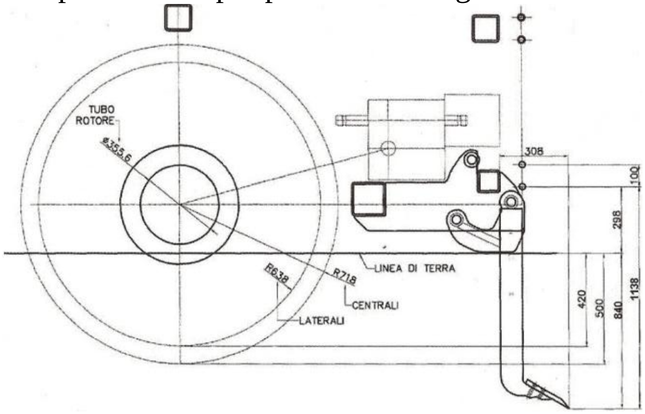

Figure 2. Diagram of the Falc rotative plow (model Falc Land 1500) modifications

In fact, the fixed blade, which is pliable during transportation (Fig. 3), can be lowered or lifted to different heights in the soil, and sits where the lances are activated in front of the support mast.

Figure 3. Particular of the CRA-ING innovations on the Falc rotative plow

In this way, the original machining comes to be replaced by a vertical and central ripping of the soil deeper than 0,8 m, and, beyond the tillage sole, by an area worked with ground remixing of about 0,54 m in the central part and 0,45 m in lateral part with a length of 1,5, m (Fig. 4).

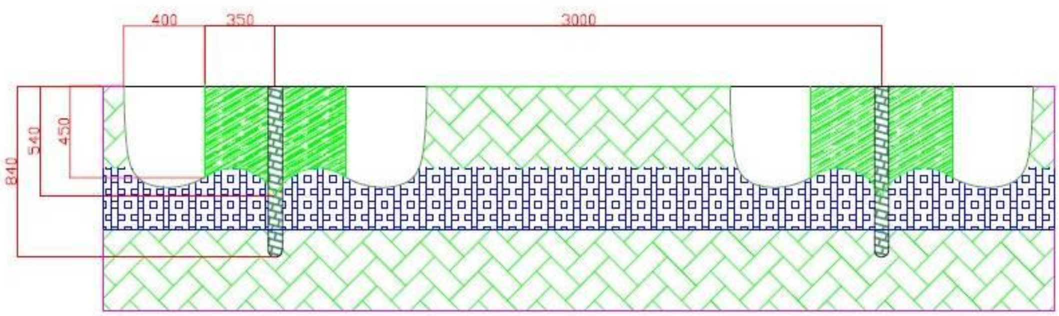

Figure 4. Scheme of vertical and central ripping of the soil

The machine was combined with a double traction 115 CV John Deere 3050 tractor (84,6kW).

3. TEST PERFORMANCE

The developing of the prototype took most of the summer of 2007, and the first experiments were conducted in the autumn of 2007. The tests were carried out via a transplanter mounted on the machine tail used to break the soil as well as to execute primary and secondary working and the planting phase, all in a single step. Taking into account also the last one aspect, tests compared four different theses in order to compare: AF2 and Monviso clones (the same as from the previous year), two different transplantation times (September and February) and two different methods of soil preparation (traditional and low input).
Two plots representing the two different transplantation times were traced to an area of 1.78.50 ha: the former used the new machine to work the soil (low-input theses Fig. 5), whereas the latter employed subsoiling, ploughing and superficial thinning techniques (high input - traditional

theses), by the means of two harrowing if the crop planting occurs after winter.

Figure 5. Particular of the modified Falc Land at work

Immediately after the first plot' s soil preparation (Fig. 6), four rows (375 m in length) for each clone (1 and 2 these) were transplanted, leaving nine (3 and 4 theses) grouped in four rows, in addition to another row at the end of the plot that had been transplanted at the end of the winter (February 2008).

Figure 6. Trial field for autumnal planting

According to the first two theses (357 m in length, 24 m in width), grouped in four rows for each row for a total of eight (rows), the soil was prepared and the cuttings (clones AF2 and Monviso) were immediately planted in order to evaluate the possibility of developing a unit of two layers and a one-step implant. For the remaining nine rows (3 and 4 theses), comprising eight rows of experimental proof in addition to another one at the end of the plot, when a few months of soil settlement were expected in winter, the system was subsequently installed in February 2008.

4. ROOTING AND CUTTING GROWTH

The first two thesis surveys (autumnal planting) conducted in November 2007 (30/11/07)showed a slow growing of both the clones, particularly for the AF2 in the low-input cultivation, probably due to a combination of two factors. A less soil refinement with lower area in contact with the cuttings together with a lack of heavy rain, shortly after cutting transplant, could have affected a prompt rooting. Further surveys were conducted in April, July and October in order to verify the cuttings rooting and growing of all the thesis in proof (Table 1).

Table 1. Trial settings, surveys date and monitored parameters

Planting Period	September 2007				February 2008			
Thesis	1		2		3		4	
Preparation of the soil	Low input		High input		Low input		High input	
Clone	AF2	Monviso	AF2	Monviso	AF2	Monviso	AF2	Monviso
Survey date 30/11/2007:								
Height (mm)	69,7	137,1	126,9	229,4	-	-	-	-
Mortality %	48,69	9,77	23,86	3,75	-	-	-	-
Survey date 29/04/2008:								
Mortality %	91,69	70,44	81,84	51,14	2,12	0,81	5,94	3,58
Survey date 19/06/2008:								
Height (mm)	375	700	525	750	925	875	900	825
Survey date 24/10/2008:								
Height (mm)	-	-	-	-	1.647,60	1.650,50	1.686,40	1.545,50
Mortality %	-	-	-	-	2,15	0,93	5,94	3,78

The Figure 7 shows the prompt growing of plants post-winter planted, two months transplanting later.

Figure 7. Spring planting after two months from cuttings transplant

Plants from the autumn planting showed vegetative regeneration only for those plants already developed during the previous year, to begin, the most, from cuttings with changing neck, without showing any sign of regeneration from the sprout already in life, little by little dried. On one hand, the system showed a high mortality rate, especially for the low-input technique, and at the same time revealed a mortality rate of over 50% for all of the techniques employed, confirming the failure of these methods.
The autumnal planting revealed greater development of the cuttings for which the traditional transplant technique was applied, whereas for the spring planting, cutting growth was almost homogenous, although the AF2 clone showed the best growth conditions.
During the last survey on the autumnal planting, characterized by a mortality rate so high that it prevented cultivation growth, there was a considerable increase in the baseline stump (Fig. 8). This was probably due to the fact that the previous year's sprouts were on the ground, followed by vegetative recovery at neck level with a significantly enlarged baseline like a sort of felling lived by the plant.

Figure 8. Particular of vegetative recovery of 1-2 thesis in autumnal planting

The post-winter planting immediately displayed good cutting roots in both thesis 3 and 4 due to the good soil and water conditions. A lower mortality rate for both clones with the use of the low input technique was also found.
The homogeneous data obtained by the last surveys conducted on post-winter planting contributed to successfully confirm the use of the low input technique carried out with the modified Falc Land.

5. COSTS AND WORKING CAPACITY

The work carried out, compared traditional working methods of the two layers to the innovative CRA-ING solutions on the base of which the working area was prepared to, and also to facilitate the most underground rooting in order to increase resistance to summer water stress.
For the preparation of the soil, five different machine combinations were used: a tractor with a subsoiler, a tractor with a plow, a tractor with a rotary harrow, a tractor with springs harrow and a tractor with the CRA-ING prototype whose the main aspects are illustrated in the following table (Table 2).

Table 2. Main dimensional aspects of the machines used for testing

Manufacter brand	Model	Type	Dimensional aspects
		Subsoiling	
John Deere	7810	DT	Power (CV) 185
Rinieri	Towed	Two spears	Depth (m) 0,8
		Ploughing	
John Deere	7810	DT	Power (CV) 185
Mattioli	Two-share plough	Reversible	Depth (m) 0,4
		Harrowing 1	
John Deere	6400	DT	Power (CV) 100
Maschio	3000	Rotating harrow	Working width (m) 3
		Harrowing 2	
John Deere	7810	DT	Power (CV) 185
Fraternali	3 m pliable	Spring harrow	Working width (m) 3
			Depth (m) 0,25
		CRA-ING prototype	
John Deere	3050	DT	Power (CV) 115
Falc	Falcland 1500 Modified	Rotary lances + central ripping tool	Working width (m) 3 Worked width (m) 1,5 Cracking depth (m) 0,84

In order to compare the different methods costs of soil preparation, it were calculated the hourly costs of the different machines, and according to the surveyed working capacity it was possible to calculate the costs of units (Table 3).

Table 3. Machines during testing: working capacity and economic aspects

Machines typology	Hourly cost (Euro/h)	Working capacity (Ha/h)	Surface vessel cost (Euro/ha)
Falc Falcland modified	54,97	0,5022	109,46
Ploughing	57,17	0,4100	139,44
Subsoiling	54,23	0,7500	72,31
Harrowing 1	40,20	0,6300	63,81
Harrowing 2	53,87	1,2000	44,89

In the first experiments, the CRA-ING prototype displayed a working speed of 1.8 km/h. If we compare this speed to the actual working width given from the transplant's inter-row space (3 m), we have an effective working capacity of 0.54 ha/h; thus, an approximate rate of 93% of production yielded an operative working capacity of two hours/ha (1,59").
The use of the machine allows not only for a reduction of more than 65% in soil preparation costs relative to the traditional techniques, but also provides the possibility for reducing by a considerable amount the number of operations in the field.

6. CONCLUSIONS

The first experiments conducted with the modified Falc Land 1500 underscore a significant reduction in soil preparation costs of more than 65% when compared to the traditional machine. The new Falc Land 1500 reveals the strategic importance of combining a deep subsoiler plow, characterized by a considerable capacity for traction, with a rollover plow, which boosts the feed thanks to the power supplied from pdp. Moreover, the trials conducted show that during the soil preparation phase, it is not appropriate to plant cuttings from the autumn period and immediately implant them; this leads us to believe that it is becoming increasingly difficult to develop a single machine capable of working and planting in a single round. Additionally, it appears that the best time for the soil preparation phase is between August and September, and the best time to plant cuttings is in February and March.
In comparison to the traditional technique, it seems that the modified Falc Land 1500 has a superior depth capacity with regard to its radical apparatus. The objective is to allow for increased depth of the radical apparatus in order to enhance plant survival during the first vegetative year. If the roots extend in the soil beyond the tillage sole, plants can survive without the aid of irrigation.