EXPERIMENTAL TRIALS TO FINDING THE BEST COMBINATION OF TRACTOR - PLOUGH

A. Natsis, G. Papadakis

Abstract*: The quality of ploughing for a certain soil depends on several factors, such as the kind of mouldboard (spiral, cylindrical, hyperbolic), the plough technical characteristics, the ploughing speed, the working width and depth.*

In this paper is presented an experimental investigation of the use of several types of mouldboard ploughs and tractors of powers of 80 HP and 100 HP. Three types of mouldboard ploughs were tested as following

type (1): mounted mouldboard plough having 3 plough furrows each of ploughing width of 35 cm,
type (2): semi mounted mouldboard plough having 5 plough furrows each of ploughing width of 35 cm,
type (3): mounted mouldboard plough having 4 plough furrows each of ploughing width of 30 cm,
Several combinations of ploughs and tractors were used and several quality and energetic indexes were recorded and assessed. The results showed that the best combination was that of the plough type (2) and tractor of 100 HP.
Key words*: Tractor power, plough type and size, combining tractor and plough*

INTRODUCTION

When combining tractor and plough, a critical question to be answered is "which is the best combination" in terms of matching tractor power size, and plough type and number of furrows so that to reduce fuel consumption to a minimum and preserve high ploughing quality, [1-6, 13-16].

In this paper is presented an experimental study to determine the best combination of tractor power and plough type according to widely accepted criteria that define 1) the quality of the work and 2) the fuel consumption.

MATERIALS AND METHODS

The combinations of tractor plough tested were as following,

Combination (1): Tractor of 80 *HP* and mounted mouldboard plough having 3 plough furrows each of ploughing width of 35 cm,

Combination (2): Tractor of 100 HP and semi mounted mouldboard plough having 5 plough furrows each of ploughing width of 35 cm,

Combination (3): Tractor of 80 HP and mounted mouldboard plough having 4 plough furrows each of ploughing width of 30 cm.

The ploughing was done at two set depths 22-26 cm and 26-30 cm. The soil type was clay; its specific resistance was 9.7 N/m^2 and the natural population of plants 610 plants$/m^2$. The soil water content at 20 *cm* and 30 *cm* depths was 19.5 % and 21 % respectively. For every combination of tractor and plough of those mentioned above, several quality and energetic indexes were determined as it is described in detail in the following. Each ploughing trial was repeated four times for a length of 100 *m*.

The technical characteristics of the plough are given in Table 1.

Table 1. Technical characteristics of the ploughs

Plough type	*Weight, kg*	*Max theoretical working depth, cm*	*Max theoretical working width, cm*	*Total max theoretical working width, cm*	*Angle* γ_o	*Angle* γ_m	$\Delta\gamma$
(1)	510	30	35	105	46	48	2
(2)	1250	30	35	175	44	48	4
(3)	570	30	30	120	38	43	5

where the angles γ_o and γ_m are defined in Fig. 1 below, ($\Delta\gamma = \gamma_m - \gamma_o$).

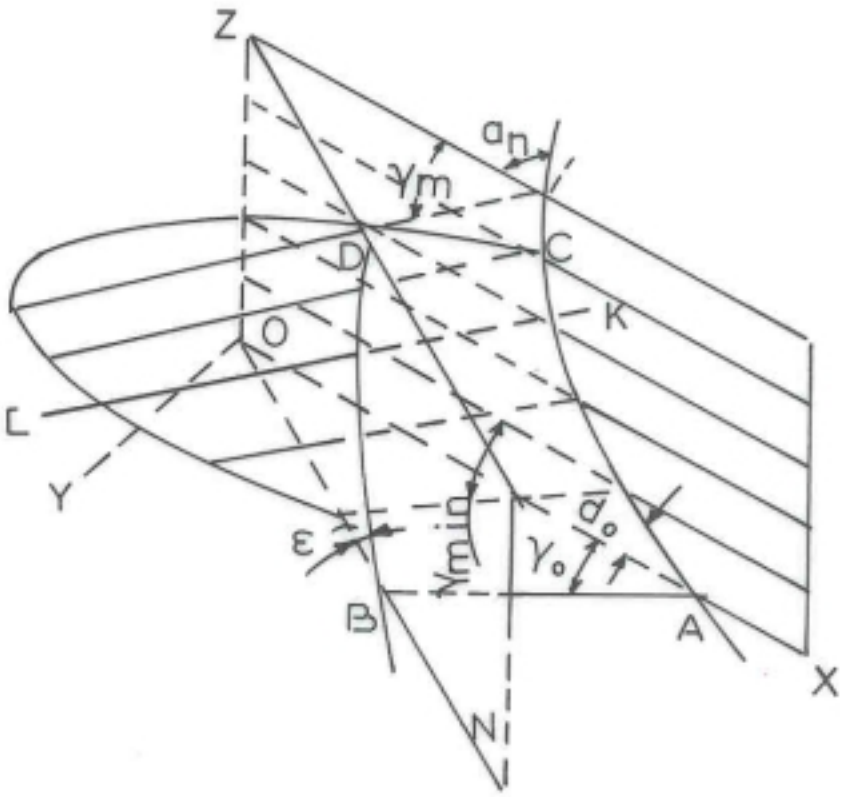

Fig. 1 Definition of angles on the mouldboard plough

The height of the mouldboard is 300 *mm* that is sufficient to secure the maximum ploughing depth of 26 to 30 cm.

3. RESULTS AND DISCUSSION

3.1. Quality indexes

A) Ploughing stability; it refers to the stability of ploughing width and depth, [7,8,9,10]. For every trial (every passage of 100 *m* length), 25 measurements of ploughing depth and width were taken. From these measurements the standard deviation from the set average depth and width was determined.
B) Soil granulation; it is determined from a soil sample from the ratio of the weight of soil clods with size less than 50 *mm* to the total sample weight, [11].
C) Weeds covering; it refers to the number of plant weeds before and after each ploughing trial, [8,11]. The number of plant weeds before and after of each trial was measured at three random areas each having dimensions 1 *m* by 1 *m*. The ratio of the plant weeds measured before and after ploughing gave the weeds covering percentage.
D) The soil surface elevation after ploughing [10, 11, 12]; it was determined by measuring the soil surface height before and after ploughing every 10 *m* at each passage.

The results of the above mentioned measured indexes are given in Table 2.

Table 2. Ploughing quality indexes

Plough type	*(1)*	*(2)*	*(3)*
Tractor Power, HP	*80*	*100*	*80*
Ploughing depth deviation, %	4.10	5.20	5.84
Ploughing width deviation, %	2.60	2.35	5.10
Weeds' covering, (%)	99.00	87.50	89.80
Soil granulation, %	60.50	54.50	52.80
Soil elevation, cm	9.70	9.30	5.30

It can be seen in Table 2 that the ploughing depth was deviated by 1 cm from the set one, for all ploughs while the ploughing width was better performed by the semi mounted mouldboard plough (2). The soil granulation of plough (1) was much better than the other two plough types. As the ploughing depth increases the soil granulation of ploughs (1) and (2) increases too, while for the plough (3) decreases. This can be explained from the fact that the plough (1) and (2) have smaller $\Delta\gamma$ than plough type (3) and thus their mouldboards resemble to a cylindrical one which granulates better the soil than a semispriral mouldboard that corresponds to the plough type (3). The better soil granualation achieved by plough types (1) and (3) is also explained by their larger mouldboard height as compared to type (3).

The weeds covering is better performed by plough (1) because at the soil surface remain less than 1 % of the natural weed plants. Ploughs (1) and (2) provide almost double soil elevation and this results to increased soil porosity and better soil aeration which is highly desirable for heavy (clay) soils. It was also noticed that during ploughing with plough (3) the soil cut could not be completely turned and this happens because the coefficient K_α defined by the ratio b/α (where b ploughing width and a is the ploughing depth) is lower than 1.27 which is the critical value for soil cut turning, [2,4,13,16].

3.2. Energetic indexes

At every ploughing passage the draught power, tractor speed, engine power, fuel consumption and specific soil resistance were measured and recorded as a function of time and then the average values were calculated for every ploughing trial. In Table 3 can be seen the results of the above mentioned measurements for the three combinations of tractor-plough tested.

Table 3. Energetic indexes

Plough type and tractor Power, HP	*(1), 80*	*(2), 100*	*(3), 80*
Specific resistance, *kN/m*	17.78	17.73	18.88
Tractor speed, *km/h*	4.67	3.04	3.70
Required ploughing power, *HP*	39	35	31
Tractor rated power, *HP*	73.2	93.4	74.6
Power ratio	0.53	0.37	0.42

It can be seen in Table 3 that the specific resistance of ploughs (1) and (2) is about 6% less than that of plough (3) and also that plough (1) can work at a higher speed and so to exploit better the tractor engine power reserve.

The results of the fuel consumption are presented in Table 4, where it can be seen that the 80 *HP* tractor with plough (1) consumes 2.57 *lt* less oil per 1000 m^3 ploughed soil than the same tractor consumes with plough (3). The 100 *HP* tractor with

plough (2) consumes 0.41 *lt* less oil than the 80 *HP* tractor with plough (1).

Table 4. Oil consumption, *l/ha*

Plough type and tractor Power, HP	*(1), 80*	*(2), 100*	*(3), 80*
Ploughing depth 22-25 *cm*	25.60	27.30	30.88
Ploughing depth 26-30 *cm*	33.17	30.60	40.73
Average	29.30	29.02	35.70
	Per 1000 m^3 of ploughed soil		
Ploughing depth 22-25 *cm*	11.06	10.51	13.37
Ploughing depth 26-30 *cm*	12.30	11.87	15.31
Average	11.70	11.29	14.27

The work rate was also calculated and the results are presented in Table 5.

Table 5. Work rate, ha/h

Plough type and tractor Power, HP	*(1), 80*	*(2), 100*	*(3), 80*
Ploughing depth 22-25 cm	0.64	0.66	0.52
Ploughing depth 26-30 cm	0.52	0.53	0.40
Average	0.58	0.60	0.46

It can be seen in Table 5 that the combination tractor 100 *HP* and plough (2) is the most productive.

4. CONCLUSIONS

1. The best quality indexes are obtained by the combination tractor 80 *HP* and plough (1).
2. Over all, the combination, tractor 80 *HP* and plough (1) is the more efficient one.

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