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Full Length Research Paper

A research on cost analysis and determination of management data in paddy drilling with steel wheel tractor

G. Cicek* and S. K. Sumer

Department of Agricultural Machinery, Faculty of Agriculture, Canakkale Onsekiz Mart University, 17020 Canakkale, Turkey.

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In this research, management data were determined for paddy seed broadcaster being used with steel wheel tractor (John Deere 5625) in rice farms. Simple cost comparison between seed broadcaster and hand broadcasting was performed. Paddy drilling with broadcaster were refured separately for 540 and 540E power take off (PTO) options. Cost analysis was done for the two method. In conclusion average speed, effective field capacity and fuel consumption were found to be 9.47 and 7.57 km/h, 6.63 and 5.3 ha/h, 8.11 and 5.9 lt/h for 540 and 540E, respectively. Variable cost was found as 22.64 €/ha for hand broadcasting, 3.47 €/ha for 540 and 3.75 €/ha for 540E. Equivalent cost of field was determined to be 10.15 and 10.3 ha for 540 and 540E, respectively.

Key words: Paddy drilling, equivalent cost analysis, PTO, management data.

INTRODUCTION

Paddy, which is one of the main food materials has been produced at an area of 939 000 da in the year 2007 and an average yield of 690 kg/da has been obtained with a total production of 648 000 ton. Paddy production which forms 0.9% of the total crop area and 2% of the total crop production quantity (TUIK, 2008) is the third in the world and sixth in our country among all crops. It is known that to increase the obtained product per unit area, the applied agricultural technologies are as important as watering and fertilization. In order to increase the contribution of paddy agriculture to the country economy, modern methods should be applied. That is why in order to ensure the highest efficiency in paddy production, the operation quality, field structure, work to be done and the basic operation parameters of the agricultural machine to be used should be known. Having compiled data at hand for various machines will give the user a chance to select the right machine by considering their different characteristics.

Drilling process which is an important stage in paddy agriculture is generally done either by hand broadcasting or by using a seed broadcaster in our country as well as in the world. Even though drilling by hand broadcasting is more common in Turkey, seed broadcasters are being used as well. Especially with the usage of laser controlled leveler machine production in larger field has become possible. The increase of fields has obligated machine drilling. During drilling, in order to avoid slipping of plastic wheels, steel wheels should be used on tractors that are used to sow paddy onto fields filled with water via seed broadcaster. Thus human labor is replaced by mechanical power to carry out the drilling process. Drilling process is done by using seed broadcaster. Among seed sowing methods based on volume adjustment, broadcast drilling has the best seed spacing (Onal, 2005). Seed broadcasters that can make broadcast drilling have the lowest purchasing price among the drilling machines (Hunt, 2001). Whereas in certain areas in which human labor supply is more than the demand it may not be economical to purchase and use a machine for a specific area, in other places where the labor supply is less and more processes should be done in a shorter amount of time due to climate conditions, usage of such devices may be both economical and also inevitable (Sindir, 1999). When compared with human labor, the investment

*Corresponding author. E-mail: giyas@comu.edu.tr. Tel: +90 286 218 00 18. Fax: +90 286 218 05 45.

Table 1. Locations in Southern Marmara region where paddy is produced and the production quantities.

Product locations	Product area (ha)
Biga	5581.6
Ezine	742.6
Gonen	7146.8
Manyas	5000.0
Total	18471.0

cost evaluations of machinery that paddy plants require for technical reasons should be made and investments having high profitability should be selected. On the other hand, completion of the harvest within the optimum period which varies according to crop differences is another important factor for a successful harvest operation (Say, 2009).

This study was performed in Southern Marmara region which supplies 15.5% of the total paddy production in Turkey (Gaytancioglu, 1997). Locations in Southern Marmara region where paddy is produced and the production quantities are shown in Table 1. Hand broadcasting method is widely used for paddy drilling in the region of this research. The objective of this research is to analyze the possibilities of machine drilling as an alternative to hand broadcasting and also to determine their economical differences. To this end, the operational data related to seed broadcaster used with steel wheeled tractor in paddy plants have been separately determined for both 540 and 540E PTO speeds, simple cost comparison has been made in order to determine the technical and economical differences of these two methods. Equivalent cost analysis method has also been applied to determine at which field sizes these two methods are more economical.

MATERIALS AND METHODS

Materials

In this study, experiments have been carried out in paddy fields belonging to an establishment in Ezine, a district of Canakkale province. Soil of the field reflects the properties of the region which is loamy (26.8% clay, 24.7% silt and 48.5% sand). In the trials John Deere 5625 tractor and seed broadcaster connected to a three point linkage system was used (Table 2). The front and rear wheels of the tractor have been removed and replaced with steel wheels. Since during the pre runs the steel wheels sank in the fields especially when used on soft surfaces, circular apparatuses have been added to the sides of the wheels (Figures 1). Seed broadcaster has been tried for both 540 and 540E PTO speeds. For both applications the PTO rpm was 540 1/min. 540E application defined as economical PTO supplies the standard PTO rpm (540 1/min) at a lower engine rpm.

Fuel consumption values have been determined by using a flow meter measuring the amount of fuel passing through the line between the fuel tank and injection pump (Macnaught M05, Macnaught Pty. Ltd., Australia) and a second flow meter measuring the amount of fuel coming back from the injection pump and injectors to the fuel tank. The unit of these measured values is fuel consumed per unit time (lt/h). The difference between the measured values of these two meters gives the net fuel consumption value. In order to determine the torque and power values supplied by tractor PTO during field experiments, a PTO torque meter (Datum PTO-420) has been used.

Methods

The most important property in method comparison is to have the same start and end points for the compared methods (Dincer, 1976). In paddy drilling when hand broadcasting and machine drilling are compared, for both methods the starting point is a field ready for drilling and the end point is a field on which drilling has been completed. Another property of method comparison is to have the same working conditions for all of the compared methods. The experiments were carried out in randomized plot design with split plot arrangement with three replications. In the trials during which hand broadcasting and machinery drilling methods were applied, hand broadcasting time, tractor fuel consumption, ground speed, PTO torque and power parameters have been measured.

One of the methods used to determine the more economical of the two compared systems was Equivalent Cost Analysis (Sindir, 1999). During the trials the parameters obtained for both drilling methods were used to make cost calculations and perform equivalent cost analysis. The equations used to determine the operational data and make cost calculations in the plant are given below (Sindir, 1999).

$$C_{ET} = \frac{w.v.e_t}{10} \quad (1)$$

C_{ET} : Effective field capacity (ha/h)
w : Effective width of action of machine (m)
V : Forward speed (km/h)
e_t : Field efficiency (0.7)(ASAE, 1995)

$$D = \frac{C_O - C_N}{N} \quad (2)$$

D : Depreciation (€/year)
Co : Purchase price (€)
C_N : Salvage or selling price (€)
N : Time between buying and selling (year)

$$I = \frac{(C_O - C_N).i}{2} \quad (3)$$

I: Interest cost (€/year)
i : Interest rate (decimal)

$$i_r = \frac{i_n - i_g}{1 + i_g} \quad (4)$$

i_r : Real interest rate (decimal)
i_n : Nominal interest rate (decimal)
i_g : Rate of inflation (decimal)

$$VSK = \frac{2.C_O}{100} \quad (5)$$

Table 2. Technical properties of the tractor and the seed broadcaster.

Technical properties of the tractor	
Tractor mark	JD 5625
Maximum engine power (kW) HP	(62.5) 85
PTO rpm (1/min)	540
Engine rpm (540/540E) (1/min)	2400/1700
Technical properties of the seed broadcaster	
Work width (m)	10
Store capacity (lt)	510 - 580
Maximum rpm (1/min)	540
Required engine power (HP)	40-60

Figure 1. Paddy drilling with steel wheel tractor.

VSK : Tax, insurance and shelter costs (€/year)

SDYG= SDYT.BDYF (6)

SDYG : Fule cost (€/h)
SDYT : Fuel consumption (lt/h)
BDYF : Fuel price (€/lt)

HDYG = SDYG/C_{ET} (7)

HDYG : Fule cost per ha (€/ha)

SYG = SYT.BYF (8)

SYG : Oil cost (€/h)
SYT : Oil consumption (lt/h)
BYF : Oil price (€/lt)

HYG = SYG/C_{ET} (9)

HYG : Oil cost per ha (€/ha)

SYT = 0.00059.P+0,02169 (10)

P : Tractor engine power (kW)

$$C_{BOM} = (RF1).C_O.(\frac{h}{1000})^{RF2} \quad (11)$$

C_{BOM} : Repair and maintenance costs (€)
RF1 and RF2: Repair and maintenance factors (RF1: 0.63 RF2: 1.3) (ASAE, 1995)
h : Accumulated hours of use (h=1200 h) (ASAE, 1995)

Table 3. Management data of seed broadcaster.

Management data	540	540E
Average speed (km/h)	9.47	7.57
Effective field capacity (ha/h)	6.63	5.30
Fuel consumption (lt/h)	8.11	5.90
PTO rotation moment (Nm)	58.00	58.00
PTO power (kW)	3.28	3.28

$$HIG = SIM/C_{ET} \quad (12)$$

HIG : Labor cost per ha (€/ha)
SIM : Labor cost per hour (€/h)

$$EMA = \frac{SG_A - SG_B}{DG_B - DG_A} \quad (13)$$

EMA : Equivalent cost area (ha)
SG_A : Fixed costs (€/year)
SG_B : Fixed costs for hand broadcasting (€/year)
DG_A : Variable costs (€/ha)
DG_B : Variable costs for hand broadcasting (€/ha)

RESULTS

Operational data

The operation data obtained when drilling is done by seed broadcaster using steel wheel tractor has been given in Table 3. The effective field capacity were found to be 6.63 and 5.3 ha/h for 540 and 540E PTO speeds respectively. Fuel consumption values were found to be 8.11 and 5.9 lt/h for 540 and 540E PTO speeds respectively.

Expenses in machine drilling

In the calculation of interest value the nominal interest ratio (I_n) was calculated as 0.175, inflation ratio (I_g) was calculated as 0.085 and real interest ratio (I_r) was calculated as 0.083. The total of fixed expenses comprised of depreciation, interest, tax, insurance and protection was determined to be 194.56 €/year. In machine sowing a total of 10.61 €/h expense was determined for 1 tractor driver and 2 drilling workers (transferring the seeds to the machine). The labor cost per unit area was calculated to be 1.6 €/ha. The fuel and oil consumption values for 540 PTO speed was determined to be 1.74 €/ha and that of 540E PTO speed was determined to be 1.59 €/ha. Maintenance and repair cost was calculated to be 0.12 and 0.16 €/ha for 540 and 540E PTO speeds respect- tively. Based on these calculations the total variable cost in machine sowing was determined to be 3.47 and 3.75 €/ha for 540 and 540E PTO speeds respectively (Figure 2 and Table 4).

Expenses in hand broadcasting

As a result of the trials the work success in hand broadcasting was determined to be 0.625 ha/h. A total of 14.15 €/h expense was determined for 1 spreader and 3 spillers. The unit area cost was calculated as 22.64 €/ha. When hand sowing and PTO options are compared variable costs were determined to be 22.64 TL/ha for hand broadcasting, 3.47 €/ha for 540 PTO speed and 3.75 €/ha for 540E PTO speed (Figure 2 and Table 4).

Equivalent cost analysis

When the tractor is used in 540 PTO speed the equivalent cost area was determined to be 10.15 ha and it was determined to be 10.3 ha for 540E PTO speed (Figures 3 and 4). As a result of the data obtained from the trials it has been determined that machine drilling is more economical for areas greater than 10.15 ha for 540 PTO speed and greater than 10.3 ha for 540E PTO speed.

DISCUSSION

The tractor ground speeds of machine drilling operations performed at 540 and 540E PTO speeds were determined to be 20% lower for 540E PTO speed in comparison with that of 540 PTO speed. The differences in movement speeds are due to the fact that PTO rpm is supplied at different motor rpms. Sumer et al. (2009) have carried out field trials with various PTO driven machines in order to determine economical PTO operation characteristics. They have stated that during the field trials carried out with centrifugal fertilizer spreader in 540E instead of 540 applications at the same gear level, the tractor speed has decreased 15.89 - 22.6% in comparison with the 540 application. Gasp- aretto et al. (1992) have carried out their studies at 2.5 and 6 km/h speeds in order to determine the rolling resistance of steel wheels. Tezer and Sabanci (1991) and Ulger et al. (2002) have stated that the movement speed in broadcast drilling is between 6.4 -10 km/h. In this study the movement speeds are within the intervals specified by the researchers.

The seed broadcaster used in the region is also used for fertilizer spreading as well. Yon (1980) has determined the effective field capacity as 5.2 ha/h as a result of the study made by using a fertilizer spreader machine. In this research fuel consumption values of 540E PTO speed have been determined to be 27.25% less on average than that of 540 PTO speed (Table 3). Yon (1980) has determined similar fuel consumption values in the study he carried with fertilizer spreader machine for 540 PTO speed. In the field experiments carried out with different tractor and machines, Sumer et al. (2009) have determined fuel consumption savings of 14.88 -34.41% in

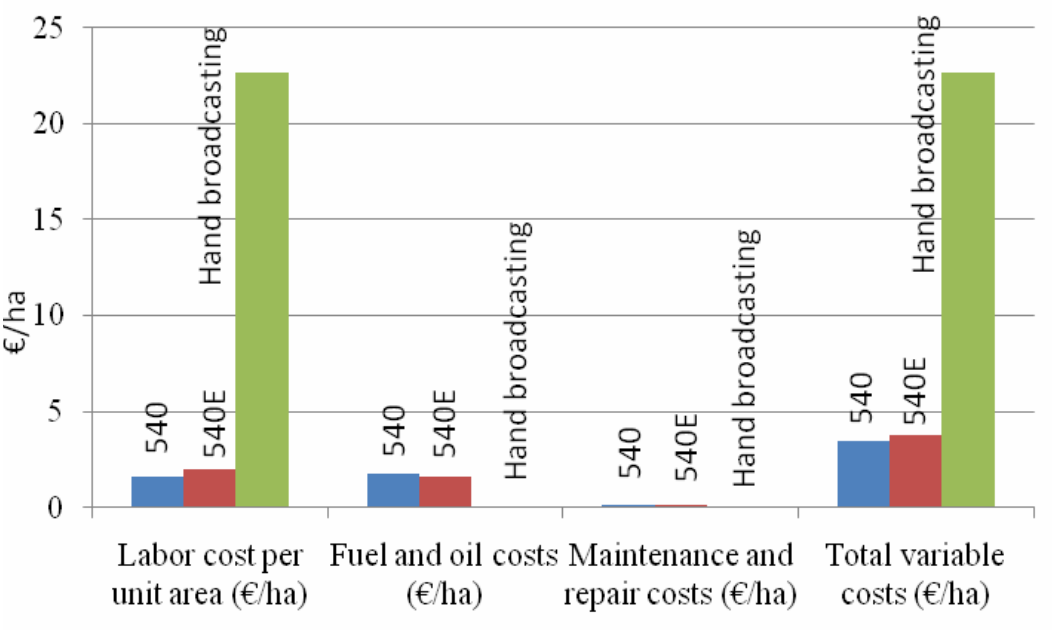

Figure 2. Variable costs for seed broadcaster and hand broadcasting.

Table 4. Variable and fixed costs for seed broadcaster and hand broadcasting.

	540	540E	Hand broadcasting
Labor cost unit area (€/ha)	1.60	2.00	22.64
Fuel and oil costs (€/ha)	1.74	1.59	-
Maintenance and repair costs (€/ha)	0.12	0.16	-
Total variable cost (€/ha)	3.47	3.75	22.64
Total fixed cost (€/year)	194.56	194.56	-

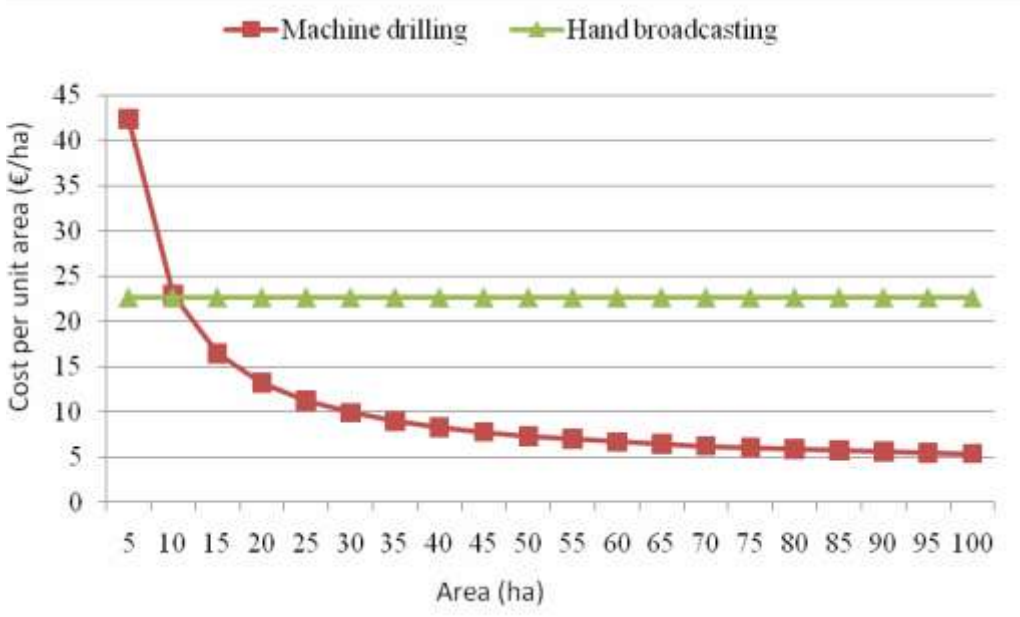

Figure 3. Equivalent cost area to hand broadcasting and seed broadcaster (for 540 PTO).

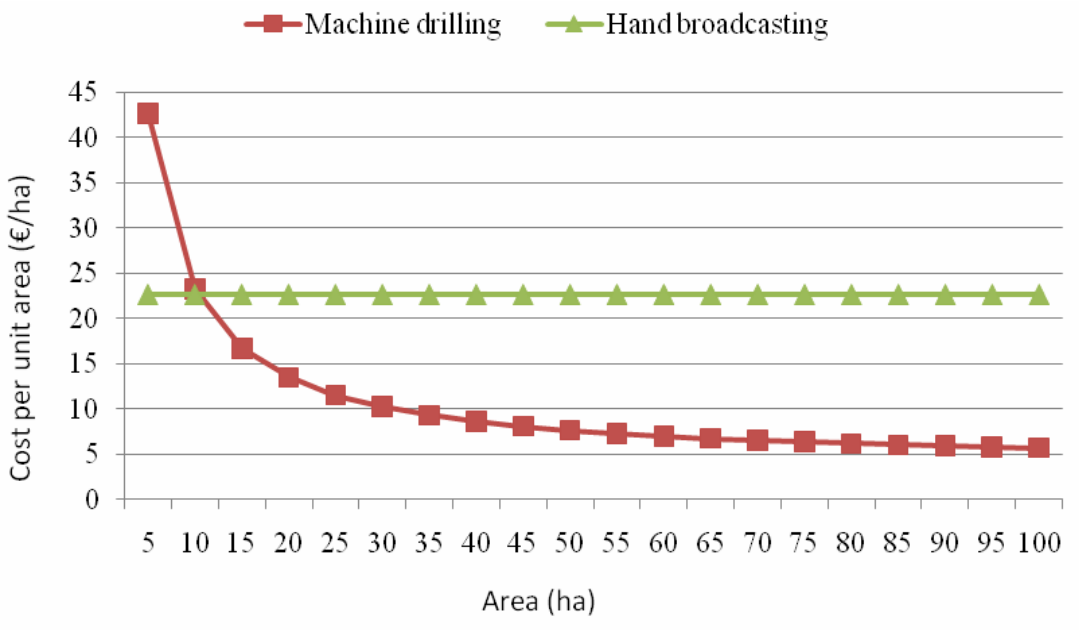

Figure 4. Equivalent cost area to hand broadcasting and seed broadcaster (for 540E PTO).

540E PTO speed in comparison to the other PTO speed. Due to the decrease in movement speed of 540E PTO speed in comparison with 540 PTO speed; even though fuel consumption decreases in 540E PTO speed, it is disadvantageous in terms of the effective area capacity (Table 3). Taking into account that the PTO speed is 540 1/min for both PTO speeds the required moment value for the drilling machine directly affects PTO power since moment and rpm are functions of power. In the experiments, since for PTO rotation moment and power data evaluations the PTO rev for 540 and 540E speeds are the same (540 1/min) the average of the two speeds were taken into account (Table 3).

The cost per unit area was also the highest for hand broadcasting. When PTO options are considered the unit area cost of 540E PTO speed which is thought to be economical was found to be higher than that of the 540 PTO speed. The decrease in effective area capacity may be the reason for the increase in variable cost even though the fuel consumption value is less when passing from 540 to 540E PTO speed. The decrease in effective area is due to the decrease in movement speed at the same gear level. In order to balance the decrease in movement speeds when 540E PTO speed is used instead of 540 at the same operating conditions, a gear level enabling higher movement speeds may be used. When the tractor is used in 540 PTO speed the equivalent cost area was determined to be 10.15 ha and it was determined to be 10.3 ha for 540E PTO speed (Figures 3 and 4). These areas are where total costs of machine and hand broadcasting are equal. Whereas machine drilling is more economical for areas greater than the determined areas, for areas smaller than the determined areas hand broadcasting is more economical. In this study during which machine and hand broadcasting were compared, threshold area magnitude was determined by equivalent cost analysis. As a result of the data obtained from the trials it has been determined that machine drilling is more economical for areas greater than 10.15 ha for 540 PTO speed and greater than 10.3 ha for 540E PTO speed. Among the businesses which have an average paddy production area of 5.74 ha (Anonymous, 2007) and where machine drilling is not used 12.5% (forming 42.2% of the total paddy production in the region) have greater paddy drilling areas in comparison to the threshold area values.

Conclusion

In this study hand broadcasting and machine drilling were compared, it has been determined that machine drilling should be preferred for areas larger than a specific value (about 10 ha). In order to increase quantity and quality in agricultural production, all these processes should be completed expediently in the shortest amount of time possible. This is possible by effectively using agricultural machines. Paddy producers that have small parcels can't perform machinery farming. The combination of parcels to form larger fields will force the manufacturers to use machines and as a result savings in both time and cost will occur along with the minimization of possible losses thereby dramatically increasing efficiency.

Manufacturers that gain a more flexible structure by this means will also have been saved from possible problems that might arise in labor management. As can

be seen from the results obtained, there is an increase in costs due to the decrease of effective area capacity even though there is a saving in fuel consumption. In the long term, it is seen that 540E PTO speed is not economical for this research. It will be much better to inform the farmers based on results of other studies that will be performed by using different agricultural machines.

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