Selcuk Journal of Agriculture and Food Sciences
http://sjafs.selcuk.edu.tr/sjafs/index
Research Article

Selcuk J Agr Food Sci
(2023) 37(1), 179-187
e-ISSN: 2458-8377
DOI: 10.15316/SJAFS.2023.018

Evaluation of Energy Efficiency of Different Sowing Methods in Grain Corn Production

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HIGHLIGHTS

- Grain yields of conventional, cross and parallel corn planting methods were determined.
- Energy inputs and outputs of conventional, cross and parallel sowing methods have been determined.
- Energy efficiency of conventional, cross and parallel sowing methods has been determined.
- Energy efficiency was compared between conventional, cross and parallel sowing methods

Abstract

In the study, the mean germination time (MED) was determined as 16.6 days, 21.08 days, and 9.75 days in the conventional sowing method, cross double row sowing method and parallel double row planting method, respectively, and the germination rate index (ERI) in the same order. It was found as 0.31 - 0.52 - 0.40 pieces/m day. Grain yield was 15260 kg/ha in conventional sowing method, 22330 kg/ha in cross double row sowing method and 18300 kg/ha in parallel double row sowing method. As a result of the experiments and calculations, the net energy yield was found to be 297.353,23 MJ/ha, 238.986,57 MJ/ha, 194.782,97 MJ/ha, respectively, then the cross-double row planting method, parallel double row planting method and conventional planting method. The maximum energy efficiency was obtained in the cross-double row planting method as 0.79 kg/MJ, followed by the parallel double row planting method and the conventional planting method with the values of 0.66 kg/MJ and 0.55 kg/MJ, respectively. The maximum output/input ratio was found in cross double row planting with 11.54%, then parallel double row planting with 9.59% and conventional planting with 8.03%. This study reveals that the cross-planting method is more advantageous than other methods and that this method can be used economically.

Keywords: Energy efficiency, Cross double row planting, Parallel double row planting

1. Introduction

One of the problems caused by various global causes and uncontrolled population growth in the world is the increasing need for food resources. This unfavourable situation has once again revealed the importance of agricultural production. It is known that increasing the food resources will be realised by expanding the

Citation: Citil E, Kırılmaz H, Marakoğlu T (2023). Evaluation of energy efficiency of different sowing methods in grain corn production. *Selcuk Journal of Agriculture and Food Sciences*, 37(1), 179-187. https://doi.org/10. 15316/SJAFS.2023.018
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Received date: 04/01/2023
Accepted date: 31/03/2023

agricultural lands where agricultural production is made and increasing the amount of product obtained from the unit area. The increase in population leads to the growth of human living areas and industrialisation and causes a decrease in agricultural lands, which in turn leads to a decrease in agricultural production and a decrease in human and animal food resources.

Maize plant is cultivated in our country due to the reasons such as the high yield of the product obtained from the unit area and the effective use of agricultural machinery compared to other products, and the production area and production amount are increasing every year. In general, a significant portion of the maize produced in our country and in the world is used as feed in the food sector and animal husbandry, and some of it is utilised in different industrial sectors. As a result of the increasing use of advanced agricultural machinery, there are about seven varieties of maize used for different needs (Sönmez et al., 2013).

Bakal and Arıoğlu, (2013) stated that the highest seed yield was obtained 112.97 kg/da in double row sowing method, while the lowest seed yield was obtained from single row classical sowing method with 84.87 kg/da yield.

Cox et al. (2006) determined that the yield obtained from the planting method with narrow row spacing was higher than the yield obtained from the planting method with 76 cm row spacing.

Taşçılar, (2008) reported that the highest yields were obtained from the double row sowing method in a 2-year study to determine the effect of different sowing densities on green grass yield and grain yield in single and double row sowing methods in the production of main crop grain maize and silage maize. As a result of the 2-year study, it was reported that double row sowing method was 4.6-6.9% and 7.6-10.0% higher in green grass and grain corn yield, respectively, compared to single row sowing method.

In agricultural production, it is always desirable to obtain the maximum yield with minimum energy inputs (Alam et al., 2005). With the efficient use of energy in agriculture, not only financial savings will be achieved, but also the reduction of fossil fuel consumption and consequently the reduction of air pollution will be ensured. As a result, sustainable agricultural production will be made (Uhlin, 1998; Azarpour et al., 2013).

This study was conducted to determine the energy efficiency of different sowing methods in the production of grain maize, which has an important place in terms of the economy of our country. This study was carried out to determine the most suitable planting method for maize production by comparing three different methods as conventional maize planting, cross double row maize planting and parallel double row maize planting after tillage.

2. Materials and Methods

The experiments were carried out in Sarıcalar Application Farm of Selçuk University, Faculty of Agriculture. The plot sizes were 6x100 m for each treatment. In order to determine the energy efficiency of conventional sowing, cross double row sowing, and parallel double row sowing methods in maize grain production, the experiments were carried out in irrigated agricultural conditions with 3 replications. The total annual rainfall of the experiment area was 272.5 mm.

In the sowing process, a 4-row pneumatic cross double row precision sowing machine was used and the conventional single row and double row sowing methods were carried out with the same machine. Single row sowing was carried out by closing each unit of the double rows in the machine. The working width of the double row seeder used during the sowing process was 280 cm.

Figure 1. Twin row pneumatic precision seed drill used in the trial

The maize variety used in the experiment is in the FAO 500 maturity group and has a growing period of 110 days. Since it is an early variety, it can easily adapt to arid conditions and water stress. It is widely cultivated as grain in Central Anatolia region.

In the 1st application, after tillage, conventional maize sowing was carried out with 70 cm between rows and 16 cm above rows with a plant density of 8900 seeds/ha (Figure 2).

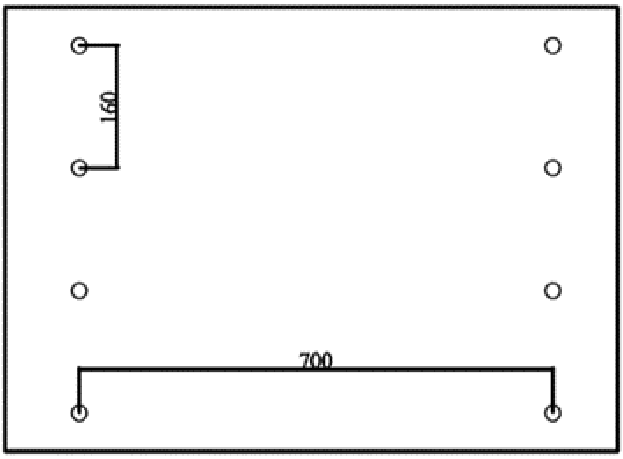

Figure 2. Conventional maize sowing practice

In the 2nd application, after tillage, double row cross sowing method was applied with a plant density of 16428 seeds/ha with 50 cm between rows (70 cm between centres) and 16 cm above rows (Figure 3).

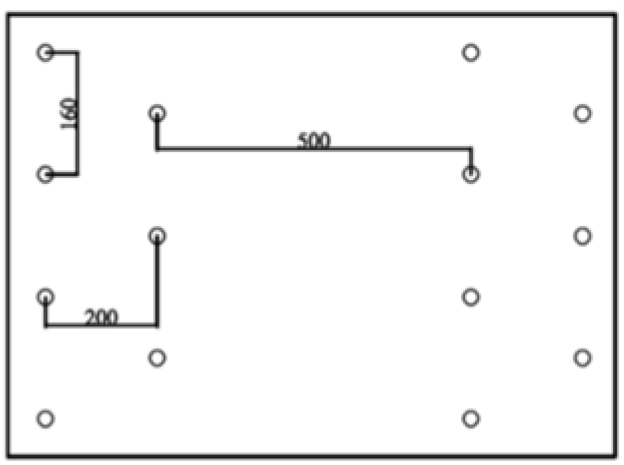

Figure 3. Double row cross sowing method

In the 3rd treatment, sowing was done after tillage (parallel) with double row sowing method with a plant density of 8900 seeds/ha with 50 cm between rows (70 cm between centres) and 25 cm above rows (Figure 4).

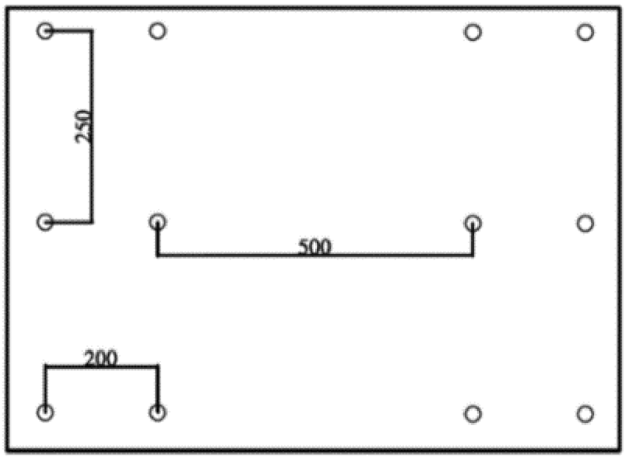

Figure 4. Double row sowing application

In order to determine the average germination date, germination rate index and field sprout emergence values of maize, 3 randomly selected strips of 1 m length from 3 different lines in each plot were observed during the germination period and the sprouts emerging on the soil surface were counted and calculated using the following relations (Konak and Çarman, 1996).

$$MED = \frac{N_1D_1+N_2D_2+\cdots.N_nD_n}{N_1+N_2+\cdots.N_n} \quad (1)$$

$$ERI = \frac{Total\ Number\ of\ Germinated\ Seeds\ in\ One\ Metre}{MED} \quad (2)$$

$$FED = \frac{Total\ Number\ of\ Germinated\ Seeds\ in\ One\ Metre}{Total\ Number\ of\ Seeds\ Sown\ in\ one\ Metre} \quad (3)$$

MED: Mean germination time (days)

N: Number of germinated seeds in each count

D: Number of days after sowing (days)

ERI: Germination rate index (pcs $m^{-1}day^{-1}$)

FED Field shoot emergence degree (%)

Table 1. Inputs and outputs in the Energy Balance Sheet

Specifications		Unit	Energy Equivalent (Mj/Unit)	References
A. Inputs				
Labour force		h	2.3	Kızılaslan(2009),Barut et al. (2011)
Machine		h	121.3	Doering (1980), Barut et al. (2011)
Tractor		h	158.3	Doering (1980), Barut et al. (2011)
Fuel-oil		L	41	Reinhardt, 1993
Drug		kg	120	Çanakçı et al.,(2005);Mandal et al.,2002; Singh 2002
Fertiliser	N	kg	60.6	Bojaca ve Shrevens (2010) Öztürk(2011)
	P	kg	11.1	Kaltschmittc ve Reinhardt, 1997
Irrigation		m^3	2.93	Çalışır (2007)
Seed		kg	14.58	Pimentel (1980)
B. Output				
Grain		kg	14.58	Pimentel (1980)

Table 2. Energy use units

Parameters	Unit	Definitions
Total energy input	MJ /ha	EI
Total energy output	MJ/ ha	EO
Total energy output	MJ/ ha	Total energy output - Total energy input
Outpru/İnput rate	%	Total energy output / Total energy input
Net energy rate	%	Net energy yield / Total energy input
Energy efficiency	Kg/ MJ	Grain and biomass yield / Total energy input
For unit product energy required	MJ/ kg	Total energy input / Grain and biomass yield

Table 3. Agricultural machinery used in the experiment

	Work width (cm)	Conventional sowing method (L/ha)	Cross double row sowing method (L/ha)	Parallel double row sowing method (L/ha)
Plough	187,5	18.2	18.2	18.2
Cultivator+ rotary harrow (2 times)	320	10.9	10.9	10.9
Roller	280	9.1	9.1	9.1
Pneumatic single grain sowing machine	280	9.5	7.5	7.5
Mineral fertiliser spreading machine	1000	3	3	3
Spraying machine	1000	3	3	3
Intermediate hoeing machine	195	5.5	5.5	5.5
Total		70.1	68.1	68.1

3. Results and Discussion

The mean germination time (MED) values varied between 16.6 days and 21.08 days. Germination rate index values were found between 0.31 and 0.52 pcs m.day^{-1} (Table 4).

Table 4. MED, ERI, FED values of the applications

	MED (days)	ERI pcs/m day	FED (%)
Conventional sowing method	16.6	0.31	100
Cross double row sowing method	21.08	0.52	100
Parallel double row sowing method	19.75	0.40	100

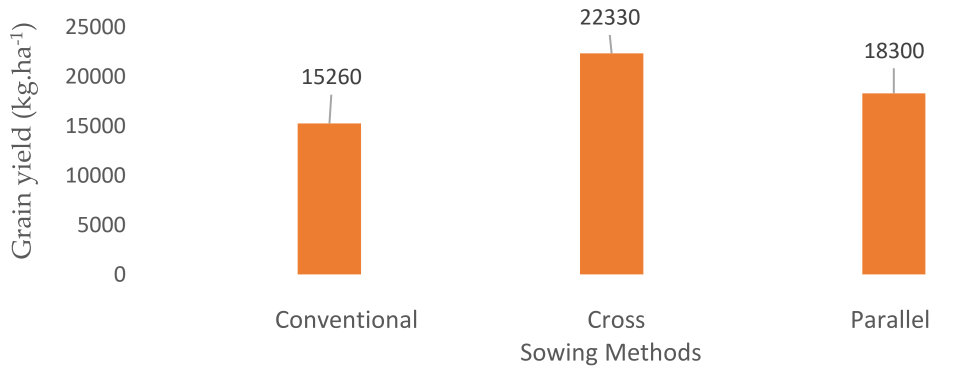

Figure 5. Applications grain yield

Table 5. Energy input and output of applications

A. Inputs		Conventional		Cross		Parallel	
		MJ/ha	%	MJ/ha	%	MJ/ha	%
Labour		11.96	0.04	11.96	0.04	11.96	0.04
Tractor		267.45	0.97	267.45	0.95	267.45	0.96
Machine		197.83	0.71	235.43	0.83	235.43	0.85
Fuel-oil		2792.10	10.08	2874.10	10.19	2874.10	10.33
Drug		276.20	1.00	276.20	0.98	276.20	0.99
Fertiliser	N	9792.96	35.34	9792.96	34.70	9792.96	35.19
	P	1223.22	4.41	1223.22	4.33	1223.22	4.40
Irrigation		12716	45.89	12716	45.06	12716	45.70
Seed		430.11	1.55	820,85	2.91	430.11	1.55
Total Input		27707.83	100	28218.17	100	27827.43	100
B. Output							
Yield		222.490,80		325.571,40		266.814,00	

As seen in Table 5. It is seen that irrigation energy has the highest share among the production inputs of the treatments, followed by Energy input and output of applications fertiliser, fuel-oil, seed, machinery and pesticide energies, respectively.

The share of irrigation energy values in total energy inputs was determined as 45.89%, 45.06% and 45.70% for conventional, crossed double row and parallel double row sowing methods, respectively. Fertiliser energy values were determined as 39.75%, 39.03% and 39.59% for the conventional and parallel double row sowing methods, respectively.

The reason why seed inputs are higher in cross sowing method than other methods is due to the high number of seeds per unit area.

Table 6. Energy rates of applications

	Conventional	Cross	Parallel
EI	27.707,83	28.218,17	27.827,43
EO	222.490,80	325.571,40	266.814,00
Net Energy Yield	194.782,97	297.353,23	238.986,57
Output/Input Ratio	8.03	11.54	9.59
Net Energy Ratio (%)	7.03	10.54	8.59
Energy Efficiency (kg/MJ	0.55	0.79	0.66
Energy Required for Unit Product (MJ/kg)	1.82	1.26	1.52

As seen in Table 6. When the treatments were analysed in terms of the energy value required for the production of one kg of product, the best result was obtained from the cross-double row sowing method with 1.26 MJ/kg, followed by the parallel double row sowing method and the conventional sowing method, respectively.

In terms of net energy yield, the highest value among the treatments was obtained from cross double row sowing method with 297.353,23 MJ/ha, followed by 238.986,57 MJ/ha from parallel double row sowing method and 194.782,97 MJ/ha from conventional sowing method.

When the treatments were analysed in terms of energy efficiency, the highest energy yield was obtained from the cross-double row sowing method with 0.79 kg/MJ, 0.66 kg/MJ from the parallel double row sowing method and 0.55 kg/MJ from the conventional sowing method.

Table 7. Energy types of applications

Energy Input Types	Conventional		Cross		Parallel	
	Energy Input (MJ/ha)	Rate (%)	Energy Input (MJ/ha)	Rate (%)	Energy Input (MJ/ha)	Rate (%)
Renewable Energy (Human Labour, Water, Seed)	13.158,07	47.49	13.548,81	48.01	13.158,07	47.28
Non-Renewable Energy (Fuel, Fertiliser Drug, Machinery)	14.549,76	52.51	14.669,36	51.99	14.669,36	52.72
Total	27.707,83	100	28.218,17	100,00	27.827,43	100
Direct Energy (Human Labour, Water, Fuel)	15.520,06	56.01	15.602,06	55.29	15.602,06	56.07
Indirect Energy (Seed, Fertiliser, Chemicals, Machinery)	12.187,77	43.99	12.616,11	44.71	12.225,37	43.93
Total	27.707,83	100	28.218,17	100,00	27.827,43	100

-The net energy yield per unit area obtained from the cross-double row sowing method was 52.6 % higher than the conventional sowing method and 24.44 % higher than the parallel double row sowing method.

When the practices were evaluated in terms of energy efficiency, it was determined that the energy efficiency of the cross-double row sowing method in production was 43 % higher than the conventional sowing method and 19,6 % higher than the parallel double row sowing method.

The output/input ratio obtained from the cross-double row sowing method was 43.7 % higher than the conventional method and 20.3 % higher than the parallel double row sowing method.

Energy consumption per unit crop was found to be 44.4 % higher than cross double row sowing and 19.7 % higher than parallel double row sowing.

-The fact that the energy required for the unit crop amount is less in the cross-double row sowing method compared to the other methods, and that the cross and net energy yield is the highest in the cross-double row sowing method, is effective in the formation of the opinion that the double row sowing method is economically feasible and can be an alternative application to other applications.

-The fact that the yield obtained in the cross-double row sowing method is higher than the other methods despite the high input in the cross-double row sowing method, the net energy ratio is 49,9 % higher than the conventional sowing method and 22,7 % higher than the parallel double row sowing method.

As seen Table 7. It was determined that the ratio of renewable energy was the highest and the ratio of non-renewable energy was the lowest among the energy inputs of the cross-double row sowing method.

The above-mentioned evaluations show that the cross-sowing method is more advantageous than the other methods and that this method can be used economically

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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