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DEVELOPMENT AND EVALUATION OF SMALL-SCALE POWER WEEDER

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ABSTRACT

Small-scale power weeders are an important and challenging task in many countries, where the farm size in hectare per capita is very low and is declining over time. Therefore, the development of suitable mechanized weeding methods is an imperative to meet the demand for farmers. An economical mechanical power weeder that can be used as inter and intra-row weeding method was developed and evaluated in triple hybrid 314 variety of maize. Developed power weeder consisted of engine, blades assembly and transmission system. Modified vertical blades were used with the weeder and mounted on a circular rotating element on its horizontal side; the motion was transferred to blades units by amended transmission system. The effect of weeder forward speeds, depth of operation, number of blades and soil moisture content on fuel consumption, plant damage, weeding index, effective field capacity, field efficiency, energy required per unit area and total cost were studied. Three levels of soil moisture content (7.73, 12.28 and 16.18 %), two blades arrangements (two and four vertical blades for each unit), three weeder forward speeds (1.8, 2.1 and 2.4 km/h) and two depths of operation (from 0 to 20 and from 20 to 40 mm) have been chosen. The results showed that, the minimum value of fuel consumption was 0.546 l/h and recorded by using two blades with 1.8 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. The highest field efficiency was 89.88% by using two blades with 1.8 km /h weeder forward speed at depth of operation ranged from 0 to 20 mm and soil moisture content 16.18%. The minimum value of effective field capacity was 0.198 fed/h by using four blades, weeder

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forward speed 1.8 km/h, soil moisture content 7.73% and under depth of operation ranged from 20-40 mm. The lower value of total cost was 55.09 L.E /fed and was obtained by using two blades with 2.4 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %.

Keywords: Mechanical weeding, small-scale, vertical blades, powered weeder, weeding index.

INTRODUCTION

In Egypt, Maize is essential for livestock and human consumption as an available source of carbohydrate, oil and slightly for protein, where the production quantity of this crop in the year 2011 was 6876473 tonnes ***(FAO, 2011).*** Competition between maize and weeds is still a serious challenge to crop production; weeds compete with maize crop for nutrients, light, space and water, therefor weed control between rows (inter-row) and within rows (intra-row) in maize plants are necessary and important to achieve maximum productivity. Mechanical weed control is effective in controlling weeds as well as it benefits the crop by breaking up the surface crust, aeration of soil, stimulating the activity of soil microflora, reducing the evaporation of soil moisture and facilitating the infiltration of rainwater. ***Hemeda and Ismail (1992)*** developed and evaluated a cultivator for inter-row cotton cultivation, the idea was to construct and develop a combined sweep type tool to be used extensively for grass and weed control. This type is considered highly efficient in smoothing the soil surface, but it caused the drifting of weeds without cutting. Two shares were added on both sides of the main sweep at different angles (15, 20 and 25°) to improve the weed cutting efficiency among rows. ***Pitoyo et al. (2000)*** reported that the development of a power weeder for mechanical control of weeds in the rice field. The machine is driven by two strokes engine 2HP/6500 rpm. The machine performance was 15 hours/ha capacity at traveling speed 1.8 km/h. the mass of the machine was 24.5 kg. The pulverizing effect caused by turning of hexagonal ratavator could destroy weed effectively. ***(Singh, 2001)*** indicated that Mechanical cultivation is still the most important method used in controlling weeds and still, generally, the most economical method, which is recommended from the standpoint of pollution of the environment. As an example for required cost to operate a rotary weeder, the cost of weeding was 63% more than wheel hand hoe and 72% less than chemical control. ***Pannu et al. (2002)*** evaluated a self-propelled, engine operated power weeder, which has a diesel engine of 3.8 hp (2600 rpm), as a power source, this weeder was found to be suitable for weeding in wider row crops like maize, cotton, sugarcane etc. The moisture content of the soil at the time of evaluation was 17-18 %; the depth of operation ranged from 4-7 cm, the weeding efficiency of 88% was obtained. ***Victor and Verma (2003)*** designed and developed a power operated rotary weeder for wetland paddy. A 0.5 hp petrol driven engine was used for power weeder with a reduction gear box. The power transmission from engine to traction wheel and to the cutting unit was provided. They concluded that with 200 mm spacing, the field capacity of the machine varied between 0.04-0.06 ha/h with field efficiency of 71 %. The weeding efficiency of the machine was 90.5%. ***Alexandrou et al. (2003)*** evaluated the finger weeder and obtained weed efficiency results of 61%. ***Manian and Arvinda (2004)*** developed and evaluated weeding cum earthing equipment for cotton. The unit was evaluated for its performance with the available weeder and conventional method of weeding. Manual weeding using hand hoe registered the maximum efficiency of 82.56 percent (wet basis). The weeding efficiency of tractor drawn weeding cum earthing up equipment was 60.24 percent (wet basis). ***(Cloutier et al., 2007)*** stated that mechanical weed control is generally widespread and used by farmers who do not use herbicides and recommendations always come to control weed during the early crop stages because limited tractor and cultivator ground clearance and machine-plant contact may potentially damage the crop foliage at later growth stages**.**

To control weeds within the crop rows, mechanical intra-row weeder is developed and accomplishes their goal using two different approaches depending on the crop density. The first approach is to use selective machines or add-on tools that can perform weed control close to the crop, The second approach is to use machines that have weeding tools that move sideways to conduct weed control around the crop canopy. The finger weeder is a simple mechanical intra-row weeder that uses two sets of steel cone wheels to which rubber spikes (fingers) are affixed. ***Manuwa et al. (2009)*** designed and developed a power weeder with a working width of 0.24 m for weeding in row crop planting. Effective field capacity, fuel consumption and field efficiency of the machine were 0.53 ha/h, 0.7 l/h and 95%, respectively**.** ***Cordill and Grift (2011)*** addressed the related problem of achieving mechanical intra-row weed control in maize, and successfully design a machine to remove weed within the row by enabling dual tine carriers to engage the soil whilst circumventing the maize stalks. ***Bin Ahmad (2012)*** suggested that to design an effective intra-row power operated weeder; the weeder should be targeted for different scale crops production and to achieve intra-row weed control efficiency of 80% or more. Also, the weeder should be able to control weeds with minimal crop plant damage with low bulky overall dimensions of the weeder.

In addition, different types of power operated weeders have been developed and evaluated around the world;

Under Egyptian condition, the control of weeds and grasses has always been one of the greatest time and labor consuming operation in the crop production, in addition to that, farm sizes are gradually declining over time due to the fragmentation of agricultural holdings. Therefore, the present work has been planned with the following specific objectives:

1. To develop an economical small-scale power operated weeder suitable for small farm holder in Egypt.
2. Study the performance of the weeder and its new designed vertically rotating blades as new concept for mechanical weed control.

MATERIALS AND METHODS

This part is including materials and methods adopted for the development and field performance of small-scale power weeder. This study was conducted in the Rice Mechanization Research Center (RMC), Meet El-Deeba, Kafrelsheikh Governorate, Egypt during agriculture season 2012 for maize crop variety of triple hybrid 314.

1. Development of power weeder:

The power operated weeder is developed to carry out the weeding operations in the field, where, the weeder moves due to the thrust provided by the soil engaged vertical blades. The major parts of the power weeder are engine, blades assembly and transmission system.

1.1. Weeder engine:

Engine is mounted on the back side of the machine while sets of vertical blades on the front side to provide stability and easy handling. The power source of cultivating unit was taken from the prime mover of Kubota AR120 rice and wheat reaper after separating the reaping unit. As the main goal of the proposed research is to use minimum power required to run the developed power weeder, the chosen engine was classified as small engine size. The continuous rated output of the engine is 3.5 hp.

1.2. Designs of vertical rotating blades:

To develop and design the power weeder blade, functional requirement and consideration were:

a) Blade should be able to cut the soil properly without causing unnecessary damage to the sharpening edge.

b) The blades should be preferably designed, so that they do not enter the soil at the same time, but gradually (this helps in reducing the impact of the blades on the soil).

c) The speed of the blade and forward speed of machine should be adjusted to cut sufficient uniform part every time with considering that the bottom uniformity of the furrow is more or less.

So, locally manufactured vertical type blades were used in the study and mounted on a circular rotating element on its horizontal side. The available types of blades in markets were mostly rotary blades that can be fixed around the main rotating shaft periphery in rotary weeders. Therefore, the shape and dimensions of blades were determined as modified L-shape with angled cutting edge (Figure 1). Different parameters used in the study and have been in consideration to give safe strength and bending values for manufactured blades during weeding operation,

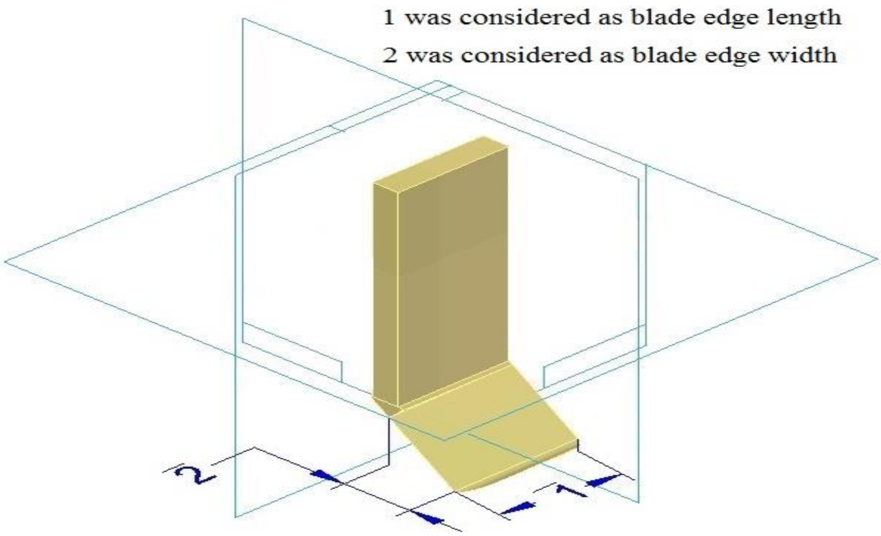


Figure 1: Expected shape of designed blade for power weeder (1: was considered as blade edge length, 2: was considered as blade edge width).

The calculation and assumptions are based on standard handbook of machine design were followed (Shigley et al., 2004). Assumption was made as follows; Number of blades in one working set = 4; Length of blade = 6 cm; Width of blade = 5 cm. to calculate the design strength of blade, we considered; revolution per minute as engine output (N) = 1200 r.p.m; radius of engine output rotor (R) = 0.017 m. Therefore, speed of engine output (u) will be:

$$u = 2\,\pi\,R\,N = 2\,\pi \times 0.017 \times 1200 = 128.2 \text{ m/min} \quad \ldots\ldots\ldots\ldots\ldots.. (1)$$

Moreover, expected Length of soil slice, $L = \frac{V}{U}\,\frac{2\,\pi\,R}{Z}$ ………..…. (2)

Where; V = Average forward speed of the machine (35 m/min); U = Peripheral velocity provided by engine (128.2 m/min at 1200 rpm); R = 50 mm as a maximum required depth of cut; and Z = Number of blades so, L will be:

Maximum force required to cut the soil for each blade (P);

$$P = p\,A = 0.57 \times 2.2 \times 6 = 7.524 \text{ kg / each blade} \quad \ldots\ldots\ldots (3)$$

Where; P = Specific resistance of soil = 0.57 kg/cm^2 (for medium firm soil); A = Area to be disturbed, A= a × length of soil slice; and a =

Assumed edge length of the blade. If we have maximum four blades but only one can cut and disturb the soil, and 3 sets in the power rotor, so the maximum force required to cut the soil by the weeder.

$$P_{max} = 7.524 \times 3 = 22.57 \text{ kg}$$

Cutting force per unit length of blade (p_a) = $\frac{22.57}{6}$ = 3.76 kg/cm length of blade.

Taking this as beam (cantilever) with uniformly distributed load, both maximum bending load and moment of inertia can be calculates as below:

Maximum bending load = $\frac{p_a a^2}{2} = \frac{3.76 \times 6^2}{2} = 67.68 \text{ kg} \cdot \text{cm}$ ….. (4)

Moment of inertia = $\frac{1}{12} ed^3 = \frac{1}{12} \times 0.7 \times 5^3 = 7.29 \text{cm}^4$ …………..…. (5)

Where; d is assumed width of blade edge, 0.05 m; and e is assumed maximum thickness of blade edge, 0.007 m. To check for bending; deflection for cantilever beam = $\frac{p a^3}{3EI}$, Where; E = 2.1 × 10^6 kg /cm^2 for high carbon steel. The value will be:

Deflection = $\frac{22.57 \times 6^3}{3 \times 2.1 \times 10^6 \times 7.29} = 1.06 \times 10^{-4}$ cm …………………….…. (6)

It is almost negligible and for safe design deflection should be < a/1200 ($1.06 \times 10^{-4} < 5 \times 10^{-3}$), so, it is safe. The manufactured sets of blades are shown in Figure 2.

1.3. Power transmission system:

In order to provide suitable, smooth and effective motion to the weeder blades, a modified transmission system was used. A shaft transmits the power from gearbox to the side drive (chain and sprocket). It is simply supported over two bearings and is welded on one side to the gear. The sprocket is keyed to the shaft with the help of a key. The shaft has a step of 3.5 mm on the sprocket side to account for mounting of bearing and sprocket. The motion from side drive transferred by using chains and gears arrangements that transmit the power coming from the gearbox via a main transmission shaft to the rotor shaft.

Figure 2: The manufactured modified L-shape blades type with cutting edge.

Figure 3 shows the transmission system used in power weeder. To reverse the direction of motion that comes from the engine, a horizontal shaft equipped with bevel gears has been chosen carefully and according to **Khurmi and Gupta (2005).** According to calculations used to determine the required diameter of the rotating shaft, the recommended shaft diameter should not be less than 17 mm.

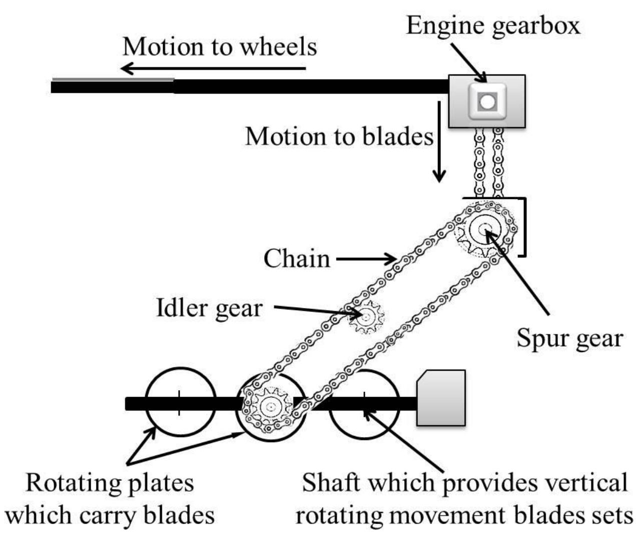


Figure 3: Plane view of transmission system used with power weeder.

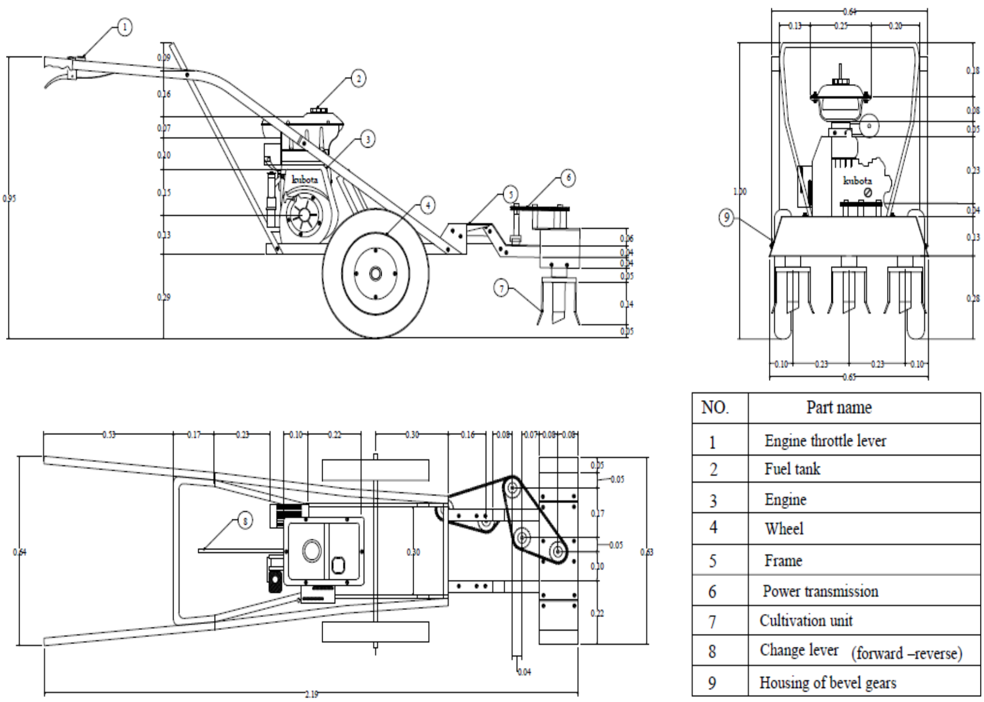
1.4. Assembling of power weeder:

After finalizing the dimensions of manufactured parts, assembling of all parts together was done and located in suitable frame, which carry the different units without baulking the performance of the engine and the weeder .Tests done to judge the machine transmission mechanisms as shown in Figure 4. Technical drawing of the machine is presented in Figure 5. From an operator's safety point of view, the chain and sprocket system was getting covered. Also, the rubber seal between the cover and housing of the chain valves was incorporated to avoid dust accumulation. Provision of check nuts on all the transmission shafts was provided.

Figure 4: Assembling of power weeder in the workshop and testing the mechanism of motion.

1.5. Depth of operation control arrangement:

In addition to the above mentioned arrangements done for the weeder, a depth of operation control device was used with the weeder; this arrangement makes the weeder working in a stable depth with minimum variation as shown in Figure 6.



NO.	Part name
1	Engine throttle lever
2	Fuel tank
3	Engine
4	Wheel
5	Frame
6	Power transmission
7	Cultivation unit
8	Change lever (forward –reverse)
9	Housing of bevel gears

Dim in m
Scale 1:25

Figure 5: Technical drawing of developed power weeder.

2. Field experimental treatments, technique and layout:

An area of 1.1 feddan of clay soil was used and divided into three parts for weeder experiments; every part consists of (31×50 m^2). Another part was left for traditional manually weed control method as a control. Each part of the field divided into 36 plots to cover the different variables with three replications. Each plot had width from 0.7 to 1 m (average 0.85 m) with fixed length for the field of 50 m.

Both independent and dependent variables used in the study were as shown in Table 1.

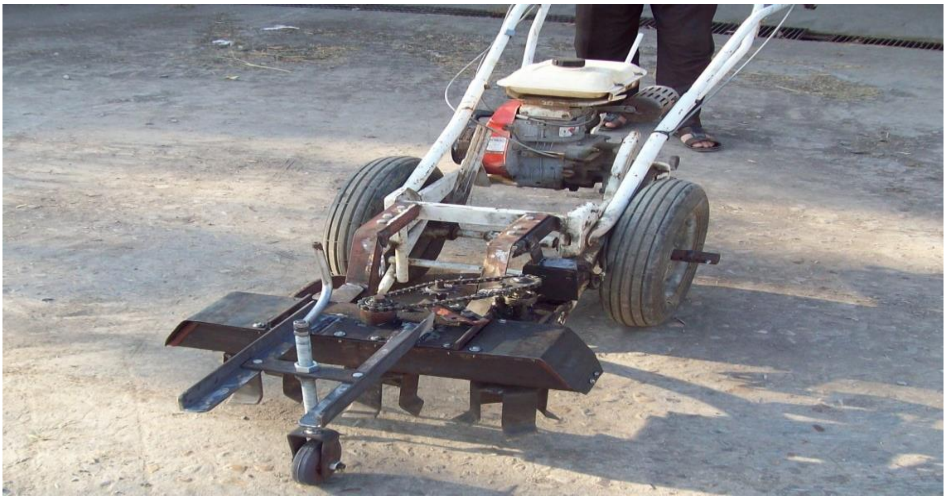


Figure 6: Arrangement done to control the depth of operation during usage of weeder as inter-row method.

Table 1: Independent and dependent variables.

Independent variables and their levels	
Soil moisture content	7.73, 12.28 and 16.18, % (dry basis)
Blades arrangement for each unit	Two and four vertical blades
Forward speed	1.8, 2.1 and 2.4, km/h.
Depth of operation	From 0 to 20 mm and from 20 to 40
Dependent Variables:	
Fuel consumption	Weeding Index
Plant damage	Effective field capacity
Field efficiency	Total cost
Energy required per agricultural unit area	

Standard tools, equations and methods have been used to measure all required variable in laboratories as well as in the experimental field. the split -split design was followed in the study. The experimental data was analyzed statistically. The analysis of variance (ANOVA) used by using XLSTAT package and the critical difference at 5% level of significance was observed for testing the significance of difference between different treatments and the standard deviation (S.D.) was generated too.

RESULTS AND DISCUSSION

Results of the study undertaken regarding the influences of some operational parameters have been presented and discussed in this part.

1 - Fuel consumption:

At soil moisture content 7.73 % the fuel consumption increased by 19.4 and 10.6 % when the depth of operation increased from 0-20 to 20-40 mm for 2.1 and 2.4 km/h and by using two blades respectively. Moreover, the increasing percentages in fuel consumption were 14.6 and 3.7 % when the depth of operation increased from 0-20 to 20-40 mm for 2.1 and 2.4 km/h weeder forward speeds and by using four blades respectively (Figure 7). Under different levels of soil moisture content, the results cleared that, there was a reduction in fuel consumption by 14 % when the soil moisture content increased from 12.28 to 16.18 % by using two blades with 1.8 km/h for weeder forward speed and depth of operation ranged from 20-40 mm. The minimum value of fuel consumption was 0.546 l/h and was recorded by using two blades with 1.8 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. While, the maximum value of fuel consumption was 0.936 l/h and was recorded by using four blades with 2.4 km/h weeder forward speed at depth of operation ranged from 20-40 mm and soil moisture content 7.73 %. Modelling data by using analysis of variance (ANOVA) in Table 4 showed that the two depths of operation had significant effect on fuel consumption with standard deviation (S.D.) 0.110.

2 - Effective field capacity:

Figure 8 shows that as the depth of operation increased, the effective field capacity decreased. At 7.73% soil moisture content when the depth of operation increased from 0-20 to 20-40 mm, the effective field capacity decreased from 0.204 to 0.199 and from 0.200 to 0.198 fed/h with 1.8 km/h weeder forward speed and by using two and four blades, respectively. In addition, it was clear that the effective field capacity increased with increasing weeder forward speed. Values of effective field capacity increased from 0.204 to 0.222 and from 0.199 to 0.217 Fed/h when the weeder forward speed increased from 1.8 to 2.1 km/h for two

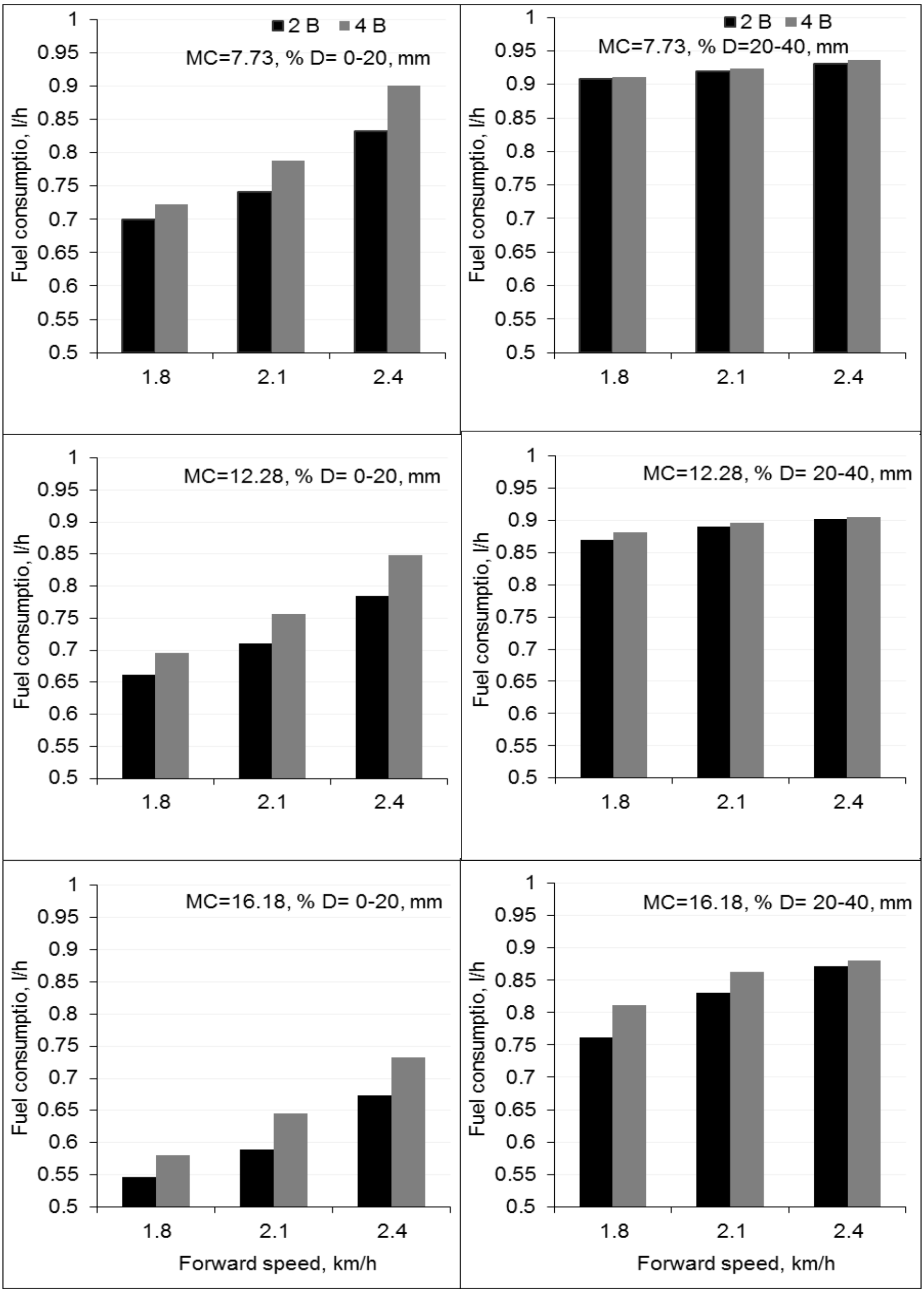


Figure 7: Effect of weeder forward speed, number of blades and depth of operation on fuel consumption at different soil moisture contents.

depths of operation 0-20 and 20-40 mm and by using two blades, respectively. At the different levels of soil moisture content 7.73, 12.28

and 16.18 % the values of effective field capacity were 0.204, 0.219 and 0.231 fed/h for 1.8 km/h weeder forward speed, 0-20 mm depth of operation and by using two blades. The maximum value of effective field capacity was 0.284 fed/h and achieved by using two blades with 2.4 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. Modelling data by using analysis of variance (ANOVA) in Table 4 showed that the soil moisture content and forward speed had significant effects on effective field capacity with standard deviation (S.D.) 0.023.

Table 2: Standard deviation and type III sum of squares analysis at 95% confidence interval excluding values of interaction at 2 levels for fuel consumption, effective field capacity, field efficiency and weeding index.

Fuel Consumption : Std. deviation (0.110)				
Source	DF	Sum of	Mean squares	F
Soil moisture content	2	0.270	0.135	853.684
Depth of operation , mm	1	0.741	0.741	4680.037
Forward speed, km/h.	2	0.166	0.083	524.363
Blades arrangement	1	0.026	0.026	165.441
Replications	2	0.001	0.000	2.998
Effective Field Capacity : Std. deviation (0.023)				
Soil moisture content	2	0.021	0.011	2038.107
Depth of operation , mm	1	0.002	0.002	300.398
Forward speed, km/h.	2	0.032	0.016	3044.266
Blades arrangement	1	0.001	0.001	135.131
Replications	2	0.000	0.000	0.063
Field Efficiency: Std. deviation (6.141)				
Soil moisture content	2	2350.263	1175.132	2108.597
Depth of operation , mm	1	177.973	177.973	319.345
Forward speed, km/h.	2	1309.365	654.682	1174.729
Blades arrangement	1	75.334	75.334	135.175
Replications	2	0.109	0.055	0.098
Weeding Index: Std. deviation (4.838)				
Soil moisture content	2	1353.033	676.516	549.179
Depth of operation , mm	1	463.846	463.846	376.539
Forward speed, km/h.	2	35.946	17.973	14.590
Blades arrangement	1	384.956	384.956	312.497
Replications	2	27.156	13.578	11.022

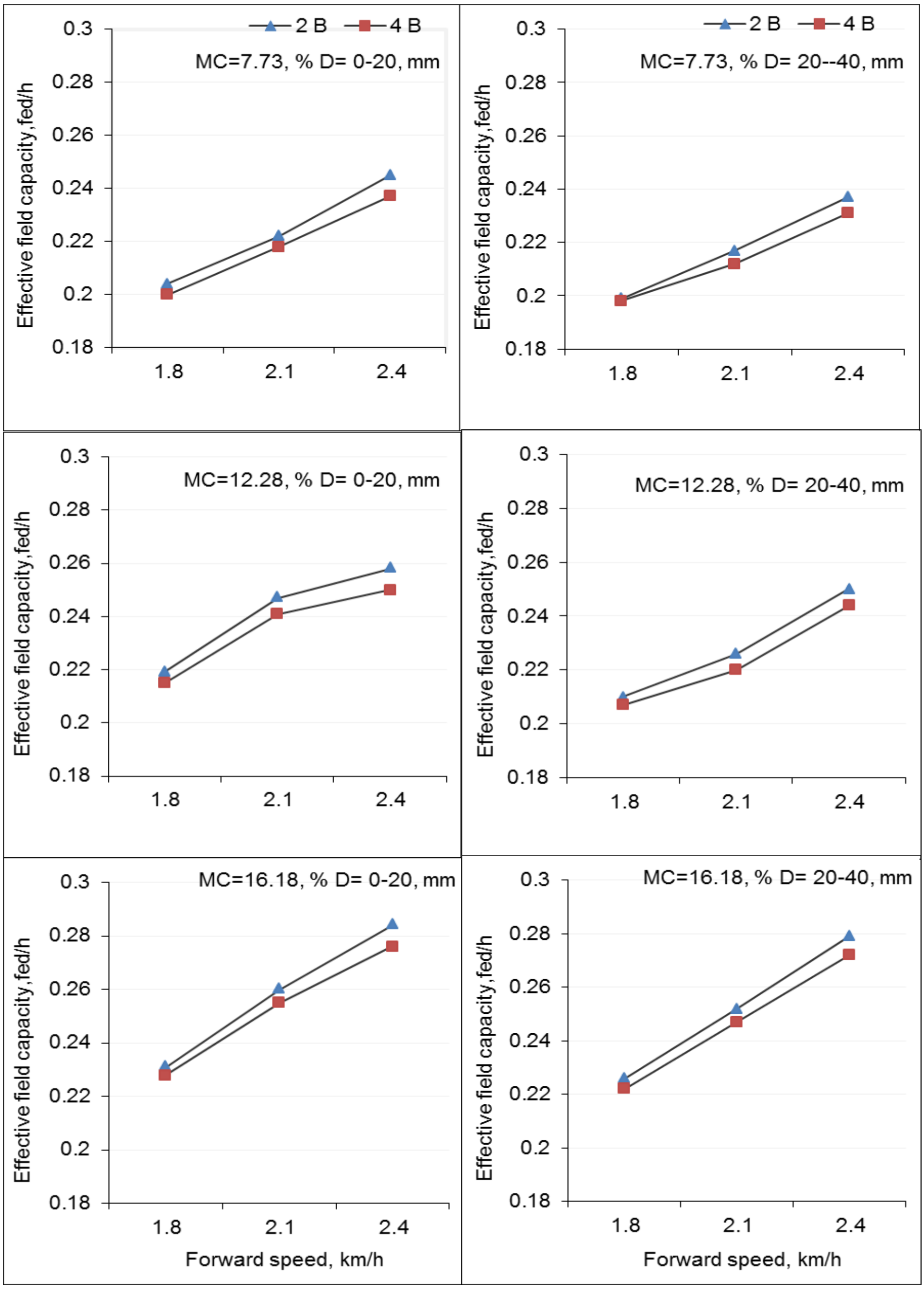


Figure 8: Effect of weeder forward speed, number of blades and depth of operation on effective field capacity at different soil moisture contents.

using four blades, that was observed under all the different variables used. The minimum value of field efficiency was 67.44% and was recorded by using four blades with 2.4 km/h weeder forward speed for 20-40 mm depth of operation. The maximum value of field efficiency was 89.88% and was recorded by using two blades with 1.8 km /h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18%. Modelling data by using analysis of variance (ANOVA) in Table 4 showed that the soil moisture content and forward speed had significant effects on field efficiency with standard deviation (S.D.) 6.141.

Table 3: Field efficiency as affected by various parameters.

Depth of operation, mm	**Forward speed, km/h**	**No of blades /set**	**Field efficiency, %**		
			Moisture content, %		
			7.73	12.28	16.18
0-20	1.8	2	79.37	85.05	89.88
	1.8	4	77.94	83.52	88.71
	2.1	2	73.77	82.44	86.55
	2.1	4	72.77	80.33	84.88
	2.4	2	71.42	75.41	82.79
	2.4	4	69.18	73.07	80.36
	Average		74.07	79.97	85.52
20-40	1.8	2	77.69	81.58	87.93
	1.8	4	76.91	80.54	86.63
	2.1	2	72.44	75.55	84.21
	2.1	4	70.66	73.44	82.33
	2.4	2	69.09	72.78	81.43
	2.4	4	67.44	71.23	79.39
	Average		72.37	75.85	83.65

4 - Weeding index:

The ratio between the numbers of weeds removed by weeder to the number of weeds present before weeding in a unit area has been calculated under different variable levels as weeding index. Figure 9 shows the effect of this variation on weeding index at 7.73, 12.28 and 16.18 % soil moisture content. At 7.73 %, it was clear that, as the depth of operation increased, the weeding index increased. As the depth of operation increased from 0-20 to 20-40 mm, the weeding index increased from 71.83 to 75.01 % and from 74.52 to 77.08 % with 1.8 km/h weeder forward speed and by using two and four blades, respectively. Also, it was clear that the weeding index decreased with increasing in weeder forward speed. Weeding index values decreased from 71.83 to 71.38% and from 75.01 to 74.91% when the weeder forward speed increased from 1.8 to 2.1 km/h for two depths of operation 0-20 and 20-40 mm and by using two blades, respectively. The maximum value of weeding index was 90.77 % and was obtained by using four blades with 1.8 km/h weeder forward speed at depth of operation ranged from 20-40 mm and 16.18 % soil moisture content. Modelling data by using analysis of variance (ANOVA) in Table 4 showed that the soil moisture content, depth of operation and blades arrangement had significant effects on weeding index with standard deviation (S.D.) 4.838.

5 - Plant damage:

The tillers, which were either cut by the blades or crushed beyond the recovery, were considered as damaged. Total number of tillers for a length of 5 m was counted before operation. The numbers of tillers damaged were counted for the same stretch of five meter. The plant damage was given by Plant damage percentages and calculated directly after cultivation. From Table 4 as the depth of operation increased, the plant damage percentage increased. However, it was observed that no damage occurred (zero %) at 1.8 km/h weeder forward speed by using two and four blades, when the soil moisture content was 7.73% and the depth of operation ranged from 0-20 mm. The maximum value of plant damage percentage was 1.93% and was recorded by using four blades with 2.4 km/h weeder forward speed at depth of operation ranged from 20-40 mm and 7.73% soil moisture content. Modelling data by using analysis of variance (ANOVA) in Table 7 showed that depth of operation and forward speed had significant effects on plant damage with standard deviation (S.D.) 0.501.

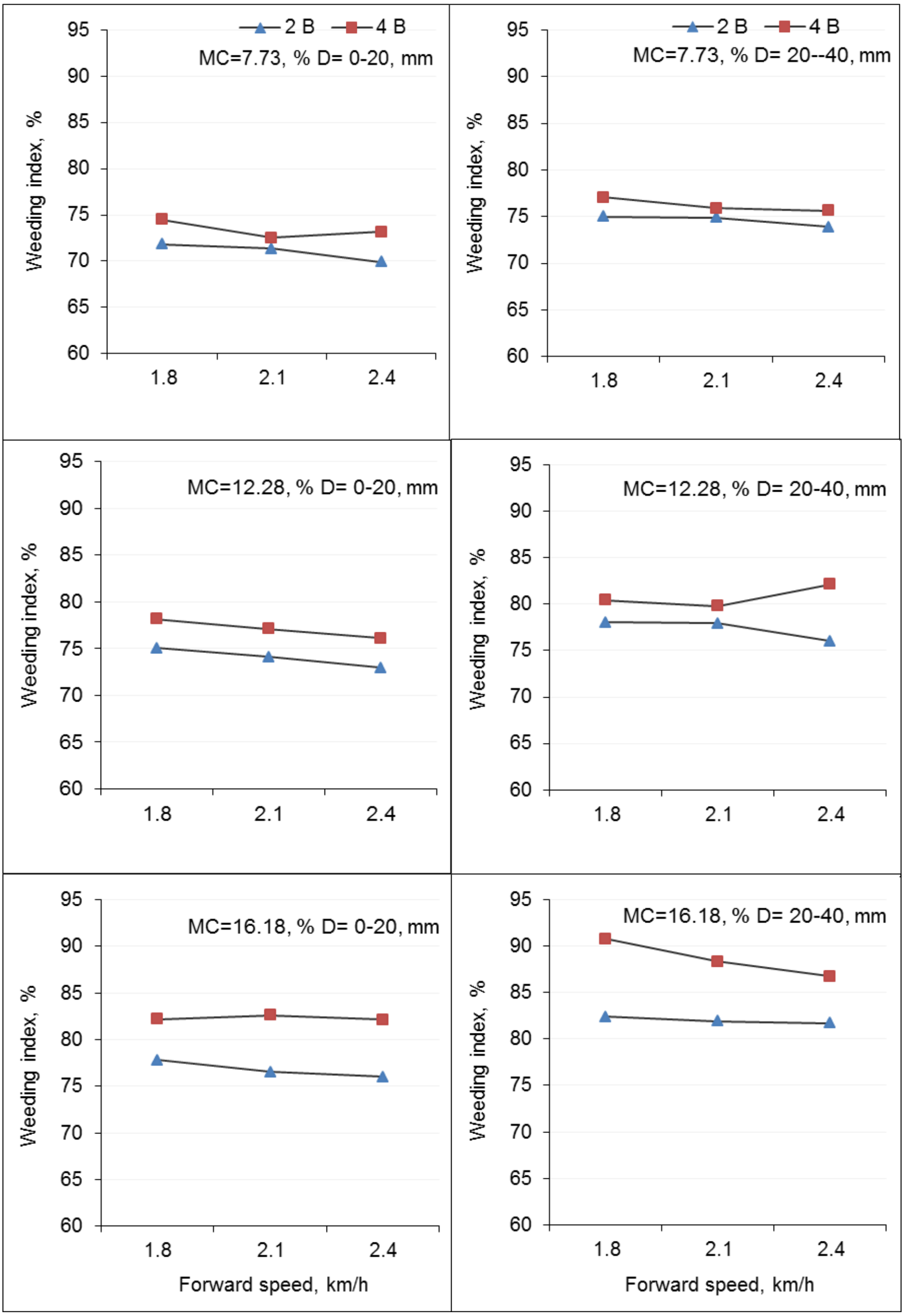


Figure 9: Effect of weeder forward speed, number of blades and depth of operation on weeding index at different soil moisture contents.

Table 4: Plant damage as affected by various parameters.

Depth of operation, mm	Forward speed, km/h.	No of blades /set	Plant damage percentages, % Moisture content, %		
			7.73	12.28	16.18
0-20	1.8	2	0	0	0
	1.8	4	0	0	0
	2.1	2	0.816	0.733	0.633
	2.1	4	0.966	0.866	0.750
	2.4	2	1.116	0.983	0.883
	2.4	4	1.400	1.150	1.016
	Average		0.716	0.622	0.547
20-40	1.8	2	0.683	0.583	0.516
	1.8	4	0.800	0.683	0.616
	2.1	2	1.080	0.900	0.750
	2.1	4	1.416	1.066	0.916
	2.4	2	1.700	1.416	1.166
	2.4	4	1.933	1.633	1.400
	Average		1.268	1.046	0.894

6 - Energy required per agricultural unit area:

Based on engine brake power and effective field capacity, the energy required per agricultural unit area was calculated. Figure 10 presents the effect of weeder forward speed, blades arrangements, soil moisture content and depth of operation on energy required per agricultural unit area. The energy required per agricultural unit area decreased from 6.423 to 5.661 kW.h/fed when the soil moisture content increased from 7.73 to 12.28 % by using two blades with 1.8 km/h weeder forward speed and depth of operation ranged from 0-20 mm. While, at the highest soil moisture content 16.18 % the value of energy required per agricultural unit area decreased to 4.429 kW.h/fed at the same operating conditions. The minimum value of energy required per agricultural unit area was 4.246 kW.h/fed and was obtained at soil moisture content 16.18 % by using two blades with 2.1 km/h forward speed of the weeder and depth of operation ranged from 0-20 mm. The maximum value of energy required per agricultural unit area was 8.634 kW.h/fed and was obtained at soil moisture content 7.73 % by using four blades with 1.8 km/h forward speed of the weeder and depth of operation ranged from 20-40 mm.

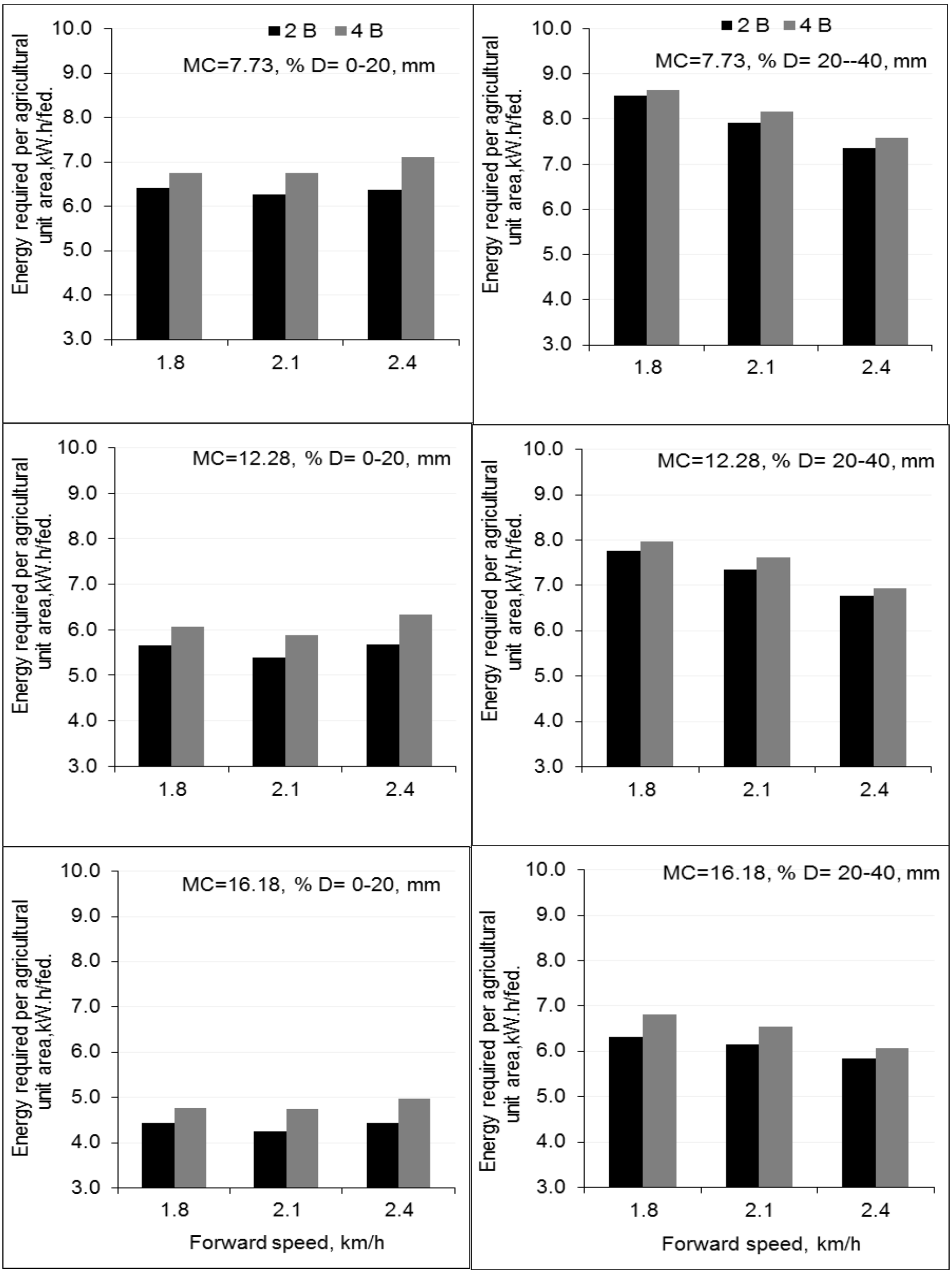


Figure 10: Effect of weeder forward speed, number of blades and depth of operation on energy required per agricultural unit area at different soil moisture contents.

Table 5: Standard deviation and type III sum of squares analysis at 95% confidence interval excluding values of interaction at 2 levels for plant damage, energy required per agricultural unit area and total cost.

Plant damage : Std. deviation (0.501)				
Source	DF	Sum of	Mean squares	F
Soil moisture content	2	1.346	0.673	285.056
Depth of operation , mm	1	5.267	5.267	2231.268
Forward speed, km/h.	2	17.938	8.969	3799.546
Blades arrangement	1	0.585	0.585	247.919
Replications	2	0.034	0.017	7.129
Energy required per agricultural unit area : Std. deviation (0.070)				
Soil moisture content	2	0.002	0.001	11.630
Depth of operation , mm	1	0.160	0.160	1874.945
Forward speed, km/h.	2	0.320	0.160	1869.632
Blades arrangement	1	0.002	0.002	20.097
Replications	2	0.000	0.000	2.341
Total cost : Std. deviation (6.681)				
Soil moisture content	2	1903.814	951.907	2217.948
Depth of operation , mm	1	238.402	238.402	555.478
Forward speed, km/h.	2	2479.863	1239.932	2889.048
Blades arrangement	1	66.207	66.207	154.263
Replications	2	0.048	0.024	0.056

7 - Total cost:

Table 6 presents total cost values obtained under different variables. When the depth of operation increased from 0-20 to 20-40 mm, the total cost increased from 76.84 to 79.58 and from 78.37 to 80.41 L.E/fed at 1.8 km/h weeder forward speed by using two and four blades respectively, and soil moisture content 7.73%. The percentages of total cost were increased from 3.75 and 2.76 % when the depth of operation increased from 0-20 to 20-40 mm for 2.1 and 2.4 km/h weeder forward speeds, respectively, by using four blades. However, it was clear that the total cost decreased with increasing in weeder forward speed. The values decreased from 76.48 to 71.01 and from 79.58 to 73.17 L.E/fed when the weeder forward speed increased from 1.8 to 2.1 km/h for two depths of operation 0-20 and 20-40 mm, respectively by using two blades. The minimum value of total cost was 55.09 L.E/fed and was recorded by using two blades with 2.4 km/h weeder forward speed under depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. The maximum value of total cost was 80.4 L.E/fed and was recorded by using four blades with 1.8 km/h weeder forward speed under depth of operation ranged from 20-40 mm and soil moisture content 7.73 %.

Table 6: Total cost as affected by various parameters.

Depth of operation, mm	Forward speed, km/h.	No of blades /set	Total cost, L.E /fed		
			Moisture content, %		
			7.73	12.28	16.18
0-20	1.8	2	76.84	71.50	67.17
	1.8	4	78.37	73.00	68.21
	2.1	2	71.01	63.42	59.92
	2.1	4	72.21	65.28	61.33
	2.4	2	64.55	60.94	55.09
	2.4	4	66.92	63.15	56.99
	Average		71.65	66.22	61.45
20-40	1.8	2	79.58	75.59	69.64
	1.8	4	80.41	76.63	70.91
	2.1	2	73.17	70.02	62.57
	2.1	4	75.03	72.06	64.14
	2.4	2	67.15	63.62	56.75
	2.4	4	68.82	65.02	58.25
	Average		74.03	70.49	63.71

CONCLUSIONS

Using such developed small powered mechanical weeder under different variables and conditions can lead to finalize suitable operating parameters to fit farmers need. Using four blades with forward speed 2.4 km/h and depth of operation ranged from 20-40 lead to higher fuel consumption, higher value of plant damage and more power required from engine to operate the weeder. The minimum value of effective field capacity was 0.198 fed/h and was obtained by using four blades, weeder forward speed 1.8 km/h, soil moisture content 7.73% and under depth of operation ranged from 20-40 mm. reducing the number of blades to two is a good option while using the machine at higher moisture content with 1.8 km/h forward speed with depth of operation up to 20 mm, in such condition the field efficiency was 89.88%. To minimize the total cost to be 55.09 L.E/fed using two blades with 2.4 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 % is recommended. Weeding index was increased by increasing the depth of operation, soil moisture content, number of blades in every set and by decreasing weeder forward speed. Whereas, the maximum value of weeding index was 90.77 % and was recorded at the highest soil moisture content 16.18 % by using four blades with 1.8 km/h weeder forward speed and depth of operation ranged from 20-40 mm.

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الملخص العربى

تطوير وتقييم آلة عزيق ميكانيكية للمساحات الصغيرة

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الهدف الرئيسي للبحث هو تطوير وتقييم وحدة عزيق صغيرة تستخدم للعزيق بين الصفوف وداخلها وتلاءم احتياجات ومتطلبات المزارعين لإجراء عملية العزيق خصوصا فى المزارع الصغيرة والمتوسطة الحجم. وأجرى ذلك باستغلال مصدر القدرة لآلة الحصاد اليابانية KUBOTA REAPER AR 120 حيث تمت عمليات التطوير والتصنيع والاختبارات الأولية للنموذج الأولى لوحدة العزيق فى ورشة ومزرعة مركز ميكنة الأرزبميت الديبة – معهد بحوث الهندسة الزراعية- كفر الشيخ على محصول الذرة الشامية (هجين ثلاثى ٣١٤) في موسم صيفي ٢٠١٢ على مساحة ١,١ فدان تقريبا. حيث تم تصنيع ٣ مجموعات عزيق راسية تم تركيبها على Reaper وتم تعديل نظام نقل الحركة من صندوق التروس وتحويلها من حركة ترددية إلى حركة راسية.

وتم دراسة تـأثير كل من المحتوى الرطوبى للتربة (٧,٧٣، ١٢,٢٨، ١٦,١٨٪ على اساس جاف)، عدد الأسلحة في وحدة العزيق (٢ و ٤ أسلحة)، السرعة الأمامية للعزاقة (١,٨، ٢,١، ٢,٤ كم/ساعة) وعمق العزيق (صفر الى ٢٠مم ومن ٢٠-٤٠مم) على استهلاك الوقود، السعة الحقلية، الكفاءة الحقلية، نسبة التلف في النباتات، معامل العزيق، الطاقة المطلوبة لوحدة المساحة والتكاليف الكلية.

<u>وقد أوضحت النتائج ان:</u>

- أعلى قيمة لاستهلاك الوقود هي ٠,٩٣٦ لتر/ساعة وذلك عند اقل محتوى رطوبى ٧,٧٣ ٪ وأكبر عمق للعزيق ٢٠– ٤٠مم وأيضا عند أعلى سرعة أمامية للعزاقة ٢,٤ كم/ساعة وأكبر عدد من الأسلحة ٤اسلحة لكل وحدة عزيق.

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- اعلى قيمة للسعة الحقلية الفعلية هى ٠,٢٨٤ فدان/ساعة عند محتوى رطوبى للتربة ١٦,١٨ ٪ وعمق عزيق من٠ــ ٢٠مم وسرعة أمامية للعزاقة ٢,٤ كم/ساعة وعدد من الأسلحة ٢سلاح لكل وحدة عزيق.
- كانت اقل قيمة لكفاءة مقاومة الحشائش (معامل العزيق) ٦٩,٩٣٪ وذلك عند محتوى رطوبى للتربة ٧,٧٣٪ وعمق للعزيق ٠ــ ٢٠مم وعدد من الأسلحة ٢سلاح لكل وحدة عزيق وعند سرعة أمامية للعزاقة ٢,٤ كم/ساعة.
- أعلى قيمة للطاقة المطلوبة لكل وحدة مساحة هى ٨,٦٣٤ كيلو وات.ساعة/فدان وذلك عند محتوى رطوبى للتربة ٧,٧٣٪ وعمق عزيق ٢٠-٤٠ مم وسرعة أمامية للعزاقة ١,٨ كم/ساعة عدد من الأسلحة ٤ سلاح لكل وحدة عزيق.
- بلغت اقل تكلفة تشغيل للعزاقة المطورة ٥٥,٠٩ جنيه / فدان وذلك عند استخدام أعلى سرعة أمامية للعزاقة ٢,٤ كم / ساعة وعدد من الأسلحة ٢ سلاح لكل وحدة عزيق وعمق عزيق ٠-٢٠ مم ومحتوى رطوبى للتربة ١٦,١٨٪.