DEVELOPMENT AND EVALUATION OF RAISED BED MACHINE TO SUIT FABA BEAN PLANTING

Tarek FOUDA[1], Abeer ABDELSALAM[1], Atef SWILAM[2], Mohamed El DIDAMONY[1]

[1]Tanta University, Faculty of Agriculture, Agriculture Engineering Department, Egypt, E-mails: tfouda628@gmail.com, abeergmal1369@gmail.com, agri.mid@gmail.com
[2]University of Zagazig, Faculty of Agriculture, Agriculture Engineering Department, Egypt, E-mail: a.swelam@cgiar.org

Corresponding author: tfouda628@gmail.com

Abstract

The research aimed to develop and evaluate the raised bed machine to suit faba bean planting with local materials. Metering plates were designed with different shapes index and slots shapes suitable for faba bean planting and tested at the Department of Agriculture Engineering, Faculty of Agriculture, Tanta University, Egypt. The raised bed machine was tested and evaluated under three different forward speeds (2, 3.5, and 4.5 km/h), and three different planting distances (D1, D2, and D3 were 15, 20, and 25 cm). The results indicated that the lowest percentage of missing hills, seed damage, germination ratio, and dispersion ratio were 1.4%,1.2%, 97.57%, and 8.5% at a forward speed of 2km/h and planting distance of 15 cm. The highest value of the actual field capacity, the lowest value of specific energy, and the lowest value of operating costs were 1.25 fed/h, 11. 66kW.h/fed, and 280 L.E./faddan (4,200 m^2), respectively for first metering plate (TPU Materials, Hole Length 19mm, Hole Width15mm, Slot Shape Ellipse and Shape Index1.76. Linear regression analysis were performed to predict the operating parameters for the raised bed machine the machine at different forward speeds during different planting distances.

Key words: *faba bean, local manufacture, raised bed machine, forward speeds, planting distances*

INTRODUCTION

Agriculture has an important role in the global economy and food security since it contributes significantly to the Gross domestic product [4].
The main leguminous crop in the world is the faba bean (*Vicia faba* L.). With the expansion of specialized areas. The faba bean is the most important cool season food and feed legume crop grown in various places across the world. The crop may grow in a variety of soil types and environmental conditions. Over 4.1 million households reported farming the crop on approximately 0.5 million hectares of land, yielding more than a million tonnes of grain [6, 1].
Beans (*Vicia faba* l.) are Egypt's most frequently grown as legume crop, accounting for the majority of cultivated area, total production, and consumption. Humans use beans (*Vicia faba* l.) as processed food because they provide a high-quality percentage of carbs (58%) and protein (28%), as well as several vitamins and minerals. With an average farmed area of 86.1 hectares per year and an average output of 4.47 tonnes per hectare, Egypt has the greatest bean production in the Mediterranean region [12].
Plowing the field to produce a series of linear incisions known as furrows is a traditional planting method. The seeds are subsequently dispersed across the field. This approach has severe disadvantages; such as seeds not being buried at the right depth or with sufficient space between them. The seeds that fall into the furrows are protected from the weather, and raking or natural soil erosion gradually covers them up [11].
Manual approaches' poor seed placement, low efficiency, late planting, and significant stiffness difficulties for farmers limit the size of the field that may be sown. The timeliness of operation is one of the most significant things that can be efficiently achieved via the right deployment of agricultural machinery [9].
The agricultural industry has various obstacles, including a lack of qualified labor to carry out agricultural activities and long

processing periods. Because the world's population is always growing, agricultural commodities are becoming more focused, as are industrial demands. Raised bed farming methods integrate the majority of conservation agriculture principles and have generated promising outcomes in a range of environmental circumstances. RBM has the ability to minimize field compaction and physically damaged soil structure, as well as save water and boost crop output while lowering the danger of water logging [16].

With a growing population and rising per capita food consumption, food demand is expected to soon outpace our ability to supply it. Combating this issue needs not just new agricultural areas, but also optimizing crop yields from existing agricultural land. Over the previous four decades, the world's expansion in this business has been considerable, with increased agricultural land use contributing to lower productivity. As a result, the agricultural sector has been able to increase output in response to increased food demand [10].

On three seed-metering systems, the influence of levels of factors such as forward speed, cell shape, and seed metering performance characteristics was studied. Mean seed spacing, miss index, and seed damage rose as forward speed increased for all metering plates tested, although multiple index decreased. The average seed spacing was 140.8 mm, which was near to the theoretical maximum of 150 mm. The best quality feed index was 1%, the worst miss index was 6.1%, and seed damage was 0.38 percent [15].

The main frame, seed hopper, seed metering mechanism, driving wheels, seed tube, furrow opener, furrow closer and push handle were all designed and tested for a manually row planter for field crop seeds. The designed machine had a high field capacity of 7.6 and 10.2 times for maize sowing at 1.89 and 2.61 km/h forward speeds, respectively, and 8.9 and 11.9 times for faba bean sowing at 1.83 and 2.58 km/h forward speeds, respectively, and the amount of seeds per hectare was reduced by 40 and 11.5 percent, respectively, when compared to manual planting. The overall cost of planted hectare by the single row planter was 95.92 & 96.63 % and 89.35 & 89.84 % less than manual planting at the two possible speeds [14].

Experiments were conducted in the laboratory as a function of metering device speed and cell size (1 seed/cell and 2 seed/cell). Experiments in the field were carried out to optimize machine forward speed and planting depth. Seed damage, plant dispersion, emergence, crop yield, specific energy, and planting cost were all investigated. According to the trial results, the created faba bean planter should be utilised under the following conditions: forward speed of 3.5 km/h, cell size of 2 seeds/cell, and planting depth of 50 mm. At ideal circumstances, the following results were obtained: plant emergence of 97.70%, seed yield of 3.99 ton/ha, ground wheel slip of 3.9%, necessary power of 4.04 kW, specific energy of 8.66 kW h/ha [5].

In this context, the research aimed to develop and evaluate the raised bed machine to suit faba bean planting with local materials. Metering plates were designed with different shapes index and slots shapes suitable for faba bean planting and tested at the Department of Agriculture Engineering, Faculty of Agriculture, Tanta University, Egypt.

MATERIALS AND METHODS

The raised bed machine (Photo 1 and Fig. 1) was designed and simulated at the Agricultural Engineering Department, Faculty of Agriculture then manufactured at Tanta Motors Abou Freikha Factory and tested at a privet farm in Kafer Essam, Tanta, Egypt.

Faba bean metering plates

The faba bean metering plates were designed by using Solidworks software with four different shapes and printed with five different materials (ABS+, TPU, NYLON, PTFE, and Ertalon) as shown in Fig. 2 and Table 1 showed the parameters of metering plates.

Measurements

The measurements made in this research regard: Fuel consumption, Energy requirements, Specific energy consumption, Slippage, Theoretical field capacity, Effective field capacity, Field efficiency, Dispersion Ratio, Missing Hill and Operational costs,

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 1, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

whose formulas of calculation are presented in Table 2.

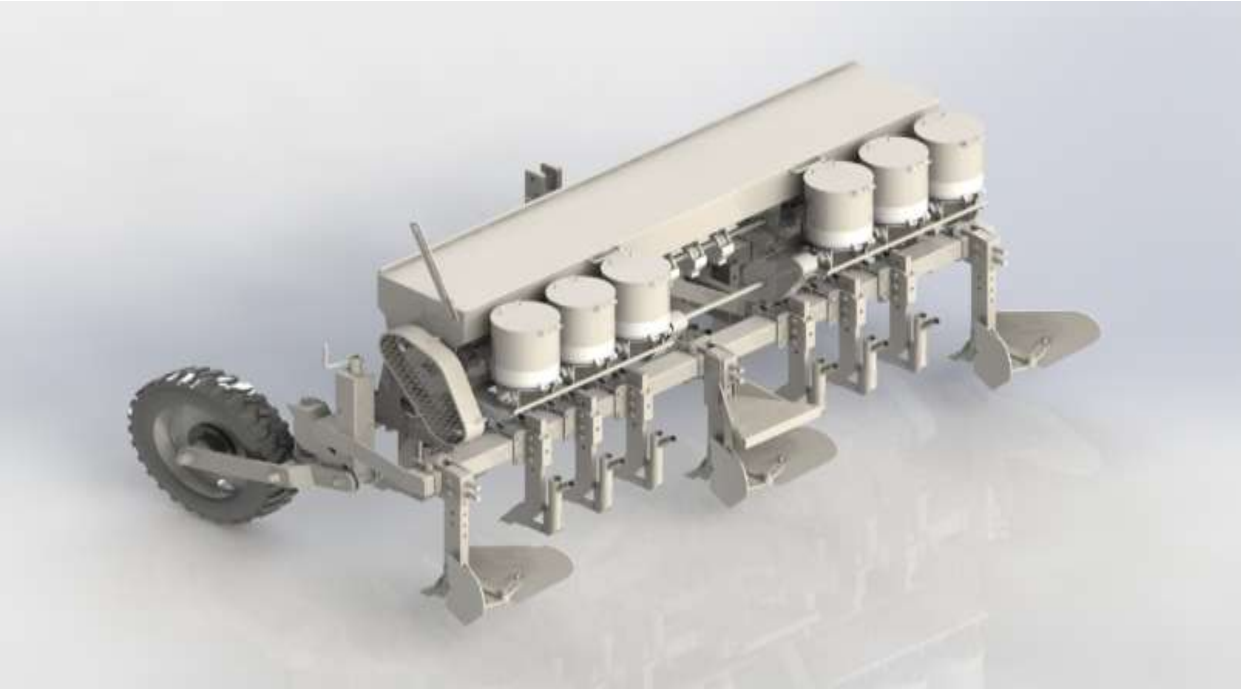

Photo 1. The Raised Bed Machine
Source: Authors' determination.

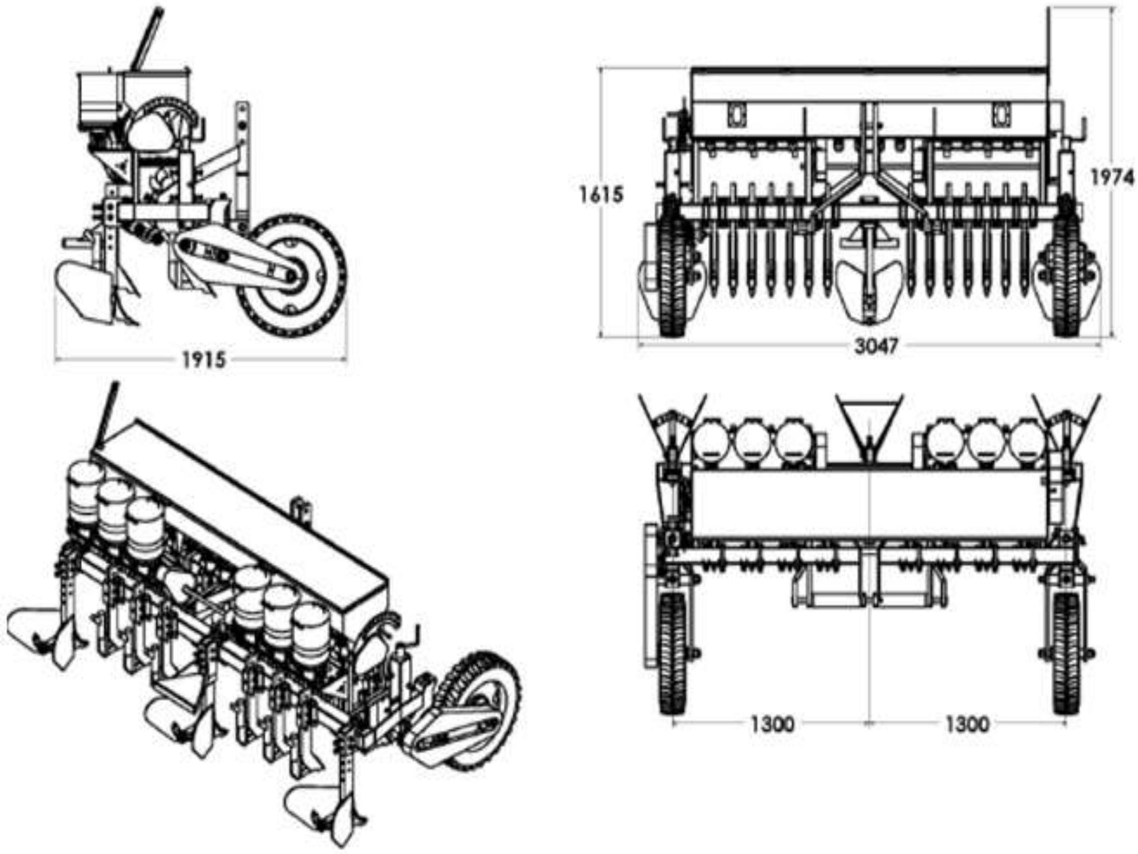

Fig. 1. Schematic views of the Raised Bed Machine
Source: Authors' determination.

Fig. 2. Faba Bean Metering Plates
Source: Authors' determination.

Table 1. Faba bean metering plates parameters

Items	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6	Plate 7	Plate 8
Materials	ABS			ABS			Ertalon	PTFE
	TPU			TPU				
	NYLON			NYLON				
Hole Length	19mm			21mm			25mm	$\phi = 20mm$
Hole Width	15mm			17mm			19mm	
Slot Shape	Ellipse			Cardioid			long Ellipse	Round
Shape Index	1.76			1.78			3.01	1.65

Source: Authors' determination.

Table 2. Measurements regarding the Raised Bed Machine

Equations	Authors
Fuel Consumption= $\frac{fuelconsumption\ ,ml}{Time,sec} x\ 3.6\ L\backslash h$	**El Shal, and Awny (2019) [7]**
Energy Requirements= $\frac{RequiredPower,kw}{EffictiveFieldCapacity,fed\backslash h}$ kw. h\fed	**Hoque, and Miah (2015) [8]**
Specific Energy Consumption = $\frac{Powerrequirements}{EFC}$ kW. h/fed	**El Shal, and Awny (2019) [7]**
Slippage = $\frac{Actualdistance-theoreticaldistance}{Etheoreticaldistance}$ *100,%	**Al-Gezawe et al (2022) [5]**
Theoretical Field Capacity = $\frac{VxW}{4.2} fed\backslash h$	**Wang et al. (2002) [17]**
Effective Field Capacity = $\frac{1}{T} fed\backslash h$	**Oduma et al (2014) [13]**
Field Efficiency= $\frac{EFC}{TFC} x100\%$	**Adisa et al (2012) [3]**
Dispersion Ratio= $\frac{dispersedseeds}{totalseed} * 100$	**Wang et al. (2002) [17]**
Missing Hill= $\frac{Numberofmissingplants}{totalplants} * 100$	**Abu El-Maaty et al (2020) [2]**
Operational Cost = $\frac{MachineCost\ (L.E\backslash h)}{EffectiveFieldCapacity(fed\backslash h)} LE\backslash fed$	**Al-Gezawe et al (2022) [5]**
Note: V=Average Implement forward speed, km\h, W=The Working Width of Implement, m., T=Total Planting Time, h	

Source: Authors' determination.

RESULTS AND DISCUSSIONS

Effect of the Operational Parameter On The Fuel Consumption, l/fed

Forward speed is one of the most important elements influencing machine fuel consumption. Figure 3 depicts the relationship between forward speed and fuel consumption under various distances. it is obvious that the use of the first distance led to an increase in fuel consumption from 6.42 liters/hour to 9.36 liters/hour by increasing the forward speed from 2 km / h to 4.5 km / h. While the use of the second distance led to an increase in fuel consumption from 5.16 liters/hour to 9 liters/hour by increasing the front speed from 2 km / h to 4.5 km / h. And from 4.2 liters/hour to 8.28 liters/hour when using the third distance with the same forward speeds. Thus, the results showed a convergence of consumption levels. Linear regression analysis was performed on the equations of the raised bed machine to predict the fuel consumption at different forward speeds during different planting distances. The following equation represents the relationship:

D1: $y = 1.1417x + 3.9907$ $R^2 = 0.9479$
D2: $y = 1.5184x + 2.0351$ $R^2 = 0.99$
D3: $y = 1.6339x + 0.9417$ $R^2 = 0.9999$

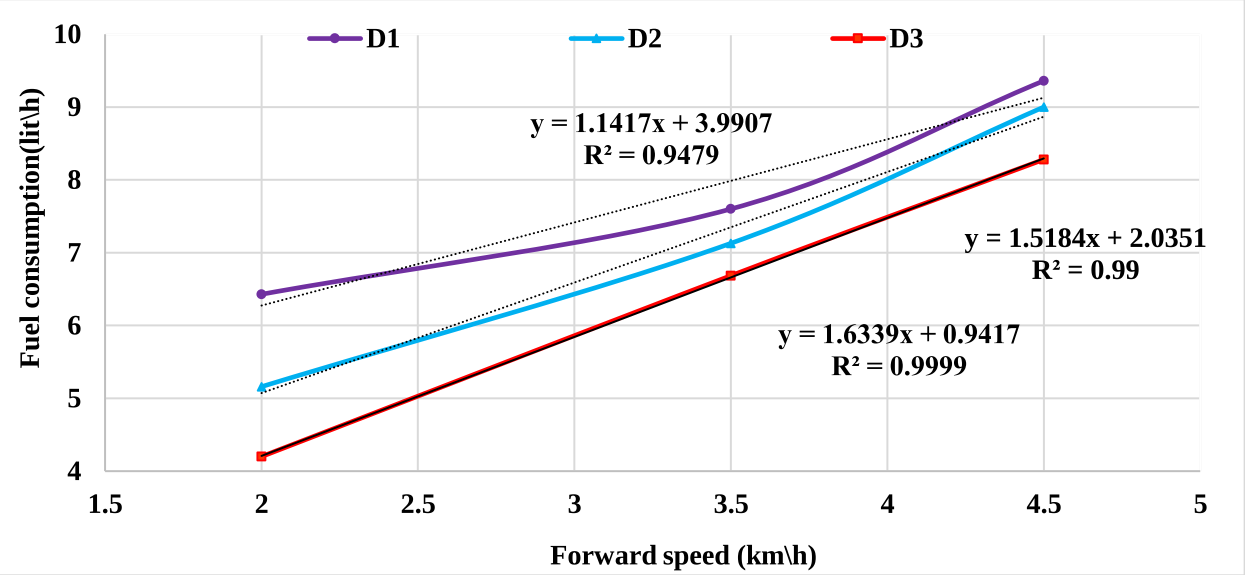

Fig. 3. Relationship between forward speed and fuel consumption under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On the Power Requirements

Figure 4 shows the relationship between forward speed and engine power required under different planting distances. It was observed that using the first distance (15 cm), the total engine power was recorded as 17.85 kW / h at a front speed of 2 km / h. It increased to 21.11 and 26 kW/ h when the forward speed was increased to 3.5 and 4.5 km/h respectively. While using the second distance (20 cm), the power was 14.33 kW/ h with a forward speed of 2 km/h, and 19.80 kW with a forward speed of 3.5 km/h, and increased to 25 kW/ h with a forward speed of 4.5 km/h. The engine power recorded the maximum value of 23 kW/ h with a forward speed of 4.5 km/h and 11.66 and 18.56 kW/ h with a forward speed of 2 and 3.5 km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the engine power at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = 3.1715x + 11.086$ $R^2 = 0.94$
D2: $y = 4.2179x + 5.6533$ $R^2 = 0.99$
D3: $y = 4.539x + 2.6161$ $R^2 = 0.99$

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 1, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

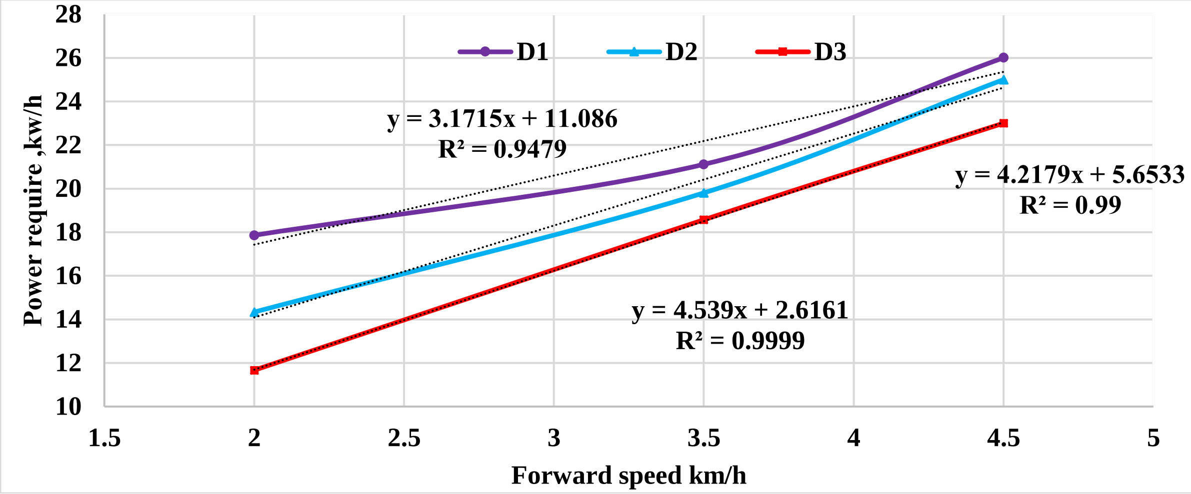

Fig. 4. Relationship between forward speed and required power under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On the Specific Energy Consumption

Figure 5 shows the effect of forward speed on energy consumed and planting distances. It was found that increasing the forward speed tends to increase the energy consumed with planting distances. However, increasing the forward speed from 2 to 4.5 km/h tends to increase the energy consumed from 13.73 to 20 kw.h/fed at a planting distance of 15 cm. The maximum energy consumed of 21.25 kWh/fed was recorded at a forward speed of 4.5 km/h, and a planting distance of 20 cm, and the minimum energy consumed of 15.52 Kw.h/fed was recorded at a forward speed of 2 km/h at same planting distance. The minimum energy consumed of 17.94 Kw.h/fed was recorded at a forward speed of 2 km/h, and a planting distance of 25 cm, and the maximum energy consumed of 24.15 kWh/fed was recorded at a forward speed of 4.5 km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the engine power at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = 2.5108x + 8.7414$ $R^2 = 0.997$

D2: $y = 2.2986x + 10.979$ $R^2 = 0.9987$

D3: $y = 2.4314x + 12.841$ $R^2 = 0.9702$

Effect of the Operational Parameter On The Theoretical Field Capacity

Figure 6 shows the relationship between forward speed and theoretical field capacity. It was clear that the theoretical field capacity increased with increasing forward speed, the theoretical field capacity was 1.23 fed/h with a forward speed of 2 km/h and reached 2.16 fed/h with a forward speed of 3.5 km. / h and recorded the highest value of 2.78 fed/h with a forward speed of 4.5 km / h. Linear regression analysis was performed on the equations of the raised bed machine to predict the theoretical field capacity at different forward speeds during different planting distances. The following equation represents the relationship.

$y = 0.7738x + 0.5159$ $R^2 = 0.9868$

Effect of the Operational Parameter On The Effective Field Capacity

Effective field capacity is an important indicator to evaluate a raised bed machine which is affected by many factors such as effective machine width, machine forward speed, and time lost in the field. The data in Figure 7 show the effect of forward speed, and planting spacing on effective field capacity. The results show an increase in effective field capacity with an increase in forward speed.

The effective field capacity was increased from 1 to 1.25 fed/h when the forward speed increased from 2 to 4.5 km/h while using the first planting distance (15 cm), the effective field capacity was increased from 0.92 to 1.76 fed/h when the forward speed increased from 2 to 4.5 km/h while using the second planting distance (20 cm) (Fig. 7).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 1, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

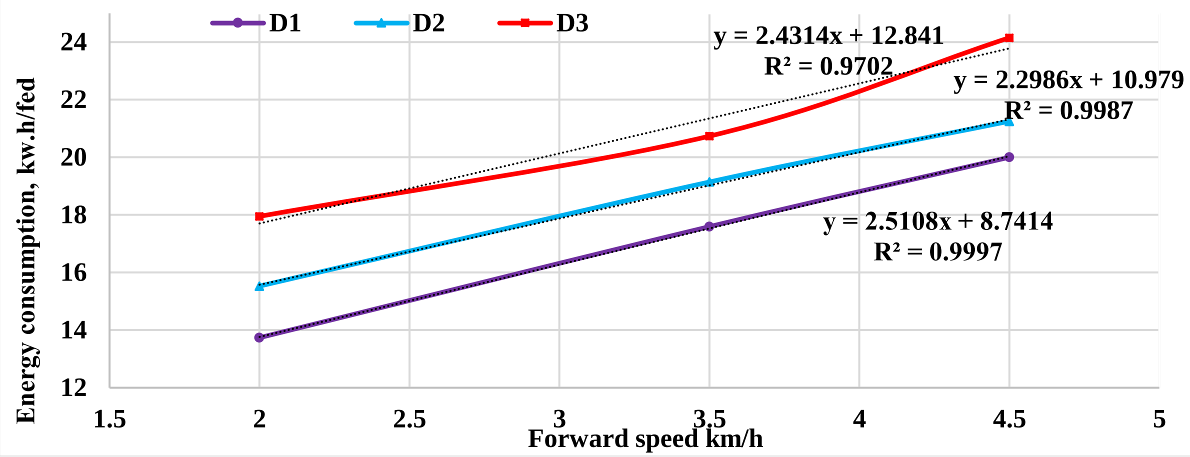

Fig. 5. Relationship between forward speed and required power under the different planting distances
Source: Authors' determination.

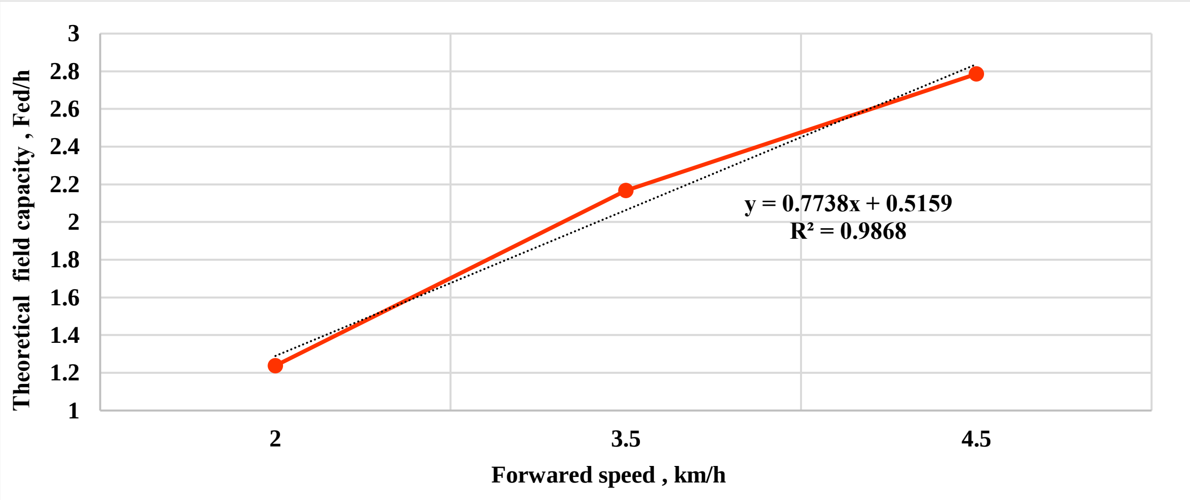

Fig. 6. Relationship between forward speed and theoretical field capacity.
Source: Authors' determination.

Also, with forward speeds 2 and 4.5 km/h the effective field capacity was 0.85, and 0.95 respectively. Linear regression analysis was conducted on the raised bed machine equations to estimate the effective field capacity at different forward speeds and planting distances. The estimated equation for this diagram is:

D1: $y = 0.0644x + 0.9658$ $R^2 = 0.9908$
D2: $y = 0.0992x + 0.7139$ $R^2 = 0.9663$
D3: $y = 0.0371x + 0.778$ $R^2 = 0.9496$
(Fig. 8).

Effect of the Operational Parameter On The Field Efficiency

The effect of forward speed on field efficiency under the different planting distances methods were shown in Figure 8. The results show a decrease in field efficiency as the forward speed increased. By using the first planting distance the field efficiency decreased from 88.1% to 44.87% with a forward speed from 2 up to 4.5 Km / h, and by using the second, and third planting distances field efficiency decreased from 74.55% to 42.23%, and from 69.23% to 34.18 % with same forward speeds. Linear regression analysis was performed on the equations of the raised bed machine to predict the field efficiency at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = -17.653x + 121.63$ $R^2 = 0.9702$
D2: $y = -13.32x + 99.244$ $R^2 = 0.9395$
D3: $y = -14.379x + 96.18$ $R^2 = 0.9547$

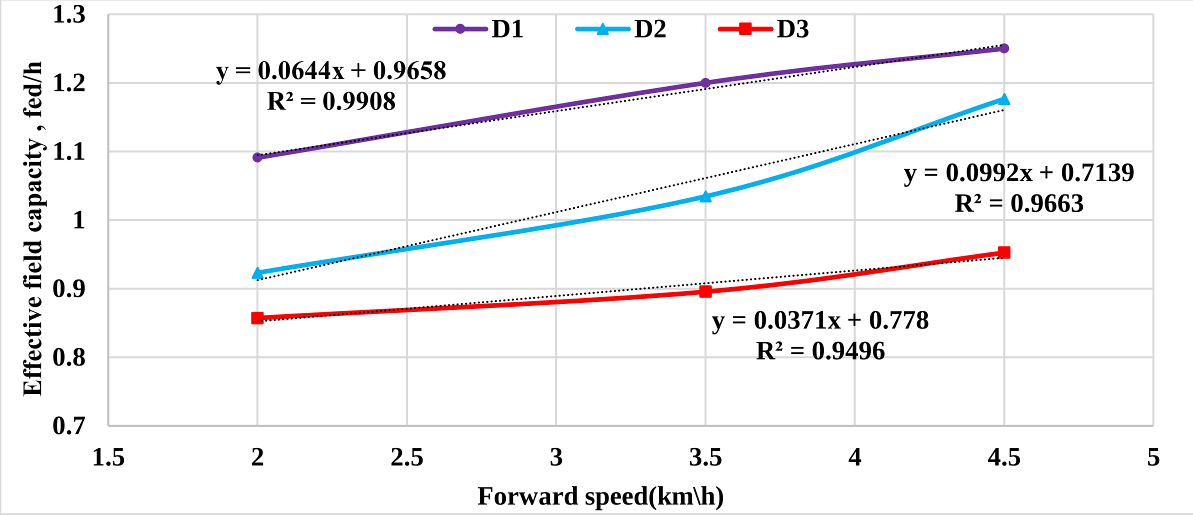

Fig. 7. Relationship between forward speed and effective field capacity under the different planting distances
Source: Authors' determination.

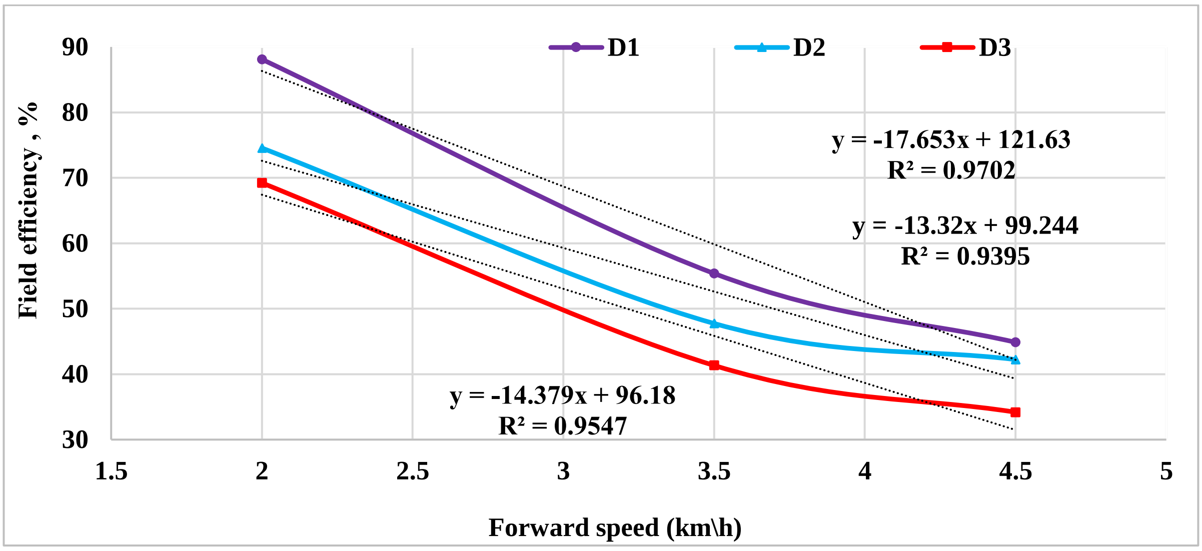

Fig. 8. Relationship between forward speed and field efficiency under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Dispersion Ratio

The effect of forward speeds on the dispersion rate of seeds during the use of four types of metering plates is shown in Figures 9, 10, 11 and 12, and it was clear that there was an increase in the dispersion ratio when using the first metering plate and three different planting distances. The dispersion rate increased from 8.57% to 18.57% at forward speeds from 2km/h to 4.5km/h for the first planting distance and from 10% to 20%, and from 12.5% to 25%, respectively, for the second and third planting distances, and at similar forward speeds for the first planting distance. As for the second metering plate, the dispersion rate for the three planting distances was 10% to 21.41%,12% to 32%, and 15% to 37.5%, respectively, with forward speeds from 2km/h to 4.5km/h. At the same time, the results were with the third metering plate for the same planting distances from 7.14% to 24.28%. 14% to 36%, and from 22.5% to 52.5%, respectively, with forward speeds of 2 and 4.5km/h. The fourth metering plate was increased from 14.28% to 34.28%, 38% to 64%, and 42.5%. to 70% with forward speeds from 2km/h to 4.5km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the dispersion ratio at different forward speeds during different planting distances. The following equation represents the relationship.

Plate1

D1: $y = 3.985x + 0.5263$ $R^2 = 0.9989$

D2: $y = 4x + 2$ $R^2 = 0.9934$

D3: $y = 5x + 2.5$ $R^2 = 0.9821$

Plate 2

D1: $y = 4.5865x + 0.9023$ $R^2 = 0.9992$

D2: $y = 8.1053x - 3.6842$ $R^2 = 0.9875$

D3: $y = 9.0789x - 2.7632$ $R^2 = 0.9944$

Plate 3

D1: $y = 6.9173x - 6.391$ $R^2 = 0.9944$

D2: $y = 8.6316x - 4.1053$ $R^2 = 0.9722$

D3: $y = 11.842x - 1.9737$ $R^2 = 0.9868$

Plate 4

D1: $y = 7.8947x - 2.0301$ $R^2 = 0.9868$

D2: $y = 10.526x + 17.579$ $R^2 = 0.9893$

D3: $y = 11.184x + 21.053$ $R^2 = 0.9801$

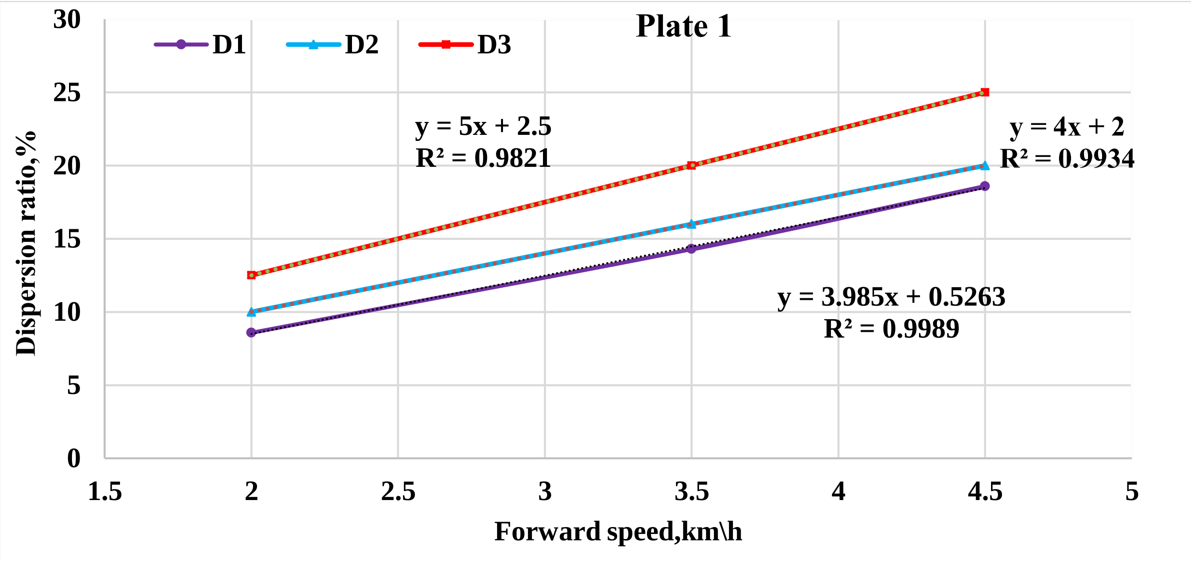

Fig. 9. The effect of forward speeds on the dispersion ratio of the first metering plate under different planting distances

Source: Authors' determination.

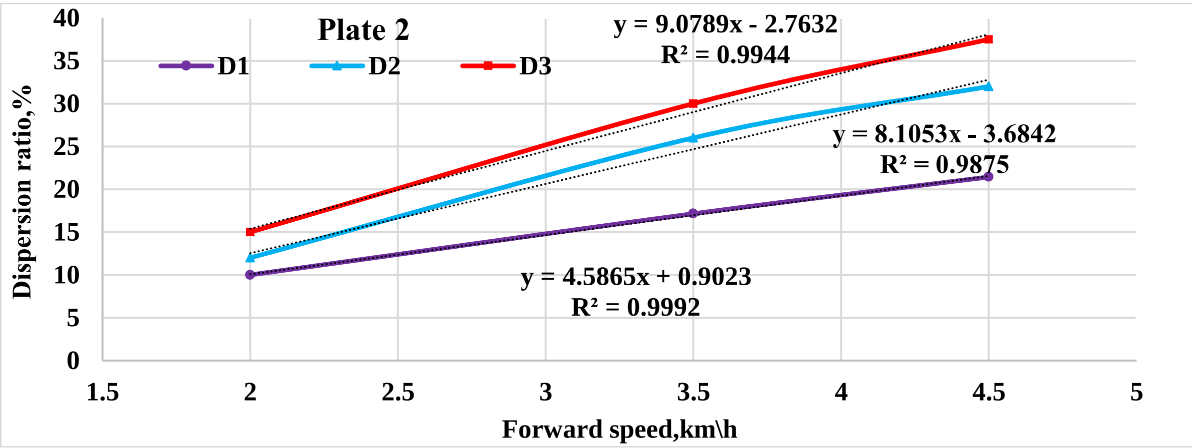

Fig. 10. The effect of forward speeds on the dispersion ratio of the second metering plate under different planting distances

Source: Authors' determination.

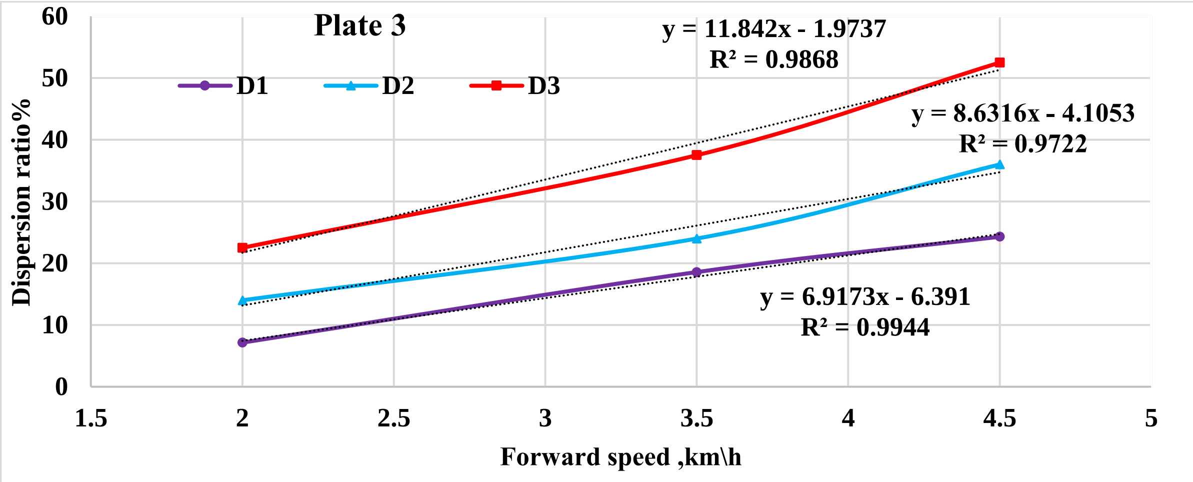

Fig. 11. The effect of forward speeds on the dispersion ratio of the third metering plate under different planting distances
Source: Authors' determination.

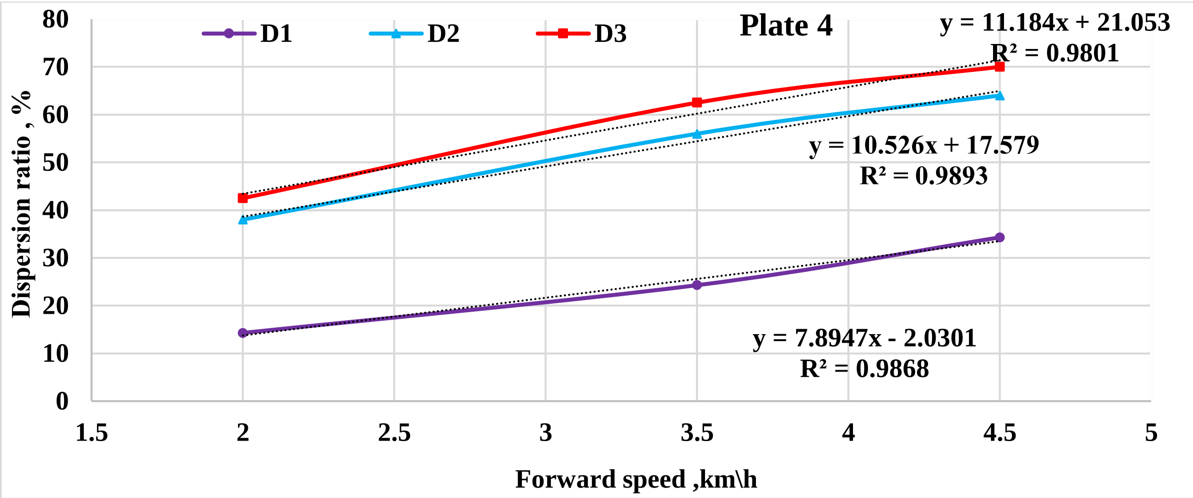

Fig. 12. The effect of forward speeds on the dispersion ratio of the fourth metering plate under different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Missing Hill, %

The effect of forward speeds on the missing hill of seeds during the use of four types of metering plates is shown in Figures 13, 14, 15, and 16, and it was obvious that there was an increase in the missing hill when using the first plate with three different planting distances. The missing hill increased from 1.4% to 4.2% during forward speeds from 2km/h to 4.5km/h for the first distance and from 2% to 6% and from 2.5% to 7.5%, respectively, for the second and third distances, and at similar forward speeds for the first distance. As for the second plate, the missing hill for the three planting distances was 2.85% to 7.14%,4% to 10%, and 5% to 15%, respectively, with forward speeds from 2km/h to 4.5km/h. At the same time, the results were with the third plate for planting distances (15, 20, and 25 cm) from 7.14% to 15.71%. 12% to 34%, and from 17.5% to 40%, respectively, with forward speeds of 2 and 4.5km/h. These results were also different from the measurements of the fourth plate, as they increased from 11.42% to 31.42%, 34% to 64%, and 50%. to 87% with forward speeds from 2km/h to 4.5km/h respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the missing hill at different forward speeds during different planting distances. The following equation represents the relationship.

Plate1

D1: $y = 1.1278x - 0.9023$ $R^2 = 0.9868$
D2: $y = 1.1278x - 0.9023$ $R^2 = 0.9868$
D3: $y = 1.9737x - 1.5789$ $R^2 = 0.9868$

Plate 2

D1: $y = 1.6541x - 0.7519$ $R^2 = 0.9098$
D2: $y = 2.3158x - 1.0526$ $R^2 = 0.9098$
D3: $y = 3.8158x - 3.5526$ $R^2 = 0.8512$

Plate 3

D1: $y = 3.3083x - 0.0752$ $R^2 = 0.9098$
D2: $y = 8.5263x - 6.4211$ $R^2 = 0.9283$
D3: $y = 8.8158x - 1.0526$ $R^2 = 0.9683$

Plate 4

D1: $y = 8.0451x - 4.4361$ $R^2 = 0.9976$
D2: $y = 12.211x + 10.632$ $R^2 = 0.9782$
D3: $y = 14.868x + 19.605$ $R^2 = 0.9942$

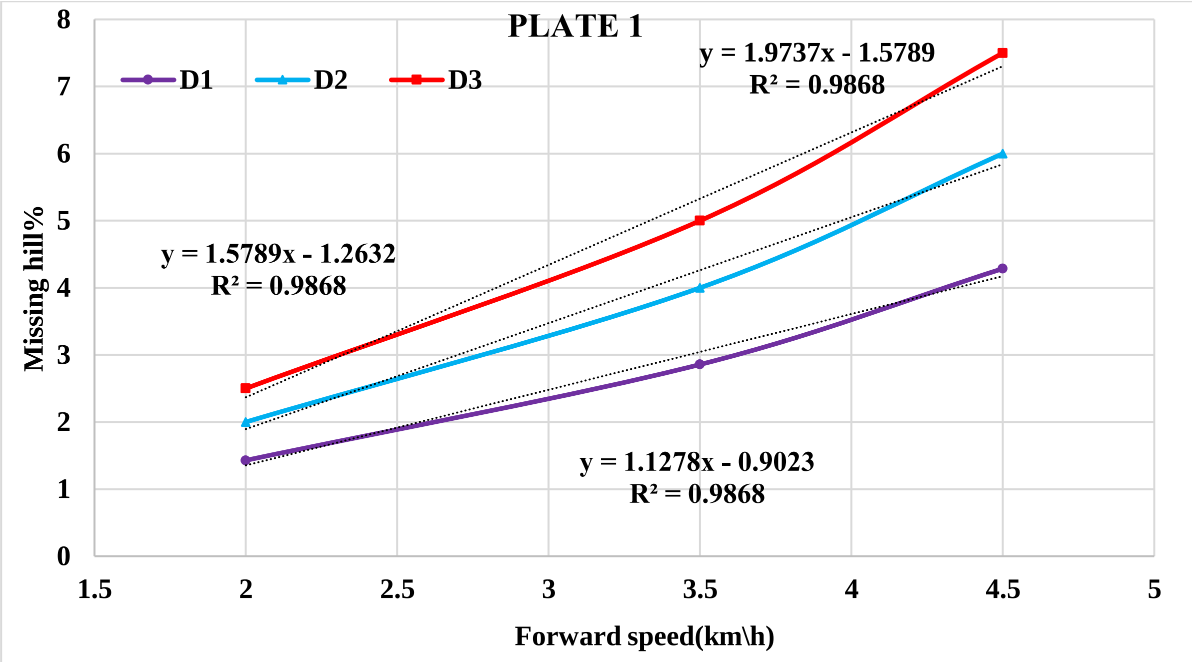

Fig. 13. The effect of forward speeds on the missing hill of the first metering plate under different planting distances
Source: Authors' determination.

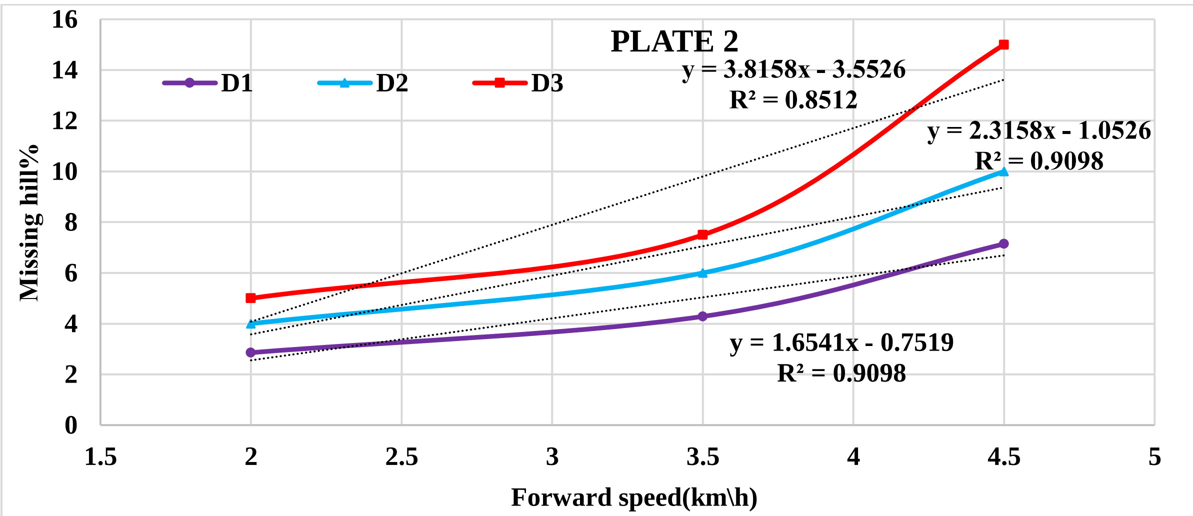

Fig. 14. The effect of forward speeds on the missing hill of the second metering plate under different planting distance
Source: Authors' determination.

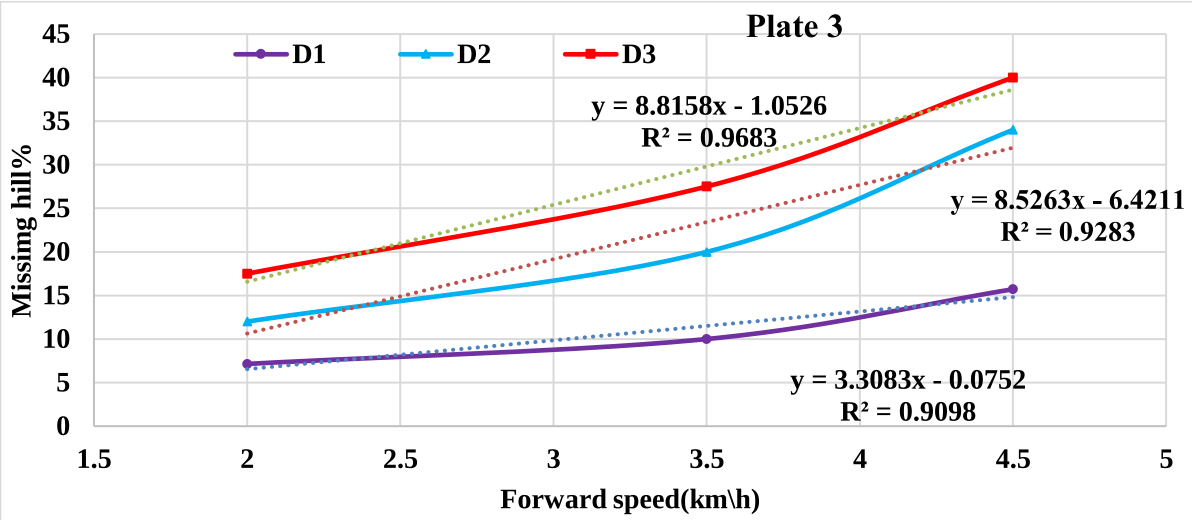

Fig. 15. The effect of forward speeds on the missing hill of the third metering plate under different planting distances
Source: Authors' determination.

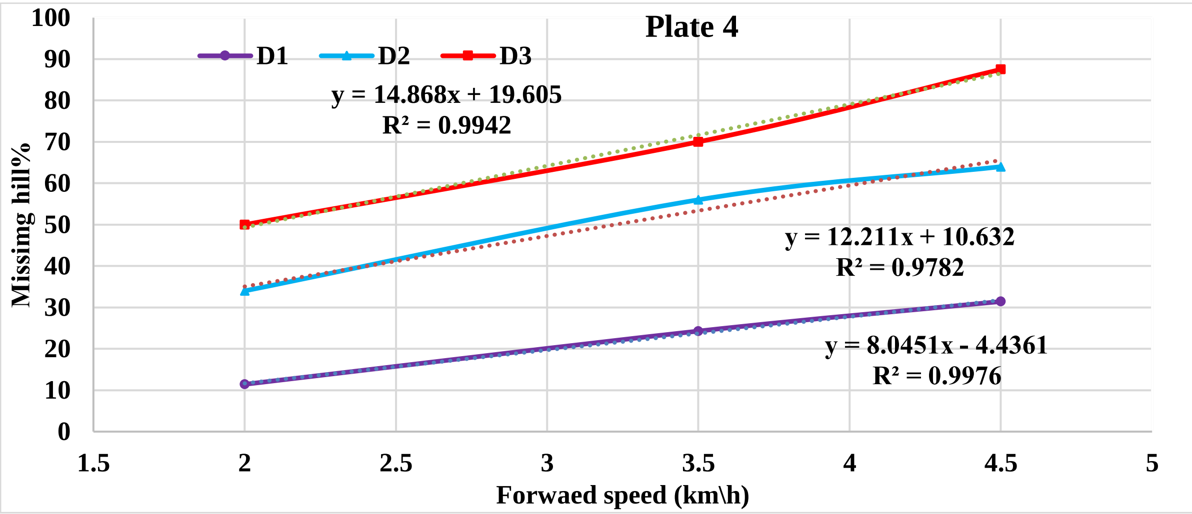

Fig. 16. The effect of forward speeds on the missing hill of the fourth metering plate under different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Seeds Damage, %

Figure 17 shows the effect of metering device speed and metering plates on seed damage percent. Results showed that seed damage decreased by increasing cell size and increased by increasing metering device speed. The maximum seed damages of 3.12%, 4.26%, 6.34%, and 10.23% were obtained at a metering device speed of 47 rpm for metering plate 1, plate 2, plate 3, and plate 4 respectively. Meanwhile, the minimum seed damages of 1.2%,2%, 3.73% and 6.6% were obtained at a metering device speed of 45 rpm for the same metering plates respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the seed damage at different rpm speeds during different metering plates. The following equation represents the relationship.

y=1.002x+0.2173 R^2=0.9714 (Plate 1)

y=1.132x+0.865 R^2=0.9997 (Plate 2)

y=1.3062x+2.5216 R^2=0.9845 (Plate 3)

y=1.8155x+4.7984 R^2=0.9998 (Plate4)

Effect of The Operational Parameters on The Total Operating Costs, L.E/fed

The results show that the operational cost decreased as the forward speed increased as shown in Figure 18. The operational cost decreased from 320.83 to 280 L.E / Fed as the forward speed increased from 2 to 4.5 Km / h for the first planting distance, and decreased from 379.16 to 297.5 LE / fed, and from 408 to 367.5 LE / fed for the second, and third planting distances with forward speed from 2 to 4.5 Km /. Linear regression analysis was run to derive equations to predict operational costs at different forward speeds during planting faba bean seeds, and the following equation represents the relationship.

D1: $y = -15.965x + 442.11$ $R^2 = 0.9616$
D2: $y = -32.237x + 445.79$ $R^2 = 0.9868$
D3: $y = -16.579x + 352.76$ $R^2 = 0.9838$

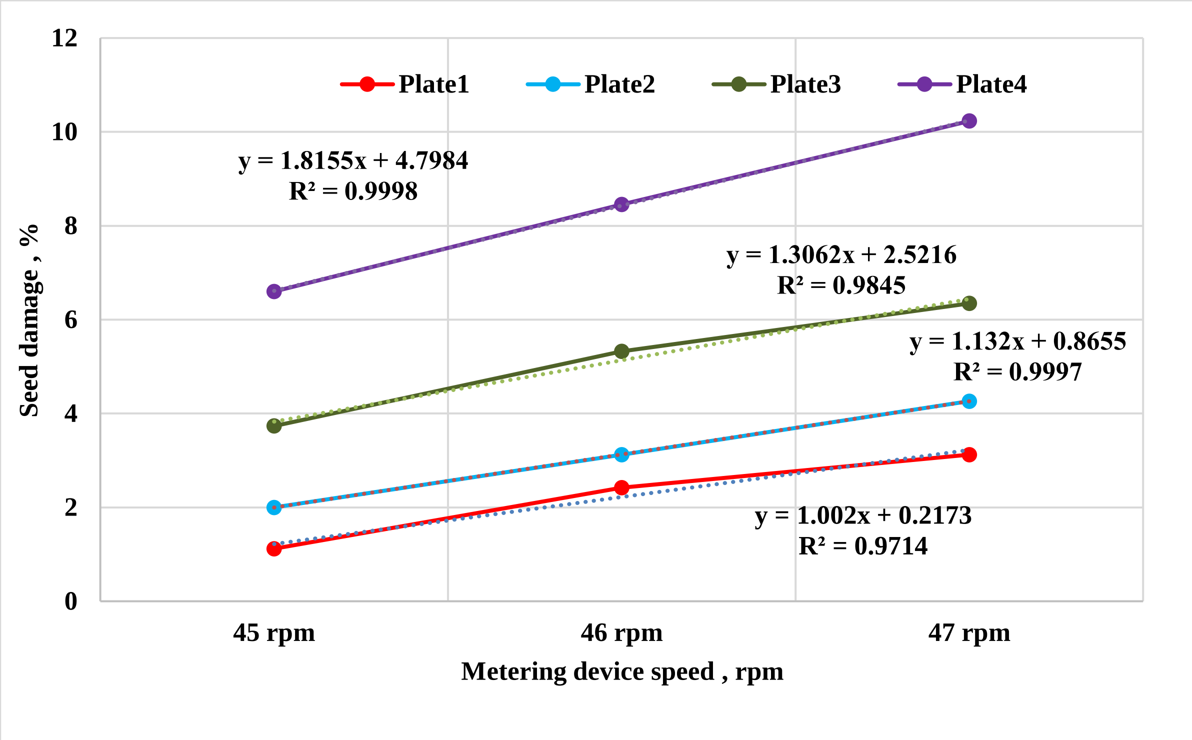

Fig. 17. Effect of metering device speed, and metering plates on seed damage percent
Source: Authors' determination.

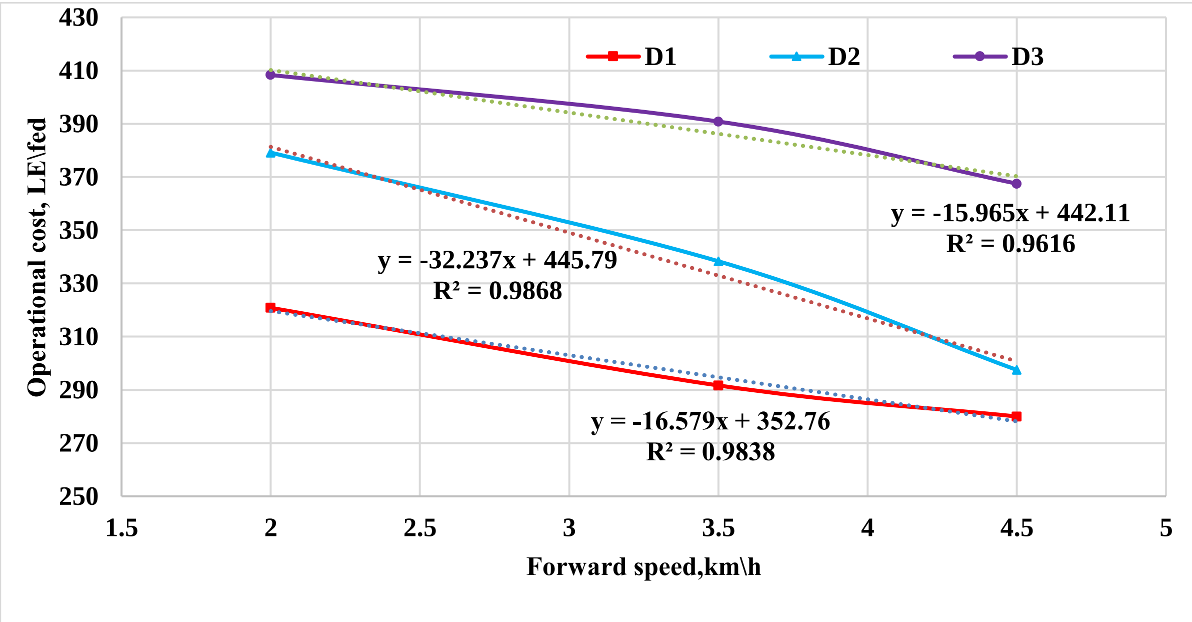

Fig. 18. Effect of machine forward speed and planting distances on the total operating costs
Source: Authors' determination.

Effect of The Operational Parameters on The Slippage, %

For the tractor as shown in Figure 19, the results showed that when the wheel was rotated for 10 revolutions, the slippage increased from 4.35% to 9.3% when the forward speed increased from 2 km/h to 4 km/h. When the tractor was connected to the raised bed machine, the results showed that with the first planting distance (15cm), the slip increased from 2.4% to 5.73. Also increased when using the second and third planting distances (20, and 25 cm) from 2.7% to 6.8%, and from 3.36% to 7.12% respectively in the same increased forward speed as shown in Figure 20. Linear regression analysis was run to derive equations to predict slippage at different forward speeds and planting distances, and the following equation represents the relationship.

D1: $y = -15.965x + 442.11$ $R^2 = 0.9616$

D2: $y = -32.237x + 445.79$ $R^2 = 0.9868$

D3: $y = -16.579x + 352.76$ $R^2 = 0.9838$

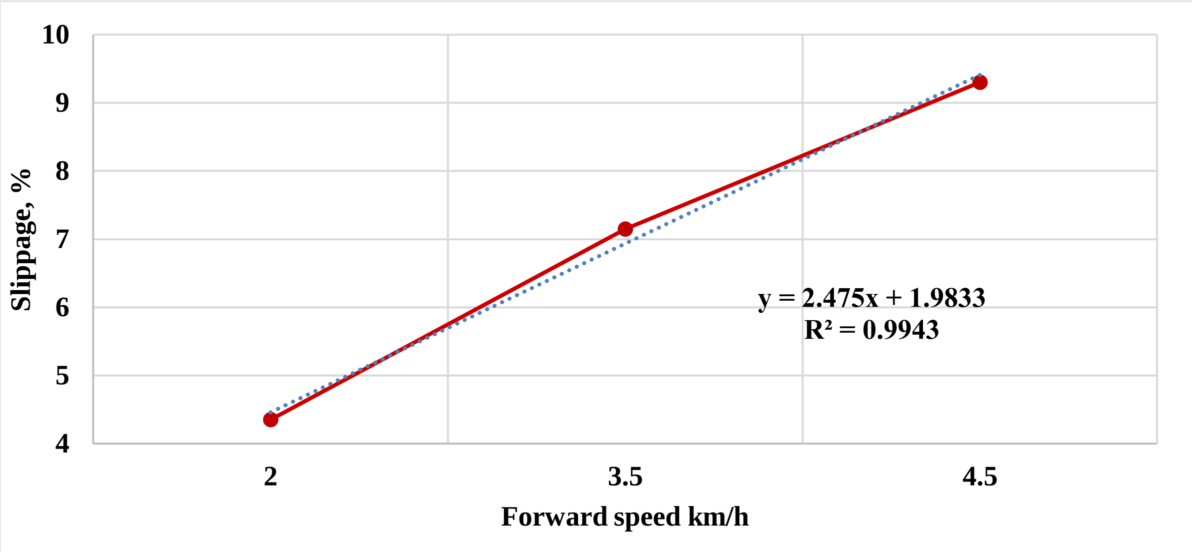

Fig. 19. Effect of machine forward speed on the slippage of tractor
Source: Authors' determination.

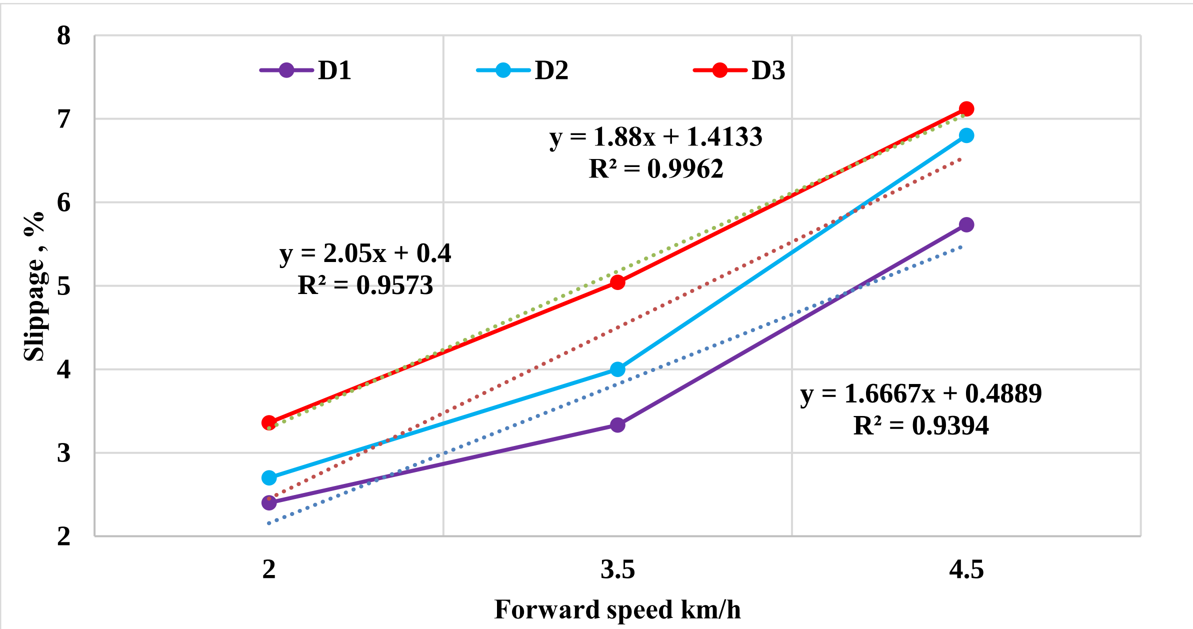

Fig. 20. Effect of machine forward speed and planting distances on the slippage of tractor with raised bed machine
Source: Authors' determination.

Effect of the Operational Parameter On the Germination ratio, %

The effect of planting distances on the germination ratio under different forward speeds is shown in Figure 21**.** The obtained results show a significant increase in the germination ratio with a decrease in the forward speed. By using the first planting distance the germination ratio was from 97.57% to 92.85% with the forward speed from 2 to 4.5 km/h respectively. By using the second and third planting distances, the germination ratio was 97.14%, and 92.85% for a forward speed of 2km/h, and for a forward speed of 4.5 km/s the germination ratio was 92%, and 88% respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the germination ratio at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = -2.3571x + 100.1$ $R^2 = 0.9852$

D2: $y = -2.5714x + 99.524$ $R^2 = 0.9838$

D3: $y = -2.4286x + 95.143$ $R^2 = 0.9897$

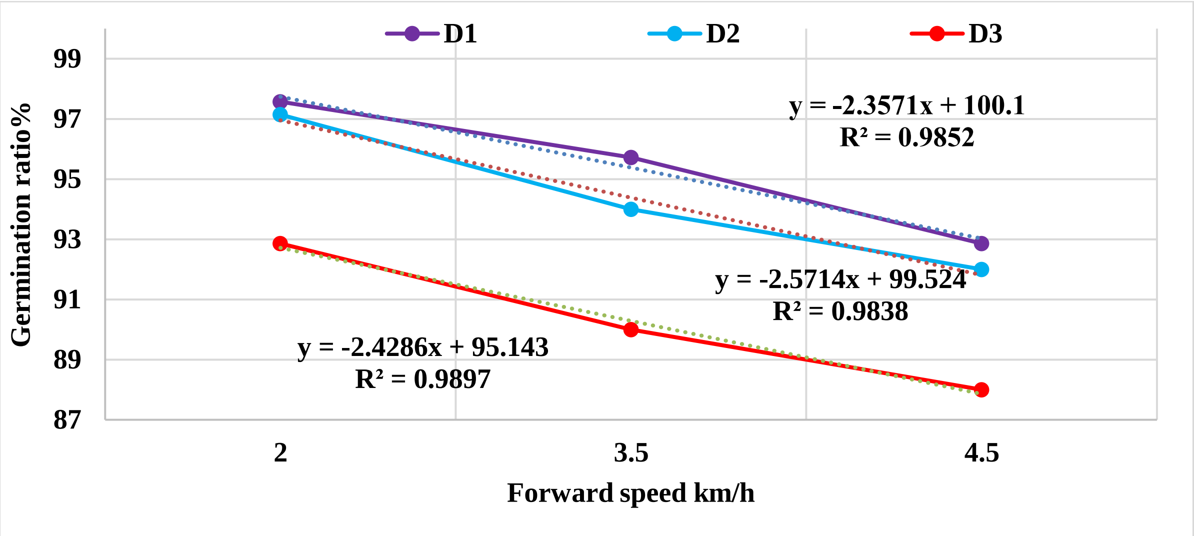

Fig. 21. Relationship between the germination ratio of faba bean seeds and the forward speeds under different planting distances
Source: Authors' determination.

CONCLUSIONS

The development of the equipment showed the first metering plate with TPU material and Shape Index1.76. gave a satisfactory performance with a missing hill, seed damage, and dispersion ratio where 1.4%,1.2%,97.57%, and 8.5%.

Also the results of the performance of raised bed machine such as the maximum value of actual field capacity, minimum values of specific energy, and operating costs where1.25 fed/h, 11. 66kW.h/fed, and 280 L.E./fed with forward speed of 2km/h and planning distance 15cm

REFERENCES

[1]Abdelsalam, A., Fouda, T., 2023, Determination of color properties, Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(1).Accessed on 25/9/2023.

[2]Abu El-Maaty, A., Fattah, A. A., Mahmoud, W. A., 2020, Study of some factors affecting a mechanical planting of coated quinoa seeds. Archives of Agriculture Sciences Journal, 3(2), 239-254. Accessed on 25/9/2023.

[3]Adisa, A. F., Braide, F. G., 2012, Design and development of template row planter. Transnational Journal of Science and Technology, 2(7), 27-33. Accessed on 25/9/2023.

[4]Ahmad, S., Riaz, M., Khan, I. H., Ashraf, H., Awais, M., 2023, Development and Performance Evaluation of Garlic Splitter Cum Grader. Development, 54(04).Accessed on 25/9/2023.

[5]Al-Gezawe, A. A., El-Termezy, G. A., Abd El Hamid, S. G., Imam, A. I., 2022, Development of a Machine for Planting Faba Bean. Journal of Positive School Psychology, 6(2), 6228-6240.Accessed on 25/9/2023.

[6]Cen, Z., Zheng, Y., Guo, Y., Yang, S., Dong, Y., 2023, Nitrogen Fertilization in a Faba Bean–Wheat Intercropping System Can Alleviate the Autotoxic Effects in Faba Bean. Plants, 12(6), 1232.Accessed on 25/9/2023.

[7]El Shal, A. M., Awny, A., 2019, Fabricating and Evaluating Performance of a Planter Prototype for Planting Chinese Garlic Cloves. Journal of Soil Sciences and Agricultural Engineering, 10(10), 605-612. Accessed on 25/9/2023.

[8]Hoque, M. A., Miah, M. S., 2015, Evaluation of different tillage methods to assess BARI inclined plate planter. Agricultural Engineering International: CIGR Journal, 17(3). Accessed on 25/9/2023.

[9]Kosariya, Y. K., Jogdand, S. V., Victor, V. M., 2022, Effect of the Machine Parameters on Field Performance of Developed Potato Planter Cum Fertilizer Applicator. International journal of Plant and Environmental, 8(04), 39-43.Accessed on 25/9/2023.

[10]Kumar, R., Govil, A., Daga, P., Goel, S., Dewangan, S., 2022, Design of automatic seed sowing Machine for agriculture sector. Materials Today: Proceedings. Accessed on 25/9/2023.

[11]Kumar, P., Ashok, G., 2021, Design and fabrication of smart seed sowing robot. Materials Today: Proceedings, 39, 354-358, Accessed on 25/9/2023.

[12]Ministry of Agricultural and land reclamation, 2019. Economic affair sector, Agricultural statistics crops. Accessed on 25/9/2023.

[13]Oduma, O., Ede, J. C., Igwe, J. E., 2014, Development and performance evaluation of a manually operated cowpea precision planter. International journal of engineering and technology, 4(12), 693-699. Accessed on 25/9/2023.

[14]Omran, M. S., 2018, Design and evaluation of a manually operated planter. Misr J. Agric. Eng. Vol. 35 No. (4): 1187-1210.Accessed on 25/9/2023.

[15]Prajaiah, Inder. M., Adarsh, K., Satish, D., Ashok, K. S., Cini, V., 2016, Development and evaluation of electronically controlled precision seed metering device for direct-seeded paddy planter. Indian Journal of Agricultural Sciences 86 (5): 598–604 Accessed on 25/9/2023.

[16]Prakash, V. S., Kumar, G. M., Gouthem, S. E., Srithar, A., 2021, Solar powered seed sowing machine. Materials Today: Proceedings, 46, 3554-3556. Accessed on 25/9/2023.

[17]Wang, D., Dimonie, V. L., Sudol, E. D., El-Aasser, M. S., 2002, Seeded dispersion polymerization. Journal of applied polymer science, 84(14), 2710-2720. Accessed on 25/9/2023.