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Levelling machines and its effect on the growth characteristics and productivity for two corn cultivars

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Abstract

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A field experiment was carried out in Abu Ghraq, 10 km north of the centre of Hila governorate, two agricultural seasons of Spring and Fall, of 2020, in silt loam soil, under the impact of levelling machines (laser, tablet), on two cultivars corn (Cadiz and Figr. 1). Experiments were conducted in a factorial experiment under complete randomized design with three replications. The results showed that the laser levelling machine was significantly better than tablet levelling machine, in all studied conditions, in terms of the germination ratio, germination speed, plant vigor index, grains extraction, root dry weight, biological yield, grain yield, and harvest index. For laser levelling machine were recorded 90.63%, 74.67%, 60.45 cm, 77.81%, 0.76 g, 6.41 t/ha, 8.59 t/h, and 74.77%, respectively, under the same operating conditions for tablet levelling machine. The spring season was significantly superior than fall in all studied parameters. While the Cadiz cultivar was significantly better than the Figr.1 cultivar, in all studied conditions. All the interactions were significant and the best results was achieved, for laser levelling machine, in spring season and Cadiz cultivar, in all studied conditions**.**

Keywords: corn; levelling machines; planting seasons; tractor; corn cultivars

Introduction

Yellow corn (*Zea mays L*) is a strategic crop and the most important economic crop in the world, and it is considered the third most important crop, after wheat and rice. It is widely cultivated in Iraq. The cultivated area in 2019 is about 76000 hectares (Al Sharifi et al., 2018; Hamzah, Al Sharifi & Ghali, 2021). The great increase in the expansion of agricultural lands, led to land reclamation in Iraq, increasing the area with corn, as an important crop for animal feed, and its entry into many industries, such as starch and dextrin. Maize is one of the crops that stresses the soil, so various means have been used to maintain soil fertility, and one of these means is to settle the soil to improve its physical and chemical properties, through the even distribution of irrigation water and increase crop productivity (Al Sharifi et al., 2020b), as the irregular level of the earth's surface has a significant impact on the germination of crops, and the degree of their tolerance to the different distribution of irrigation water in soil. Therefore, levelling the surface of the earth is considered the beginning of all agricultural practices and the most important step in the good management of soil and plants (Amaresh, Lad & Chalodia, 2018; Alaamer et al., 2021). Das et al. (2018), Alaamer & Al Sharifi (2020) used laser leveling and reduced the time required to irrigate the land, because laser leveling achieved a high economic benefit, compared with traditional methods, which require a longer working time and greater financial cost. Also, laser leveling leads to

good relative homogeneity at all points of the field, which allows the application of irrigation over the entire field area. It forms ponds with multiple negative effects, increases the cultivable area by 2% – 3%, reduces the salinity in the soil, and increases the effectiveness of water by more than 50%, the laser leveling ensures the formation of agricultural areas in a homogeneous and larger ratio, compared with the traditional methods that work on forming basins, small-scale cultivation, and then obtains a crop with good and consistent growth over the entire cultivated area (Aggarwal et al., 2010).

According to González et al. (2011) and Aquino et al. (2015), soil leveling is the process of turning it into a flat surface, or a smooth surface curve, which requires the presence of a network, that determines the heights and depressions, on the surface, in addition to the presence of large grooves and cracks. This problem requires large costs and this is reflected in the lack of effectiveness of the application of laser leveling. According to Naresh et al. (2011) and Al Sharifi et al. (2020a), the land leveling quality is mainly based on the tractor and laser leveling machine. There are standard indications for the use of lasers to level the ground, but its performance depends on the pulling force of the tractor, or its traction, as well as the large size of the leveling machine. In order to obtain high productivity from the use of laser leveling, it is necessary to use a leveling machine of an appropriate size, with the drawing force, and the possibility of these machines being well available in the areas to be cultivated. According to Aleawi & Al-Sharifi (2020) and Shtewy et al. (2020a), there is a clear increase in vegetative growth and its components, the yield and the grains yield per unit area by addition Nitrogen fertilizer for the corn crop. According to Shtewy et al. (2020c) and Al-Jezaari et al. (2021), the output of any crop is impacted by many factors, including the type and size of seeds, climatic conditions and fertilizers in addition to the soil physical properties, crop output may be impacted by factors including the use of low yielding varieties (Gagnon et al., 2017; Al-Sharifi et al., 2021b). The land precise leveling includes, changing the field in such a way that it has a fixed slope of 0-0.2%. Ground accurate leveling, using tractor a laser-equipped, increases crop yields and increases water productivity (Asharifi et al., 2021a; Shahani et al., 2016). The crop productivity constitutes the economic return of the farmer. From this point of view, the farmer must provide the necessary elements for germination and growth of the crop until production, including plowing, smoothing, leveling, irrigation and fertilization. All these factors are the basis for increasing the crop productivity (Alaamer et al., 2021a). The study aimed to know the effect of the levelling machines on some yield characteristics of maize crop.

Materials and Methods

This study was conducted to evaluate the effect of leveling machines (Laser leveling and tablet leveling) (Figure 1, Figure 2) on two corn cultivars (Cadiz and Figr .1), for the spring and fall seasons. A experiment was conducted at the Abu Gherq area by the directorate of the Babylon Department of Agriculture,10 km north of the center of Hila governorate, during spring and fall seasons of 2019, were geographic character of the location state latitude and longitude 44.6771425,32.3978923, and altitude elevation-B. M=35.453 m above sea level, dominated by a desert climate characterized by low rainfall and high temperatures in summer, which reach 50 degrees Celsius, and a warm weather prevails in winter, using a randomized complete block design arranged in split plot with three replications. (Hamzah et al., 2021).

Fig. 1. Laser leveling machine

Fig. 2. Tablet leveling machine

Topographic surveying

Points identified and readings taken, using the theodolite (Transit), Figure 3

Table 1. Specifications (Laser leveling machine)

Parameter	
Display	Seven Segment LED, Visible in Day Light, Adjustable in Brightness
Switch	Tour Sensor Switch Suitable for Dusty Condition
System Accuracy	±5 mm
Control	Programmable
Working Mode:	10 User Modes Programmable
Indications:	Working Channel, Time & Errors (LED for Up, Down, Link & Auto)
Protection:	IP65
Connectors:	Silver coated, Chroe plated atll weather bend proof
Laser Guided Land Leveller Pro-12000 Capacity 6 m Weight 4300 kg Dimensions 2500 × 3200 × 6600	
Laser Land Leveler, has a Long-range laser transmitter 1500 meters (750 radius), Computerized self-calibration. In house manufacturing. Development, and testing center for Laser Land Levelers, Rotary laser level accuracy +/-15 mm at 30 meters, . Wireless and touch control, Laser receiver working fully under HT lines, Accurate working of the rotary laser at high temperature. Get the maximum yield of crops using Laser Land Leveler.	

Table 2. Specifications (Tablet leveling machine)

Parameter	
local manufacturing machine	Iraq
hanging type	Back tractor
Width	2.76m
Weight	256 kg

$$L_T = L \times Cos\ Bearing \quad (1)$$

$$D_P = L \times Sin\ Bearing \quad (2)$$

Coordinates were calculated using the equations following

$$\Delta E_{ij} = D_{ij}\ Sin\ \theta_{ij} \quad (3)$$

$$\Delta N_{ij} = D_{ij}\ Cos\ \theta_{ij} \quad (4)$$

$$E_j = E_i + \Delta E_{ij} \quad (5)$$

$$N_j = N_i + \Delta E_{ij} \quad (6)$$

Soil topography

Soil topography contains many highs and lows, due to the large number of accumulated plowings process, and lack of leveling operations (Figure 4), the fill and cut operations were determined for soil to be settled and planting with corn, crop by adopting the Level device (Figure 5).

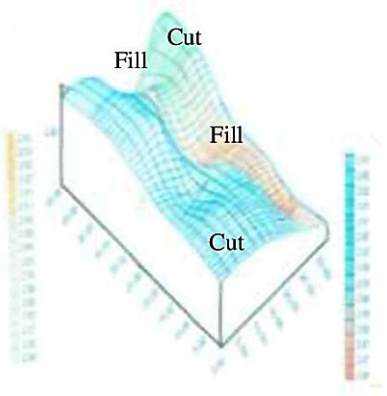


Fig. 3. Soil topography

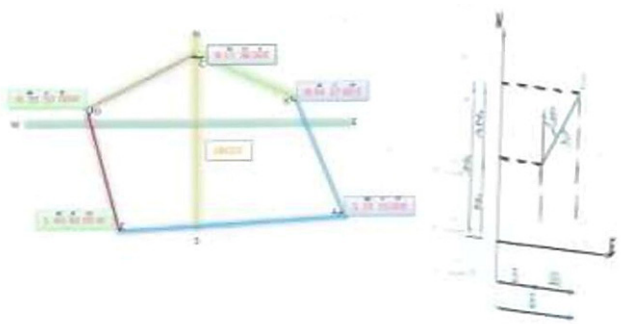


Fig. 4. Soil area specific using the theodolite (Transit)

Plane surveying

Leveling is the process of finding the levels of the points, i.e. the vertical dimensions between two land points from a fixed, sea level or from each other, i.e. the process of finding the height between the points with time. Therefore, the water surface was adopted as a sampling surface and is often taken for a period of no less than 25 years. The comparison surface for Iraq is (Shatt Al-Arab – Al-Faw).

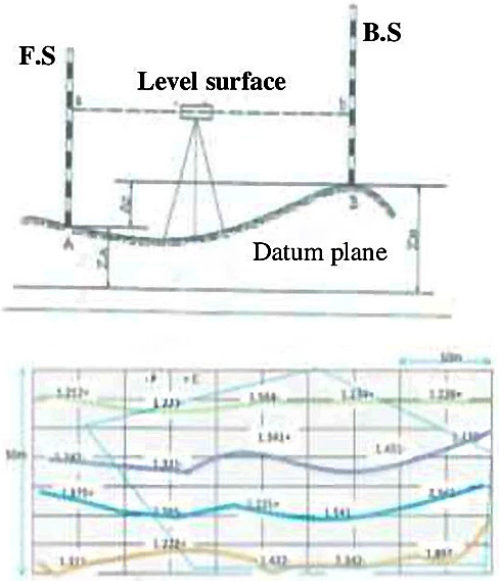


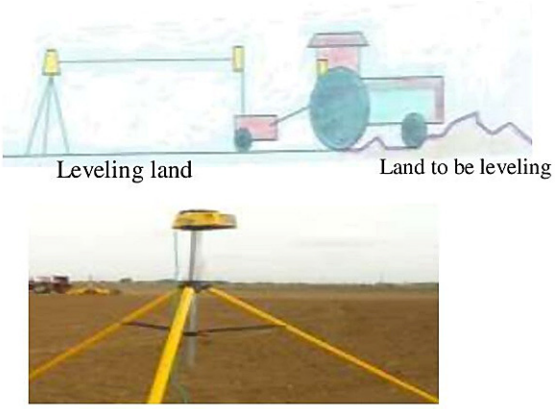
Fig. 5. Fore sight readings (F.S) and back sight readings (B.S) before making leveling process

$$ELev.B.M + B.S = H.I \quad H.I - F.S = ELev.T.P \tag{7}$$

Before the levelling process can start, the field must be plowed and a topographic survey, on this basis, in this study MFs285 tractor with a horsepower of 80 hp was used, with mold board plow on depth of 20 – 23 cm, to soil stir and provide smooth soil, using disk harrow and spike pin harrows with two opposite passes, for making soil leveling process. (Al-Suhaibani et al., 2010).

The leveling machine (laser or tablet), is attached to the tractor (Figure 6), laser leveling machine consists of a Leica Rugby 100LR transmitter, a Leica MLS700 sensor, and a Leica MCP700 control panel. The transmitter is mounted on a tripod and positioned, at a central point in the field. This allows the laser beam to sweep through sweep and the Leica Rugby 100LR transmission's beam range is 1500 m.

There are many tractors that can work with one device. The laser beam from the conveyor is detected by the receiver, which is installed on a mast on the drag bucket, and it transmits signals to the control panel that controls the level of the drag shovel by turning the hydraulic valves, as with the towing shovel can be raised and lowered and the required rate, at which the shovel is raised and lowered depends on the operating speed, and after it has finished performing its work in the experimental field, (Figure 7, Figure 8), the readings are taken to determine the level of the soil by means of the leveling device (level).



Picture view of the laser land leveling from field

Fig. 6. Attaching the laser leveling machine to the tractor and working method

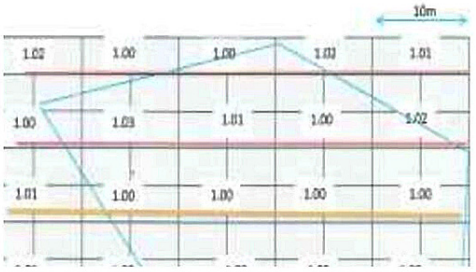


Fig. 7. Reading bed for horizontal distance using the laser leveling device (level), when leveling experimental field with the laser leveling machine

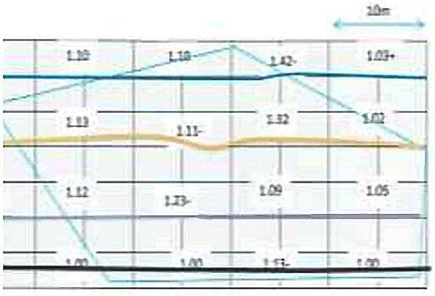


Fig. 8. Reading best for horizontal distance using the laser leveling device (level), when leveling experimental field with the tablet leveling machine

Table 3. Soil analysis of physical and chemical properties

Depth	Texture %			
	Clay	Silt	Sand	
0-25 (cm)	48	22	30	Silt Clay loam
	Soil physical properties			
	Soil bulk density (Mg m^{-3})	Total soil porosity (%)	Soil penetration resistance (Kpa)	
	1.30	50.94	1341.62	
	1.31	50.56	1398.56	
	1.31	50.56	1388.31	
VA	1.32	50.18	1352.04	
0-25	Soil chemical properties			
	E.C (ds\cm^3)	HP		
	1.39	7.38		
	Soluble cation meq\I			
	Na	K	Ca+Mg	
	11.53	12.44	46.82	
	O.C (%)	CEC (Meq\100g)	$CaCo_3$ (%)	O.M (%)
	0.45	32.91	4	0.54

Soil characteristics

Humidity was estimated according to (Hu et al., 2012; Alaamer et al., 2021)

$$W = \frac{W_w}{W_s} \times 100 \quad (8)$$

where: W is soil humidity ratio (%); W_w is mass wet soil (kg); W_s is mass dry soil.**(**kg**)**

The crop and its components

Germination percentage

It is calculated for an area of one square meter, with a number of plants and with three randomly selected replicates, and the average results are taken. (Marwat et al 2002; Al Sharifi & Ameen 2018; Alaamer et al., 2021b).

Germination speed

The germination speed was calculated (Martin &Yaklich 1982; Al-Sharifi et al.,2020a)

$$G_s = \frac{A_{B1} + A_{B2} + A_{B3}}{W_s} \times 100$$

where: G_s – germination speed %, A – number of germinated seeds, B – number of days from the cultivation date, W_s – seeds total number.

Plant vigor index (PVI)

Was calculated by the following, formula (Al-Sahuki,1990; Shtewy et al.,2020a)

$$P_{VI} = \frac{P_L \times G_P}{100}$$

where: P_{VI} – plant vigor index cm; P_L – plant length cm, G_P – Germination ratio.

Grains extraction

It was calculated according to (ALttiya & Wuhaib 1982; Al Sharifi et al., 2021c)

$$G_E = \frac{SW}{PW} \times 100$$

where: G_E – grain extraction%; SW – seed weight.pod^{-1} kg; PW – pod weight kg.

Root dry weight

The roots were extracted, cleaned with water, dried in the oven at 70° Celsius, and then weighed with a sensitive scale, with three replications for each experimental unit. (Tennant (1975); Shtewy & Al Sharifi, 2020b).

Grains yield

The grain yield was calculated (Al Sharifi, 2009).

$$G_Y = GP \times PD$$

where: G_Y grain yield t.ha^{-1}, *GP*– grain rate per plant (kg); *PD* – plant density.ha^{-1}

Biological yield

Plants were cut from the ground level, then it was dried in the oven at 70 ° Celsius, and then weighed with a sensitive scale with three replicates for each experimental unit, and it was calculated as follows (Al-Tamimi 1990; Shtewy et al, 2020c).

$$B_Y = R_p \times PD$$

where: B_Y – biological yield t/ha; R_p – rate dry weight of the plant (kg); *PD* – plant density.ha^{-1}

Harvest index

The harvest index was calculated **(**Al-Sahuki 1990; Shahani et al., 2016**).**

$$H_I = \frac{SW}{BY} \times 100$$

where: H_I – harvest index %; *BY* – biological yield t/ha; *SW*– seed weight.pod^{-1} (kg).

Corn crop was planted with rate 2-3 seeds in one hole, at a distance of 20 cm, and at a distance of 75 cm, between one planting line and another. Phosphate fertilizer was applied at the rate of 200 kg. ha^{-1}, when planting and Urea fertilizer (46% Nitrogen) was used at a rate of 400 kg. ha^{-1}, and was applied in two batches, the first one month after germination, and the second in the flowering phase. Corn stalk borer pest control, was done using Diazinion at a concentration of 10%, at a rate of 6 kg.ha^{-1}, after 40 days of germination, for two planting seasons Spring and Fall, and the study site plants were harvested after 145 days from planting.

The experiments were carried out according the Nested design, according to program Gestate V.12, was used under the (R.C.B.D) with three replications, and the least significant difference under the probability at L.S. D = 0.05 level was used to compare the averages of the treatments. (Oehlent, 2010).

Results and Discussion

Germination ratio

The results indicated Spring planting season outperformed the Fall planting season, by giving the highest percentage (89.78%) for Abu Gherq site. This is due to the mild climate conditions in the Spring season and it was positively reflected on increase in the germination percentage, compared to the Fall season. These results are consistent with Shtewy et al.(2020c). From Table 4, Cadiz corn cultivar gave the best germination ratio, compared to Figr.1 cultivar, and the recorded results were (89.72 and 86.99%), respectively, the reason for this is due to the seeds vitality and their suitability to the germination conditions of the Cadiz variety. These results are consistent with Al Sharifi & Ameen (2018). The laser leveling machine achieved the best result (90.36%), while the tablet leveling machine recorded the lowest percentage of germination (86.34%). Due to the high leveling degree, when using the laser leveling machine, and this was reflected in the uniformity water distribution on the soil surface and the increase in the germination ratio. All the interactions were significant and the best results 92.54% was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Germination speed

The laser leveling machine achieved the best result (74.67%), while the tablet leveling machine recorded the lowest germination speed (70.25%). These results are consistent with Ashraf et al. (2017), when using laser leveling machine led to give high leveling degree, and this was reflected in the uniformity of water distribution on the soil surface, and the increase in the germination speed. Table 5 shows that, the Spring planting season significant outperformed the Fall planting season, by giving the highest germination speed ratio, and were results (73.94 and 70.98%). These results are consistent with Martin & Yaklich (1982) and Al-Sharifi et al. (2020a). Cadiz corn cultivar gave the best germination speed, compared to Figr.1 cultivar, and recorded results were 77.40 and 70.03%, respectively, the reason for this is due to the seeds vitality and their suitability to the germination conditions of the Cadiz variety. These results are consistent with Aleawi et al. (2020). All the interactions were significant and the best results 78.55% was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Plant vigor index (PVI)

Results of the statistical analysis showed a significant impact for planting season, on PVI. Table 6, indicated that the PVI, of the Spring planting season is significantly better than Fall planting season. The results were 58.06 and 57.07 cm, respectively. These results are consistent with the results of Al Sharifi et al (2021a). Cadiz cultivar has the highest PVI of 59.55 cm, and Figr.1 cultivar has the lowest PVI of 55.57 cm. The suitability of the seeds and their adaptation to working conditions, and this was reflected in an increased PVI in corn variety Cadiz, as compared the Figr 1 variety on plant vigor index PVI. These results are consistent with the results

of Al-Sahuki (1990) and Shtewy et al. (2020a). The laser leveling machine give best of results of 60.45 cm, as compared to the tablet leveling machine, which required of 54.67 cm., for the laser machine and tablet machine, under the same operating conditions. All the interactions were significant and the best results 62.71 cm, was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Grains extraction

The results showed that the Figr.1 variety had the lowest grains extraction ratio of 70.46%, as compared to Cadiz variety, which gave high grains extraction ratio of 80.92%. The laser leveling machine leads to an increase of the grains extraction, while decrease the grains extraction ratio was observed, when using tablet leveling machine and the results

Table 4 Effect of seasons, corn cultivar and leveling machine on germination ratio

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring				
	Cadiz	92.54	90.11	91.32
	Figr 1	89.73	86.76	88.24
Fall	Cadiz	91.15	85.09	88.09
	Figr 1	88.03	83.43	85.73
L.S.D = 0.05	1.690			2.319
Average of levelling machine		90.36	86.34	
L.S.D = 0.05		3.280		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	91.13	88.44		89.78
Fall	89.59	84.23		86.91
L.S.D = 0.05	2.319			1.690
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	91.85	87.58		89.72
Figr 1	88.88	85.09		86.99
L.S.D = 0.05	2.319			1.690

Note: L.S.D – Least Significant Difference

Table 5 Effect of seasons, corn cultivar and leveling machine on germination speed

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	78.55	73.22	75.88
	Figr 1	74.15	69.86	72.00
Fall	Cadiz	76.82	71.01	73.91
	Figr 1	69.18	66.94	68.06
L.S.D = 0.05	1.452			1.958
Average of levelling machine		74.67	70.25	
L.S.D = 0.05		2.354		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	76.35	71.54		73.94
Fall	73.00	68.97		70.98
L.S.D = 0.05	1.958			1.452
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	77.69	72.11		77.40
Figr 1	71.66	68.40		70.03
L.S.D = 0.05	1.958			1.452

Note: L.S.D – Least Significant Difference

were 77.81% and 73.58%, respectively. This is due to precisely levelled and smooth soil surface, when using laser leveling machine. These results are consistent with the results, obtained by ALttiya & Wuhaib (1982) and Al Sharifi et al. (2021c), shown in Table 7**.** The Spring season indicated the highest grains extraction of 76.71%, against 74.67% at Fall season. Provides good conditions for the growth of the crop. This is consistent with the results by Shtewy et al. (2020a). The interaction of laser leveling machine, with Spring season and Cadiz cultivar provided the grains extraction of 84.02%.

Root dry weight

Planting season had a significant impact on the root dry weight g. The Spring planting season outperformed the Fall

Table 6. Effect of seasons, corn cultivar and leveling machine on PVI

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	62.71	58.09	60.40
	Figr 1	59.01	52.44	55.73
Fall	Cadiz	61.18	56.24	58.71
	Figr 1	58.92	51.93	55.42
L.S.D = 0.05		1.318		1.674
Average of levelling machine		60.45	54.67	
L.S.D = 0.05		1.734		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	60.86	55.26		58.06
Fall	60.05	54.08		57.07
L.S.D = 0.05	1.674			1.318
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	61.94	57.16		59.55
Figr 1	58.96	52.18		55.57
L.S.D = 0.05	1.674			1.318

Note: L.S.D – Least Significant Difference

Table 7 Effect of seasons, corn cultivar and leveling machine on grain extraction

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	84.02	80.01	82.01
	Figr 1	73.66	69.18	71.42
Fall	Cadiz	81.46	78.22	79.84
	Figr 1	72.08	66.92	69.50
L.S.D = 0.05		1.462		1.977
Average of levelling machine		77.81	73.58	
L.S.D = 0.05		2.318		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	78.84	74.59		76.71
Fall	76.77	72.57		74.67
L.S.D = 0.05	1.977			1.462
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	82.74	79.11		80.92
Figr 1	72.87	68.05		70.46
L.S.D = 0.05	1.977			1.462

Note: L.S.D – Least Significant Difference

planting season, with results 0.73 and 0.67 g., respectively, for Abu Ghraq site. The reason for this is the improvement of the physical properties of the soil, with the increase in soil moisture, during the Spring season and this was positively reflected on the increase in the dry weight of the corn roots. These results are consistent with Tennant (1975) and Shtewy & Al Sharifi (2020b) (Table 8**)**. The laser leveling machine achieved the best result (0.76 g), while the tablet leveling machine recorded the lowest percentage of root dry weight (0.65 g). Cadiz corn cultivar gave the best root dry weight, compared to Figr.1 cultivar, and the recorded results were 0.77 and 0.63 g, respectively. The reason for this is to create a suitable environment for the maize Cadiz variety, reflected on the increase in root dry weight. These results are consistent with Reena et al. (2017). All the interactions were significant and the best results 0.88 g was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Biological yield

Cadiz corn cultivar gave the best biological yield, compared to Figr.1, cultivar, results 8.84 and 7.52 t/ha, respectively. The reason for this is to create a suitable environment for the maize Cadiz variety, reflected on the increase in biological yield. These results are consistent with Asharifi et al. (2021b) and Shahani et al (2016). From Table 9 could be concluded that, that the planting season had a significant impact on the biological yield. The Spring planting season outperformed the Fall planting season, with results 8.57 and 7.80 t/ha. This is due to the mild climate conditions in the Spring season and it was positively reflected on increase in the biological yield, compared to the Fall season. These results are consistent with Al-Tamimi (1990) and Shtewy et al. (2020c). The laser leveling machine achieved the best result (8.59 t/ha), while the tablet leveling machine recorded the lowest biological yield (7.78 t/ha). All the interactions were significant and the best results (9.36 t/ha) was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Grain yield

Table 10 shows that, the planting season had a significant impact on the grain yield t.ha^{-1}. The Spring planting season outperformed the Fall planting season, with results 6.31 and 5.60 t/ha for Abu Ghraq site. This is due to the mild climate conditions in the Spring season and it was positively reflected on increase in the grain yield, compared to the Fall season. These results are consistent with Al-Jezaari et al. (2021). Cadiz corn cultivar gave the best grain yield, compared to Figr. 1 cultivar, and the recorded results were 6.43 and 5.47 t/ha, respectively. The reason for this is the obtained suitable environment for the Cadiz maize variety, reflected on the increase in grain yield. These results are consistent with Al Sharifi (2009). The laser leveling machine achieved the best result (6.41 t/ha), while the tablet leveling machine recorded the lowest grain yield (5.64 t/ha). No waste of water to check the field level, when using the laser leveling machine leads to increased grains yield. All the interactions were significant and the best results (7.16 t/ha) was achieved for laser leveling machine, at Spring season and Cadiz cultivar.

Table 8 Effect of seasons, corn cultivar and leveling machine on root dry weight

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	0.88	0.73	0.81
	Figr 1	0.71	0.62	0.66
Fall	Cadiz	0.79	0.71	0.75
	Figr 1	0.65	0.55	0.60
L.S.D = 0.05	0.019			0.027
Average of levelling machine		0.76	0.65	
L.S.D = 0.05		0.038		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	0.80	0.67		0.73
Fall	0.72	0.63		0.67
L.S.D = 0.05	0.027			0.019
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	0.83	0.72		0.77
Figr 1	0.68	0.59		0.63
L.S.D = 0.05	0.027			0.019

Note: L.S.D – Least Significant Difference

Harvest index

The laser leveling machine achieved the best result (72.96%), while the tablet leveling machine recorded the lowest harvest index (72.42%). Precisely levelled and smooth soil surface, when using the laser leveling machine leads to increased harvest index. Table 11 shows that, the planting season had a significant impact on the harvest index %. The Spring planting season outperformed the Fall planting season, with results 73.27% and 72.08% for Abu Ghraq site. This is due to the mild climate conditions in the Spring season and it was positively reflected on increase in the on harvest index, compared to the Fall season. These results are consistent with Al-Sahuki (1990) and Shahani et al. (2016). Cadiz corn cultivar gave the best grains yield, compared to Figr.1 cultivar, and the recorded results were 72.72% and 72.66%, respectively. These results are consistent with González et al. (2011) and Aquino et al. (2015). All the interactions were significant and the best results (77.11%) was

Table 9 Effect of seasons, corn cultivar and leveling machine on grain yield

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	7.16	6.63	6.89
	Figr 1	6.32	5.11	5.72
Fall	Cadiz	6.01	5.95	5.98
	Figr 1	5.56	4.88	5.22
L.S.D = 0.05		0.279		0.391
Average of levelling machine		6.41	5.64	
L.S.D = 0.05		0.558		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	6.74	5.87		6.31
Fall	5.78	5.42		5.60
L.S.D = 0.05	0.391			0.279
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	6.58	6.29		6.43
Figr 1	5.94	5.00		5.47
L.S.D = 0.05	0.391			0.279

Note: L.S.D – Least Significant Difference

Table 10 Effect of seasons, corn cultivar and leveling machine on biological yield

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	9.36	8.91	9.13
	Figr 1	8.78	7.23	8.01
Fall	Cadiz	9.03	8.09	8.56
	Figr 1	7.21	6.87	7.04
L.S.D = 0.05		0.129		0.183
Average of levelling machine		8.59	7.78	
L.S.D = 0.05		0.259		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	9.07	8.07		8.57
Fall	8.12	7.48		7.80
L.S.D = 0.05	0.183			0.129
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	9.19	8.50		8.84
Figr 1	7.99	7.05		7.52
L.S.D = 0.05	0.183			0.129

Note: L.S.D – Least Significant Difference

Table 11. Effect of seasons, corn cultivar and leveling machine on harvest index

Abu Gherq site				
Seasons	Corn cultivars	Leveling machine		**The overlap between** seasons and corn cultivars
		Laser	Tablet	
Spring	Cadiz	76.19	74.41	75.30
	Figr 1	71.80	70.67	71.24
Fall	Cadiz	66.75	73.51	70.13
	Figr 1	77.11	71.07	74.07
L.S.D = 0.05		1.187		1.265
Average of levelling machine		72.96	72.42	
L.S.D = 0.05		1.379		
Seasons	The overlap between seasons and leveling machine			Average of seasons
Spring	74.00	72.54		73.27
Fall	71.93	72.24		72.08
L.S.D = 0.05	1.265			1.187
Corn cultivars	The overlap between corn cultivar and leveling machine			Average of corn cultivars
Cadiz	71.47	73.96		72.72
Figr 1	74.45	70.87		72.66
L.S.D = 0.05	1.265			1.187

Note: L.S.D – Least Significant Difference

achieved for laser leveling machine, at Fall season and Fig.1 cultivar.

Conclusions

The laser leveling machine is significantly better than the tablet leveling machine. The Cadiz cultivar was superior significantly to Figr. 1 cultivar. Additionally, the Spring agricultural season was superior significantly than the Fall agricultural season in all studied traits. Best results obtained of the overlap between the laser leveling machine, Spring agricultural season and Cadiz cultivar, in all studied properties.

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