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Design and Testing of an Agricultural Robot to Operate a Combined Seeding Machine

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Abstract

A field experiment was conducted to study, design and testing repotting agricultural, not served for the process of seeding, fertilization and irrigation first in that one. In one of the fields of the College of Agricultural Engineering Sciences / University of Baghdad in Al-Jadriya during the year 2020-2021, and testing it to see its effect on some mechanical properties, and some soil properties. Two factors were used in the experiment: the first factor included, the speed of the agricultural robot, and in three levels: 3, 5 and 10 km / hour. The second factor included seed depth coefficients in three levels: 3, 6 and 9 cm. The traits that were studied were, field efficiency, energy consumption, number of seeds per square meter and number of individual seeds per line length. The experiment was carried out using a nest design. Nested Design Under the design of the complete randomized sectors (RCBD), with three replications, the use of the least significant difference and the level of probability (0.05 LSD). To compare averages of transactions. The results obtained can be summarized as follows: The second speed treatment of the robot excelled in increasing the field efficiency, the lowest energy consumption, the best amount of descending seeds and the best distance between seeds in the line. There is a slight significant effect of velocity and depth parameters on actual productivity and energy consumption. The increase in the operational speed of the mechanical unit from 3 to 5 and then to 10 km / hour, led to a significant increase in the practical productivity per he., but significant differences were found in the process of distributing seeds in the inequality. Superiority first depth (0- 3)Cm, and for all speed in increasing field efficiency and less energy consumption There are slight significant differences for the speed and depth parameters in the seed distribution and landing process. The agricultural robot succeeded in the process of seeding, fertilization and first irrigation with high efficiency, as the study showed the possibility of applying the robot to perform remote sensing in agricultural environments.

Keywords: agricultural robots, programming and design of agricultural robots, Field efficiency, energy consumption.

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Introduction

The idea of robot data farm in environment of agricultural served by smart machines, it is not a new idea. Where they developed many of the engineers in the past tractors without driver, but did not succeed completely for a reason not to provide the ability to have to absorb all the complexities of the world of agriculture. Most of them assumed an industrial method of cultivation, in which everything was known in advance and the machines could operate entirely in pre-defined ways. The approach nowadays is to develop smarter machines that are smart enough to operate in an unmodified or near-natural environment. This should show the equipment behavior reasonably recognized in their contexts. In this way this equipment should have enough built-in intelligence inside for it to act reasonably for long periods of time, without supervision, in a semi-natural environment (Blackmore, et al., 2005).

Autonomous vehicles were used (Robots), widely used in industrial production and warehouses, but with ensuring a controlled environment. Either in the field of Agriculture for as long as the search in a self - vehicle to lead a dream, and began the actual research in the early sixties (Fountas , et al., 2007). And in recent years, we saw this vehicle development of agricultural interest increasing, pushing the development of many of the researchers to start developing vehicles with high capabilities and met its adaptable in the agricultural environment. So in the field of independent agricultural vehicles (robots) , is being developed systems to make sure whether a vehicle for small independent leadership will be more efficient than traditional large tractors (Blackmore, et al., 2004). These vehicles must be able to work 24 hours a day throughout the year and in various weather conditions, and have an intelligence programmed inside them to act in a manner that is acceptable in a semi-natural or natural environment and for long periods of time, without supervision, while carrying out a productive task. Certain (Pedersen et al., 2005).

There are many studies that seek to T. Taiwir the equipment farm in the field of agricultural (vehicles or mobile robots the independent agricultural) and its impact on raising field efficiency and reduce energy consumption and regularity of agriculture operations, fertilization and irrigation, for example, the study carried out by both, (RESKE-NIELSEN et al., 2006), and (BLACKMORE et al., 2007). A more recent trend is to develop specially designed structures for agricultural vehicles or robots, for example the study carried out by both, BISGAARD et al., 2004, BAKKER et al., 2006, BAKKER, 2009. And in the use of various sensors and image applications to define the management of agricultural operations in the field as in (GROHS et al., 2009 and BAESSO et al., 2007) .And to keep pace with the development in the manufacture of agricultural robots in the developed world, which are used for agricultural purposes, for example, plowing, fertilization, irrigation and seeding, and in order to raise the agricultural reality in Iraq by

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improving the growth and production of agricultural crops by reducing effort and time and bypassing the difficult conditions that the farmer may go through.

From the above, the purpose of this study is to design a mechanical structure for making a mobile agricultural robot, developed using virtual prototypes (VP) , Including a model CAD and analysis of operational elements under normal operating conditions and in the worst conditions in the field to carry out the seeding, fertilization and initial irrigation process .

Materials and methods of work

The agricultural robot Figure (1) used for seeding, fertilization and initial irrigation, was designed in the workshop of the Agricultural Machinery and Equipment Department at the College of Agricultural Engineering - University of Baghdad - Al - Jadriya, for the year 2021 , after studying the physical properties of the field soil and as you are the mixture sandy type, Table (1), and the parts of robot in Figure (1) .

Table (1) shows some of the physical and chemical characteristics of the soil

Adjective		Unit	Value
Soil Practical Amylases	Sand	$g.kg^{-1}$	96
	Silt		580
	clay		324
Type os soil			Sand-mixture
Bulk Density		$g.cm^{-3}$	1.49
True Density		$g.cm^{-3}$	2.65
Pore		%	14.77
E C		$Ds.m^{-1}$	2.78
PH			7.30
Moisture contain		%	16 – 18
Soil penetration		K.Ps	4.813

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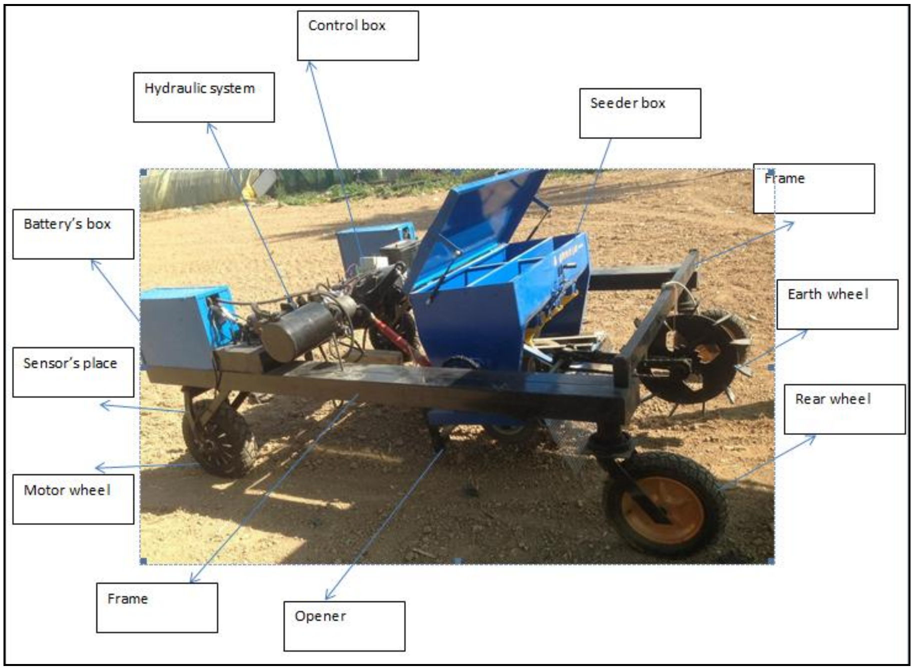

Figure (1), illustrates the design of the mobile agricultural robot.

Components of an agricultural robot

1- Structure and dimensions

Figure (1) shows the image of the robot and its dimensions ,as the structure was manufactured from an iron frame of 2.5 mm thickness and hollow to reduce weight, a width of 2 m and a length of 2.5 m, and a height of 80 cm from the ground. Four wheels were placed with a wheel in each corner of The frame is connected to the front iron wheel holder with a length of 40 cm, and the rear wheels are used with a thickness of 5 cm and a diameter of 15 cm. Rotation . The structure also contains two boxes 20 cm wide and 40 cm high, each one of which is placed on the front end of the robot for the purpose of placing the batteries and their number is six batteries per box with the control and connection wires and the unit operating the robot .The arms in the center has placed the hydraulic lift and on the right pump and tank hydraulic on the left and put the water tank with irrigation pump - related pipe irrigation connecting to the base of seeder- fertilized and four fountains by one for each fountain Glens.

2- Front traction motors , Figure (1)

The most common traction systems are wheels and spoilers . The system has a grub better distribution of the load on the surface of the soil, which dramatically reduces the pressure and the Nzlaq on the soil, and a greater capacity to private traction in soft soil or sand . This system is commonly used in large equipment or those that need high capabilities to perform or accomplish huge works , and despite this advantage , it

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has a high cost in manufacturing and maintenance. For the mobile agricultural robot (Research Project) , these characteristics are not important to some extent , but the accuracy of direction, low energy consumption and low cost are the main goal of the project . The same cheap wheels systems price, based on the reduced need for traction and load to be distributed, they meet the needs of this project. In this project , the two-way propulsion system was adopted (2WD), And to increase the agricultural robot's pulling capacity in variable field conditions, the two front wheels were placed with a capacity of 2000 watts per wheel, which gives a towing capacity of 5 electric horsepower , and an independent traction in each wheel equals 2.5 electric horsepower and a carrying weight of more than 200 kg on each tire as shown in figure (2) with engine features.

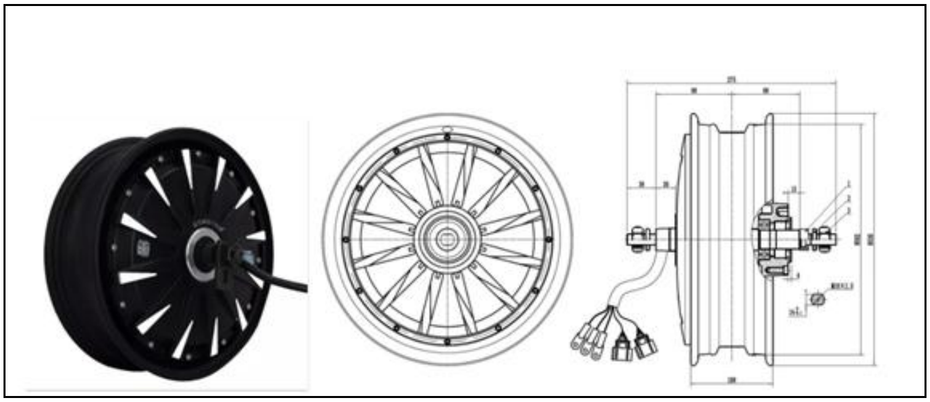

Figure (6) shows the electric motor and its specifications as follows:

1- 12 inch Hub Motor (260). 2- Type: DC Brushless Motor. 3- Version: V1, V3. 4- Power Range: 1500W, 2000W, 3000W or 5000W. 5- Voltage Range: 48V, 60V, 72V, 84V, 96V. 6- Magnet Height: 30mm, 35mm, 40mm and 45mm. 7- Wheel Size: 12 x 3.5 inch .8- Recommendation Tire: 120/70-12. 9- Speed: 30 – 100km/h. 10- Torque: 30 – 230N.m.11- Axle: dual side shaft type.12- Brake: disc brake (220mm).13- Hall Sensor: 2 sets (1 for use and 1 for backup).

3- Rear steering wheels, Figure (1)

An independent steering system has been selected for each wheel with ease of installation and steering, this steering describes the relationship between the external angles and the desired direction for each wheel depending on the dimensions of the agricultural robot structure and the ability to set the required size of each operation, in our research this the rear wheels are free to move on its axis and take an order Steering from the front wheels, when turning the vehicle to the left, for example, the front wheel is stopped from the left side of the vehicle and the wheel continues to work on the right, which gives the rear wheels an angular direction by 45 degrees, so that the result is the rotation of the vehicle around its axis by 90 degrees. The direction was set and stopped at the desired point with directional sensors that adjust the forward direction of the robot.

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4 - Power supply , Figure (2)

Batteries are a source of energy to operate all parts of the robot, as 12 batteries have been placed, six batteries for each electric motor (Series connection). The capacity of each battery is (12 volts, 20 ampere / hour), and for the hydraulic device, used a battery of capacity (12 volts, 70 ampere / hour) and for the water pump ,used a battery wiht capacity of (12 volts , 20 ampere / hour). A battery type was selected (L family) , Fig. (2), in the production of electric power to operate the compound of operating electric power and which are characterized process re - shipment to hundreds of times, (Dustmann, 1998). Which makes them with the production of electrical energy and for a long time , they are characterized by high ability to produce electric power for vehicles and feasible significant economic, in addition to reducing environmental pollution by gases emitted from the exhaust gases in the transport vehicles that run using gasoline or Diesel . (Zdrak, 1992) .

Figure No. (2) shows the type of battery used in the robot

Studied Properties

1- Field efficiency%

Field efficiency was calculated using the following equation suggested by

(Hunt, 1980).

$$\mathbf{Fe = Pp/Pt \times 100\ \%} \quad \ldots\ldots\ldots\ldots(1)$$

Fe = Field efficiency of the machine (%).

Pp = Practical productivity of the machine (hectares / hour).

Pt = The theoretical productivity of the machine (hectares / hour)

2- Energy consumption

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In electrical equations, the current is denoted by a letter I, And its intensity depends on the value of the voltage and electrical resistance, and is related to a few of them through the following equation , (Britannica, 2017) :

$$V = I * R \ldots\ldots. (2)$$

V =It is the electric potential difference between the two ends of the metal conductor (resistance) and it is measured in a unit called Voltage, and denoted by the symbol(V).

I = It is the intensity of the electric current passing through the conductor, and it is measured in units called Amps, and denoted by the symbol (A).

R = She resistance The conductor of the current is measured in units called In ohms, and is symbolized by the symbol (Ω).

3 - The number of seeds per square meter

We can express the seed rate seed rate) By number of seeds per hectare or by mass of seeds sown kg / ha. And use the following equation to calculate the number of descending seeds. (Wilhelm et al, 2004)

$$Rs = \frac{10000\, Q\, \rho b}{W\, V} \ldots\ldots\ldots. (3)$$

Rs = Seed rate, kg / hec. or seed / hec.

Q. = Seed flow rate from the feed unit, L / sec.

Pb = Bulk density of seeds, kg / liter or number of seeds per liter.

W =Width of coverage of the seed , m.

V =Seed velocity , m / s .

4- The number of seeds on the linear meter.

The number of descending seeds per meter length was calculated according to the following equation (Al-Banna et al., 1990)

$$Ns = Q / Nr \ldots\ldots\ldots\ldots\ldots (4)$$

Ns = Number of seeds per meter length.

Q = The number of seeds required per square meter.

Nr = The number of lines per square meter.

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statistical analysis

The global experiment was carried out according to a randomized complete block design with three replications. The first factor represents three velocities, which are (3, 5, 10) km / h , and the second factor represents three depths, which are (0-3, 3-6, 6-9) cm. And because of the loss of some experiment parameters, which are the second and third depth at the first speed, as a result of the robot's inability to work in the second and third depth at the first speed only, because the speed is slow and the two depths require greater capacity. Details have been analyzed according to experiments global unbalanced, compared to the averages according to the test less significant difference, at the level of probability (LSD = 0.05), The results were analyzed by programming GenStat v.12.1. (Al rawe ,at el , 1980).

Results and Discussion

1- The effect of velocity factor on studied properties :

Field efficiency%:

Figure (3) shows that the forward speed of a robot has a significant effect Slight in the characteristic of field efficiency at different levels of speed, as the speed exceeded (10) km / hour in achieving the highest value of field efficiency as it reached (65%) , and the speed (3) km / hour achieved the lowest value of field efficiency and was (64%) , while the speed (5) km / h recorded field efficiency (64.99%) . This insignificant difference is inherently beneficial to the use of robots in the field instead of agricultural machinery and the associated mechanical and environmental problems.The reason for this, is that speed is one of the components of actual field productivity and thus affects the percentage of field efficiency, so any increase in speed is followed by an increase in actual field productivity . Abdel Rahman, (1992),Gupta And others (1999).

Figure (3), shows that there are slight significant differences in the effect of the depth factor on the field efficiency%, as the depth (6) cm gave the highest field efficiency ratio of (65.03%), while the lowest percentage of field efficiency was at depth (9) CM, reaching (64.96%), and the reason is that the higher the soil resistance to the machine, the lower the operational speed of the machine, and thus the field efficiency decreases, and this is consistent with what Al-Awadi (1985) reached, and is also consistent with what Abdul Rahman (1992) pointed out.

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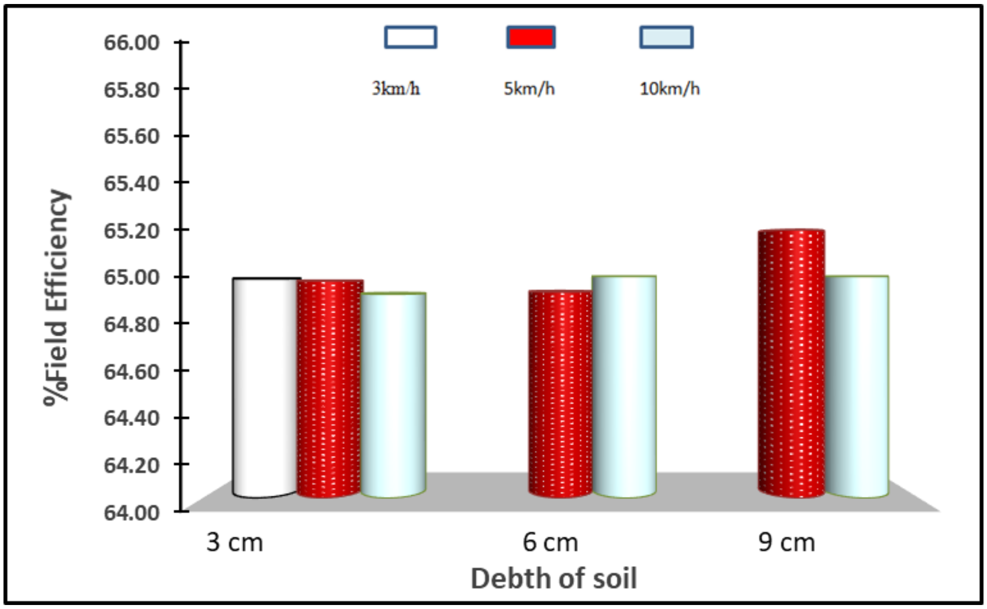

Figure (3) The effect of speed and depth on the field efficiency of the robot.

Energy consumption:

The results of the experiment showed that the higher the speed, the greater the amount of energy consumption, as the highest value of energy consumption was recorded at 9 cm load and the speed was 10 km / h, and the lowest value was 2 ampere when the load was 3 cm and the speed was 3 km / h. The reason is that the higher the speed, the greater the number of motor windings, and consequently an increase in the amount of current entering the motor required to meet the need of the specified speed.(Britannica,2007) .

The results of the research indicated, that the greater the depth, the greater the resistance of the soil to penetration, and thus an increase in the ability of the robot to provide a balance between action and reaction by increasing the appropriate current to provide the necessary capacity to detonate the soil by the breaks . Where the third depth recorded (9) cm, the highest value of energy exchange reached (8) ampere, while the lowest value of energy exchange was at the first depth (3) cm, and reached (2) ampere only. The reason for this is that increasing the depth of the seed increases the drag force, and the result is a greater energy expenditure. This is consistent with, (Blackmore, et al., 2004).

The number of seeds per square meter:

The results of the statistical analysis according to Figure (4) indicate that there are significant differences in the quality of the number of seeds per square meter when using the different speeds of the agricultural robot , as the second and third speeds significantly surpassed the first speed, and the speed , (5) km / hr achieved the best value. for the

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distribution of seeds per square meter , and was (26.80) seed / m 2 , and achieved a speed 10 km / h value amounted to (21.90) seed / m 2 , the highest value for the distribution of seeds was recorded at speed (3) K m / An hour and reached (30.03) seeds / square meter , meaning that the distribution of seeds was accurate at the second speed , and the reason for this was due to the suitability of the soil to the mechanism of the seeding action and within the aforementioned speed, which led to its stability in work and distribution of seeds. This is consistent with what was stated by both Rocha et al, (1991), Nielsen(1995), Rajbo et al, (1995), and Silva et al, (2000), Nafziger (2001).

Figure (4) indicates the existence of significant differences in the characteristic of seed distribution in a single line at different depths, as each of the second and third depths significantly exceeds the first depth, and the best percentage of seed distribution is recorded at the depth (6) cm, and reached (25.75) seeds / square meter , the lowest percentage of seeds distributed in a single line was achieved by the depth (3) cm, which is (22.59) seeds / square meter , while the depth (9) cm achieved a distribution ratio of (27.45) seeds / m 2 , and the latter did not differ significantly with depth (6 cm). The reason for the increase in the value of the ratio of the distribution of seeds per meter when increasing the depth is because the soil is well prepared, and that the greater the depth, the more stable and stable the mobile robot is when working at these depths, as well as the possibility of the seeds rolling at great depths, which led to the stability of the seed in The area in which it fell ,Boumheckel (1976), Al-Banna et al ,(1985), Morrison and Gerik (1985).

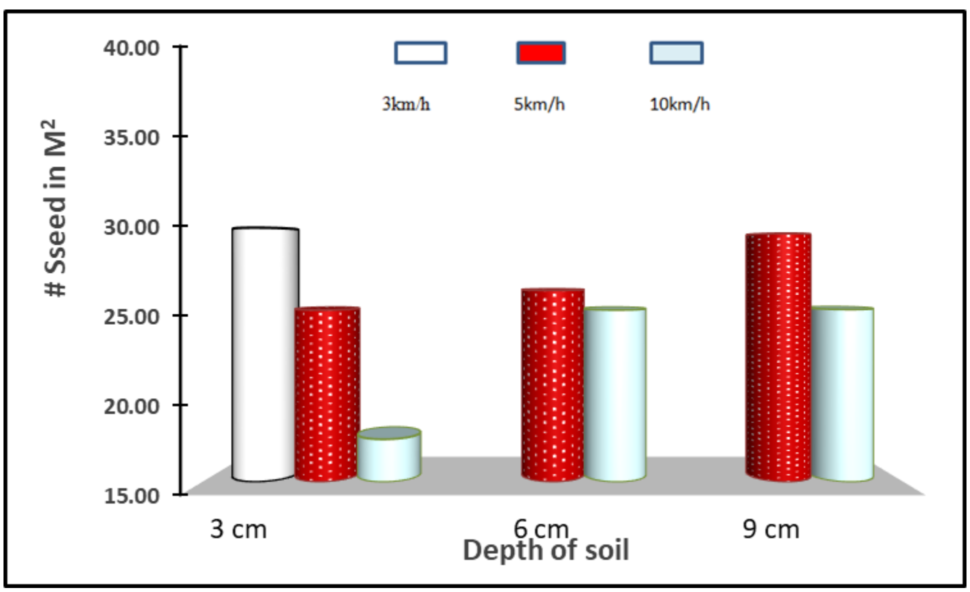

Figure (4) The effect of speed and depth on the number of seeds per square meter.

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Single seeds per line meter length;

Figure (5) shows that there are significant differences in the characteristic of distributing seeds in one line when using the different speeds of the mobile agricultural robot , as the second speed exceeded the third speed and the first speed significantly, and the speed (5) km / h was the best average for seed distribution in per line, and was (9.55) seed / line , the lowest percentage for seed distribution was recorded at speed (10) k m / h and amounted to (7.70) seed / line , and the highest distribution rate was at the speed (3) km / h reached (10.72) seed / line, meaning that the distribution of seeds was accurate, and the reason for that is due to the stability of the robot 's work in working and distributing the seeds. This is consistent with what was stated by both, Rocha et al (1991), Nielsen(1995), Rajbo et al, (1995), and Silva et al , (2000), Nafziger (2001). Figure (5) indicates that there are significant differences in the characteristic of seed distribution in a single line when using different seeding depths, as the second depth is significantly more than the third and the first depth, and the depth (6) cm has been achieved, the best average for seed distribution in a single line. It was (9.19) seeds / line, and the lowest distribution percentage for seeds was recorded at depth (3) cm, reaching (7.93) seeds / line, and the highest percentage of distribution was at depth (9) cm, reaching (9.80) seeds / line, meaning The distribution of the seeds was accurate, and the reason for this was due to the stability of the robot's work in working and distributing the seeds. This is consistent with his findings Silva et al,(2000).

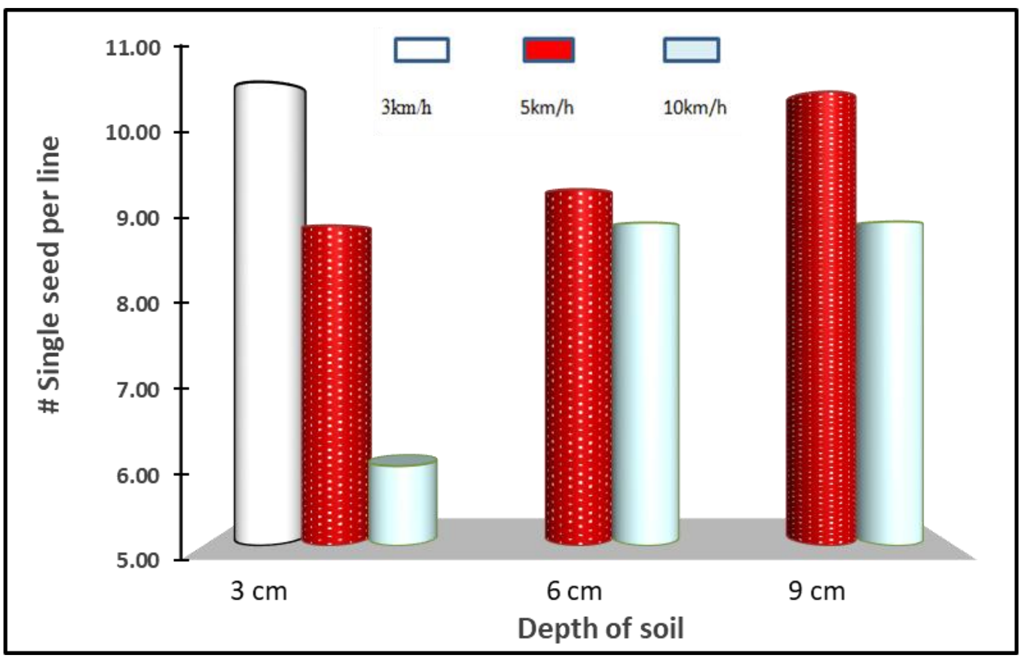

Figure (5) The effect of speed and depth on the number of individual seeds in the meter length line.

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2- The effect of the overlap between speeds and depths on the studied properties:

Field Efficiency :

Figure (3) indicates that there are slight significant differences in the field efficiency characteristic of the robot when the different speeds overlap with the different depths of the seeding process, as a slight increase in field efficiency% is observed when increasing the forward velocity of the drawer and at all depths, as the highest value was recorded (65.03%) at The depth is (6) cm with the speed (5) km / h in the field efficiency characteristic, while the depth (9) cm with the speed (10) km / h was recorded as the lowest value for the actual field efficiency (64.96%).

The number of seeds per square meter:

The results of the statistical analysis according to Figure (4) indicate that there were significant differences in the characteristic of the distribution of seeds per square meter when the different speeds overlapped with the different depths of sowing, as the best proportions of the distribution of seeds were recorded at the velocity (5) km / h with the depth (3) cm, and reached (25. 17) seed / m 2 , and the speed of 10 km / h with depth (6 cm) and amounted to (25.17) seed / m 2 .

The number of single seeds per line length:

The results of Figure (5) indicate that there are significant differences in the characteristic of the distribution of seeds in one line when the different speeds overlap with the different depths of the agricultural robot, where the best distribution of seeds was recorded on the line length at the speed of (5) km / h with the depth (6) cm. , And it reached (9.4) seeds / line, and the same is the case at the speed (10) km / hour with the depth (9) cm, reaching (9) seeds / line. As for the lowest value for this characteristic, it was recorded at depth (3) cm with speed (10) km / hour and it was (5.98) seeds / line.

Conclusions and recommendations

Successful use of robots to carry out agricultural operations (seeding, fertilization, and primary irrigation) in agricultural environments with high efficiency . It was conducted growth computer simulation and validation structure designer by middle of a particular program. And after the manufacture of the robot , it became possible to know that the methodology used in developing agricultural robots was effective and met all field needs .

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