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"DESIGN AND DEVELOPMENT OF AUTOMATIC POTATAO PLANTER FOR MINI TRACTOR"

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Abstract-

With the increased use of mini tractors (<20hp range) in agricultural operations, it is imperative to develop matching implements. Saharanpur region is one of the major potato producing regions of Uttar Pradesh. In the current study a single potato planter suitable for mini tractors was developed and field evaluations were conducted to evaluate the performance of the machine. Studies were conducted for field evaluation of potato planter crop to study the effect of depths of sowing (cm) and speed of operations (km/hr) on various dependent parameters like field capacity(ha/hr), field efficiency (%), missing seed (%). The study also revealed that depth of sowing and speed of operation significantly affected missing seed, field capacity and field efficiency. The study was conducted at Research farm, SUG. Agronomic data recorded during the field evaluation showed that the highest effective field capacity value was reported to be 0.09ha/hr at 2km/hr forward speed while the lowest value of effective field capacity was reported to be 0.07ha/hr at 1.25km/hr at a maximum depth of 15cm.The field efficiency obtained at a three different speeds and depths of sowing. It is evident from the figure that as the speed decreases the effective field capacity increases and highest field efficiency was reported at 1.25km/hr. This is because the field efficiency is the ratio of effective and theoretical field capacity and theoretical field capacity depends on implement width and speed.The highest missing seed % was reported at greater speeds and increased depths. The maximum value of missing seed % was 8.9% at 2km/hr and 12cm planting depth. A larger value of missing seed % at higher speeds can be attributed to higher chain velocity which gives little time to the seeds to fill up in the cups. Missing seed % value at 1.25 and 1.5km/hr was comparable as there was not much difference in the speeds. The minimum value of missing seed % was reported to be 5.5% at 1.25km/hr and at a depth of 12cm.

Introduction

Fruits and vegetables are important for the food and nutritional security of the vast copulation of our country. The choice and varieties of food consumed is changing from the traditional staple cereals to high value foods such as fruits arc vegetables, meat, dairy and fish. India has made a quantum jump in vegetable production starting from 28.36 million tonnes in 1969-70 to 72.83 million tonnes in 1997-98. The present vegetable production in India is 113.5 million tones in an area 7.2 million hectares with an average productivity of15.7 tones/hectare. In addition to the demand for local consumption, there is an increaseddemand of vegetables as one of the most potential commodities for export. The value of fresh, canned and dehydrated vegetables export has been to the tune of Rs 670.47 crores during 1997-98 accounting for 45.19 % aft re export of horticultural products. The per capita consumption of rabies in India has increased from 95 grams to 175grams per day, but it is muchless than the nutritional requirement of 285 grams per capita per day for a balanced diet. Vegetables contain phyoto chemicals that have anti-cancerous and anti-inflammatory properties which confer many health benefits. The major vegetables grown in India are potato, brinjal, tomato, onion and most preferred winter vegetables cauliflower and cabbage.

Potato is the most common name for a perennial plant **Solanum*Tuberosum*,** of the family **Solanaceae,** and is popularly known as the “King of Vegetables”. It is most important food crop in India after rice, and maize. Indian vegetable basket is incomplete without potato. Being a short duration crop, it produces more quantity of dry, edible energy and protein in lesser duration of time than cereals like rice and wheat. Hence, potato may prove to be a useful tool to achieve the nutritional security of the nation.Knowledge interventions are important for any production system for higher yields and make it cost effective. The main constraint to enhance the productivity and quality of vegetable crops in India is lack of technological interventions. Vegetable farming is labor intensive. One of the main constraints to increase both area under vegetable crop and its productivity is the low level of mechanization. Timeliness is the key requirement in vegetable cultivation. The main bottlenecks are inefficient methods of applying critical after quality seeds, fertilizers and pesticides as well as not accomplishing the critical operations and harvesting in time. Introduction of harvesting devices, reduce the time of operation and avoid the losses due to adverse weather conditions during the harvesting, the saving in time in harvesting may be utilized for post-harvest processes to increase storage life of the harvesting. Also, most of the vegetables are perishable in nature; hence need proper and careful harvesting, handling and storage before processing or consumption. Most of the operations, except field preparation, are manual requiring high amount of labor and drudgery.

Potato is a major crop grown in more than 100 countries in the world. The plant is probably native to the Andes, where it was cultivated by Incas. Spanish explorers are believed to have brought it in 16th century from Paris to Spain. It is believed to have been introduced in India by Portuguese sailors during early 17th century and its cultivation was spread to North India by the

British. Since 1830 it is being grown as a commercial crop. With an annual global production of about 300 million tonnes (2006-07), potato is an economically important stable crop in both developed and developing countries.

India ranks **4th** in the production area of potatoes. It is the **3rd** largest country in world in production of potatoes after China and Russian Federation. Potato is cultivated in 23 states but mainly produced in U.P., M.P., Bihar, Delhi, Punjab, Haryana, Gujarat and Himachal Pradesh about 90% of the total potato area is located in the subtropical planes, 6% in the hills and 4% in the plateau region of the peninsular India.

Nutrient content of potato

Nutrient	Without skin (156 g)	With skin (173 g)
Vitamin C	33	28
Thiamin	11	7
Niacin	11	12
VitaminB_6	23	27
Folate	4	12
Pantothenic Acid	9	7
Iron	3	10
Magnesium	10	12
Potassium	17	26
Copper	17	10
Dietary Fiber	9	15

Potato is grown in all types of soils, but light, well drained sandy clay loam soils are best suited. In India maximum Chipson-1, Kufri Chipson-2,KufriJyoti, KufriLuvkar, G-4 and Kufri Chandramukhi have been released recently by different research organization for processing purpose.In India, more than 80% of the potato crop is raised in the winter season *Rabi)*under assured irrigation during short winter days from October to March. About 8% of area lies in the hills during long summer days from April to October. Rainy season potato production is taken in Karnataka, Maharashtra, Himachal Pradesh, J&K and Uttar Pradesh.

Potato harvesting is done by human power, mechanical power or animal power. In India, it is mostly done with the help of khurpi or spade. Time of harvest of potato is very important. Main crop is ready for harvest within 75 to120 days of planting depending upon area, soil type and variety sown. In the hills, the crop should be normally harvested when the soil is not very wet. The main crop is ready for harvest when majority of leaves turn yellow brown.Manual harvesting of potatoes is very labor intensive, time consuming and causes lots of damage to the potatoes. The damage caused in digging is 16 to 21% out of which 11% is due to cutting and bruising and 5 to 10% remain undug.Animal power is used by the farmers. In this method of digging the tubers lose to 13 to 16% out of which 9% is due to cutting and bruising and 4 to 7% 'remains undug.Various tractor drawn potato planters have been developed in the country in recent past, out of which elevator type planter is the most common. On an average these types of planter expose 85 to 90% of the potatoes and covers 1 to 3 ha of area per day.

JUSTIFICATION:-

A lot of research work has been done related to the Potato planter and there are a number of potato planters which are available in the country. These planters range from automatic to semi-automatic to the ones which are bullock drawn. The correct source of power must be used with every implement and this will lead us to save a lot of power that is otherwise being wasted. The current hp range of tractors for potato planting operation is 30-55hp in which most of the power is being wasted. So, there must be implements that match with the tractor power. Mini tractors (less than 20hp) are now being commonly used in India and thus there must be matching implements designed and developed for those tractors. Keeping in mind the afore-mentioned points, a project work was undertaken with the following major objectives:

OBJECTIVE:-

- To design and development a potato planter for mini tractors (less than 20hp range).
- To evaluation and performance of the potato planter.

MATERIALS AND METHODS

This deals with the materials used and method followed in conducting experiments of the proposed study leading to design modification of a tractor drawn potato planter for sowing of potatoes.

Main parts of the unit are:-

- Seed box.
- Frame
- Three point hitch system
- Power transmission
- Seed metering mechanism
- Ridger
- Wheel

Design of the seed box:

Trapezoidal shape of seed box is used in the machine for free flow of seed in hopper bottoms. Volume of seed box is given by

$V_b = 1.1 V_s$

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$V_{s.} =$

V_b=1.1Ws/¥s ………………. Eq. (1)

Where,

W_s= weight of seed in the box, g

¥$_s$ = bulk density of seed g/cm^3

V_b= volume of seed box, cm^3

V_s= volume of seed,cm^3

Using the dimension of box, its volume calculated as:

$W_S = V_a + V_b$---------------- Eq. 2

Where,

V_a = Volume of section – a of box

V_b= Volume of section – b of box

Power transmission

The power (kw) transmitted in the planter is very low, for power transmission a medium size wheel fitted with sprocket of 12 teeth selected .Another sprocket of same size 12 teeth was used for seed pick.The seed hopper fitted on the frame of the drill in such a way that the center to center distance between wheel and shaft sprocket is 40 cm.A chain length is calculated by following equation.

m =…………………… (4)

Where,

m=number of chain link

C= center to center distance two sprocket

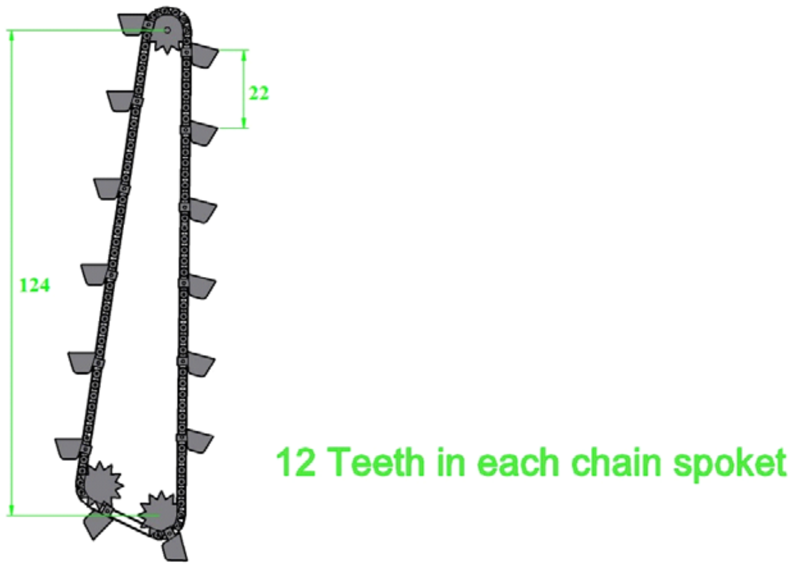
Z_1= number of teeth in driver sprocket

Z_2= number of teeth in driven sprocket

P=chain pitch, mm

This type of drive for the machine is selected because;

- The drive is transmitted to parallel shafts.
- It does not slip and give positive drive.
- It is most ideal for medium center to center between two shafts.
- It gives smaller load on the chain than the belt drive.
- It has high transmission efficiency (98%).



Schematic View of seed metering mechanism

Seed metering mechanism

The planter is to be used for potato crops. Therefore, seed metering is selected for the machine for sowing of this crops. The number of teeth on the sprocket is calculated by

$$D_r = V_r / \pi N_r \quad \text{.. Equation 4}$$

Where

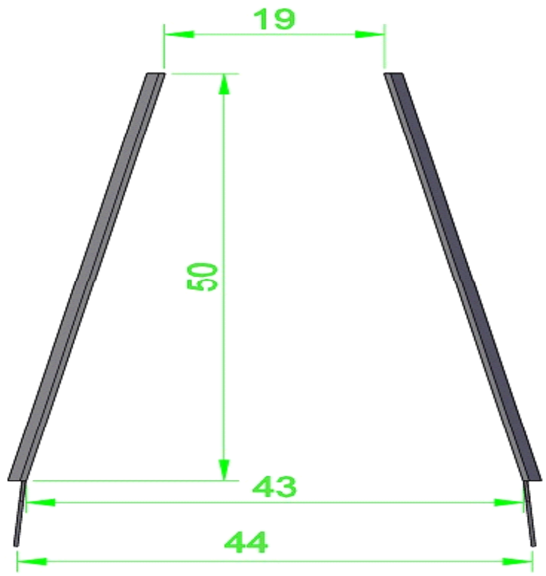
D_r = the diameter

V_r= Peripheral velocity

N_r= Revolution per minute

Ridger

It is used for making furrows and ridges potatocrops. The ridger body is operated in tilled soil by a tractor.The share point penetrate in the soil and the ridger body displaces the soil to both sides and furrow is created.

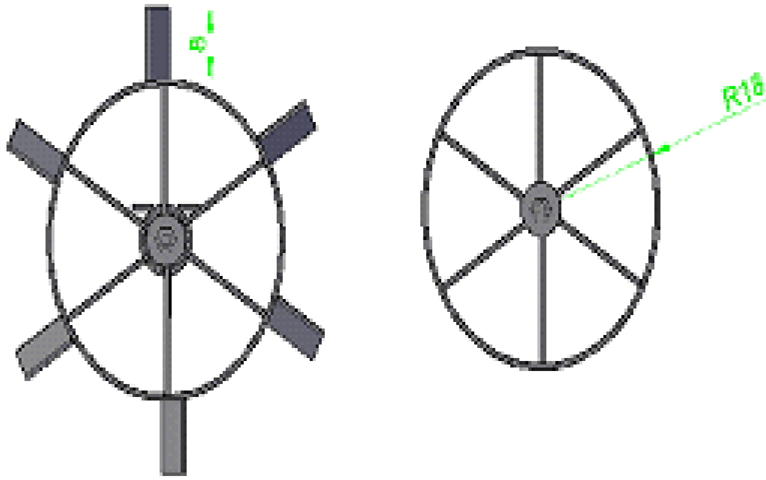


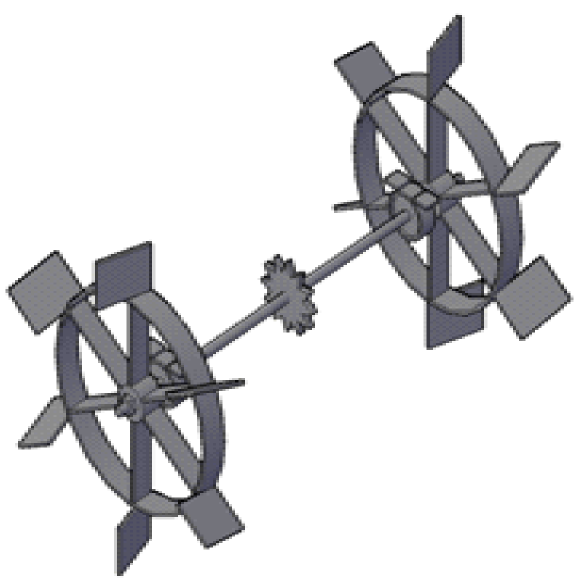
Schematic view of Ridger (Dimensions in cm)

Design of wheel:

The ground wheel diameter is selected on the basis of ground clearance that is available below theseed box.Since the ground wheel was more concerned for supporting the seed box and its movement along with the planter and for power transmission, main focus was given on the width of the wheel, so as to prevent its sink age into the soil.

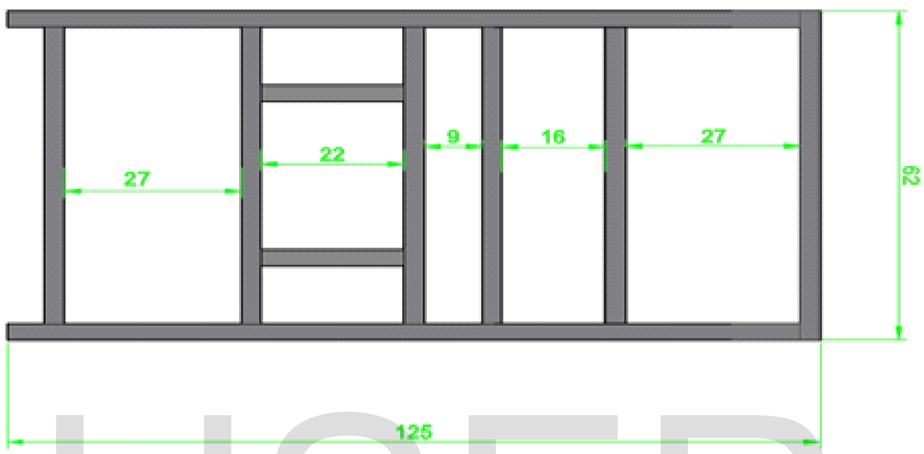
A number of strips of mild steel sheets ranging from 50mm to 100mm wide and 4mm thick were tested in different soils for its sink age at a particular load. A sheet of 100mm width and 4mm thickness was selected and radius of wheel is 18cm.





2.6 Design of frames

The frame of farm machines must be as light as possible to reduce cost,soil compaction and propelling power but strong enough to resist the shocks due to rough fields or obstacles. Tubes are closed box section are strongest for their weight and arc welding of connecting member makes to take a full advantage of their strength in both torsion and bending .They serve as well as a central frame member to which various function arms axle brackets etc.



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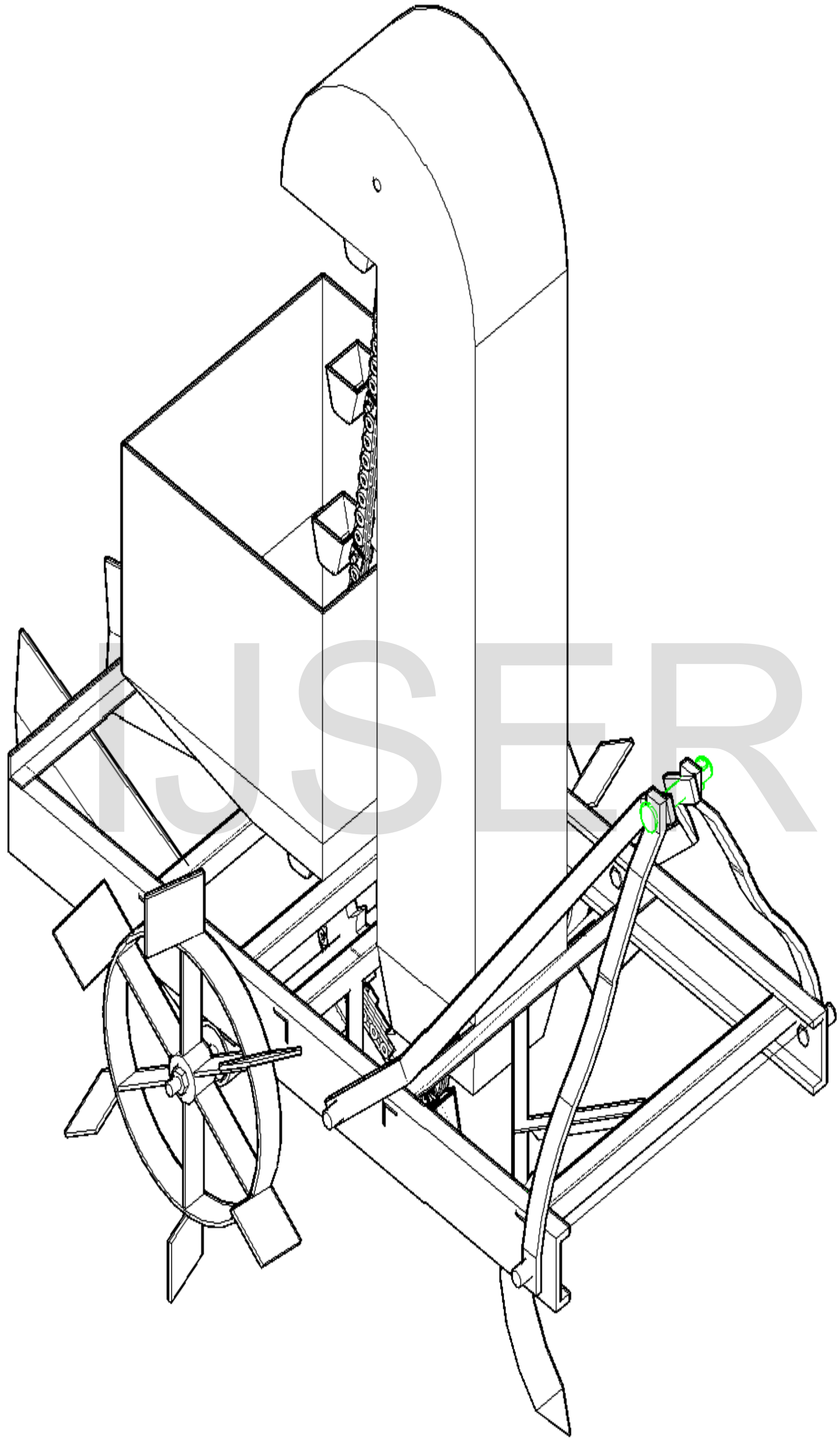

Symmetric view of the unit

AUTOMATIC POTATAO PLANTER FOR MINI TRACTOR

Table 3.3 Different parts, their dimensions and material of construction

S.N.	Name of parts	Dimension	Material
1	Seed hopper	51X46X40cm	Mild steel sheet 18 gauge
2	Frame	162x62cm	Angle iron sheet
3	Chain and sprocket	Chain with 1/2" pitch, 1/8" internal width, 3/32" external width, 12 teeth sprocket	Steel
4	Wheel	36cm	Mild steel
5	Cups	7x4 cm	Mild steel
6	Three point hitch system	30x37.5cm	Mild steel bar
7	Furrow opener	5x20 cm	Carbon steel
8	Ridger		

Working of potato planter:

The potato planter consists of chain and cup type seed metering mechanism, which gets drive from the ground wheel. As the planter moves forward, the chain and cup assembly starts moving through the seed hopper in which seeds are stored. As the chain moves up it carries seeds in the cup, which are located at some distance from each other. As the chain moves further up the cup gets inverted inside a chute which drops the seed to the ground. At the same time the furrow opener opens up a furrow in which the seeds are planted. As the planter moves further, the ridger attachment then covers the seeds and makes a ridge.

RESULT AND DISCUSSION

This chapter deal with the result of the performance evaluation obtained during the field tests. The experiments were conducted in the field to evaluate the performance of the potato plant. The effect of varying speed and depth was evaluated on the following dependent parameters.

- Effective field capacity
- Field efficiency
- Potato missing

Effective Field capacity:

The effective field capacity obtained at a three different speeds and depths of sowing is shown in figure 4.1. It is evident from the figure that as the speed increases the effective field capacity also increases. This is because the field capacity is inversely proportional to the time taken to cover an area. As the speed increased, the time required to cover an area reduced and vice versa, which increased the effective field capacity value. With the increase in depth, the effective field capacity decreased which was due to the increased time on increased depths.

Field efficiency (%) at different speeds & depths with replications

The highest effective field capacity value was reported to be 0.09ha/hr at 2km/hr forward speed while the lowest value of effective field capacity was reported to be 0.07ha/hr at 1.25km/hr at a maximum depth of 15cm.

Analysis of Variance (ANOVA) reported that forward speed as well as depth of operation had a significant effect on effective field capacity individually but the interaction of the two factors was not having any significant effect on the field capacity. The ANOVA is given in Table 4.1.

Table 4.1 ANOVA for the effect of speed and depth on effective field capacity

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	0.20258	2	0.10129	355.428**	3.4E-15	3.55456
Depth	0.00214	2	0.00107	3.75445*	0.04337	3.55456
Interaction	0.0003	4	7.5E-05	0.26472	0.89676	2.92774
Within	0.00513	18	0.00028			
Total	0.21016	26				

** Significant value at p=0.05

Field Efficiency:

The field efficiency is the ratio of effective field capacity and the theoretical field capacity. The field efficiency obtained at a three different speeds and depths of sowing is shown in figure 4.2. It is evident from the figure that as the speed decreases the effective field capacity increases and highest field efficiency was reported at 1.25km/hr. This is because the field efficiency is the ratio of effective and theoretical field capacity and theoretical field capacity depends on implement width and speed. As the speed increased, the time required to cover an area reduced and vice versa, which increased the theoretical field capacity value. With the increase in depth, the field efficiency value increased which was due to the decreased value of field efficiency on increased depths. The highest field efficiency value was reported to be 83.6% at 1.25km/hr forward speed while the lowest value of field efficiency was reported to be 60.7% at 2km/hr/hr at a minimum depth of 8cm.

Field efficiency (%) at different speeds & depths with replications

Analysis of Variance (ANOVA) reported that forward speed only has a significant effect on field efficiency while depth of operation and the interaction didn't affect field efficiency. The ANOVA is given in Table 4.2.

ANOVA for the effect of speed and depth on field efficiency

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	0.20258	2	0.10129	291.174*	2E-14	3.55456
Depth	0.00082	2	0.00041	1.18151	0.32951	3.55456
Interaction	0.00049	4	0.00012	0.35046	0.84028	2.92774
Within	0.00626	18	0.00035			
Total	0.21016	26				

** Significant value at p=0.05

Missing seed %:

Missing seed % at different speeds and depths has been reported in figure 4.3. The highest missing seed % was reported at greater speeds and increased depths. The maximum value of missing seed % was 8.9% at 2km/hr and 12cm planting depth. A larger value of missing seed % at higher speeds can be attributed to higher chain velocity which gives little time to the seeds to fill up in the cups. Missing seed % value at 1.25 and 1.5km/hr was comparable as there was not much difference in the speeds. The minimum value of missing seed % was reported to be 5.5% at 1.25km/hr and at a depth of 12cm.

Analysis of Variance (ANOVA) reported that forward speed as well as depth of operation had a significant effect on missing seed % individually but the interaction of the two factors was not having any significant effect. The ANOVA is given in Table 4.3.

ANOVA for the effect of speed and depth on field efficiency

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	26.0942	2	13.0471	19.1527*	3.5E-05	3.55456
Depth	10.889	2	5.44448	7.99229*	0.00328	3.55456
Interaction	3.06865	4	0.76716	1.12617	0.37531	2.92774
Within	12.2619	18	0.68122			
Total	52.3137	26				

** Significant value at p=0.05

Conclusion

This chapter consists of the work done one valuation of potato planter for sowing the potato.The study was conducted at the research farm, Shobhit University Gangoh..For field evaluation of the potato planter, Regional Network of agriculture Machinery test code was adopted. Forward speed and depth of sowing were taken as independent variables effective field capacity, field efficiency and missing seed % were taken as dependent variables.The highest effective field capacity value was reported to be 0.09ha/hr at 2km/hr forward speed while the lowest value of effective field capacity was reported to be 0.07ha/hr at 1.25km/hr at a maximum depth of 15cm. The highest missing seed % was reported at greater speeds and increased depths. The maximum value of missing seed % was 8.9% at 2km/hr and 12cm planting depth. Field capacity increased with increase in forward speed and field efficiency decreases with increase in forward speed and depth of sowing.

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