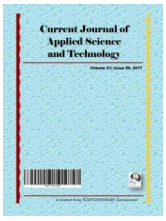

Current Journal of Applied Science and Technology

29(2): 1-9, 2018; Article no.CJAST.43589
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Exploring the Possibilities of Sowing Sugarcane Bud and Potato Tuber with a Single Equipment – A Review

Jaideep[1*], Er. Mukesh Jain[2], Vijaya Rani[2], Rahul Singh Pannu[1] and Parveen Dhanger[1]

[1]College of Agricultural Engineering and Technology, CCS HAU, Hisar, Haryana, India.
[2]Department of FMPE, College of Agricultural Engineering and Technology, CCS HAU, Hisar, Haryana, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/43589
Editor(s):
(1) Dr. Harry E. Ruda, Professor, Stan Meek Chair Professor in Nanotechnology, University of Toronto, Director, Centre for Advanced Nanotechnology, University of Toronto, Canada.
Reviewers:
(1) H. L. Garbharran, Durban University of Technology, South Africa.
(2) Hani Mansour, Egypt.
(3) Jaime Cuauhtemoc Negrete, Universidad Autónoma Agraria Antonio Narro, Mexico.
(4) A. Ashok Kumar, Acharya N. G. Ranga Agricultural University, College of Agricultural Engineering, Bapatla, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/26267

Review Article

Received 08 June 2018
Accepted 23 August 2018
Published 16 September 2018

ABSTRACT

Planting of any crop is very much important as far as the crop growth and yield is concerned. Sugarcane and potato planting is a very labour intensive job and involves considerable human drudgery. India stands second in sugarcane production in the world next to Brazil. In case of potato, India is the third largest potato producing country in the world. There are many factors which affect the seed germination and crop yield. In this article, reviews of different planting methods of potato and sugarcane crop are discussed. It was found that the rotary and cylindrical cutting mechanism for sett cutting of sugarcane seed was used in most of the mechanical planters. In most of the potato planting machines, the cup-belt type metering mechanism was used. A new technique of sugarcane bud-chip planting has been introduced for sugarcane planting. Seed rate in case of sugarcane bud-chip planting was found to be 1-1.5 t/ha which was very less as compared to mechanical planting by

**Corresponding author: E-mail: jaideepchahal24@gmail.com;*

sett cutter planter in which seed rate of approximately 9.7 t/ha was required. It was found that 75% of labour cost was saved with semi-automatic and 87.50% labour costs were saved with automatic planter as compared to conventional manual planting.

Keywords: Planting; cup-belt; sugarcane bud and potato tuber.

1. INTRODUCTION

Agriculture is one of the most significant sectors of the Indian economy. Agriculture is the only means of living for almost two-thirds of the workers in India. The agriculture sector of India has occupied 43% of India's geographical area [1], and is contributing 17% of India's GVA [2]. Agriculture still contributes significantly to India's GDP despite the decline of its share in India's GDP. There are a number of crops grown by farmers. These include different food crops, commercial crops, oil seeds etc. Sugarcane and potato are the important commercial crops grown in India.

Generally planting of any crop is very much important as far as the crop growth and yield is concerned. Sugarcane and potato planting is a very labour intensive job and involves considerable human drudgery. India stands second in sugarcane production in the world next to Brazil. It is estimated that sugarcane is grown on about 4.95 million hectares with an approximate average production of 71 t/ha, with an annual harvest of 352 million tons during 2015-16 [1]. In the case of potato, now India is the third largest potato producing country in the world. During 2015-16, 2.06 million hectares of the area was under potato cultivation. Total production was estimated at 45.57 million metric tons with an average productivity of 22.09 tons/ha.

Efficient use of precious farm resources has always been critical for sustainable agriculture growth. Seeds are important to farm resources. Accurate seed placement in soil not only helps in ensuring good plant population in the farm but also reduce the cost of production of crops by optimum utilisation of available farm inputs. A planter should place seed in an environment for reliable germination and emergence. Many factors affect seed distributions in the soil. Seed metering mechanism, tube, furrow openers design, seed quality and soil condition, all play a vital role in determining seed distribution. A brief review of past research has been incorporated into this paper.

For sugarcane planting, sugarcane bud chip planting is the latest technique of sugarcane planting, wherein the bud along with a portion of the nodal region is chipped off and planted. Many sugarcane and potato planting equipment have been developed in the past by various research organisations.

2. PHYSICAL PARAMETERS OF POTATO TUBER AND SUGARCANE SETT

Physical properties of agricultural crops are the most important parameter in the designing of metering mechanism and seed hopper of planters and seed drills. Among the physical properties, mass, volume, and projected area are the most important ones in the handling systems [3]. Other important parameters are the width, length, and thickness [3]. Researcher [4] studied the size and shape of potato tubers of four Iranian potato varieties and found a linear relationship between mass and volume of the potato tubers. Diameters of different varieties were found from 41.7 to 93 mm and sphericity from 71 to 83 percent. Gamea et al. [5] studied the physical characteristics and chemical properties of potato tuber under different storage conditions. The diameter of potato tubers was found to be 46.75 to 83.28 mm and sphericity from 65 to 93 %. A study conducted by [6] showed that the diameter of potato tuber was between 35.09 and 68.40 mm. Sphericity varied from 62 to 80%. Yossry [7] also conducted an experiment on the determination of physical properties of potato tubers of three varieties. Results of the experiment showed that the diameter of potato tubers varied from 38.65 to 74.99 mm and sphericity varied from 64.10 to 75.55%. Singh et al. [8] studied the physical properties of two Indian potato varieties and found that the average diameter of the potato tubers varied from 30.23 to 57.68 mm and sphericity varied from 62 to 80%.

In the case of sugarcane planting, the sett length was measured. Sugarcane piece was cut into two to three budded setts by cutter planter for planting. Sett length measured was 300 - 500 mm [9]. Kumar and Singh [10] also measured the sett length which was found to be 33.59 mm. But nowadays, a new technique of sugarcane planting in which only single budded sett of about 40 mm length is used for planting.

Fig. 1. Sugarcane single budded sett

3. METHODS USED FOR SUGARCANE PLANTING

Sugarcane planting is considered as a very crucial and critical operation because the seed cost of sugarcane carry about 30% of the total cost of sugarcane cultivation. Improving uniformity within row spacing is expected to decrease competition between plants. A number of sugarcane planting machines have been developed in the past by various research organisations.

Planting of sugarcane mainly includes the opening of furrows, cutting of cane into pieces (setts), transportation of setts to field and placing them in the furrows, covering the setts with soil.

3.1 Manual Method of Sugarcane Planting

This method is not manual but semi-manual. In this method of sugarcane planting, farmers prepare the field very well by using disc harrows and cultivators. Tractor-drawn ridges are used to open furrows. Furrow to furrow spacing of 65-75 cm is most common in sugarcane. Labourers are employed to cut the sugarcane into three budded pieces, which is called setts. Fifty to sixty quintals of the cane are required to meet the seed requirement for one hectare. The huge amount of setts are transported to the field and then manually dropped in the furrows. Then the setts are covered with soil by animal operated plankers. The labour requirement was found to be 350 man-h/ha and bullock usage of 30.6 bullock-pair-h/ha [10].

3.2 Ring or Pit Planting

The ring or pit system of planting was developed by the Indian Institute of Sugarcane Research, Lucknow [11]. In this method of sugarcane planting, the pits are dug using specially designed tractor drawn power tillers. The pits are then filled with topsoil, farmyard manure (FYM) and other required nutrients and are watered well before planting. Pit depth is kept at 37.5 cm to 45 cm. Under 'ring pit' system, around 6700 pits are made per acre. After planting setts by this method, care is taken to see that only thirty mother shoots are allowed to develop which then leads to robust and healthy millable cane of 1.25-1.75 kg each. This technology can give a yield of 200-275 t/ha (or around three times of conventional method) if the recommended package of practices is fully adopted. The ring pit method of sugarcane cultivation is more water and nutrient efficient as well. This method not only reduces water use but also enhances nutrient use efficiency.

The effect of different planting patterns on the productivity of sugarcane was studied by Chand et al. [12]. The study consisted of five treatments viz. flat planting at a row spacing of 75, 90, 105 & 120 cm and pit planting at the centre to centre distance of 120 cm between two pits.

Fig. 2. Ring or pit method

Results of this study indicated that highest cane yield and returns were obtained in pit planting method as compared to the conventional planting of sugarcane.

3.3 Sugarcane Planting by Means of Mechanical Planters

Many sugarcane planters have been developed in the past by various research organisations. In most of the sugarcane planters, cylindrical or rotary cutting mechanism was used. In most of the sugarcane planters, 2 or 3 labours were required to operate the planter. Different types of sugarcane planters were evaluated for their field capacities, economic feasibility, the effect of forwarding speed on the multiple and missing indexes. Patel and Patel [13] studied the effects of sett length and seed rate on the yield of sugarcane crop. They found that planting of

sugarcane with two bud sett was significantly superior in increasing number of millable canes (110250/ ha), cane yield (110.42 t/ha) as compared to three and single bud setts during all the three years of experimentation. The increase in cane yield was 6.86 and 25.72 % in three and two-bed setts, respectively over single bud sett.

Researchers [14] developed a prototype of two-row tractor mounted sugarcane cutter planter, and performance evaluation of this planter was carried out. It was found that the field capacity was 0.2 ha/h with a field efficiency of 80.0 percent at the effective working width of 1.35 m and forward speed of 1.85 km/h at 2nd low gear. The sett length was 31.8 cm with an average overlap of 6.48 cm observed at the speed of 2.5 km/h.

Performance evaluation of two designs of sugarcane cutter planters namely IISR Lucknow designed ITI make and Khalsa PE 630 was carried out under laboratory and field conditions [9]. It was found that cutting force required to cut sugarcane setts varied from 12.2 to 106.57 N depending upon the diameter of the cane. The cutting force varied from 29.14 to 106.57 N in the cylindrical cutting mechanism used in Khalsa PE 630 planters and from 12.2 to 81.20 N in the rotary cutting mechanism used in IISR planter. The depth of planting varied from 12 - 25 cm. It was found that the rotary cutting mechanism required less force for cutting of setts than cylindrical cutting mechanism.

Patil et al. [15] also evaluated the above-mentioned sugarcane cutter planters namely, Khalsa PE-630 type cutter planter and ITI makes cutter planter. The field capacity of Khalsa makes planter was 0.20 ha/h with the field efficiency of 87.50% at the effective working width of 1.34 m and forward speed of 2.5 km/h at 2nd low gear. A sett length of 32.96 cm with an average overlap of 6.14 cm was observed at the same speed and the seed rate achieved was 9.0 t/ha. On the other hand, field capacity of ITI makes planter was observed as 0.21 ha/h with field efficiency of 76.92% at the effective working width of 1.50 m and forward speed of 1.8 km/h at 1st low gear. A sett length of 26.96 cm and an average overlap of 3.68 cm were observed at the same speed. Seed rate achieved was 9.23 t/ha.

Evaluation of mechanised planting of sugarcane was carried out by Khedkar and Kamble [17]. In this study, two-row semi-automatic drum type and automatic setts cutter sugarcane planters were tested to obtain actual data on overall machine performance. The automatic setts cutter planter was provided with cutter blades, which cut the whole sugarcane into setts of required length and dropped them in the furrow, whereas in the semi-automatic planter pre-cut setts of desired length (35-40 cm) was fed to the planter. The effective field capacity was found to be 0.15 and 0.176 ha/h for semi-automatic and automatic planter, respectively. The field efficiency of the semi-automatic and automatic planter was found to be 55.55 and 51.76%. The cost of planting operation per hectare was worked out to be Rs. 1687 and Rs. 1491, respectively compared to conventional sugarcane planting of Rs 1765. The number of setts required for 10 m row length was 23 and 24 in semi-automatic and automatic planter, and overlapping of the setts was found as 9-15 cm in the automatic planter. Labour requirement for planting operation was 8 and 4 in semi-automatic and automatic planter, respectively and 32 labourers in conventional planting. It saved 75 and 87.50% labourers in the semi-automatic and automatic planter, respectively compared to conventional practice.

Fig. 3. Two row mechanical sugarcane planter
Sources: Singh P.R. [16]

Kumar and Singh [10] studied the performance feasibility and economic viability of sugarcane planter in the western plane zone of Uttar Pradesh. Prototype feasibility testing as per RNAM test code and demonstrations were conducted with Khalsa make three-row sugarcane cutter planter at farmers' field over an area of 106.1 ha. Both field research feasibility testing of the planter and grower input has indicated that the planting of sugarcane substantially differed between automatic machine and manual planting methods. The average length of setts cut by the machine was 33.59

mm. The average overlap between the setts was found to be 30 mm for 3rd low gear. Average effective field capacity of the machine was 0.38 ha/h. The average depth of furrow made by the machine was 190 mm. The average cost of planting by the machine was calculated to be Rs. 1,556 per ha. A time saving of 65% with this machine was found. The field capacity was found to be 2.8 ha/day. The labour requirement was 32 man-h/ha, whereas in conventional sugarcane planting it was found to be 350 man-h/ha and bullock usage of 30.6 bullock-pair-h/ha.

Naik et al. [18] studied on mechanisation of planting of sugarcane bud chip settlings raised in portrays. Sugarcane bud chip planting is the latest technique of sugarcane planting, wherein the bud along with a portion of the nodal region is chipped off and planted in portray with FYM soil and sand. A tractor mounted two-row mechanical planter for settlings raised from sugarcane bud chips was developed. Power to the metering mechanism was given from ground wheel by means of chain and sprockets. Two persons were required for placing the bud into the holes of the metering device. The optimum speed of operation was standardised as 1.4 km/h by experimentation where the missing percentage was 2.33%. The field capacity of the equipment was 0.15 ha/h. Cost economic analysis of planting with mechanical planter showed 40 and 85%, saving in cost and labour, respectively over manual bud chip settling planting. Seed rate was found to be 1-1.5 t/ha.

A tractor operated sugarcane cutter planter for mechanisation of sugarcane planting in deep furrows was developed [19]. The developed planter consisted of deep furrow opener, sharp-edged blades to cut whole cane into 350 mm long pieces as seed material, a metering device for application of fertiliser and insecticide, soil covering shovels and tamping roller for pressing soil cover. The planter was pulled by the tractor, and its cutting blades and fertiliser metering rollers were driven by tractor PTO shaft. At the forward speed of 0.5 m/s, mean overlapping between two successive setts were 72 mm, which was acceptable and well within the desired overlapping range of 50–100 mm for sub-tropical India. Its performance was compared with the conventional method of planting. The depth of furrow was 250 mm in case of the planter as against 120 mm in the conventional method. Mean soil covering depth over planted setts was 80 mm. Mean bud emergence improved by 3.7% in the case of the planter as compared to conventional planting. Only 25 man-h/ha labours were involved for planting with the developed planter which is about 11 times less than the conventional method of planting (280 man-h/ha). Cost of planting operation was also saved by about 63% using the developed planter.

From the above-said reviews, it can be concluded that the cylindrical and rotary cutting mechanism was mostly used in mechanical planters for making of setts for sugarcane planting. The average sett length was found between 30 cm to 45 cm. The average fields capacities of all cutter planters varied between 0.15 ha/h to 0.21 ha/h. The cost saving was considerably high with mechanical planters as compared to the manual planting of sugarcane.

3.4 Sugarcane Bud/Settling Trans-planting

For sugarcane planting, sugarcane bud chip planting is the latest technique of sugarcane planting, wherein the bud along with a portion of the nodal region is chipped off and planted. A bud chipping machine for sugarcane was designed and developed [20]. The bud chip technology holds great promise in rapid multiplication of new cane varieties. The left-over cane can be well utilised for preparing juice or sugar or jaggery. The concept contains a punching stainless steel tube connected to a torque lever and a spring mechanism. When the torque lever is moved down, it moves the piercing rod on the sugarcane thereby punching out the sugarcane buds. The average force required for punching was 600 N, as mean torque generated by 99 percentile men is 457.22 N-m. The initial results indicated that equipment has reduced/ totally eliminated the manual effort, as required for generating the sugarcane buds as compared to traditional tools.

Bhange et al. [21] worked on the development of an automated sugarcane node cutting machine via image processing. The study revealed that the time required for image processing and cutting of a single node was 2 seconds. The capacity of machine was to cut 1800 nodes/h.

Patel et al. [22] reviewed the design of sugarcane transplanting machines and recommended to use sugarcane transplanting technique as this technique saves up to two months of crop production season.

Malwa et al. [23] studied the mechanisation of sugarcane transplanting. The bud chips or short

setts that include one bud used to establish the sugarcane seedlings nursery. After full germination of the seedlings, the operation of transplanting in the main field was done when the seedlings age was up to 8 weeks.

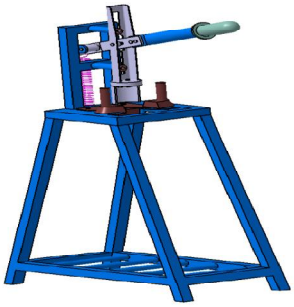

Fig. 4. Bud chipping machine

A mechanical trans-planter that was developed especially for sugarcane seedlings was studied. In this study; seedling size, germination, missing hills and mortality were determined. It was found that missing hills were largely affected by the machine kinematic factor and mortality was largely affected by the seedling age. The mechanical transplanting of sugarcane should replace traditional planting method to save production cost. This technique saves 2000 m^3 of irrigation water and up to two months of the production season.

An experiment was conducted on the planting of sugarcane bud chip settlings raised in portrays [18]. A tractor mounted two-row mechanical planter for settlings raised from sugarcane bud chips was developed. Power to the metering mechanism was given from ground wheel by means of chain and sprockets. Two persons were required for placing the bud into holes of the metering device. The optimum speed of operation was standardised as 1.4 km/h by experimentation where the missing percentage was 2.33%. Cost economic analysis of planting with mechanical planter showed 40 and 85%, saving in cost and labour, respectively over manual bud chip settling planting. Seed rate was found to be 1-1.5 t/ha. So, past studies on bud chip planting have shown that there was large saving in seed per hectare and this method is effective for sugarcane planting. However, since the machine was not automatic, the adoption level of the machine was less.

The review of sugarcane bud technologies has revealed that the seed rate (1 to 1.5 t/ha) in sugarcane bud planting was considerably less as compared with the mechanical (9 to 10 t/ha) and manual planting of sugarcane. Hence, sugarcane bud technology needs to be adopted and popularised.

4. METHODS USED FOR POTATO PLANTING

Potato planting is considered as a very crucial and critical operation because it directly affects the yield and the farming cost. Improving uniformity within row spacing is expected to decrease competition between plants.

4.1 Manual Method of Potato Planting

Potato is being grown in India by traditional methods using hand tools and animal-drawn implements. In traditional methods, the field is prepared and then shallow furrows are opened on the flat surface. Potatoes are planted in furrows and immediately after planting tubers, small ridges are made. Later on, these ridges are made thick by earthing up of the site soil. Proper development of tubers depends upon aeration, moisture availability and proper soil temperature. Therefore proper earthing up is necessary.

4.2 Potato Planting by Means of Mechanical Planters

A number of potato planting machines have been developed in the past by various research organisations. The cup-belt metering mechanism is the most commonly used mechanism used in potato planters. In this type of mechanism, potatoes are transferred from a hopper to the conveyor belt with cup sized to hold one tuber.

Misener [24] studied the relative performance of cup and pick type potato planter. Seed piece placement was measured for eight potato planters over a total of 196 trials. The coefficient of variation of spacing for the cup and pick type planters ranged from 59.2 to 87.1 and from 55.3 to 68.7, respectively. The multiple indexes in relation to the total number of seed pieces were high for both types of planters. The average number of doubles per 30.5 m of row length ranged from 6.2 to 33.6% for the cup type and from 6.8 to 29.0% for the pick type planter over various forward speeds and nominal spacing. The range of skips for the cup planter was 3.2 to 14.7% and for the pick type planter, from 3.0 to 12.1%. With cut seed, the pick type potato planter tended to be more accurate in seed piece placement than the cup type planter. Less

variability of the pick type planter was noted when coefficients of variation were compared for spacing in the trials. The incidence of doubles was high with both types of planters. The pick type generally produced fewer doubles than did the cup types. Little difference was noted between the two types of planters regarding missing index.

Buitenwerf et al. [25] studied the behaviour of potatoes in the cup-belt planter. To determine the origin of the deviation in uniformity of placement of potatoes a theoretical model was built. The model calculates the time interval between each successive potato touching the ground. Referring to the results of the model, two hypotheses were posed, one with respect to the effect of belt speed, and one with respect to the influence of potato shape. A planter unit was installed in a laboratory to test these two hypotheses. A high-speed camera was used to measure the time interval between each successive potato just before they reach the soil surface and to visualise the behaviour of the potatoes. Both the model and the laboratory test showed that the higher the speed of the belt, the more uniform the deposition of the potatoes at zero horizontal velocity. This leaves less effect on the shape of the potato and the positioning of the potato on the cup. A relationship with the belt speed was found. So, to provide more room for reductions in the cup-belt speeds while keeping a high planting accuracy it is recommended to decrease the radius of the roller till as low as technically possible.

Ebrahem et al. [26] made a small potato planter, using a feeding system with chain-spoon (cup-belt) to plant potato tuber pieces with previously grown sprouts. In this planter chain, sprocket transmission system was used. Two furrow openers with three furrow closing units were provided in this planter.

The planter was calibrated and adjusted to achieve 25 cm spacing between tubers in a row and 71 cm spacing between rows. This study revealed that the missing index was increased as the forward speed was increased and multiple indexes decreased as the forward speed was increased. The quality of the potatoes planted was evaluated using the Shatter Index (SI %), which showed that the new configuration was more delicate with the tuber pieces.

Al-Gaadi and Marey [27] studied the effect of forward speed and tuber characteristics on tuber spacing uniformity for a cup-belt planter. The performance of the planter was evaluated in terms of the mean tuber spacing, the coefficient of variation, the multiple indexes, the miss index and the quality of feed index. The study showed that an increase in the forward speed caused an increase in the mean tuber spacing. Also, the forward speed affected tuber spacing uniformity significantly. Tuber size induced slight effects on the mean tuber spacing. The effect of tuber size was found to be significant on tuber spacing uniformity as indicated by the values of coefficient of variation, multiple and missing indexes. Tuber size of 35-45 mm induced better tuber spacing uniformity than other tested sizes. Potato variety exhibited significant effects on both mean tuber spacing and tuber spacing uniformity. From the results of this study, a forward speed in the range of 2.25 km/h, tuber size of 35-45 mm and spherical tuber shape could be recommended for the cup-belt potato planter.

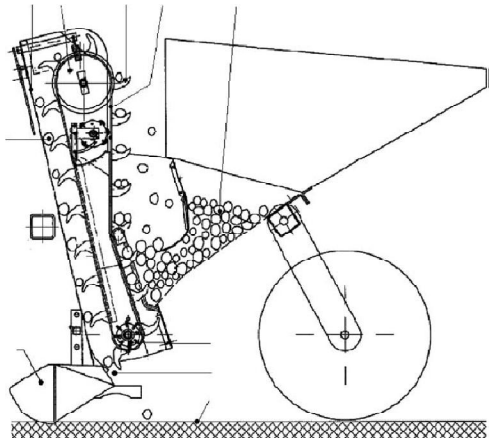

Fig. 5. Sketch of cup belt type potato planter

El- Yamani [28] studied and manufactured a new metering mechanism for potato tuber planting. The developed metering system had a vertical rotary disc which was used for feeding potato tubers planter. The modified planter was tested to suit planting potatoes with four travelling forward speeds of 3.1, 3.8, 4.7 and 5.6 km/h, four planting spaces of 18, 24, 29 and 37.5 cm and three levels of planting depth were 5, 7 and 10 cm. The results indicated that the maximum field capacity of the machine was 1.2 ha/h and field efficiency was 78.5%. Also, the maximum emergence ratio was 98.9%, seed tuber spacing uniformity was 88.5%, and specific fuel consumption was 0.812 l/kWh. The optimum operating condition for modified potato planter with a new metering system having rotary disc was as follows: forward speed of 4.7 km/h,

planting depth of 5 cm and seed row planting space of 18 cm.

Mustafa and Faith [29] conducted research on the influence of seed physical properties and speed on the external mechanical damage index and in-row spacing uniformity in an automatic potato planter. In this study, a fully automatic potato planter was used in which the planting metering mechanism consisted of cups and hold pins attached to the circumference of a vertical disc. To evaluate the performance of the planting metering mechanism, in-row spacing uniformity, multiple indexes, missing index and external mechanical damage index were determined (P<0.01). In this experiment, two potato varieties (Marfona and Agria) and two potato sizes (25-45 and 45-65 mm) were used. From the experiment, it was concluded that the forward speeds and tuber physical properties significantly influenced tuber spacing accuracy and external mechanical damage index (P<0.01). While the forward speed increased, the accuracy of tuber spacing decreased. The highest coefficient of variation (CV %) and highest damage index was obtained at the forward speed of 7.3 km/h.

Seyedbagheri [30] studied the dependency of potato planter performance on several key factors such as seed piece size and planter speed. Potato planter performance was evaluated by seed spacing, planter speed, and seed depth. The study showed that the smaller piece can produce higher vigour, increase tuber set and less disease. The results of this study showed that at the low forward speed of potato planter, missing index and multiple indexes were very low. So, planter performance was high at low speed. Optimum speed was found to be 3.2 km/h.

5. SUMMARY AND CONCLUSION

In most of the sugarcane mechanical planters, cylindrical or rotary cutting mechanism was used for cutting of setts. Researchers found that the rotary cutting mechanism in sugarcane cutter planters required less force for cutting of setts as compared to the cylindrical cutting mechanism. Seed rate required was approximately 9.30 t/ha with mechanical cutter planter. It was found that 75.0% of labour cost was saved in semi-automatic and 87.5% labour costs can be saved with automatic planter compared to conventional practice. The average length of setts cut by cutter planters was 350 to 400 mm. Sugarcane bud-chip planting is the latest technique of sugarcane planting, wherein the bud along with a portion of the nodal region is chipped off and planted. Seed rate in case of sugarcane bud-chip planting was found to be 1-1.5 t/ha. The cup-belt metering mechanism is the most commonly used mechanism used in potato planters. It was found that with an increase in forward speed, accuracy of tuber spacing decreased. The highest coefficient of variation (CV %) and highest damage index was obtained at the high forward speed of 7.3 km/h.

It is found that the physical parameters of potato tuber and sugarcane bud are nearly the same. Therefore, a two-in-one planter may be developed for the planting of both sugarcane bud-chip and potato tubers to reduce the investment in purchasing farm machinery.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Annual Report 2016-17. Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India.
2. Annual Report 2016-17, Ministry of Statistics and Programme, Govt. of India.
3. Peleg K. Produce handling, packaging, and distribution. The AVI Publishing Company. Inc. Westport, Connecticut. 1985;38(8):55–95.
4. Tabatabaeefar A. Size and shape of potato tubers. Int. Agrophysics. 2002;16:301–305.
5. Gamea GR, Abd El-Maksoud MA, Abd El-Gawad AM. Physical characteristics and chemical properties of potato tubers under different storage systems. Misr J. Ag. Eng. 2009;26(1):385-408.
6. Teye E, Abano EE. Physical properties of two varieties of sweet potato grown in Coastal Savannah Zone of Ghana. International Journal of Science and Nature. 2012;3(1):105-109.
7. Yossry B, Abd Elhay. Determination of some physical and mechanical properties of potato tubers related to design of sorting, cleaning and grading machine. Misr J. Ag. Eng. 2017;34(3):1375–1388.
8. Singh DK, Goswami TK, Chorasia MK. Physical properties of two popular Indian potato varieties. Journal of Food Process Engineering. 2006;29:337–348.

9. Yadav RNS, Chaudhuri D, Sharma MP, Singh PR, Tajuddin A, Kamthe SD. Evaluation, refinement and development of tractor operated sugarcane cutter planters. Sugar Tech. 2004;6(1&2):5–14.
10. Kumar S, Singh BR. Performance feasibility and economic viability of sugarcane planter in western plane zone of Utter Pradesh, India. Sugar Tech. 2012;14(2):101-108.
11. Singh Kishan, Yadav RL, Hora BS, Singh Bakhtawar, Singh RV, Singh RA. Ring method of planting sugarcane-A new technique. Biological Memoirs. 1984;9(2): 161-166.
12. Chand M, Khippal A, Singh S, Lal R, Singh R. Productivity and profitability of sugarcane as affected by different planting patterns. Agric. Sci. Digest. 2013;33(3): 203–206.
13. Patel D, Patel R. Influence of sett size, seed rate and sett treatment on yield and quality of sugarcane. The Bioscan. 2014; 9(1):55-57.
14. Mandal S, Maji P. Design refinement of two row tractor mounted sugarcane cutter planter. Agril. Engg. Intl.: The CIGR Ejournal. Manuscript PM 06 020. 2008;2.
15. Patil A, Dave AK, Yadav RNS. Evaluation of sugarcane cutter planter. Sugar Tech. 2004;6(3):121–125.
16. Singh PR. IISR tractor mounted sugarcane multipurpose planter. Coordinating Cell AICRP on Farm Implements and Machinery Institute of Agricultural Engineering (Bhopal); 2004.
17. Khedkar MB, Kamble AK. Evaluation of mechanized planting of sugarcane. International Journal of Agricultural Engineering. 2008;1(2):136-139.
18. Naik R, Annamalai SJK, Nair NV, Prasad NR. Studies on mechanisation of planting of sugarcane bud chip settlings raised in portrays. Sugar Tech. 2013;15(1):27-35.
19. Singh AK, Singh PR. Development of a tractor operated sugarcane cutter planter for mechanization of sugarcane planting in deep furrows. Sugar Tech. 2016;19(4): 416-423.
20. Ningappa HK, Naik RJ. Design and development of sugarcane bud chipping machine. International Journal of Research in Aeronautical and Mechanical Engineering. 2015;3(12):97-110.
21. Bhange K, Bhong A, Chattar A. Automated sugarcane node cutting machine via image processing. International Journal of Advance Research in Science and Engineering. 2016;5(12):233-237.
22. Patel KH, Patel PG, Patel SR, Parmar NK, Tailor JR. A review paper on design of sugarcane transplanter machine. International Journal for Scientific Research & Development. 2016;4(7):869-871.
23. Mawla HA, Abd El, Hemida B, Mahmoud WA. Study on the mechanization of sugarcane transplanting. International Journal of Engineering and Technical Research. 2014;2(8):237-241.
24. Misener GC. Relative performance of cup and pick type potato planters. Can. Agric. Eng. 1979;21:131-134.
25. Buitenwerf H, Hoogmoed WB, Lerink P, Muller J. Assessment of the behavior of potatoes in a cup-belt planter. Biosystems Engineering. 2006;95(1):35-41.
26. Ebrahem IZ, Ayman AE, Guidetti R. A new small potato planter for Egyptian agriculture. J. of Ag. Eng. – Riv. Di Ing. Agr. 2011;3:7-13.
27. Al-Gaadi KA, Marey SA. Effect of forward speed and tuber characteristics on tuber spacing uniformity for cup-belt potato planter. Middle-East Journel of Scientific Research. 2011;8(4):753-758.
28. El-Yamani AE. Manufacturing a new metering system for potato tuber planter. Egypt. J. Agric. Res. 2012;90(2):777-795.
29. Mustafa GB, Fatih U. Influence of seed physical properties and speed on the external mechanical damage index and in-row spacing uniformity in an automatic potato planter. Journal of Agricultural Sciences. 2012;18:126-136.
30. Seyedbagheri Mir-M. Planter performance impacts on quality and yield. Presented at the UI Potato Conference. 2015;1-11.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26267