Current Journal of Applied Science and Technology

39(48): 153-161, 2020; Article no.CJAST.64873
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Development and Evaluation of Manual Operated Two Row Planter for Onion Seeds

Balveer Singh Meena[1*], Atul Kumar Shrivastava[1] and R. K. Dubey[1]

[1]Department of Farm Machinery and Power Engineering, JNKVV, Jabalpur, Madhya Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author BSM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AKS and RKD managed the analyses of the study. Author RKD managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i4831212
Editor(s):
(1) Dr. Rui Xiao, School of Energy and Environment, Southeast University, China.
Reviewers:
(1) Minfeng Tang, Kansas State University, USA.
(2) Sachin Kawade, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/64873

Original Research Article

Received 25 October 2020
Accepted 30 December 2020
Published 31 December 2020

ABSTRACT

Onion (Allium Cepa L.) is cultivated globally as a one of the prominent vegetable crop. India is the second largest producer of onion in the world next to China, but still there is large of scope to enhance the production and productivity. In India, the cultivation of onion is not fully mechanized, only progressive farmers are using the machineries for cultivation. Therefore, it's required the intensive labour, resulted low productivity with high cost of cultivation. Generally farmers are doing the manual sowing of seeds or manual transplanting system. To address this issue, a manual operated two row planter was developed for directly sowing the seed in prepared field. This machine can easily be operated by a single man/woman by pushing action while walking in the field. Evaluation of the machine was successfully performed in enclosed environment (*i.e.* laboratory) and on the grounds of some performance parameters that plays a crucial role in performance evaluation of machine. The parameters such as missing index, multiple index and quality of feed index were determined respectively that yielded numerical values of 11.5 per cent, 25 per cent and 63 per cent, respectively. On the basis of obtained results, it was easily justified that metering mechanism of vertical rotor type with dimensions of slot size 2.5 mm × 3 mm was most suitable for mechanical sowing of onion seeds having an operational speed of 2 km h^{-1} to obtain the optimum seed rate of 7-8 kg ha^{-1}. The field capacity and field efficiency of the developed machine for sowing of onion seeds

**Corresponding author: E-mail: balveermeena5@gmail.com;*

were found to be 0.042 ha $h^{-1}$and 78 per cent respectively at the average operational speed of 1.8 km h^{-1}. But as far as the labour requirement is compared, in instance of the onion planter, only 48 man-h are required for planting of 1 ha area, whereas in case of manual transplanting method, about 800-960 man-h are required for 1 ha area. The developed machine results in savings in terms of seed, labour requirement, inputs *i.e*. fertilizers, chemicals, water etc. by providing 15 cm of row to row spacing uniformly with an addition of 10 cm plant to plant spacing. Uniform crop establishment also enhance the mechanization of subsequent operations *i.e*. weeding, spraying and harvesting. The yield obtained by developed seed drill was 14.9 t ha^{-1}which is very close to the yield obtained with manual transplanting of onion seedlings *i.e*. 15.6 t ha^{-1}.

Keywords: Manual planter; mechanization; onion; planter; sowing machine.

1. INTRODUCTION

In India, onion is an important commercial crop grown on a large area for local consumption, medicinal and export purpose. The onion (Allium cepa-L.) is also known as the bulb onion. India is the second largest producer of onion in the world next after China. In year 2017-2018 onion is cultivated in an area of 12.85 million hectares, with the annual production of 23262 MT with an average productivity of 16.12 tonnes ha^{-1} [1]. Onion is grown in three cropping seasons, namely, Kharif (harvested in October-November), late Kharif (January-February) and Rabi (April–May). However, Rabi season crop accounts for about 60% of annual production while kharif and late kharif each account about 20%.

Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh, Gujarat, Rajasthan, Biharand Haryana are the major onion producing states of India. Maharashtra is the largest producer of onion in India, grown in an area of 468.00 hectare, contributing 30.48% of market share. Madhya Pradesh is the second leading state for growing of onion in an area of 122.31 hectare with the production of 3687.90 MT, next to Maharashtra. Throughout the world there are hundreds of varieties of onion grown and according to colour they are classified as red, yellow and white types. Primarily, red and white onions are the most preferred varieties that are cultivated on a larger scale in India. In 2012-13 [2] production of onion in India was declined by around 7 % to 16.3 million tons due to a decrease in planted area in response to poor planting conditions in major growing regions, despite yield scaling a new record of 17 tonnes per hectare.

In case of conventional cultivation of onions, seeds are sown in nursery for further transplanting in such a manner that 15 cm of row to row spacing and subsequently 7.5 cm plant to plant spacing is acquired for proper nourishment of plant in order to get optimal yield.

It is matter of fact, that during cultivation of onions followed by consequent seedlings transplanting; inter culture and harvesting are the predominant activities that is abrupt in labor requirement preferred over a larger scale in India [3,4]. In case of manual method of onion seedlings transplantations, the labour requirement is very high (i.e. 100–120 man-days ha^{-1}) with seedling populations as 8.9 lakh seedlings per hectare [5]. Meanwhile, shortage of farm labours at peak time of requirements triggers the sole fact of mechanization in onion cultivation in order to increase net sown area of onion [6,7].

Mechanization not only increases the production and productivity, but also reduces the labour cost and drudgery. The site specific application of seed to maintain crop growth is an essential part to minimize the cost of production [8,9]. As a result, it produces more within the shortest possible period of time by using minimum manpower and improved cultural practices. Several works have been successfully performed on semi-automatic transplanters in India for mechanical sowing of wider row vegetable crops. However, very little research activities have been carried out with regard to onion transplanters. Onion can also be cultivated by adopting direct seeding method which is an advancing technology that can also serve in enormous labour savings.

In the broadcasting method, onion do not grow properly and their shape and size are affected and yield is also less. Seed drills driven beneath tractors are developed in recent times but they are costly for small farmers as well as marginal farmers. So, manual operated direct seed planting machine is required for those farmers.

Recent development studies regarding mechanization of onion seeding operations advocated its numerous advantages. Idago et al. [10] performed evaluation of multi-row onion seeder whose findings portrayed a planting capacity of 0.41 ha h^{-1} and a field efficiency of 77.23 %, with further reduction in time and labour requirements.

2. MATERIALS AND METHODS

2.1 Development of the Manual Operated Two Row Planter for Onion Seeds

2.1.1 Main frame

The functional prerequisite in machine development was direct sowing of onion seeds in two rows. In order to achieve the goal, the first step was to fabricate the main frame by utilizing a combination section which is rectangular in shape made up of mild steel. In addition to it, an arrangement was provided so as to fix seed hopper, adjusting handle, ground wheel, power transmission mechanism and seed placement furrow openers. Frame may be design in such a way that is suitable to bear all possible loads during operation of machine.

2.1.2 Seed hopper

For the successful sowing of onion seeds in two rows, seed box was developed for each set of seed metering mechanism of two rows. Independently, two units were taken into consideration for two vertical plates. Keeping in mind, the scenario of frequent filling in seed box, the capacity of the seed box was chosen as 1 kg based on the recommended seed rate of 5-6 kg ha^{-1}. Seed hopper shape of conical type was adopted that can contain 1 kg onion seeds.

2.1.3 Fabrication of metering plate

The metering device was designed and developed in such a way that it shall be capable of performing the required task effectively without trouble. Precision planting implies an accurate placement and spacing of individual seed in a row, therefore seeds should be metered in such a way that single seed should be delivered into the seed tube at a time. The seeds should not to be damaged during the process of metering and should safely enter into the seed tube. Material of construction of metering plate is plastic and diameter of plate is 76 mm and grove size is 2.5×3 mm.

2.1.4 Ground wheel

For continuous provision of drive to seed metering mechanism, a lugged ground wheel was placed in front of the machine. The dimensions of the ground wheel was 318 mm diameter with 50 mm spike length situated over its periphery to avoid slippage when the field is completely covered with stubble. The ground wheel having a direct mechanical connection with metering mechanism was substantially helpful in sowing with significant reduction in wheel slippage and missing of seed metering mechanism.

2.1.5 Furrow openers

A set of two furrow openers having T-shape was adopted to open the soil horizon in order to place the seeds at desired depth. Furrow opener was made using mild steel.

2.1.6 Handle

Length of handle and angle of inclination with the horizontal surface are interdependent. Angle of operation was based on functional design and geometry of tool and generally lies between 300 to 450 and the recommended handle grip diameter is 30 to 35 mm. Length of handle is based on average standing elbow height of male and female farm machine operators. For mean values of elbow height in case of male and female worker, numerical values of 1027 mm and 960 mm was taken, respectively.

2.1.7 Covering device

The function of covering is to provide a protecting cover to seed and level the field for proper irrigation. Covering device was made with mild steel hollow pipe and stainless steel chain. The details specifications of developed planter is given in Table 1.

2.2 Experimental Set-up

Onion seed plant machine was tested in the laboratory of CAE, JNKVV, Jabalpur, M.P. Height of setup according to the seeds were drawn in the polythene properly and mark on the wheel of machine. The parameters selected for machine testing are given in Table 2.

Table 1. Specification of manual operated two row planter for onion seeds

Description	Specifications
Type	2 row manual operated
Frame	Plus shape type
Depth control mechanism	Adjustable type
Seed metering system	Vertical plate type
Diameter of vertical plate	76 mm
Number of grooves per vertical plate	10
Furrow openers	Inverted T type
Number of furrow openers	2
Row to row spacing	150 mm
Ground wheel drive	Spoke type
Diameter	320 mm
Power transmission for metering systems	Ground wheel, transmission rod and metering mechanism
Overall dimensions	1160 x 600x 100 cm

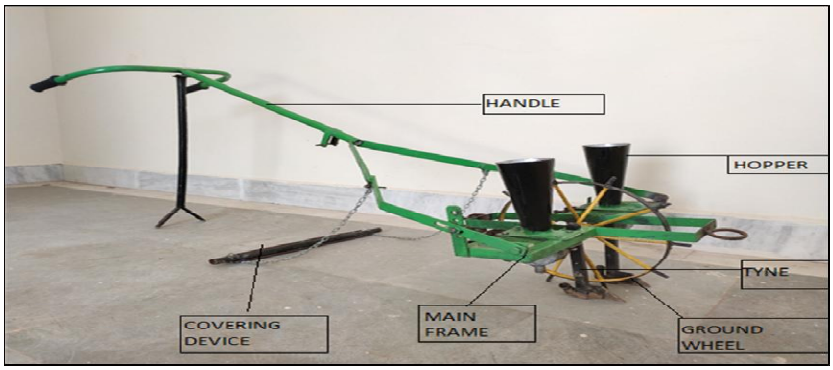

Fig. 1. Developed manual operated two row planter for onion seeds

Table 2. Independent and dependent variables selected for the study

Independent variables	Values	Dependent variables
No of revolution	10,20,30	1. Missing index
Seed metering plate groves	10	2. Multiple index
		3. Quality of feed index

2.3 Missing Index

Missing index (M) is termed as the inefficiency of the seed metering section to drop even a single piece of seed at the desired variation of seed spacing. The seed metering section should be designed for minimum missing index to achieve the desired plant population.

$$M = n_1/N \quad (1)$$

Where,

n_1= Number of spacing which is greater than 1.5 times of the theoretical spacing in the given set of observations; and

N = Total number of observations.

2.4 Multiple Index

Multiple index (D) includes a set of two or more seeds picked simultaneously and subsequently dropped by the seed metering section from a single hole present over the metering plate.

$$D = n_2/N \quad (2)$$

Where,

n_2 = Number of spacing which is less than or equal to half of the theoretical spacing in the given set of observations; and

N = Total number of observations.

2.5 Quality of Feed Index

The quality of feed index (A) is a measure of how often the spacing was adjacent to the theoretical spacing claimed. The quality of feed index is mathematically expressed by the following formula:

$$A = n_3/N \quad (3)$$

Where,

n_3 = Number of spacing between 0.5 times of the theoretical spacing and 1.5 times of the theoretical spacing in the given set of observations; and
N = Total number of observations.

2.6 Performance Evaluation of Manual Operated Two Row Planter for Onion Seeds

2.6.1 Field preparation

Prior to planting, the field was well prepared by using power tiller. Field was prepared at that level where manual operated plant machine can easily be operated without any difficulty to the operator. The crop was planted on an area of 15x6 m^2. The irrigation was applied on next day of sowing after manuring. The germination count of germinated and non-germinated seeds was taken on 28 days after planting (DAP). The soil type is black cotton soil and the variety of onion selected is Bhima Shakti.

3. RESULTS AND DISCUSSION

3.1 Laboratory Evaluation of Developed Machine

Study was conducted in laboratory for determining the effect of the considered parameters on the effective performance of the seed metering section. The performance was evaluated on the basis of certain set of parameters such as missing index, multiple index and quality of feed index. The findings of the experiment have been duly tabulated in Table 3.

3.2 Germination Test

Germination test of the onion seeds to be planted in field was carried out in the laboratory. The observations based on seed germination was taken for a time period of 14 days. The results for the same are given in Table 4.

3.3 Field Performance Evaluation

For the field evaluation of the manual operated two row planter for onion seeds, a good seed bad was prepared. On the basis of optimum parameters obtained during laboratory studies, the manual operated two row planter for onion seeds was operated at forward speed 2 km/h and 10 groove plate was used as seed metering plate.

3.4 Germination

The germination count of germinated and non-germinated seeds was taken on 25 days after planting (DAP). The germinated seeds include singles and multiples. Results of the germination count are shown in the Table 6 and plate 3.

3.5 Comparison of Manual Operated Two Row Planter for Onion Seeds and Manual Transplanting Method

Seed rate in machine operation are slightly more as compare to transplanting method. In case of mechanical planting through machine operation, spacing between consecutive rows and plants are more than transplanting method. The depth of sowing cannot be controlled in case of manual transplanting method because it depends on labour's skill. But as far as the labour requirement is compared, onion planter only requires 48 man-h are required for planting of 1 ha area, whereas in case of transplanting method, about 800-960 man-h are required for 1 ha area.

Fig. 2. Germination of seeds after 10 days

Table 3. Effect of total number of revolutions on seed metering plate on missing index, multiple index and quality of feed index

Number of revolution	Number of groves on metering plate	Missing index (%)	Multiple index (%)	Quality of feed index (%)
10	10	10	25	62
20	10	11.5	24.5	63
30	10	11	24.5	62.5

Table 4. Germination of seeds in laboratory

Sample	Germination %
1	86
2	80
3	85
Average	83.66

Table 5. Field performance data of the manual operated two row planter for onion

Performance Parameters	Values
Average operating speed(km h^{-1})	2
No of grooves in metering mechanism	10
Average depth of placement(cm)	2
Row spacing (cm)	15
Plant spacing (cm)	10
Average theoretical field capacity (hah^{-1})	0.0601
Average actual field capacity(ha h^{-1})	0.0421
Field efficiency (%)	78
Draft (Kgf)	23
Power (kW)	0.127

Table 6. Germination in field

No. of plants/m row length							
R1	R2	R3	R4	R5	R6	R7	Avg.
11	10	9	13	12	9	13	11

Crop after 30 days of planting

Crop after 50 days of planting

Crop after 65 days of planting

Crop after 85 days of planting

Crop ready for harvesting

Fig. 3. Various growing stage of onion crop

Table 7. Yield of onion crop

Parameters	Replications					Avg.
	R1	R2	R3	R4	R5	
No. of plants(m^{-2})	70	75	82	79	68	74
Weight of onion with Plants(kgm^{-2})	5.1	4.8	4.6	5.6	5.2	5.06
Weight of onion(kgm^{-2})	4.23	3.94	3.81	4.73	4.45	4.23
Bulb size, cm	5.23	4.91	5.13	5.62	5.38	5.30
Bulb weight, g	60.23	56.27	58.28	65.45	62.23	60.49

Table 8. Comparison of manual operated two row planter for onion seeds and manual transplanting method

Parameter	Machine operation	Transplanting method
Seed rate, kg ha^{-1}	7-8	5-6
Plant to plant spacing, cm	10	8-10
Row to row, cm	15	12-15
Depth of sowing, cm	2-3	1-3
No of irrigation	15-20	14-18
Germination, %	85	97
No of labour required, man-day ha^{-1}	48	800-900
Yield, t ha^{-1}	14.9	15.6
Cost of planting operation, □ ha^{-1}	3600	24000

4. CONCLUSION

On the basis of the results obtained from laboratory evaluation, the manual operated two row planter for onion seeds was developed with overall dimensions (Length x Width x Height) and weight of 1.16 m x 0.60 m x 1 m and 25 kg, respectively. The developed machine used for execution of onion seeds sowing yielded a field capacity of 0.042 ha/h in addition to which field efficiency of 78% was obtained respectively. For obtaining the values of field capacity along with field efficiency mean operational speed of the machines was kept at 1.8 km h^{-1}. In terms of cost economics, while sowing onion seeds a sum of 150 $h^{-1}$was levied. For sowing one hectare of land by the developed manual operated two row planter for onion seeds the cost of operation came to □ 3600 ha^{-1}. For complete sowing of 1 ha piece of land by conventional transplanting method, a sum of □ 24000 ha^{-1}would be required. The yield was obtained by developed seed drill was 14.9 t ha^{-1} which is very close the yield obtained with manual transplanting of the onion seedlings i.e. 15.6 t ha^{-1}. Due to light in weight and easy operation procedure the developed machine can also be used for kitchen garden for cultivation of onions. In terms of performance, the developed machine was found satisfactory for selected onion seeds with significant saving in cost and labour requirement as compared to traditional method. It would be useful for small and marginal farmers of India to promote production and productivity of onion crop as a whole.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous; 2018.
   Available: http://www.indiastat.com
2. Anonymous; 2013.
   Available: http://www.indiastat.com
3. Nare B, Shrivastava AK, Naik RK, Prakash A. Design, development and evaluation of self-propelled garlic (Allium Sativum L.) clove planter. AMA-Agricultural Mechanization in Asia Africa and Latin America. 2014;45(2):74-79.
4. Harshavardhan K, Shrivastava AK. Development and performance evaluation of manually operated seedling planter for horticultural crops. Current Journal of Applied Science and Technology. 2018:1-8.
5. Rathinakumari AC, Mandhar SC, Gowda RH. Development of drum seeder for onion. Downsizing Technology for Rural Development. 2003;1:31-37.
6. Rao JH, Meena BS. Performance and cost economics evaluation of different types of reaper binder for harvesting of wheat in satna district of Madhya Pradesh, India. International Journal of Current Microbiology and App. Sci. 2019;8(10): 2115-2124.
7. Ryu HI, Kim KU. Design of roller type metering device for precision planting. Translocation of the American Society of Agricultural Engineers. 1998;41(4):923-930.
8. Guru PK, Tiwari PS, Tiwari KB, Shrivastava AK, Naik RK, Nare B. Generation of database for development of a control system for precision seed drill. Agric Eng Int: CIGR Journal. 2015;17(3):242-247.
9. Shrivastava AK, Jain SK, Dubey AK, Singh VC. Performance evaluation of tractor

drawn six row inclined plate planter for oilseed and pulses. JNKVV Research Journal. 2003;37:72-75.

10. Idago RG, Dela Cruz RS, Flores ED, Miranda DR, Gomerson Corpuz M. Performance evaluation of multi-row onion seeder. Agricultural Engineering International: CIGR Journal. 2019;21(3): 69 –75.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/64873