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DESIGN, DEVELOPMENT AND FIELD EVALUATION OF RAISED BED INCLINED PLATE PLANTER FOR DIRECT SOWING OF ONION (*Allium Cepa* L.) SEED ON BEDS

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Abstract: In India Onion (*Allium cepa* L) occupies an area of 1064 thousand ha, with production of 15118 thousand tons. The export of onion during 2011 -12 was 13,09,863.26 thousand tons with a value of *Rs* 1,722.85 crores. India is the 2nd largest producer of onion, in the world next only to China but the productivity of onion in India is very low i.e. 14.21 t.ha^{-1} as compared to China and other countries like , Egypt, Netherlands, & Iran etc. India is the world's second largest producer of vegetables after China. Timeliness of operations and efficient use of the inputs are the important keys in achieving higher levels of productivity and quality. In order to increase area under onion cultivation and make it competitive and profitable, it is important to introduce mechanized technologies for its cultivation. Manual sowing and transplanting of onion is very laborious and costly operation. Therefore to mechanize its sowing operation a tractor operated raised bed planter with inclined plate metering mechanism was designed and developed based on onion seed properties. The developed prototype was evaluated in field for its performance evaluation for direct sowing of onion seed variety *Punjab Naroya* on beds. The planter was operated at three speeds 1.5, 2.0 and 2.5 km·h^{-1} and three plate angles 26º,36º and 46º and two row spacings of 15 and 18 cm. The average seed spacing varied between 6.09-11.68 cm. Average seed spacing at 2 km/h forward speed and 36° plate angle was 7.6 cm that was closer to the required theoretical spacing of 7.5cm. The overall saving in cost and time with raised bed onion planter as compared with manual method were 57.89 % and 98.75 % respectively.

Key words*: raised bed planter, inclined plate planter, maize, germination, yield*

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INTRODUCTION

The onion is an important vegetable and has been grown in almost all the parts of India. India ranks second in area and production after China. Major onion producing states in India are Maharashtra, Karnataka, Gujarat, Rajasthan and Bihar contributing more than 50% of total production in India. Productivity of onion in India is very low about 15-16 t/ha as compared to other countries [1]. Large amount of labour is required for transplanting and the labour requirement is as high as 100-120 man days·ha^{-1} [5].

Direct sowing of onion is more economical as compared to transplanting as there is saving in labour cost and time. Planters can be used for direct sowing of onion and other row crops as it maintains both plant to plant and row to row spacing. A study was conducted on use of mechanized machinery in sowing of onion seeds. Highest productivity was at plant density of 571-714 thousand plants per hectare. Seed planted at depth of 1-2 cm ensured plant emergence by 81-91% [2].

A study was conducted to develop and test a vacuum planter for onion. The highest values of the actual seed spacing were obtained with the seed plates of 0.8 mm hole diameter at 0.08 m·s^{-1} disc speed [6]. A two row manually operated direct seeder for onion crop with inclined plate metering mechanism was developed and evaluated in the field. Seed plates with 12, 24 and 36 grooves were used. The required plant population was achieved with the plate having 24 grooves. The neck thickness, bulb weight and yield of transplanted onion were slightly higher than direct sown crop [3]. A manually operated drum seeder was developed for onion and its performance evaluation was carried out. Developed seed drum width was 60 cm for six rows with row spacing of 10 cm. The sowing time (6 h/ha) was significantly lower for drum seeder than manual line sowing (48 h/ha) which contributes to reduce the cost of sowing for direct seeded onion [4]. Inclined plate seed metering device was designed and evaluated in laboratory for singulation and uniform placement of maize and soybean seeds at three different cell shapes and sizes. The performance parameters like average spacing, multiple index, quality of feed index and precision were measured. Among the combinations of design variables, the seed metering plate with semi-circular cell shape having cell size 7 mm diameter was found to be the optimum for metering maize seed. Average spacing, quality of feed index, multiple index, miss index and precision were 17.48 cm, 79.33 %, 18.67 %, 2 % and 10.5 %, respectively. Likewise, the seed metering plate with semi-circular cell shape having cell size of 12 mm diameter was found to be optimum for metering soybean seed. Average spacing, quality of feed index, multiple index, miss index and precision were 9.65 cm, 77.33 %, 14.33 %, 8.34 % and 18.73 %, respectively. Therefore, considering all the performance parameters, inclined plate metering device with semi-circular shape of cell diameters 7 mm and 12 mm were selected for maize and soybean seeds, respectively [7].

Based upon these reviews inclined plate planter was decided to be developed with depth control provision and evaluate it in the field. The reason for selection of inclined plate planter was its lower cost as compared to vacuum seeders and precise metering as compared to drum seeders.

MATERIAL AND METHODS

The inclined plate planter was designed, developed and evaluated for Punjab Naroya onion seeds. The procedure used to perform this study has been presented as under:-

Seed properties determination: The properties of the onion seed namely, size, sphericity, thousand seed weight and germination percentage were studied in the laboratory. The three major dimensions of the seed were determined using overhead projector. Sphericity of the seeds was calculated from these measured dimensions. Thousand seed weight was determined for three random samples on an electronic balance with least count 0.001 g. Germination test was done by placing onion seeds on a moistened germination paper and then in an incubator for required temperature conditions. Germination count was taken after fourteen days and converted into percentage. Germination percentage of the seeds was 80.67 %. The measured properties are shown in Tab. 1.

Table 1. Physical properties of Punjab Naroya onion seed

S. No.	*Particulars*	*Range*
1	*Major dimension (mm)*	*2.87-3.10*
2	*Sphericity (%)*	*64.32-75.28*
3	*Thousand seed weight (g)*	*2.90-3.10*
4	*Angle of repose*	*24.12º*

Development of the metering mechanism: Based on onion physical properties obtained and desired plant to plant spacing an inclined plate was developed for onion seed and various dimensions of metering plate are shown in Tab. 2.

Table 2. The values of various variables selected for inclined plate

Parameter		*Purpose*	*Value*
Dg	*Depth of the groove*	*It should be slightly larger than the length of seed.*	*3.4 mm*
θ_g	*Opening of the groove*	*It determines the loading process of the groove.*	*3.8 mm*
β_{rs}	*The right side angle of the groove*	*It determines the ease in loading process of the groove.*	*47°*
β_{ls}	*The left side angle of the groove*	*It determines the seed holding capacity.*	*29°*

The developed metering plate for onion seed is shown in Fig. 1.

Main Frame : The functional requirement of the machine was to sow seven rows of onion on a raised bed with 1m top width. It was made up of a mild steel square section of 60x60x8 mm. It was provided with an arrangement to fix the seed box, fertilizer box, bed maker, transmissions, seeding and fertilizer furrow openers.

Seed metering mechanism : An inclined platemetering mechanism was selected for the prototype to be built. Metering plates were developed based upon the design procedure followed by Chinna (2010). The groove size and geometry was selected according to size and shape of onion seed. The more number of grooves were selected owing to closer spacing requirement of onion crop. Seed box was made from mild iron

sheet of 2 mm thickness. The length of the seed box was 1420 mm. Dimensions of the seed box are shown in Fig 2.

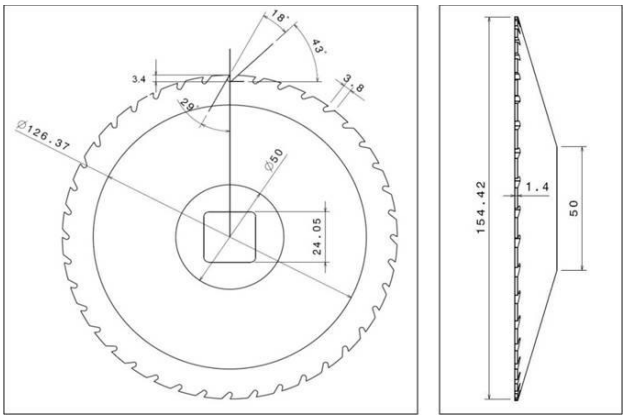

Figure 1. Front and side view of metering plate

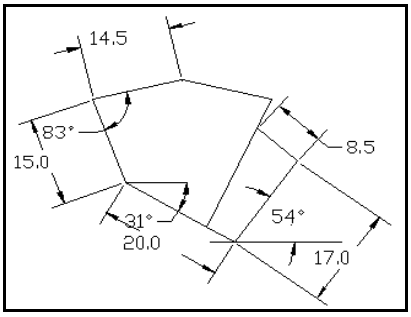

Figure 2. Seed box dimensions (cm)

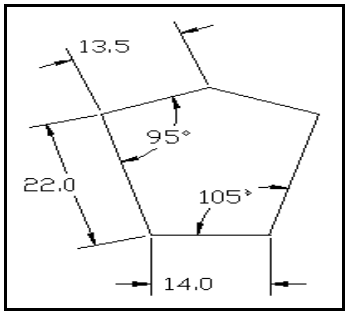

Figure 3. Fertilizer box dimensions (cm)

Fertilizer metering mechanism: The fertilizer metering mechanism was inducted in the developed onion planter to reduce the labour required for fertilizer application. Fertilizer fluted rollers made of cast aluminium were used. Trapezoidal shaped fertilizer box as shown in Fig 3 was made up from mild steel iron sheet of 2 mm thickness. The length of the fertilizer box was 1420 mm. Fertilizer box was provided with a lever to adjust the fertilizer rate.

Bed maker: A bed maker was attached having 1000 mm top width and 1400 mm bottom width. Two furrowers made up of high carbon steel were attached on both sides of the bed maker for scouring of soil to make beds. This bed maker was made from mild steel iron sheet of 3 mm thickness. This bed maker also acted as depth control device.

Furrow openers: Seven shoe type furrow openers made of high carbon steel were used to open the soil for seed placement at required depth. Plastic tubes were used to convey the seed from metering mechanism to the furrow openers. The furrow openers for seed placement were fitted behind the bed maker. The furrow openers were fitted to main frame with a mild steel strip. A slot was provided in the strip to vary the depth of

seed placement. The furrow openers spacing was kept at 150 mm and number and spacing can be varied according to other small seed crops.

Figure 4. Planter during development phase

Table 3. Specifications of the developed raised bed tractor operated onion planter

Description	*Specifications/type*	*Material of component*
Tractor HP required	*50 HP*	--
No. of rows	*7*	
Frame	*Box section frame*	*Mild steel square section*
Bed maker components shovel with wing bed maker	*Plough shape 1.0 m top bed with Triangular section furrows*	*High carbon steel Mild steel*
Seed metering mechanism	*Inclined plate*	*Aluminium*
Diameter of inclined plate (mm)	*154.42*	---
Number of grooves on inclined plate	*40*	---
Fertilizer metering mechanism	*Fluted roller*	*Aluminium*
Number of fluted rollers	*6*	---
Seed and fertilizer delivery tubes	----	*Plastic*
Furrow openers	*Shoe type*	*High carbon steel*
Depth of placement	*Adjustable with respect to bed maker*	----
Row to row spacing	*Adjustable*	----
Ground wheel	*Lugged*	*Mild steel*
Diameter (mm)	*420*	----
Power transmission for metering systems	*Chain, sprockets and bevel gear*	*Mild steel*
Speed ratio between ground wheel and seed metering plate	*3:4*	---
Overall dimensions (mm)	*1845 x 1520 x 1230*	----

Ground wheel: A lugged ground wheel made from mild steel sheet of 6 mm thickness was used to give drive to the seed and fertilizer metering mechanisms. It was

of 420 mm diameter and 90 mm width and was fitted with twelve lugs on the periphery for the positive rotation on the stubble field conditions. A spring was provided between the wheel arm and main frame to keep the wheel pressed on ground surface during the sowing operation for reducing wheel slip and missing of seed metering mechanism.

Power transmission for metering mechanisms: The power required to run the metering mechanism was provided from the ground wheel with the help of sprockets and chain. The power transmission from the ground wheel to the seed metering and fertilizer metering mechanisms is shown in Fig. 5. A fifteen teeth sprocket was used to transmit power from the ground wheel to a main shaft having fifteen teeth sprocket with the help of chain. The power from the main shaft was transmitted to the fertilizer shaft that was fitted with 24 teeth sprocket. In series the power is transmitted to the seed metering unit shaft that was fitted with set of sprockets (15, 24 and 31 teeth) to vary the speed ratio.

Figure 5. Developed raised bed inclined plate onion planter

The seed and fertilizer boxes were mounted on the planter. The height of seed drop was kept at 700 mm. Planter during development phase is shown in Fig. 4 and developed tractor operated raised bed onion planter is shown in Fig 5. The details of the different components of the developed prototype are given in Tab. 3.

RESULTS AND DISCUSSION

Field evaluation of the tractor operated onion planter : The recommended spacing for *Punjab Naroya* variety is 15 x 7.5 cm. The field was irrigated and well prepared at optimum soil moisture before sowing of onion. Then at optimum moisture direct sowing of onion seed on beds was done.

The developed planter was evaluated at three forward speeds (1.5, 2.0 and 2.5 $km.h^{-1}$) at three angles of inclined plate with horizontal (26°, 36° and 46°) for sowing of *Punjab Naroya* onion variety at 15 cm and 18 cm row spacings. The planting depth was maintained at 1.5-2.0 cm. The onion seed planter during field operation is shown in Fig. 6. The parameters like fuel consumption, forward speed were recorded. Then after germination of the onion crop the plant to plant spacing was recorded and is shown in Tab. 4. It is clear from Tab. 4 that as the planter forward speed and inclination of plate

were increased the average seed spacing also got increased. The view of germinated onion crop (variety Punjab Naroya) sown with inclined plate planter is shown in Fig. 7.

Figure 6. Onion seed planter during operaion

Figure 7. View of germinated onion crop

The statistical analysis was also done and shown in Tab. 5. The statistical data shows that effect of forward speed and plate inclination individually and combinedly was significant at 5 % level of significance.

Economic Analysis : Economic analysis of the machine was done to determine its cost effectiveness as compared to manual transplanting of the onion crop and is shown in Tab. 6 . Some suitable assumptions were made to calculate the economic viability of the developed raised bed onion planter. The seed requirement in direct sowing was 5.12 $kg \cdot ha^{-1}$ lesser than transplanting thus helps in saving of Rs 14,760 per hectare. Total cost of planting onion by machine was found to be Rs 19,944.58. In case of traditional method the nursery raising and transplanting cost was found to be Rs 47,366.75. The total saving from machine planting was *Rs* 27,422.17 per hectare.

Table 4. Average seed spacing at 15 and 18 cm row spacing

Row Spacing cm	Speed km.h^{-1}	Plate angle (°)	Average Seed Spacing (cm)			Average
			R1	R2	R3	
15	1.50	26	5.85	6.14	6.3	6.09
		36	7.44	6.13	6.81	6.79
		46	8.99	8.11	8.06	8.72
	2.00	26	5.99	5.86	7.48	6.44
		36	7.03	6.62	9.16	7.6
		46	11.04	9.43	10.24	10.24
	2.50	26	6.47	6.5	8.26	7.08
		36	8.39	8.32	8.81	8.5
		46	10.51	12.82	10.75	11.36
18	1.50	26	6.21	6.15	6.02	6.13
		36	6.83	7.12	6.96	6.97
		46	9.23	8.45	8.51	8.73
	2.00	26	6.72	6.75	5.99	6.48
		36	8.36	7.21	7.56	7.71
		46	10.04	10.16	10.4	10.2
	2.50	26	7.2	7.3	6.96	7.15
		36	8.37	8.41	8.75	8.51
		46	11.28	12.59	11.17	11.68

Table 5. ANOVA Table for effect of forward speed and angle of inclined plate with horizontal on average seed spacing

SOURCE	df	SS	MSS	F-Ratio	CD (5%)	C.V.
Factor A	1	0.1884	0.1884	0.4092	NS	
Factor B	2	31.2668	15.6334	33.9452	0.4588	
Factor C	2	117.523	58.7615	127.5904	0.4588	
A * B	2	0.0492	0.0246	0.0534	NS	
A * C	2	0.0602	0.0301	0.0654	NS	
B * C	4	6.2281	1.557	3.3808	0.7946	
A * B * C	4	0.1114	0.0278	0.0605	NS	
Error	36	16.5797	0.4605			8.3627

**A=Row spacing, *B= Forward speed and *C=Angle of inclined plate with horizontal*

Table 6. Economic analysis of the developed planter

Parameters	Method of planting	
	Inclined plate planter	Manual Transplanting
Land Preparation Cost, Rs.ha^{-1} [Disc harrow(2)+cultivator(2)+planker (1)]	6116.75	6116.75
Seed Requirement, kg.ha^{-1}	5.12	12.50
Seed cost, Rs. ha^{-1}	10,240.00	25,000.00
Nursery raising cost, Rs.ha^{-1}	--	3,750.00
Operation cost, Rs.ha^{-1}	35,87.83	12,500.00
Total cost of planting, Rs.ha^{-1}	19,944.58	47,366.75
Field capacity, ha.h^{-1}	0.20	0.0025
% saving in cost	57.89	----
% saving in time	98.75	----

CONCLUSIONS

1. An inclined plate planter was designed and developed for direct sowing of onion seed on beds.
2. The average seed spacing got increased with increase in the forward speed of the planter and increase in plate angle.
3. Average seed spacing at 2 km.h^{-1} forward speed and 36° plate angle was 7.6 cm that was closer to the required recommended spacing of 7.5cm.
4. The overall saving in cost and time with raised bed onion planter as compared with manual transplanting method were 57.89 % and 98.75 % respectively.

BIBLIOGRAPHY

[1] Anonymous. 2014. *Package of practices for cultivation of Vegetables,* Punjab Agricultural University, Ludhiana, India, pp 56.

[2] Autko, A.A., Moisevich, N.V. 2006. Technology of mechanized onion production in Belarus.*Veg crops Res* 64:107-118.

[3] Chinna, R.S. 2010. *Studies on mechanical seeding of onion seed*, Ph. D. dissertation.Punjab Agricultural University, Ludhiana, India.

[4] Hoque, M.A., Wohab, M.A. 2013. Development and evaluation of drum seeder for onion. *Int J Agril Res Innov and Tech* 3(1): 26-28.

[5] Rathinakumari, A.C., Mandhar, S.C., Gowda, R.H. 2003. Development of drum seeder for onion. *Downsizing Technology for Rural Development* 1: 31-37.

[6] Shaaban, U.A., Afify, M.T., Hassan, G.E., El-Haddad, Z.A. 2009. Development of aVacuum Precision Seeder for Onion seeds. *Misr J Ag Eng* 26(4): 1751-1775.

[7] Singh, H.J., De, D., Sahoo, P.K. 2014. Development and evaluating of metering mechanism for multi-crop planter for hilly regions. Agricultural Engineering 4 :21-33.

KONSTRUKCIJA, RAZVOJ I TERENSKA ISPITIVANJA SADILICE ZA DIREKTNU SADNJU LUKA (*Allium Cepa* L.) U LEJE

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Sažetak: U Indiji crni luk (*Allium cepa*, L.) zauzima površinu od 1064 ha, sa proizvodnjom od 15118 hiljada tona. Izvoz luka tokom 2011 -12 bio je 13,09,863.26 hilada tona u vrednosti od *Rs* 1,722.85. Indija je drugi najveći proizvođač luka u svetu odmah posle Kine, ali prinos luka u Indiji je veoma nizak, 14.21 t.ha^{-1} u poređenju sa kinom i drugim zemljama kao što su Egipat, Holandija, Iran i dr. Indija je drugi proizvođač povrća u svetu posle Kine. Trajanje postupaka i efikasna upotreba inputa su od ključnog značaja u postizanju visokih nivoa proizvodnosti i kvaliteta. Radi povećanja

površine pod lukom i povećanja konkurentnosti i profitabilnosti proizvodnje, važno je uvoditi mehanizovane tehnologije u njegovom gajenju. Ručna sadnja i presađivanje luka je veoma skupa operacija koja zahteva mnogo rada. Zato je konstruisana sadilica sa mernom kosom pločom za sadnju luka u leje sa pogonom od traktora, na osnovu osobina semena luka. Razvijeni prototip bio je testiran u poljskim uslovima radi ocene njegovih karakteristika u direktnoj setvi luka varijeteta *Punjab Naroya* u leje. Sadilica je radila sa tri brzine 1.5, 2.0 i 2.5 km·h^{-1}, tri ugla ploče 26º,36º i 46º i dva međuredna rastojanja 15 i 18 cm. Srednje rastojanje u redu variralo je od 6.09 do 11.68 cm. Srednje rastojanje u redu pri brzini od 2 km·h^{-1} i nagibu ploče od 36° bilo je 7.6 cm, što je bliže traženom teorijskom rastojanju od 7.5 cm. Ukupna ušteda troškova i vremena sa ovom sadilicom u poređenju sa ručnom sadnjom bila je 57.89 % i 98.75 %, redom.

***Ključne reči**: sadilica, sadilica sa kosom pločom, kukuruz, klijanje, prinos*

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