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EFFECT OF SELECTED PARAMETERS ON TRAY ANGLE FOR SMOOTH DROPPING OF SEEDLINGS IN SEMI-AUTOMATIC VEGETABLE TRANSPLANTER

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Abstract: Studies were conducted on a single row semi-automatic vegetable transplanter to determine the optimum tray angle in the feeding and metering mechanism at different seedling ages and different types of seedlings. The optimum tray angle at which the finger trays have been fitted to the carrying chain has been determined through laboratory experimentation. The experiments have been designed as a three factors *C.R.D.* with four replications. The percentage of seedlings properly dropped (*PSPD*) increased with finger tray angle from 20 to 30 degree where per cent dropping was observed irrespective of type of crop and length of seedlings. The *PSPD* decreased as the finger tray angle was increased above 30 degree. Chilli had the highest *PSPD* at any particular tray angle setting in comparison to other crops whereas tomato had the least per cent of seedlings properly dropped. The smaller seedlings (100-150 mm) as well as larger seedlings (250-300 mm) showed relatively more difficulty in dropping properly than the medium length (150-250 mm) seedlings.

Key words: *Seedlings, finger trays, dropping tube, conveyer chain*

INTRODUCTION

India is the second largest producer of vegetables in the world next to China with a production of 162.18 million tons from an area of 9.20 million hectares [1]. Vegetable production in India stands at 7% of the world production. Manual transplanting of seedlings, weeding and harvesting are the most labour consuming operations in

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vegetable cultivation. Transplanting of vegetable seedlings in developed countries like U.S.A., China, Holland, Japan and Canada is being mechanically done with either fully automatic or semi-automatic vegetable transplanters. However, in India, transplanting of vegetable seedlings is done manually all over the country, as very few works has been made to develop vegetable transplanters. The mechanical transplanting has been considered the most promising option, as it saves labor, ensures timely transplanting and attains optimum plant density that contributes to high productivity [9]. Some attempts have been made in recent years on semi-automatic vegetable transplanters for adoption under our conditions. In automatic type vegetable transplanters both feeding and metering of seedlings are automatic where as in semi-automatic type feeding is done manually and metering is done mechanically. Generally, semi-automatic transplanters use bare root seedlings.

Various seed drills and transplanters with different metering mechanisms have been developed, evaluated and reported by various researchers as reported in literature, i.e. [2] [3] [4] [7] [13] [16]. Metering systems must be designed to maintain desired plant to plant distance in a row. The seed and plant spacing majorly depends on the machine technical variables such as the type of seed pickup mechanism, machine operating speed, overall gear ratio between drive wheel and seed plate, and also on seed quality to some extent [15]. Garg et al. reported the development and evaluation of a single row semi-automatic transplanter with single cone type metering mechanism with a drop chute for placing seedlings into a furrow by gravity [6]. Two operators alternatively place a single seedling at one time. The rotating plate strikes the cone opening it, and the seedling moves in the drop chute pipe. Bare root chilly seedlings transplanted with the machine had missing of 14.47 per cent and the machine had a low capacity. Semi-automatic potato planter and sugarcane planter with revolving magazine type metering mechanism can plant 90 tubers of potato and 60 sets of sugar cane per minute by chilli transplanter with finger type metering mechanism [14]. Craciun and Balan developed a rotary cup type planting unit with open cup bottoms and supported on a horizontal stationary plate with an opening through which the seedling was discharged [5]. This type of planting device allows the operator to rapidly place several seedlings and then have a brief time to untangle or remove seedlings from cells rather than having to maintain exact timing for each seedling [12]. Transplanter with such type of metering unit can plant 50-80 seedling/min/row, depending on the required plant spacing. But this type of planting unit was used for planting pot seedlings in semi-automatic vegetable transplanter. Satpathy et al. reported that in two row tractor operated vegetable transplanter with finger type metering mechanism; plant missing was within acceptable limit of 3-4 per cent at 1 to 1.2 $km \cdot h^{-1}$ with two operators feeding seedlings per row [14]. Narang et al. tested semi-automatic vegetable transplanter with revolving magazine type metering mechanism and reported that average plant missing in case of brinjal was 2.22 to 4.44 per cent and the quality of feeding decreased with increase in plant missing and ranged between 95.57 to 97.78 per cent [11]. Conveyor-Type Planting Unit One advantage of this type of unit is that a substandard seedling can be easily identified using a suitable vision system and replaced with good-quality seedlings as the seedlings are carried by the conveyor [8]. In this study small trays called finger trays have been designed in semi-automatic vegetable transplanter on which the seedlings are to be kept manually. The seedling feeding and metering mechanism consists of a feeding chain carrying ten finger trays, a bevel assembly and a chain and sprocket assembly. The optimum tray angle at which the finger trays have been fitted to the carrying chain has been determined through laboratory experimentation.

MATERIAL AND METHODS

The following considerations have been made while designing the feeding system for the vegetable transplanter.

Small trays called 'finger trays' have been designed on which the seedlings are to be kept manually. The dimension of the finger trays have been fixed in such a way that the largest seedling placed on it can move freely along with the chain (Fig. 1)

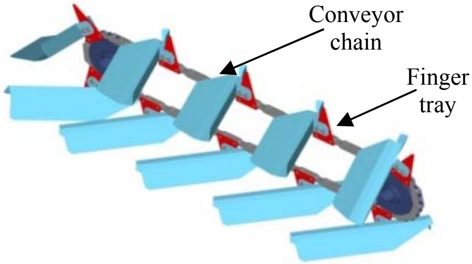


Figure. 1 Design of finger tray and metering mechanism

Laboratory test was conducted to find out the angle (β) in horizontal direction between finger tray on which the seedlings were kept manually and the moving chain. This angle β helps in dropping the seedling in such a way that the seedlings are properly guided into the drop tube. The levels of the factors were decided after observing the preliminary tests.

The test was statistically planned as a three factor completely randomized design (*CRD*) with four replications as shown in Table 1.

Table 1. Design of experiment for Laboratory Test

Sl No.	*Factor number*	*Factor description*	*Levels*
1	*Factor A*	*Angle β*	$\beta_1 = 20°$, $\beta_2 = 25°$, $\beta_3 = 30°$, $\beta_4 = 35°$
2	*Factor B*	*Crop C*	C_1 = *Brinjal*, C_2 = *Chilli*, C_3 = *Tomato*, C_4 = *Cabbage*, C_5 = *Knolkhol*
3	*Factor C*	*Length of seedling L*	L_1 = *100-150 mm*, L_2 = *150-200 mm*, L_3 = *200-250 mm*, L_4 = *250-300 mm*

RESULTS AND DISCUSSION

The purpose of finding the finger tray angle was to drop the seedlings in such a way that the roots of the seedlings were always guided towards the dropping tube. The mean of the replications of the experiment has been shown in Tab. 2.

Table 2. Mean of seedlings dropped properly into the funnel of seedling dropping tube

Tray angle	Crop	Seedlings dropped properly into the funnel			
		L = 100-150	L = 150-200	L = 200-250	L = 250-300
20°	Chilli	8.660 (75)	9.150 (84)	9.150 (84)	8.060 (65)
	Brinjal	8.293 (69)	8.660 (75)	8.800 (78)	7.750 (60)
	Tomato	8.370 (70)	8.370 (70)	8.060 (65)	7.750 (60)
	Cabbage	8.215 (68)	8.657 (75)	8.587 (74)	8.297 (70)
	Knolkhol	8.442 (71)	8.660 (75)	8.940 (80)	8.730 (76)
25°	Chilli	8.940 (80)	9.220 (85)	9.220 (85)	8.870 (79)
	Brinjal	8.940 (80)	9.220 (85)	9.220 (85)	8.660 (75)
	Tomato	8.940 (80)	8.940 (80)	8.660 (75)	8.655 (75)
	Cabbage	8.800 (78)	9.150 (84)	9.150 (84)	8.660 (75)
	Knolkhol	8.940 (80)	9.220 (85)	9.490 (90)	8.940 (80)
30°	Chilli	10 .0(100)	10 .0 (100)	10 .0 (100)	9.810 (96)
	Brinjal	10 .0 (100)	10 .0 (100)	10 .0 (100)	9.875 (98)
	Tomato	10 .0 (100)	10 .0 (100)	10 .0 (100)	9.617 (93)
	Cabbage	9.938 (99)	10 .0 (100)	10 .0 (100)	9.872 (98)
	Knolkhol	9.938 (99)	10 .0 (100)	10 .0 (100)	9.810 (96)
35°	Chilli	9.150 (84)	9.353 (88)	9.490 (90)	9.220 (85)
	Brinjal	9.010 (81)	9.220 (85)	9.220 (85)	8.940 (85)
	Tomato	8.870 (80)	9.220 (79)	9.220 (85)	8.940 (80)
	Cabbage	9.010 (81)	9.010 (85)	9.010 (85)	9.010 (81)
	Knolkhol	9.010 (81)	9.288 (86)	9.217 (85)	8.940 (80)

* *Data in the parentheses are actual data in percentages (rounded to integer)*
** *Data outside the parentheses are transformed data for analysis of variance.*

Effect of Length of crop on *PSPD*

The percentage of different lengths of seedlings of chilli, brinjal, tomato, cabbage and knolkhol properly dropped through the seedling tube irrespective of tray angle setting has been shown in Fig. 2.

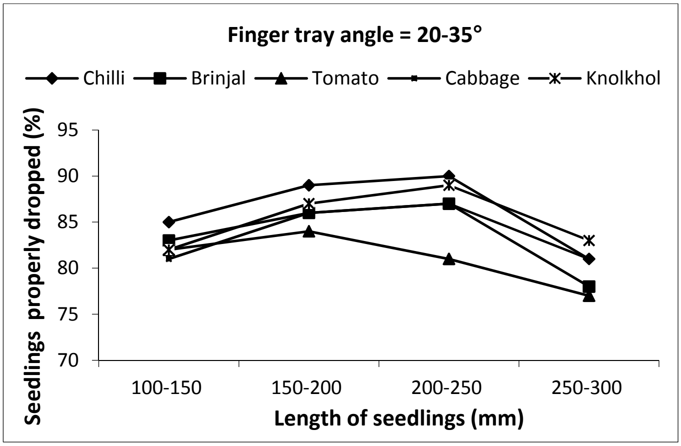


Figure 2. Effect of type of crops and length of seedlings on percentage of seedlings properly dropped (PSPD)

It was found that the average PSPD increased from 85, 83, 81 and 82 to 90, 87, 87 and 89 in case of chilli, brinjal , cabbage and knolkhol respectively as the length of seedlings increased from 100-150 mm to 200-250 mm and decreased to 81, 78, 81 and 83 when the length of seedlings increased to 250-300 mm. But in case of tomato, *PSPD* increased from 82 to 84 as the length of seedlings increased from 100-150 mm to 150-200 mm and then decreased to 81 and 77 when length of seedling is 200-250 mm and 250-300 mm respectively. The smaller seedlings (100-150 mm) as well as larger seedlings (250-300 mm) showed relatively more difficulty in dropping properly than the medium length (150-250 mm) seedlings except tomato, where the smaller seedlings dropped easily than larger seedlings.

The ANOVA for the effect of seedling length and type of crop on tray angle is shown in Table 3. It was evident from the ANOVA that all the three factors viz. finger tray angle, type of crop and length of seedlings affect *PSPD* significantly (at 1% level).

Table 3. Analysis of variance for the effect of seedling length and type of crop on tray angle (CRD)

Source	*DF*	*Sum of squares*	*Mean square*	*F Value*	*Prob*	*SEM*	*CD*	
							1%	*5%*
Factor A	*3*	*88.203*	*29.401*	*2106.8518*	*0.00*	*0.0132*	*0.0485*	*0.0368*
Factor B	*4*	*3.316*	*0.829*	*59.4078*	*0.00*	*0.0148*	*0.0543*	*0.0412*
AB	*12*	*2.422*	*0.202*	*14.4619*	*0.00*	*0.0295*	*0.1083*	*0.0822*
Factor C	*3*	*7.352*	*2.451*	*175.6031*	*0.00*	*0.0132*	*0.0485*	*0.0368*
AC	*9*	*1.546*	*0.172*	*12.3123*	*0.00*	*0.0264*	*0.0969*	*0.0735*
BC	*12*	*1.371*	*0.114*	*8.1864*	*0.00*	*0.0295*	*0.1083*	*0.0822*
ABC	*36*	*3.047*	*0.085*	*6.0643*	*0.00*	*0.0591*	*0.2170*	*0.1646*
Error	*240*	*3.349*	*0.014*					
Total	*319*	*110.606*						
Coefficient of variation: 1.29%								

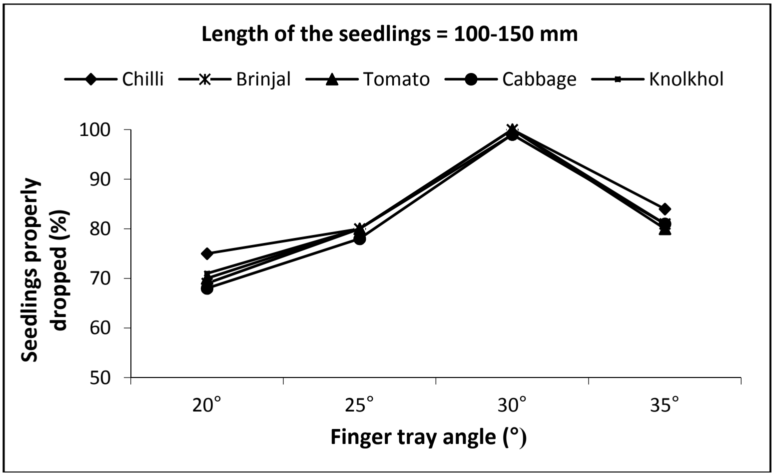
Factor A : Finger tray angle (Level = 4)
Factor B : Seedlings of five different crops (Level = 5)
Factor C : Length of seedlings (Level = 4)
No. of replications: 4
Dependant variable: Seedlings properly dropped, %

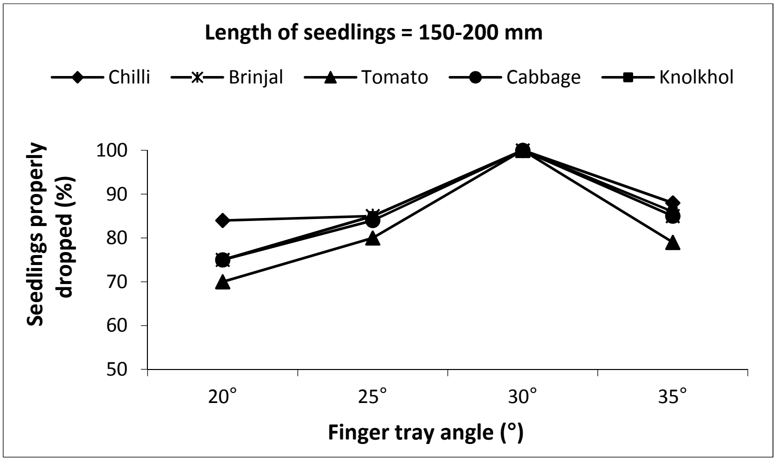
Effect of type of crop on finger tray angle

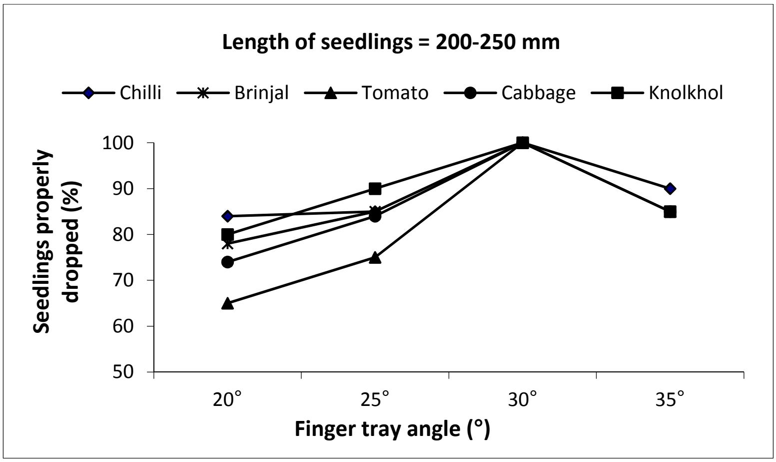
The percentage of seedlings properly dropped (*PSPD*) with different crops at different setting of tray angle has been presented in Fig. 3.

Chilli had the highest *PSPD* at any particular tray angle setting in comparison to other crops whereas tomato had the least per cent of seedlings properly dropped (Fig. 2 and 3). This was observed because chilli had the least foliar development and hardy stem compared to other crops under study, where as tomato stem was very soft and it had more foliar development. The percentage of seedlings properly dropped in case of other crops lie in between chilli and tomato.

As seen from the Fig. 3, the percentage of seedlings properly dropped increased from 76.875 to 99.063, 70.313 to 99.375, 66.25 to 98.125, 71.25 to 99.063 and 75.625 to 98.75 in case of chilli, brinjal, tomato, cabbage and Knolkhol respectively with finger tray angle increases from 20° to 30°.


Length of the seedlings = 100-150 mm
Chilli
Brinjal
Tomato
Cabbage
Knolkhol
Seedlings properly dropped (%)
100
90
80
70
60
50
20°
25°
30°
35°
Finger tray angle (°)


Length of seedlings = 150-200 mm
Chilli
Brinjal
Tomato
Cabbage
Knolkhol
Seedlings properly dropped (%)
100
90
80
70
60
50
20°
25°
30°
35°
Finger tray angle (°)


Length of seedlings = 200-250 mm
Chilli
Brinjal
Tomato
Cabbage
Knolkhol
Seedlings properly dropped (%)
100
90
80
70
60
50
20°
25°
30°
35°
Finger tray angle (°)

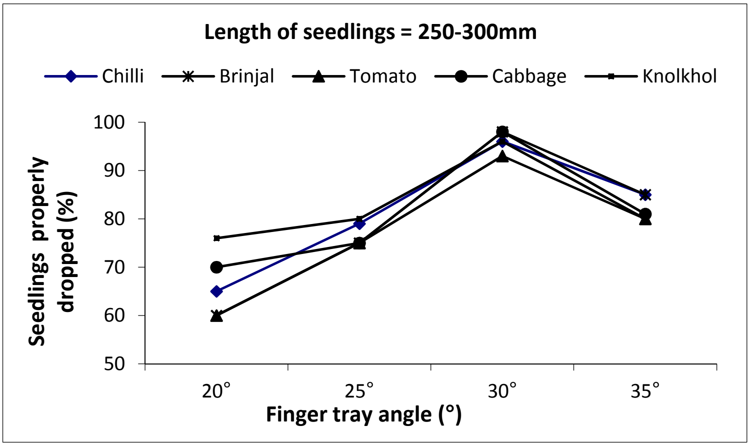


Figure 3. Effect of finger tray angle on percentage of properly dropped seedlings through seedling dropping tube with four levels of seedling lengths

So nearly cent per cent dropping was observed irrespective of type of crop and length of seedlings in 30° tray angle. The *PSPD* decreased from 99.063 to 86.563, 99.375 to 82.813, 98.125 to 82.188, 99.063 to 83.125 and 98.75 to 83.125 in case of chilli, brinjal, tomato, cabbage and Knolkhol respectively as the finger tray angle was increased from 30° to 35° irrespective of type of crop and length of seedlings. Therefore, finger tray angle of 30° has been taken as optimum value for designing the feeding system of the semi-automatic vegetable transplanter.

CONCLUSIONS

During the process of designing the semi-automatic vegetable transplanter, from laboratory test it was found that finger tray angle of 30° is the optimum value for smooth dropping of seedlings from the feeding unit irrespective of type of crop and length of seedlings. Medium length (150-250 mm) seedlings showed better dropping from feeding unit except tomato where as tomato seedlings dropped properly at 100-150 mm size seedlings. The smaller seedlings (100-150 mm) as well as larger seedlings (250-300 mm) showed relatively more difficulty in dropping properly than the medium length (150-250 mm) seedlings [10].

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UTICAJ UGLA POSTAVLJANJA TRANSPORTERA SADNICA NA KVALITET SADNJE KOD POLUAUTOMATSKE SADILICE ZA POVRĆE

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Sažetak: Istraživanje je imalo za cilj ispitivanje jednoredne poluautomatske sadilice za povrće, kako bi se odredio otimalan ugao zahvatanja i ulaganja različitih tipova sadnica rasada u zemljište. Optimalni ugao vođice na kojoj su prihvatni prsti pričvršćeni na noseći lanac, je određen u labaratorijskim uslovima. Eksperiment je urađen kao trofaktorijalni C.R.D. sa četiri ponavljanja. Procenat sadnica rasada, pravilno postavljenih (PSPD) se povećavao sa uglom postaljvaja od 20 do 30 stepeni. Za ovaj dijapazon se pokazalo da tip sadnice i njena dužina ne utiču na kvalitet sadnje. *PSPD* se smanjivao sa povećanjem ugla postavljanja vođice, preko 30 stepeni. Čili sadnice su imale najviši *PSPD* u poređenju sa ostalim kulturama, dok je *PSPD* bio najniži kod paradajza. Sitnije sadnice (100-150 mm) kao i krupnije (250-300 mm) su pokazale poteškoće prilikom sadnje u poređenju sa srednje razvijenim (150-250 mm) sadnicama.

***Ključne reči**: rasad, vođica sa hvatačima, mehanizam za ulaganje rasada, lanac konvejera*

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