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A STUDY FOR THE DEVELOPMENT OF A VEGETABLE PLANTER FOR OPTIMUM STAND ESTABLISHMENT

Muslim Abbas Zaidi[1,*], Nadeem Amjad[1] and Shamim-ul-Sibtain Shah[2]

[1]Agriculutal and Biological Engineering Institute; 2Farm Operation and Services, National Agricultural Research Centre, Park Road, P.O. NIH, Islamabad, Pakistan
[*]Corresponding author's email: muszaidi@comsats.net.pk

Seed placement and establishment is probably the most crucial phase in the life of a vegetable crop, therefore, the role of the planter or seeder is of vital importance. The objective of this study was to assess the demand of a vegetable planter/seeder and to collect information from farmers, machinery manufacturers and stakeholders to design a new planter for vegetables, initially for pea crop. To achieve the objective of this study, a survey was conducted in three provinces (Punjab, Sindh and Baluchistan) of the country and 34 farmers, 21 officers from the concerned institutions and 14 manufactures were interviewed. Furthermore, three existing planters/drills used for sowing different crops were picked from different sources for evaluating their comparative performance for planting pea. The status of vegetable planting or sowing as a whole was not found encouraging in the country and most vegetables are grown manually that are time consuming and labour intensive practices. Farmers are vigorously demanding a planter or seeder for vegetables. From the evaluation of existing machines, it was concluded that a pneumatic planter for sowing vegetables on beds is the most precise method that drops 10 to 20 seeds per meter length at recommended forward speed with single seed placement per hill. This ensures not only the optimum seed rate, but also eliminates the need for thinning after germination. Using this machine farmers may be able to save two third of the seed quantity for pea crop together with achieving additional benefits of vegetables mechanisation. Therefore, a vegetable planter, initially for pea, should be developed locally to enhance productivity of vegetables, because root establishment of vegetable crops is very critical factor that affects ultimate yield.
Keywords: vegetable planter, pea planter, pneumatic metering system, bed sowing

INTRODUCTION

Vegetables comprise a wide range of plant organs, which are essential sources of carbohydrates, vitamins and minerals necessary for healthy diet. The tuber vegetables, such as potato and yam are valuable sources of carbohydrates. Potatoes contain 25-30% starchy dry matter. Pulses, such as peas and beans are high in protein and fibre. Salad vegetables, such as lettuce and cucumber have water content up to 95% and provide essential fibre, vitamins and minerals to the diet. Broccoli and cauliflower are the floral vegetables, whereas capsicums and peppers provide a spicy aromatic flavour to the diet (Anonymous, 2005). Pea (*Pisum sativum* L.) is the world's third most significant legume grain after soybean and common beans (Timmerman-Vaughan *et al*., 2005). In Pakistan, pea is one of the leading and popular vegetables, which is grown throughout the country for its diverse uses as food and fodder. However, Punjab is the leading province, which contributes 70-80% of the total production. The average fresh grain yield of pea in Pakistan was 596 Kg ha^{-1} during the year 2005 (Anonymous, 2005), which is very low as compared with other advanced countries. There is a great potential to increase pea yield by adopting high-yielding, disease-resistant varieties, improved production practices and advanced precise planting technology. Although research on high-yielding and disease-resistant cultivars is very important to cultivate high yield, the availability of a precise planting/sowing technology is equally important. Therefore, well organised and coordinated institutional efforts are needed to enhance pea yield to meet the national consumption demand. Currently, there is no appropriate vegetable planter or seeder available in the local market except for potatoes. Pea planting is mainly done by broadcasting method, which does not ensure proper seed establishment depth and hence the seed does not get the required moisture content necessary for seed germination. Farmers usually use more than the recommended seed rate to guarantee the optimum plant population and to increase yield, which adds an additional seed cost.

Different types of vegetable planters/seeders are being used throughout the world, such as belt type, plate type, roller type, vacuum type and pneumatic type (Murray *et al*., 2006; Yenpayub *et al*., 2002). Some of them are designed as unit planters, where each planting unit has a separate and complete planting system, whereas others are powered from a common drive shaft. Selection of an appropriate planter depends on factors, such as the size and shape of seeds, soil

characteristics, total area to be seeded and personal preference of the grower (Daum and Orzolek, 2004). Furthermore, the final yield of vegetables is ultimately related to the initial seed establishment; therefore, the correct choice of a vegetable planter for individual vegetable is very critical. A vegetable planter should be capable to open soil generally by a furrow opener, to metre seeds from the hopper, to place metered seeds into the furrows and to cover and compact the seeds with soil in the furrows (Borlagdan, 1994; Murray *et al*., 2006). Due to unavailability of vegetable planters, farmers in Pakistan are demanding a bed planter for sowing vegetables specifically pea according to the local farming conditions. Pea seed is normally broadcasted on ridges. Therefore, the objectives of this fundamental study were to study the status of vegetable planting in the country and to asses the adaptability of a new vegetable planter, to evaluate the performance of three existing planters/drills for pea planting and to establish the design criteria for the development of a new vegetable bed planter.

MATERIALS AND METHODS

***Data acquisition*:** Field survey of main vegetable growing areas of Baluchistan, Punjab and Sindh was carried out to ascertain the machine demand, to establish the unified machinery selection criteria and to determine the vegetable production problems. The places visited for this purpose were Quetta, Kalat, Mastung and Pishin in Baluchistan; Hyderabad, Mirpur Khas and Tandojam in Sindh and Gujranwala, Daska, Lahore, Okara, Faisalabad and Chiniot in Punjab provinces. Information was collected from 34 farmers, 14 manufacturers and 21 officers from different institutions. Information was also obtained about the available vegetable planting/seeding machines with the farmers, manufactures and other stakeholders. A total of four planters/drills were found for planting vegetables and other crops. A semiautomatic type Agritec bed planter with fluted roller type metering mechanism was available with Zaraee Traqiati Bank Limited (ZTBL) Farm, Islamabad. Another Gaspardo pneumatic planter was found with Oilseed Programme, NARC. Besides, a bed sowing drill was also found from Wheat Programme, NARC for wheat sowing. A small experimental unit of manually drawn planter for onion planting was also available with Agricultural Research Station, Quetta. This unit was not included in the experiment because it was not good for pea planting due to manual operation.

***Machines description*:** Three machines were picked from the stakeholders to establish design criteria to develop a new machine for vegetable planting that could be affordable by the target farmers. The detail of these machines is given below and their specifications are given in Table 1.

These machines were tested at NARC for pea seed placement establishment data, for example, established seed density, seed depth, double seed placed per hill per unit length, mean number of seeds per unit length and mean seed spacing.

1. ***Gaspardo pneumatic planter*:** The pneumatic planter was a four-row tractor rear-mounted machine (Fig. 1). It was driven by a tractor PTO at 540 rpm to operate its aspirator blower. Planting depth and intra-row spacing were adjustable. The metering mechanism of the planter used air suction that was produced by the aspirator blower. The vacuum disc of each row was connected to the inlet chamber of the aspirator blower through a rubber tube. The seed metering disc had holes on its periphery. Air suction from the holes of the metering disc caused the seeds to stick against them. The ground wheel drove the seed disc. The stuck seed was released from the rotating disc with the help of baffle cut, which was situated near the opener. The absence of suction allowed the seed to drop into the furrow. The planter was not provided with the bed-making facility; therefore, it could plant peas on a flat field or on existing beds.

2. Agritec planter: Agritec planter (Fig. 2) was also a four-row bed-planter with the fluted roller metering mechanism. The seed rate was adjustable by changing the exposed length of fluted roller through a lever. The row-to-row distance was fixed, whereas plant to plant distance could not be maintained with this planter. Continuous seeds were dropped in a small furrow opened by the furrow opener on the raised

Table 1. Specifications of machines

Specification	Gaspardo planter	Agritec planter	Bed sowing drill
Length (cm)	167	264	159.2
Width (cm)	274.5	322	246.7
Height (cm)	154	121	133
Metering system	Pneumatic	Fluted roller	Fluted roller
Tractor mounted	Yes	Yes	Yes
Number of rows	4	4	4
Adjustable row spacing	Yes	No	Yes
Adjustable seed rate	Yes	Yes	Yes
Power required (hp)	60	75	45
Bed making	No	Yes	Yes

bed. A ground wheel was provided for driving metering mechanism through a chain drive system.

***3. Bed sowing drill*:** Bed sowing drill *(*Fig. 3) was also comprised four rows. It also had the fluted roller metering mechanism and seeds were sown on the beds. It had provision for adjusting row-to-row spacing.

Figure 1. Gaspardo pneumatic planter

Figure 2. Agritec planter

Figure 3. Bed sowing drill

***Experimental procedures*:** *The* experiment was conducted for pea planting at the experimental farm of Agricultural and Biological Engineering Institute (ABEI), NARC, Islamabad with the following four treatments.

1. Gaspardo pneumatic planter (bed planting)
2. Gaspardo pneumatic planter (flat planting)
3. Agritec planter (bed planting)
4. Drill (bed planting)

The seedbed was prepared well in the experimental field with multi-operations of different cultivators/ploughs and a wooden plank. The field was divided into four equal subplots. In first plot, the beds were prepared with the Agritec planter (prepared beds only without dropping seed) and seeds were sown with pneumatic planter. In the second plot, seeds were sown with pneumatic planter on flat bed. Third plot was sown with the Agritec bed-planter, whereas the fourth field was sown with the bed sowing drill.

RESULTS AND DISCUSSION

The status of vegetable planting as a whole was not found encouraging and most vegetables are grown manually that are time consuming and labour intensive practices. For example, pea is sown by broadcasting method, where farmer uses more than the recommended seed rate to achieve proper number of plants in the field. A good number of seeds remain uncovered in this method and are eaten by birds or are buried deep in the bed-making process after broadcasting, which cannot emerge. This increases the cost of production. Therefore, vegetable production can be optimised only if successful stand establishment is achieved because each plant contributes to the total yield. Sowing recommended plant density of a vegetable crop is important because decreased or increased plant population will reduce yield or quality of the vegetable crop. To achieve optimum stand establishment of vegetable crops, a vegetable planter is needed for increasing the yield and reducing the losses during planting or sowing process.

Survey results of machine selection criteria are shown in Table 2. The preferences included type of machine, size of the machine, power source and the price of the machine. Perhaps the price of the machine was the most important criterion for adaptation of the machine in the local farming community. The local farmers are demanding a vegetable bed-planter, initially for pea, in less than Rs. 50,000, which is not possible with pneumatic metering system because in the local market the price of the available machine is already more than this. For example, an ABEI designed pneumatic planter without having a bed making system costs about Rs. 90,000 that is low when a low cost pneumatic planter cost US $3000 in India (Rajan and Sirohi, 2012). The price of the machine can be reduced in future by installing precise mechanical seed metering mechanism instead of pneumatic system. Furthermore, the pneumatic system also needs power for seed metering that adds an extra amount of fuel charges and requires a bigger sized tractor for operating the machine.

Based on the responses of the stakeholders as reflected in Table 2, it was found that the planter must be, 1) a tractor mounted, 2) comprising 4-rows, 3) fully automatic and 4) be locally manufactured.

The comparative performance tests of the three machines were conducted only for seed stand establishment for pea only. The plant establishment data revealed that there were 15 and 18 seeds in one meter length, which were distributed by Agritec bed planter and bed sowing drill, respectively (Table 3). However, the pneumatic planter distributed 10 seeds in both cases (bed sowing and flat sowing). It was also found that single seed placement was only achieved in case of pneumatic planter, whereas 9.4% and 22% more than one seed were placed with Agritec bed planter and bed sowing drill, respectively (Table 3). Percent double hill placement of seeds over a one metre length is shown in Table 4. Both Agritec planter and drill placed double seeds on hills, whereas pneumatic planter did not drop any double seeds in the seeding furrow that shows excellent performance as compared with a low cost pneumatic planter having 90% singularity index (Rajan and Sirohi, 2012). The best intra-row spacing was obtained with the pneumatic planter because of low coefficient of variation (Table 5).

Table 2. Unified machine selection criteria

Parameters		Punjab			Sindh			Balochistan		
		F	M	I	F	M	I	F	M	I
Preference	Manual									
	Machine	*	*	*	*	*	*			*
Machine type	Fully automatic	*	*	*		*	*			
	Semi automatic									
Size	2 row									
	4 rows	*	*	*			*			*
Power source	Tractor operated	*	*	*	*		*			*
	Self propelled									
Price (Rs)	<50,000	*			*			*		
	>50,000		*	*			*		*	
Make	Local	*	*	*			*			*
	Imported									

*Note: Responses in the respective columns are based on the averages of survey results; * indicates answer in "Yes" and empty boxes reflect the answers in "No"; M = Manufacturer, F = Farmer and I = Institute*

Table 3. Number of established plants per meter for different machines

Treatment	R1	R2	R3	R4	R5	Average
Gaspardo planter with Agritec beds	9	10	9	9	10	10
Gaspardo planter	9	10	8	9	10	10
Agritec planter	11	16	15	16	14	15
Bed sowing drill	15	17	19	21	18	18

Table 4. Percent double-hill in the length of one meter furrow

Treatment	R_1	R_2	R_3	R_4	R_5	Average
Gaspardo planter with Agritec beds	0	0	0	0	0	0
Gaspardo planter	0	0	0	0	0	0
Agritec planter	9	12	7	12	7	9.4
Bed sowing drill	5	29	26	33	15	22

Table 5. Mean intra-row spacing (cm) of three machines

Replications	Agritec planter with Agritec beds		Gaspardo planter		Agritec planter		Bed sowing drill	
	X	CV	X	CV	X	CV	X	CV
R1	11.88	43.51	10.56	21.24	10.89	58.70	7.87	56.82
R2	11.22	27.38	11.00	14.21	8.08	37.10	9.10	47.60
R3	11.38	32.54	12.88	26.40	7.00	44.42	9.40	51.92
R4	11.75	22.17	10.78	26.15	6.80	64.15	7.29	42.19
R5	11.00	45.45	11.10	14.37	7.00	52.05	--	--
Average	11.45	34.21	11.26	20.47	4.95	51.28	8.42	49.63

Where, X is the mean and CV is coefficient of variation.

An air-jet singulator was developed and evaluated by Shafii *et al.* (1991) and concluded that both air-jet singulation and mechanical singulation worked well with acceptable levels of planting efficiency, singles, skips, doubles and multiples.

Table 3 suggests that the pneumatic seed metering mechanism is very precise and should be employed on the new planter. With fluted roller type seed metering systems, plant to plant distance cannot be maintained. First, an extra amount of seed will be required in such metering systems and then extra labour will be required for thinning the emerged seeds to get optimal plant density for better development of seeds in pods. Although a planter with pneumatic metering mechanism is a precise one, but the pneumatic type metering system requires power from the PTO of the tractor, therefore, a bigger sized tractor is needed for operating this type of planter. On the other hand, Agritec planter and drill are relatively easier to pull behind the tractors and small sized tractors are needed for operation. But, plant to plant distance cannot be maintained. From the results of this study, it is suggested that a pneumatic type metering system will give precise seed establishment and will be used in the development of a new vegetable/pea planter.

From these initial results, it was determined that extra seeds were required for Agritec planter and bed sowing drill. Also extra labour was required for thinning to maintain the plant population after emergence. With Gaspardo pneumatic planter, the seed distribution was ideal. However, there was no bed sowing system and only flat sowing was possible with the currently available model.

***Conclusion*:** The overall status of vegetable planting in the country is not found encouraging and most vegetables are grown manually that are time consuming and labour intensive practices. Vegetable production can be optimised only if successful stand establishment is achieved at the time of sowing. It is concluded that a tractor operated pea planter with pneumatic seed metering mechanism on beds is needed to develop keeping in view the local farming conditions. The pneumatic seed metering system is the most precise method that ensures single seed placement per hill. This ensures not only the optimum seed rate, but also eliminates the need for thinning after germination. However, the planter with the pneumatic metering mechanism may be expensive. For reducing cost of the planter, it is also suggested that a mechanical seed metering mechanisms should be designed and developed in future that can be used for planting various vegetable crops.

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