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Design And Analysis Of An Automated Seeder For Small Scale Sowing Applications For Tray Plantation Method

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1. Abstract

Even though India is the second largest producer of vegetables but the average production rate is lower as compared to other countries in Asia. It was observed that lack of technology aid in production and cultivation practices are the main reasons. As observed, in many vegetables and fruits are kept in nurseries for its early stages for better germination. Seeds are placed in a plug tray which is available in various capacities like 104,102 etc but generally tray of 104 is preferred. Worker has to deposit one by one seed in each cup. Worker has to perform this tedious task for long time, which needs patience and ability to retain concentration for a long time. Such complex and hectic operation leaves Worker with severe ergonomic effects such as back ache, pains in fingers and arm, which is why Workers are apprehensive about the sowing task.

Automation in the seeder will help in reducing the wastage of the costly seeds, time required for sowing and it will indirectly affect the cost of the vegetables and fruits through minimizing the workers expenses. Literature review shows that little investigation has been done so far about frugal design and automation of the seeders. The small survey undertake in some of the nurseries and green houses in Kolhapur district reveals that nursery owners are willing to adapt to the new technologies, which can satisfy set of requirements, although the high cost associated with automation is holding them back.

2. Introduction

India has been bestowed with wide range of climate and physio-geographical conditions and as such is most suitable for growing various kinds of horticultural crops. Its horticulture production has increased by 30 per cent in the last five years. This has placed India among the foremost countries in horticulture production, just behind China. During 2012-13, its contribution in the world production of fruits & vegetables was 12.6 % & 14% respectively. Total production of fruits during 2012-13 was 81.2 million tonnes while that of vegetables was 162 million tones whereas the second advance estimates put the production at 84.4 million tonnes and 170.2 million tonnes respectively for 2013-14. India's

significant horticulture production is despite its comparatively lower productivity.

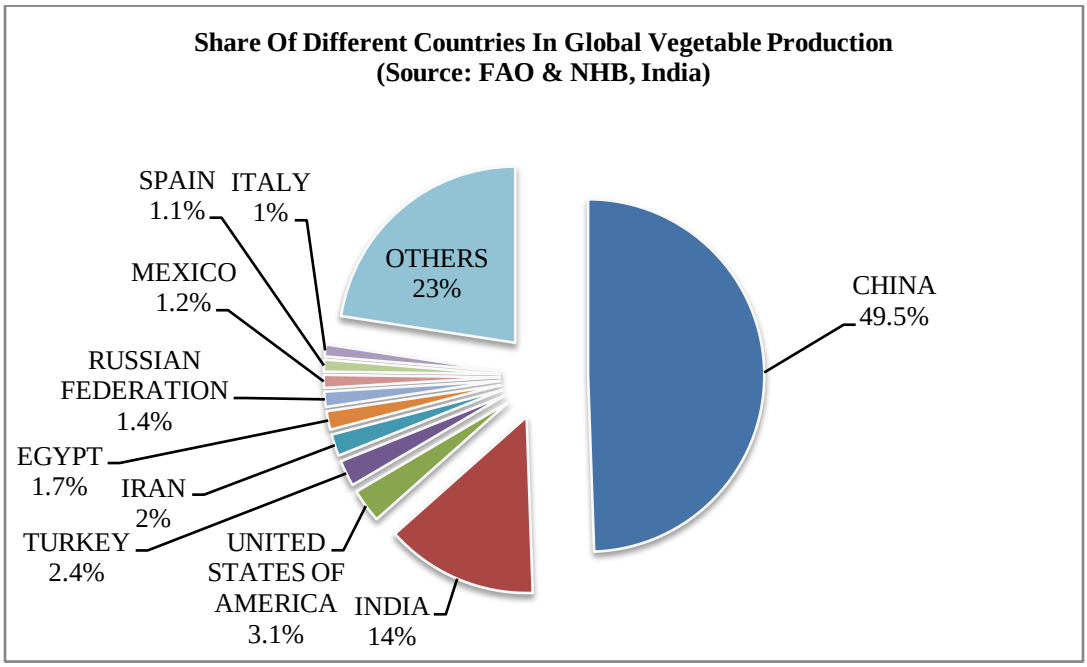

Figure 1: Share Of Different Countries In Global Vegetable Production

An ever increasing trend of utilizing F1 hybrid seeds has been observed in the vegetable production sector and a major portion of area under vegetable cultivation is now sown with these seeds. Although more expensive than ordinary seeds, these seeds result in higher yields and better quality. In interest of justifying the use of these costly seeds, it is of utmost importance to achieve maximum germination of the seeds into healthy seedlings.

2.1 Seed Sowing In Nurseries

This technique ensures that a large number of seedlings can be raised in minimum space & low cost to get quality seedlings. Chili is normally transplanted because much better results are gained when seedlings are raised in a nursery. There are three methods of raising seedlings in the nurseries which can be used:

(A) Sowing on seedbed
(B) Sowing in the plug trays
(C) Sowing in the poly house

The method of direct sowing, which has been traditionally adopted, has its own disadvantages such as longer growth period, higher water and nutritional consumption, higher seed rate and non-uniform plant density. Apart from these disadvantages, the seeds are exposed to soil-borne diseases, insects, pests and birds and adverse climatic conditions like excessive heat, frost, wind, heavy rainfall etc. Due to these factors, seed germination and plant establishment is generally poor, thus making the use of hybrid seeds uneconomical for direct sowing. As a solution to these problems, a method wherein seedlings are raised in a nursery and later transplanted in the field is adopted.

2.2 Sowing in Plug Trays

Plug tray sowing has many advantages such as are minimum natural damages to tender seedlings at the nursery stage, lower water consumption during transplanting period, reduction in transplanting shocks and extremely low plant mortality, overall reduced operating costs, low inputs like water, fertilizers and enhanced germination and growth rates. Also, once transplanted, there are further benefits for the crops such as shorter growth period, efficient land utilization, early crop maturity, extended crop production, efficient use of irrigation water and better weed management. It also helps in maintaining desired plant density, facilitates inter-cropping and saves on the seed cost. Most importantly, it helps in planning the planting time so as to minimize incidences of diseases, insects and pest infestations and to schedule crop harvest

according to the market demand and price. Plug transplants establish better in the field due to disease free and prolific root development. Indian farmers have started using this technique for value seedlings such as tomato, capsicum, cucumber, broccoli, chilies, etc. for its obvious advantages. This technique has also started to establish itself as an independent agro-enterprise. A large number of such nurseries are operating in Karnataka, Maharashtra and several other states where seedlings are raised in plug trays and sold on pre-order basis to cultivators. The cultivators acquire the required number of healthy seedlings grown in a greenhouse or a net house at scheduled time while not bothering to raise a nursery of their own.

2.3 Manually Sowing in Plug Trays

First of all empty PVC plug tray is taken. The tray having the 104 number of cup of specific shape also now available in different shape and number of cups. Then the pouring of growing media (Coco-pit, vermin compost) is done manually, which may requires the 0.17 m^3 volume of growing medium (Fig. 3). After this the Worker manually takes the seeds and drop one by one in PVC plug tray, till the tray is full. The size of seeds is very small, due to which it is difficult to fill each plug tray with a single seed. The time required for this operation is more than two minutes for an experienced worker. At the same time it requires more concentration during filling a plug tray, making it a monotonous and strenuous task.

Worker	Time reqd./ tray (min)	Avg. Time Reqd. (min)	Seed Wastage (Nos.)	Avg. Seed Wastage (Nos.)
A	3.10	2.94	31	27
B	3.17		26	
C	2.56		23	

Table 1: Seed Wastage Experiment Results

Figure 2 : Chilly seed sowing by manual method

3. Automation in Sowing - Experimentation

To bring about the much needed automation in this area, we first set about trying to reduce the workload of carefully dropping seeds in the plug trays. For this, we chose to work with cucumber, eggplant, chili pepper and tomato, since these were the plants that were sowed using the plug tray sowing technique. We tested the properties of their seeds in an experiment, the results of which are shown in the table below.[6]

Seed	Geometrical Sizes (mm)			Thousand Kernel Mass (gms)	Rest Angle (Deg)	Sliding Friction Angle (Deg)	Floating Speed Rate (m/s)
	Length	Width	Thickness				
Cucumber	9.00	3.87	1.42	26.49	19.36	21.80	6.38
Eggplant	3.07	2.63	0.92	4.27	19.83	24.95	5.02
Pepper	3.96	3.40	0.76	5.94	20.56	25.66	4.24
Tomato	3.23	2.36	0.63	2.80	26.24	31.82	3.78

Table 2 : Seed Parameters Calculation

3.1 Vibratory Seeder

First experimental design was that of a vibratory seeder, where in a hand tool like architecture was used. A stainless steel strip, with a small baffle was introduce as a seeding element, to which a vibratory coil was attached. Also, a small Lithium Ion battery was provided to power the vibrating coil, for which a charging point was introduced. It was a simple and frugal design, costing very less, about Rs. 1,000 per device.

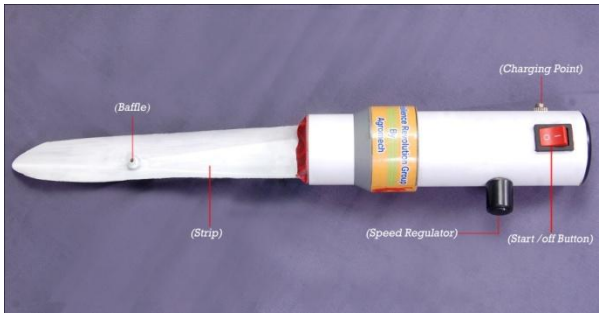

Figure 3 : Vibratory Seeder

A test run of a vibrating seeder was carried out and the times required to fill a plug tray was recorded with three workers were recorded. The results are given in the table below.

Worker	**Time reqd./ tray (min)**	**Avg. Time Reqd. (min)**
A	2.56	**2.37**
B	2.35	
C	2.20	

Table 3 : Vibratory Seeder Results

3.2 Needle Seeder

Needle seeders use a vacuum and thin needle to pick up seeds, and seed them one row at a time to a plug tray. Seed is placed in a vibrating tray that spans the width of the flat. The vibration keeps the seed spread evenly in the tray. Thin-tipped needles are dipped into the tray and pick up one seed each. The needles are lifted up to a row of clear plastic tubes, and released into the tubes The tubes align with the cells of the tray, so the seeds drop into the cell. The planting tray is advanced one row, and the process is repeated.

Needle seeders have a variety of adjustments, including needle size, vibration speed, suction pressure, ejection pressure, indexing (how far the tray is advanced), and tray width. Needle seeders have a better ability than a vibrating seeder to handle odd-shaped seed because the needles can get into crevices of the seeds. Switching needles and drop tubes to accommodate new seeds and/or new flats requires about five minutes for a trained worker.

Advantages are, increased speed of operation, as vibrating seed feeder is capable of putting a single seed in single cup but in vacuum seed feeder we can place eight seeds in eight different cups. Vibrating seeder requires manual skill for moving our wrist at right time otherwise there are chances of dropping multiple seeds in one cup which is undesirable. Vibration and continuous motion of the wrist may cause serious effect on human body, where the vacuum seeder clearly gives better results.

Needle seeder contains a vacuum pump which is attached to the pressure regulating valve. One end is attached to the flexible pipe which is then attached to the seed placing device. Seed placing device is made up with a PVC pipe which is easily available and sustainable to the suction pressure. This placement device is drilled at regular interval so that the needles can be attached to this drill. The needles are grinded so that their sharp end get flat. The suction pump has provided with a thermo cutout so that at temperature greater than the one desired, it stops operating to prevent seed damage.

Figure 4.1 : Seed Placement Device

Figure 4.2 : Seed Stand

Figure 4.3 : Final Assembly

A test run of a needle seeder was carried out and the times required to fill a plug tray was recorded with three workers were recorded. The results are given in the table below.

Worker	Time reqd./ tray (min)	Avg. Time Reqd. (min)
A	1.05	**1.43**
B	1.30	
C	1.30	

Table 4 : Needle Seeder Results

3.3 Automatic Seeder

With two experiments, it was clear, that a further automation was needed, which could focus on more speed and similar accuracy as the vacuum seeder. With this purpose, the new, automatic seeder was designed. The construction of the seeder is discussed here.

3.3.1 Seeder Pipe

Seeder pipe is very much the same as it is in the needle seeder. It has eight needles fitted at regular intervals connected to the vacuum pipe, to suck the seeds and to drop them into seed guidance mechanism. The seeder pipe is attached to a swiveling mechanism that rotates back and forth between the seed tray and the seed guidance mechanism.

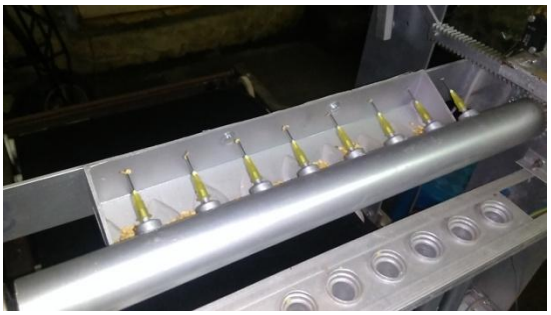

Figure 5.1 : Seeder Pipe

3.3.2 Flexible conduit pipe

The purpose of the flexible conduit pipe was to provide a flexible connection between the seeder pipe and cut-off device assembly and the pressure regulating arrangement so that the seeder pipe could be easily moved over the plug tray. A flexible rubber pipe with inner diameter of 12 mm and outer diameter of 16 mm was used as the flexible conduit pipe. The pipe wall thickness was 2 mm, which was sufficient to resist the pipe from collapsing inwards under suction pressure. The conduit pipe was connected to the cut-off device at one end by sliding it over the port of the cut-off device and at the other end it was connected to the pressure regulating arrangement using a 12.7 mm steel adapter. Figure 3.8 shows the flexible conduit pipe.

Figure 5.2 Flexible Conduit Pipe

3.3.3 Pressure Regulating System

The function of this system was to maintain the required level of negative pressure in the seeder pipe. Pressure regulation was achieved by using a solenoid coils viz. coil 1 and coil 2

diversion line having one open end to the atmosphere. A vacuum gauge was fixed in series to the main line. One end of the pressure regulating system was connected to the suction unit while the other end was connected to the flexible conduit pipe. Figure 3.9 shows the pressure regulating system.

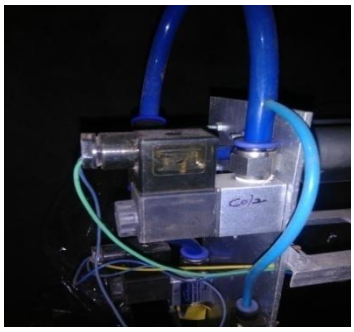

Figure 5.3 : Pressure Regulating System

3.3.4 Suction Unit

Amongst the different types of suction units commercially available, a single stage vacuum pump is used operating on 230 V AC supply was selected as it was the cheapest option available. The suction unit having free air displacement 2.0 CFM and ultimate vacuum 150micron.The details of the suction unit are shown in appendix F. Figure 3.10 shows the suction unit.

Figure 5.4 : Suction Unit

3.3.5 Seed Tray

The cross section of the seed tray was made 'Tapered rectangular box' shaped so that as the quantity of seeds in the holder reduced during operation, the remaining seeds could slide down the slope and the seed mass would aligned itself in a linear manner along the length of the seed holder, which was necessary for efficient singulation when the depth of seeds in the holder was very less. The side slope of the seed holder was kept greater than the highest value of angle of repose amongst cabbage, chilly and tomato seeds. Tomato seeds have the highest angle of repose of 33.24° amongst the three types seeds (Salawu et al, 2014). A side slope of 45° was thus selected. The length of the seed holder was kept as 440 mm so that all the needles on the seeder pipe could be inserted into the seed holder without obstruction. In order to achieve better singulation vibrations are provided to seed tray with the help of vibrator. Vibrator is attached to the bottom surface of the tray. The tray was made of 2 mm thick acrylic sheet. Figure 3.11 shows the view of the seed tray.

Figure5.5 : Seed Tray

3.3.6 Conveyor

Conveyor is used for advancement of plug tray. Conveyor also serves the purpose of supporting the plug tray. Conveyor having 20 no. of rollers. The distance between two rollers was kept 10cm. The resin material is selected as a belt due to availability and cost factor. Initially prototype is made so to minimize the cost factor. A-PVC material is selected for the rollers. The bearing is selected so as to it should be easily assembled in rollers. [4]

Figure 5.6 : Conveyor

3.3.7 Seed Guiding system

Seed picking unit picks up seeds from the seed holder and release it in seed guiding system. This system is provided because the released seed should be properly placed in the seed tray. Seed guiding system is based on the design of the seed tray. If the size of the seed tray changed accordingly the center distance between the successive cups gets changed. The said system is having 8 no. of seed guiding ways made up of hollow pipe which only guides the released seed from seed picking unit to cups of seed tray. The center distance between two hollow pipe is kept 35mm because the seed tray having 35 mm center distance between two cups.

Figure 5.7 : Seed Guiding Arrangement

3.3.8 Operation of Automatic Seeder

When tray is inserted on the conveyor it touches the lever of master switch i.e. limit switch no 1. This gives supply to the motor no 1which results in forward moment of the rack at this stage the seeds are already sucked by the needles. When rack reaches its extreme end it activates limit switch no.3. As limit switch activates it gives NC to NO signal also shut off the solenoid coil no1. And parallel activates solenoid coil no.2.

As soon as coil no 2 activates it results in dropping the pressure which release seeds from seeder pipe to seed guiding arrangement at this state rack is at extreme forward position. After this position rack starts moving backward direction which causes pushing of limit switch liver 2. As limit switch liver gets pushed NC signal goes to NO signal and resulting in supplying the motor no 3. Also motor no3 is parallel connection with vibrator motor. Vibrator motor is attached at the bottom of the seed tray which vibrates the seed tray. Vibrations are provided for easy seed simulations.

4. Results

The study was conducted in two stages. First, Laboratory experiments were carried out to determine relevant properties of cabbage, chilly seeds and machine design parameters for metering single seed in plug tray cells. In the second stage, a prototype pneumatic nursery tray seeder was developed based on the design parameters, and was tested for its performance. This chapter includes the results of testing of the prototype precision plug seeder for cabbage, chilly and cauliflower seeds. The automated seeder is compared here with all the other methods that have been discussed previously, i.e. manual sowing, vibratory seeder and the needle seeder. Cost economics of the seeder has also been presented.[13]

Sr. No	Method	Worker	Time reqd./ tray (min)	Avg. Time Reqd. (min)
1	Manual sowing	A	3.10	2.94
		B	3.17	
		C	2.56	
2	Vibrating seeder	A	2.56	2.37
		B	2.35	
		C	2.20	
3	Needle seeder	A	1.05	1.43
		B	1.30	
		C	2.56	
4	Automated Seeder (Cauliflower Seed)	A	0.20	0.249
		B	0.22	
		C	0.18	
		D	0.21	
		E	0.36	
		F	0.25	
		G	0.18	
		H	0.19	
		I	0.22	
		J	0.23	
5	Automated Seeder (Chilly Seed)	A	0.23	0.201
		B	0.19	
		C	0.22	
		D	0.17	
		E	0.21	
		F	0.26	
		G	0.20	
		H	0.16	
		I	0.18	
		J	0.19	

Table 5 : Comparison of Automated Seeder with other methods

5. Conclusions

The saving on seeding cost by using the pneumatic nursery tray seeder was found to be Rs. 20.23 per 1000 seeds sown. This was 66.08 per cent of the manual sowing cost. The pay-back period of the pneumatic nursery tray seeder was estimated to be 27.87 hours of operation, which was 1.39 per cent of its expected life.

6. References

[1] B.B.Gaikwad, N.P.S. Sirohi (2007).“Design of a low-cost pneumatic seeder for nursery plug trays.”

[2] D. Karayel, Z.B.Barut, A. Ozmerzi (2004). “Mathematical Modelling of vacuum pressure on precision seeder.”

[3] R.C.Singh, G.Singh, D.C.Saraswat (2005). “Optimization of Design and Operational Parameters of a Pneumatic Seed Metering Device for Planting Cottonseeds.”

[4] Yi- Chinch Chiu, Din-Sue Fon, Gang-Jhy Wu (2006). “Development of an Automatic Pallet Handling system for Seeded Trays.”

[5] Journal of Sowing and Planting Equipment.

[6] Boyer,J.N., D.B.South, C.A.Muller,and H.Vanderveer (1985). “A comparison of nursery sowers. ” Tree Planters Notes 36(3):20-24.

[7] Bhaskar Gaikwad , N.P.S. Sirohi and Adarash Kumar (2007). “Studies on vacuum Singulation of Seeds for

sowing Nursery Plug Trays." Journal of Agricultural Engineering Vol.44(4):October- December, 2007.

[8] D.Karayel (2009) "Performance of modified precision vaccum seeder for no-till sowing of maize and soybean." Soil and Tillage Research 104 (2009) 121–125.

[9] A. Lozanon, A.González-Espinosa,J.A.García, E.Calvo,J.Barroso, F. Barreras (2014). "High flow-rate ultrasonic seeder."

[10] Sefa Alfikat, Ahmet Celik, Zinnur Gozubuyuk (2012). "Effects of various no-till seeders and stubble conditions on sowing performance and seed emergence of common vetch."

[11] A. Soza, G.Botta, M.tourn and R.Hidalga (2004). "Sowing efficiency of two seeding machines with different metering devices and distribution systems with different metering devices and distribution systems; a comparison using soybean, Glycine max (L) , Merr."

[12] Rajvir Yadav, Sahastrarashmi Pund, N.C.Patel, L.P.Gite (2010) "Analytical study of strength parameters of Indian farm workers and its implication in equipment design."

[13] B.Mursec, P.VIndis, M.Janzekovic, F.cus, M.Brus (2008) "Testing of quality of sowing by pneumatic sowing machines." Journal of achievements in materials and manufacturing. Volume26.