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Performance Evaluation of a Seed Dispenser for Sowing Seed into Nursery Tray

Hafidha, A.*, Mohd Fazly, M., Mohd Taufik, A. and Norahshekin, A.R.

Engineering Research Centre, Malaysian Agricultural Research and Development Institute, 43400 Serdang, Malaysia

This research was carried out to evaluate seed distribution pattern of a nursery seeding machine namely the Tray Seeder. This machine has been developed to assist local farmer in sowing seed into cell perforations of readymade polycarbonate nursery tray. It consists of vacuum receptacle, dispensing plate, nursery tray holder, detachable frame and vacuum connector. Two experiments were conducted to study the efficiency of the machine. Three types of seeds were used in the experiment; cauliflower, paddy and chilli. This study has proven that different types of seeds may have effect on the performance of the Tray Seeder which sows one seed per cell in the nursery tray ($p < 0.001$). This machine works well with round shaped seeds of similar size such as cauliflower seeds. Maximum seed singulation in apertures of dispensing plate and cells of nursery tray was obtained when machine was used to sow cauliflower seed at vacuum power of 2000W.

Keywords: Sowing, seed, seed dispenser, nursery tray, dispensing plate, cell perforations

I. INTRODUCTION

Seeds are essential to human life as they produce crops to provide human with nutrition and secure food for world population (Finch-Savage and Bassel, 2016). Seeds are very expensive nowadays especially premium seeds. The common practice of seed-sowing has been direct seeding where the amount of seeds used are not systematically controlled and thus resulted in seed wastage. Sowing in nursery tray can solve the issue of seed wastage as opposed to direct seeding (Space and Balmer, 1977). In nursery practice, single seed is sowed in every perforated cell of nursery tray using high quality seeds. As farmers prefer to invest in high quality seeds in order to maximize the yield and at the same time secure their return of investment (Pandiyaraj *et al*., 2017), thus it is preferable to single-sow rather than multiple-sow seeds in a container in order to reduce labour cost for thinning process (Tara Luna *et al.*, 2014). After several weeks, germinated plants are transferred to a grow container or soil. Transplanting seeding encourages similar plant growth, promotes maximum number of crops growing in a field in a given time and helps economize on expensive seeds (Fisher, 1982).

Sowing in a nursery tray is an important part of modern plant breeding. However, there is a challenge with seeding vegetable or flower seeds as the size is small and they are light weight (Hu Jian Ping *et al*., 2008). Manual seeding of small seed in each cell of nursery tray is a back breaking process as it is a slow, tedious and a labour-intensive operation (Yeoh, 1995; Atul B. Ekad *et al*., 2016). The conventional seeding is not a good ergonomic practice (Dhairyashil *et al*., 2017). In order to solve the issue from occurring in conventional seeding, a several numbers of seeding machines have been developed in the market. Utilization of nursery seeding machine can increase work rate and reduce number of labours (Olimpia Pandiaa *et al*., 2015; Thorat Swapnil *et al*., 2017). However, many farmers cannot afford to buy the existing machine due to its high cost and is considered to be uneconomic for local nursery growers (Gaikwad and Sirohi 2008).

MARDI has developed a new Seed Dispenser, the Tray Seeder. This machine is an upgraded version from the semi-mechanized technique for the production of seedlings such as chilli seeds (Yeoh, 1995). The purpose of using the Tray Seeder is to fill all the cells of nursery tray with only one seed

*Corresponding author's e-mail: hafidha.mardi@1govuc.gov.my

per cell at any one time regardless of the number of cells of the nursery tray that are used. The Tray Seeder is developed to complement the present monopolized black nursery tray in the market. Test had been carried out to evaluate the performance of the Tray Seeder.

II. MATERIALS AND METHODS

A. Tray Seeder

The Tray Seeder is used for holding and sowing seeds into cells of a nursery tray. This machine consists of eleven parts as shown in Figure 1 and Table 1.

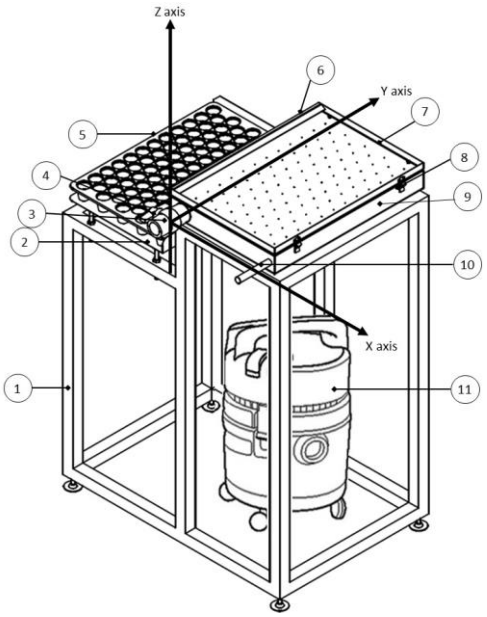

Figure 1. Tray Seeder

The dispensing plate consists of 104 apertures with a diameter of 0.5mm. This plate can be tailored to a different number of apertures, depending on the nursery tray used. The dispensing plate is attached to the top of the vacuum receptacle and is secured using clips. The receptacle comprises of a control valve and orifice which acts as a vacuum connector which protrudes from a wall of the receptacle to the vacuum source. At rest position, the vacuum receptacle is located on the upper right of the frame while the nursery tray is placed on the lower left of the receptacle.

A negative pressure was applied to the bottom side of the seed dispensing plate, to hold seeds onto the apertures plate. The plate was then moved to close over the nursery tray whereby the negative pressure was replaced by a positive pressure to release the seeds and deposit them into cells of nursery tray.

Table 1. Parts of Tray Seeder

No	Part
1	Frame
2	Nursery Tray Holder
3	Vacuum connector
4	Ball valve
5	Nursery Tray
6	Seed trapper
7	Dispensing plate
8	Clip
9	Vacuum receptacle
10	Handle
11	vacuum power

B. Nursery Tray

A number of cell perforations to support the seed dispensing tray is included in the nursery tray. It is placed in an inverted position above the nursery tray to facilitate dispersion of one seed into each cell. A black readymade polystyrene plastic nursery tray with 104 cells was used in this experiment.

C. Tray Seeder Mechanism

The process of sowing began with the dispensing of a selected number of seeds onto the top of the dispensing plate. Initially, all apertures on the dispensing plate were free from holding any seeds. When the vacuum power was turned on, a negative pressure or vacuum was produced on the bottom side of the dispensing plate. The vacuum filled the receptacle and a power suction was produced into 104 small apertures causing the seeds on top of the plate to be pulled in place toward the apertures. The seeds covered the apertures, as shown in Figure 2, and the vacuum suction held the seeds until the vacuum was cut off. The receptacle would then incline and move forward and backward in the Y-axis direction, to ensure the seeds were distributed into each aperture of the dispensing plate. After all apertures were covered by the seeds, the receptacle was then rotated to 180°, anti-clockwise, The Y-axis ended with facing the nursery tray in an inverted

position as shown in Figure 3. When the receptacle was rotated anti-clockwise at 90° or more, the remaining seeds which were not attached to any apertures, moved into the trapper and safely placed in the corner until the plate returns to its rest position.

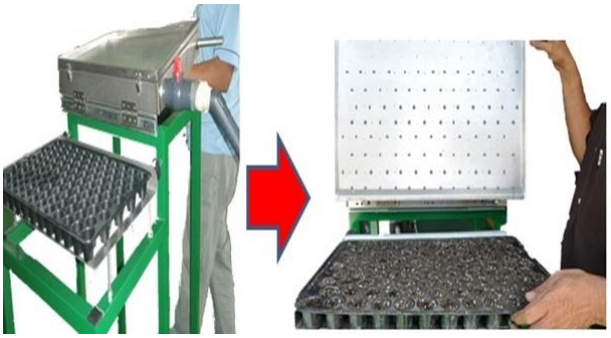

Figure 2. Seed attached to every aperture on dispensing plate

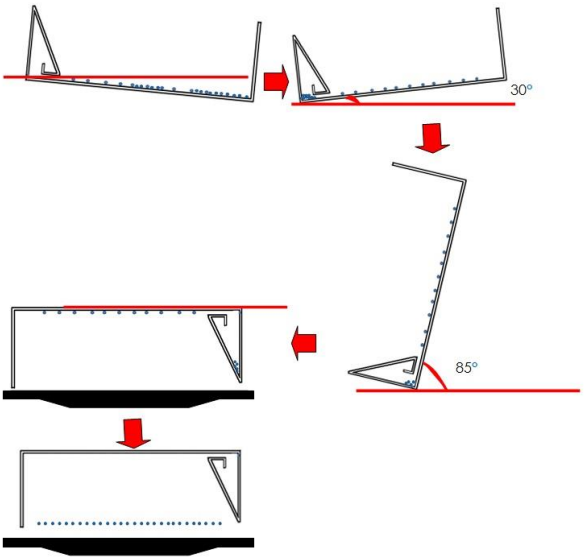

Figure 3. Mechanism of seed dispenser for sowing seed into nursery tray

When the receptacle was rotated to 180° anti- clockwise, each aperture of the dispensing plate was positioned above the centre of each perforated cell of the nursery tray. The vacuum was then turned off and the negative pressure was replaced by a positive pressure to release the seeds and deposit them into the nursery tray. Seeds attached to the apertures were finally released into each cell in the nursery tray.

The process ended with the receptacle going back to its initial rest position. The remaining seeds stored in the trapper were released into the dispensing plate when the receptacle was rotated to 85° clockwise or less towards the rest position.

D. Data Collection

Two experiments have been conducted to study the machine's efficiency. Two observations were made and recorded. The first observation made is the pattern of seed distribution on the dispensing plate where data is taken when the dispensing plate was at 90°. At this angle, all apertures were covered by the seeds. The aperture might hold a single seed, more than one seed or it might not hold any seed. The number of apertures holding a single seed, more than one seed and none at all were recorded. The second observation is the pattern of seed distribution on the nursery tray where data was taken at the end of seeding operation. At this stage, all seeds were released into cells of the nursery tray. The cell might contain a single seed or more or might not contain any seed. The number of cells containing a single seed, more than one seed and none at all were recorded. The variable of the experiment are the seeds and the power supply of the vacuum. The experiment has three replications.

Three types of seed were used in this experiment which were cauliflower RAMI hybrid, paddy MR219, and Kulai chilli. The seeds used were of different sizes and shapes. Cauliflower seeds are sphere and are 1.6mm in diameter while paddy seeds are long and thin with the length of 10mm and the width are 3mm, respectively. On the other hand, the Chilli seeds are thin and have uneven shape.

Two different vacuum powers, 1800W and 2000W, were used on the receptacle to hold seeds on the dispense plate before releasing the seeds into the nursery tray. The ball valve was used to control the pressure of the vacuum entering the receptacle. The valve was turned to maximum opening and one third of full opening which is declared as the minimum opening to study the effect of the different vacuum suction for holding seeds. The variables and response variables in the experiments are shown in the Table 2.

III. RESULTS AND DISCUSSION

A. Seed Distribution at Dispensing Plate

Based on the experiment carried out, it has been proven that the ability of the dispensing plate aperture to hold a single seed or more or neither is affected by the type of seeds which is proven by ($F_{2,35} = 778.36$; $P =< 0.0001$) , ($F_{2,35} = 700.52$; $P =< 0.0001$), and ($F_{2,35} = 45.23$; $P =< 0.0001$) respectively. The interaction between seed and vacuum power has also shown some evidence, however, it is not as compelling ($F_{2,35} = 3.13$; $P = 0.0620$), ($F_{2,35} = 4.04$; $P = 0.0308$), and ($F_{2,35} = 3.12$; $P = 0.0626$) respectively.

There is statistical evidence that proves different types of seeds affect the seeds distribution ($p < 0.001$). Using LSD, cauliflower seeds, have the best seed distribution with 95 units with standard error of 1.3. Paddy seeds have an average of 43 units with standard error of 1.3 and chilli seeds have the lowest seed distribution of 24 units with standard error of 1.3. There is also statistical evidence that vacuum power has effect on seed distribution ($p = 0.042$).

Table 2. List of variables and response variables in the experiment

Type of seed	Vacuum power (kW)	Vacuum suction (valve opening)	Number of apertures (on dispensing plate)	Number of cell perforations (on nursery tray)
Cauliflower	1.8	min	With 0 seed attached to the aperture	With 0 seed released into the cell
Paddy	2.0	max	With 1 seed attached to the aperture	With 1 seed released into the cell
Chilli			With >1 seed attached to the aperture	With >1 seed released into the cell

However, there is no statistical evidence that vacuum controlled valve opening has effect on seeds distribution ($p = 0.9713$). There are several statistical evidences that interaction of seed and vacuum power has effect on seed distribution ($p = 0.062$). Interaction of seed and vacuum controlled valve opening ($p = 0.2321$) and interaction of vacuum power and vacuum controlled valve opening ($p = 0.3353$) show no statistical evidence on the effect of seed distribution. Figure 4 shows the number of apertures on dispensing plate holding 3 types of seeds with different strength of vacuum power and suction.

1. Cauliflower seed

From the study, it is observed that more than 90 apertures of dispensing plate held single cauliflower seed for both condition of vacuum controlled valve opening. Less than 10 multiple seeds were attached to the aperture. Less than 3 apertures did not grip any seed. The sphere shape of Cauliflower causes seeds to roll easily and evenly distributed into all apertures. High number of single seed was easily attached to each aperture since the sphere shape of the seed can be strongly gripped by the vacuum suction. Two third of the seed body were placed into the aperture and hindered the vacuum suction to pull multiple seeds onto one place.

2. Paddy seed

From the experiment it is found that there are 40 apertures of dispense plate holding single paddy seed for both condition of vacuum controlled valve opening. More than 55% of apertures held multiple seeds and less than 5 apertures did not hold any seed. The shape of Paddy which is long and thin causes multiple seeds to be easily attached to each aperture since the diameter of hole was larger than the seed. The aperture might hold the middle or the end part of the seed.

3. Chilli seed

From the experiment, 20 apertures of dispense plate were found holding single Chilli seed for both condition of vacuum controlled valve opening. About 20 apertures held multiple seeds and less than 3 apertures did not hold any seed. The shape of chilli is uneven. This causes multiple seeds to be easily attached to each aperture.

B. Seed Distribution at Cell Perforations of the Nursery Tray

There is statistical evidence that different types of seeds affect seed distribution ($p < 0.001$) into perforated cells of nursery tray. By using LSD, cauliflower has the best seed distribution with 92 units with standard error of 1.2. Paddy seed has an average of 42 units with standard error of 1.2 and chilli has the smallest seed distribution of 22 units with standard error of 1.2. There is no evidence that vacuum power has effect on seed distribution ($p = 0.382$). There is no statistical evidence that vacuum controlled valve opening has effect on seed distribution ($p = 0.3031$). There is statistical evidence that interaction of seed with vacuum power has effect on seed distribution ($p = 0.0039$). Interaction of seed with vacuum controlled valve opening ($p = 0.4661$) and interaction of vacuum power with vacuum controlled valve opening ($p = 0.2075$) shows no statistical evidence on the effect of seed distribution.

Figure 5 shows the number of perforated cells of nursery tray filled with 3 types of seeds with different strength of vacuum power and suction.

1. Cauliflower Seed

More than 88 cells of nursery tray consist of single seed for both conditions of vacuum controlled valve opening at the end of sowing operation. Less than 15 cells contain multiple seeds and less than 3 cells do not contain any seed. The sphere shape of cauliflower seeds cause seeds to strongly grip onto the apertures when the vacuum power was turned on and seeds were easily released into the cells of nursery tray when the power of vacuum was turned off.

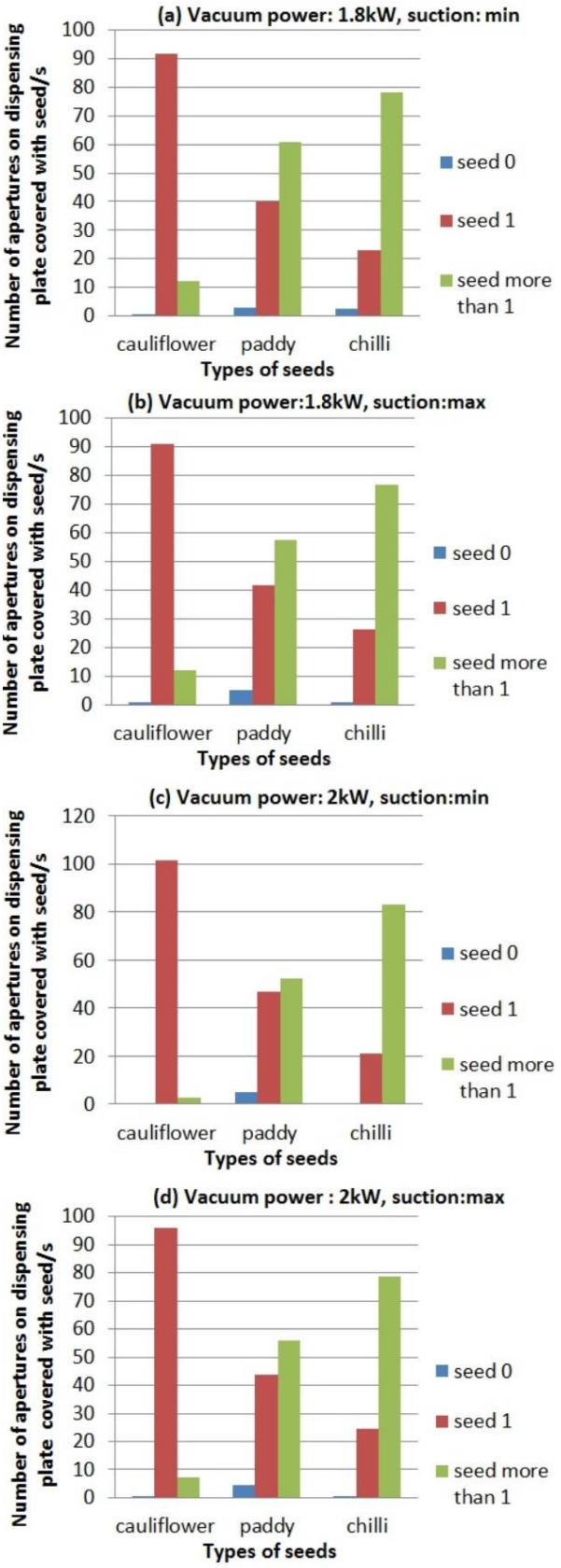

Figure 4. Comparison of number of apertures on dispensing plate covered with seed/s vs type of seeds for (a) vacuum power:1.8kW & minimum suction, (b) vacuum power:1.8kW & maximum suction (c) vacuum power:2kW & minimum suction (d) vacuum power:2kW & maximum suction

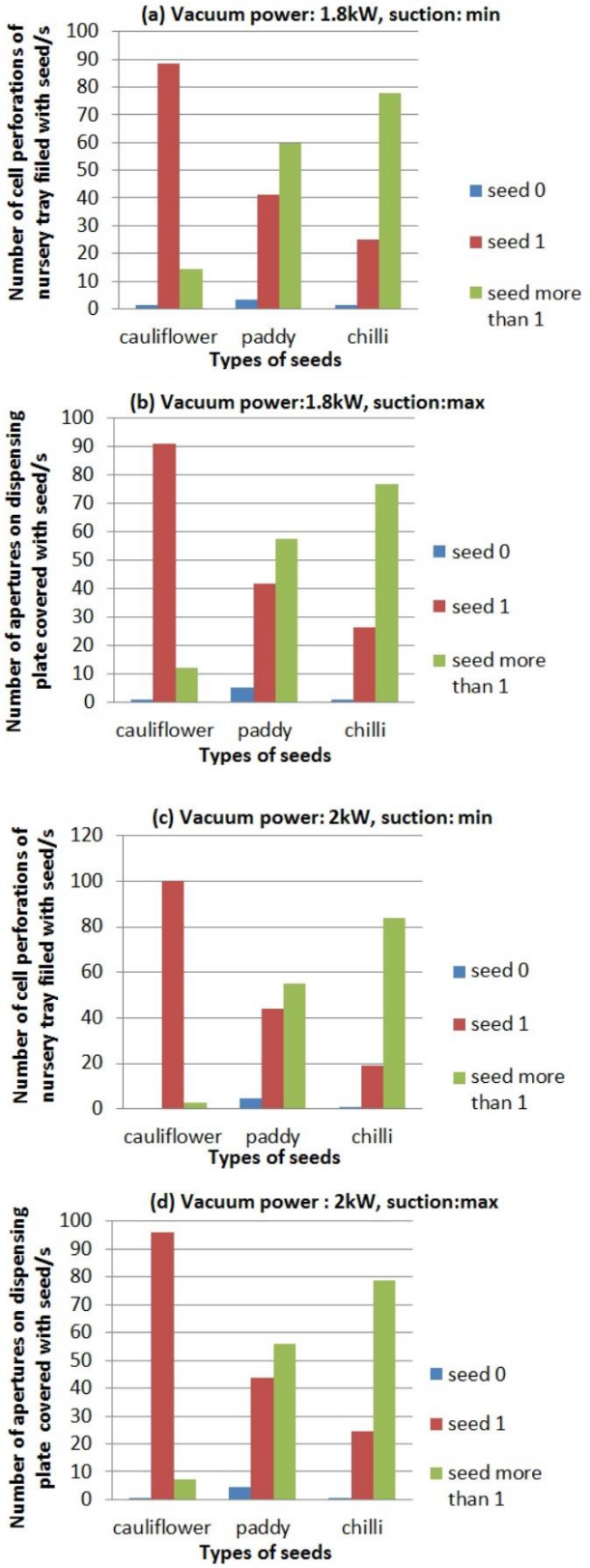

Figure 5. Comparison of number of cell perforations of nursery tray filled with seed/s vs type of seeds for (a) vacuum power:1.8kW & minimum suction, (b) vacuum power:1.8kW & maximum suction (c) vacuum power:2kW & minimum suction (d) vacuum power:2kW & maximum suction.

2. Paddy Seed

More than 45 cells of nursery tray consist of single seed for both condition of vacuum controlled valve opening at the end of sowing operation. Less than 60 multiple seeds released into the cells and less than 3 cells did not contain any seed. The shape of paddy causes more multiple seeds to grip to the apertures when the vacuum power was turned on in comparison to single seed. Seeds were then released into the cell of nursery tray when power of vacuum was turned off.

3. Chilli Seed

More than 20 cells of nursery tray consisted of single seed for both condition of vacuum controlled valve opening at the end of sowing operation. Less than 80 cells contained multiple seeds and less than 3 apertures did not contain any seed. The shape of chilli causes more multiple seeds to grip to the apertures when the vacuum power was turned on in comparison to single seed. Seeds were then released into the cell of nursery tray when the power of vacuum was turned off.

IV. CONCLUSION

The study was done to evaluate the performance of Tray Seeder by using 3 different seeds, 2 types of power suction and vacuum source. This study has proven that different types of seeds could affect the performance of Tray Seeder to sow seeds into nursery tray ($p < 0.001$). Maximum seed singulation at apertures of dispensing plate and cells of nursery tray was obtained with machine sowing cauliflower seeds at vacuum power of 2000W regardless of any volume of opening valve.

(i) Singulation seed distribution of Cauliflower to apertures of dispensing plate is 95 units with standard error of 1.3.

(ii) (ii) Singulation seed distribution of Cauliflower in perforated cells of nursery tray is 92 units with standard error of 1.2.

The vacuum power also effects the ability of the dispense plate to hold a single seed before it is released into the perforated cells of the nursery tray ($p = 0.042$ effect the seed distribution at aperture and $p = 0.0039$ effect the seed

distribution into the cell of nursery tray). The opening valve to control the power of vacuum suction had no effect to seed distribution of the Tray Seeder.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

Atul B Ekad, Sonal N Salunke, Sunaina B Gawde, Archana K Said & GL Suryawanshi 2016, 'Design and Development of Pneumatically Operated Automatic Seed Sowing Machine'. *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 5 (7), pp. 12171 – 12178.

BB Gaikwad & NPS Sirohi 2008, 'Design of a low-cost pneumatic seeder for nursery plug trays, *Biosystems Engineering*, 99(2008), pp. 322 – 329.

Dhairyashil Ashok Naik & Harshad Madhav Thakur 2017, 'Design and analysis of an automated seeder for small scale sowing applications for tray plantation method', *International Journal of Engineering Research and Technology*, ISSN 0974-3154 Volume 10(1).

Hu Jian Ping, Liu Zhao Qin & Zuo Zhi-yu 2008, 'Development and test of the magnetic precision seeder for plug Seedlings; Jiangsu University Zhenjiang China', *Journal of Machinery Design & Manufacturer*, 01.

KJ Fisher 1982, 'Comparison of the growth and development of young asparagus plants established from seedling transplants and by direct seeding', *New Zealand Journal of Experimental Agriculture*, Vol 10S (405 – 408).

Olimpia Pandiaa, Ion Saracinb, Ion Bozgaa & Tefania Eliza Tanasiec 2015, 'Studies regarding pneumatic equipment for sowing small seeds in cups', *Agriculture and Agricultural Science Procedia*, 6 (2015), pp. 690 – 695.

Pandiyaraj P, Yadav Rajeev Kumar, Vijayakumar S & Das Arindam 2017, 'Modern Nursery Raising Systems in Vegetables', *International Journal of Agriculture Sciences*, Vol 9 (52), pp. 4889 – 4892.

Space, JC & Balmer, WE 1977, 'Minimum cost calculation for container planting. USDA Forest Service', South Eastern Area State and Private Forestry.

Tara Luna, Kim M Wilkinson & R Kasten Dumroese 2014, 'Seed germination and sowing options', Agricultural Handbook 732: Tropical nursery manual: A guide to starting and operating a nursery for native and traditional plants, (Chapter 9) USDA Forest Service.

Thorat Swapnil V, Madhu L Kasturi, Patil Girish V & Patil Rajkumar N 2017, 'Design and Fabrication of Seed Sowing Machine', *International Research Journal of Engineering and Technology* (IRJET), vol 04 (704 – 707).

WE Finch-Savage & GW Bassel 2016, 'Seed vigour and crop establishment: extending performance beyond adaptation', *Journal of Experimental Botany*, vol 67, No 3 pp. 567 – 591, 2016.

Yeoh, KC 1995, 'Semi-mechanized nursery technique for commercial production of vegetable seedling', in *Proceedings Kongres Sains dan Teknologi Malaysia 95*.