WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.13 (2): 176-178. 2015 *www.world-food.net*

A primary research of vegetable seeds physical properties

Mi Tang, Ju-hong Zhu, Jian Ren, Xian-feng Shi and Jin-guang Peng
Wuhan Institute of Agricultural Science, Wuhan Academy of Agricultural Science, Wuhan 430345, P.R.China.
**e-mail: tommy512@163.com*

Received 8 January 2015, accepted 17 March 2015.

Abstract

China is the largest producer and consumer of vegetables in the world. Manual indenting and sowing of small vegetable seeds in plug trays is a slow and labor-intensive operation. Therefore, seeding operation of plug trays should be mechanized to increase the capacity of the rapidly expanding nursery industry. A tray precision seeding machine is one of the key devices used in industrialized plug seedling production. To reduce the miss-seeding and reseeding rates of seeders, we tested main varieties of different vegetables, such as cucumber, eggplant, pepper, and tomato, by obtaining their seeds (grain diameter ≤7 mm) as materials. The physical characteristics (geometrical size, 1000-kernel mass, rest angle, and sliding friction angle) and aerodynamic characteristic (floating speed) of these vegetable seeds were measured. The results showed that the average geometrical sizes (length, width, and thickness) were 9.00, 3.87, and 1.42 mm (cucumber);3.07, 2.63, and 0.92 mm (eggplant);3.96, 3.40, and 0.76 mm (pepper);and 3.23, 2.36, and 0.63 mm (tomato).One-thousand kernel mass values were 26.49, 4.27, 5.94, and 2.80 g, respectively. Rest angles were 19.36°, 19.83°, 20.56°, and 26.24°, respectively. Sliding friction angles (stainless steel plate) were 21.80°, 24.95°, 25.66°, and 31.82°, respectively. Finally, floating speed rates were 6.38, 5.02, 4.24, and 3.78 ms^{-1} , respectively.

Key words: Vegetables, seeds, characteristics.

Introduction

China is the largest producer and consumer of vegetables in the world[1]. Strong and healthy seedlings are the fundamental elements of vegetable production because more than 60% of vegetables need seedlings to produce. Manual indenting and sowing of small vegetable seeds in plug trays is a slow and labor-intensive operation[2]. During the peak season, manual labor hardly meets the requirement for raising vegetable seedlings. Therefore, seeding operation of plug trays should be mechanized to increase the capacity of the rapidly expanding nursery industry. Labor cost should be cut and necessary development of many automatic equipment should be met to modernize the industrial seedling production of vegetables.

A tray precision seeding machine is one of the key devices used in industrialized plug seedling production [3-5]. In China, most vegetable seeds are sown by bunch planting or manual sowing. The inefficiency does not meet the needs of developing modern agricultural production. Precision sowing has been a major thrust of agricultural engineering research for many years; however, most of the research and development work has focused on seeders for agronomic crops. The main purpose of sowing is to place the seed in a certain space and depth in the seedbed. Precision seeders place seeds at the required spacing and provide a better growing area per seed. Precision seeders have two common types: belt and vacuum. Various types of cleaning, grading, separation, and sowing equipmentss are designed based on the physical properties of seeds. However, no model has described seeder parameters, such as vacuum pressure related to the physical properties of seeds. The physical properties of the seeds are the most important factors in determining the optimum vacuum pressure of the precision vacuum seeder. In recent years, many studies were conducted in North China to develop devices for seeding machines[6-12]; however, few investigated the physical properties of vegetable seeds from the entire country. Studying the physical properties of such seeds could supply the parameters for device design in precision seeding mechanisms.

In this study, we obtained main varieties of several vegetable seeds as materials (grain diameter d≤7 mm), including cucumber, eggplant, pepper, and tomato. We measured their physical characteristics (geometrical size, 1000-kernel mass, rest angle, and sliding friction angle) as well as aerodynamic characteristic (floating speed).

Material and Methods

Plant material and treatments: We obtained seeds of 7 cucumber, 6 eggplant, 10 pepper, and 18 tomato cultivars from the provinces of Anhui, Guangxi, Hubei, and Shandong (Table 1).The measurements were carried at Wuhan Institute of Agricultural Science in Wuhu Agriculture Ecological Garden in Wuhan, China (latitude 18°20' N, longitude 109°10' E).

Table 1. Cultivars and sources of measured seeds.

	Cultivar	Source
Cucumber	'Changhuanggua'	Anhui
	'Jinbichunqiu'	Anhui
	'Lvbo No.6 F1'	Hubei
	'Jinyou No.1'	Hubei
	'Dongmei 205'	Shandong
	'Dongmei 935'	Shandong
	'Jinyou 35'	Shandong
Eggplant	'Wanqie No.2'	Anhui
	'Guilinzichangqie'	Guangxi
	'Weilonghongqie'	Guangxi
	'Wuzazaoqie'	Hubei
	'Chunqiuchangqie'	Hubei
	'Molichangqie'	Hubei
Pepper	'Wanjiao No.4'	Anhui
	'Wanjiao 18'	Anhui
	'Dingjiandajiao'	Anhui
	'Fuxingchaotianjiao'	Guangxi
	'Hongjiao No.1'	Guangxi
	'Guihang No.1'	Guangxi
	'Xiangzaoxiu'	Hubei
	'Hangjiao No.2'	Hubei
	'Jizhuaxjilin'	Hubei
	'Shijihong'	Shandong
Tomato	'Wanfen No.5'	Anhui
	'Wanhong No.7'	Anhui
	'Wanza 15'	Anhui
	'Jinhuanghou'	Guangxi
	'Aidi518'	Guangxi
	'Ji'ao'	Guangxi
	'Bisita'	Guangxi
	'Aote(TR-33)'	Guangxi
	'Shanghaihezuo 908'	Hubei
	'Jingdan No.1'	Hubei
	'Difenni'	Shandong
	'Helanfenba'	Shandong
	'Ouguan'	Shandong
	'Heba'	Shandong
	'Oubei'	Shandong
	'Huiyu'	Shandong
	'Ruixing No.2'	Shandong
	'Fenyunta'	Shandong

Determination of seed properties:

Thickness of seed: A total of 100 seeds were chosen randomly as one group, and the thickness was measured by using a vernier caliper. Three groups were measured.

Length and width of seed: A total of 100 seeds were chosen randomly as one group, and the length and width were measured by stereoscopic microscope and static measurement. Three groups were measured.

One-thousand kernel mass of seed: A total of 100 seeds were chosen randomly as one group, and the thickness was measured by using an electronic balance. Eight groups were measured and the result was calculated to 1000-grain weight.

Sliding friction angle of seed (stainless steel plate): A friction angle measurement instrument was used (Fig. 1). A total of 30 seeds were chosen randomly as a group, and three groups were measured .

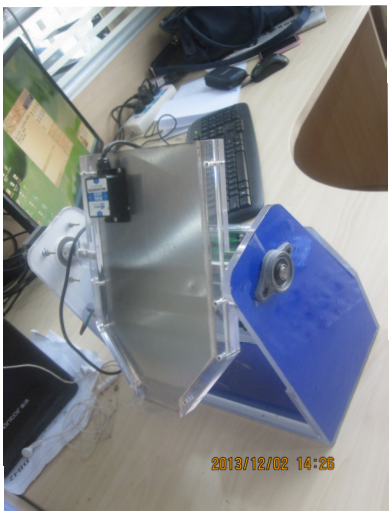

Figure 1. Sliding friction angle and rest angle measurement instrument**.**

Rest angle of seed: A rest angle measuring instrument was used. A total of 30 seeds were chosen randomly as a group, and three groups were measured.

Floating speed of seed: A suspension speed testing device (DFPF-25, China) was used. A total of 30 seeds were chosen randomly as a group, and three groups were measured.

Statistical analysis: Data of each vegetable kind were expressed by the arithmetic mean value of all the cultivars.

Results and Discussion

Vegetable seeds have different shapes and sizes with a wide margin (Table 2). The nozzle diameter was good between 2.5 and 3.5 mm. In addition, one of the key factors that would affect the design of suction pressure was the 1000-kernel mass. The mass was heavy, and the pressure must be strong. In this study, the 1000-kernel mass of the vegetables varied from 1.74 g (tomato) to 33.43 g (cucumber). Even for a single type of vegetable, such as pepper, the average value of 1000-kernel mass was 5.94 g, but wide variation from 4.81 to 7.38 g was observed. Thus, a conversion device for seeds with different size and weight should be used in the seeder.

The sliding friction angle and rest angle of different vegetables (Table 3) varied from 48.60° to 11.79°. The minimum sliding friction angle and rest angle of cucumber were 21.80° and19.36°, respectively. The maximum sliding friction angle and rest angle of tomato were 31.82° and26.24°, respectively. Thus, the included

Table 2. Geometrical size and 1000-kernel mass of cucumber, eggplant, pepper, and tomato seeds.

	Length (mm)			Width (mm)			Thickness (mm)			1000-kernel mass (g)		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
Cucumber	9.00	11.8	5.90	3.87	4.90	2.70	1.42	1.98	0.73	26.49	33.43	22.45
Eggplant	3.07	4.40	2.17	2.63	3.83	1.78	0.92	1.60	0.52	4.27	5.11	3.49
Pepper	3.96	5.68	2.26	3.40	4.79	1.90	0.76	1.26	0.34	5.94	7.38	4.81
Tomato	3.23	5.12	0.77	2.36	4.43	0.59	0.63	1.12	0.22	2.80	3.48	1.74

Table 3. Sliding friction angle, rest angle, and floating speed of cucumber, eggplant, pepper, and tomato seeds.

	Sliding friction angle (°)			Rest angle (°)			Floating speed ($m \cdot s^{-1}$)		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
Cucumber	21.80	36.78	16.31	19.36	29.39	10.04	6.38	6.94	5.72
Eggplant	24.95	35.82	16.56	19.83	31.13	12.65	5.02	5.61	4.30
Pepper	25.66	41.10	15.04	20.56	37.48	11.79	4.24	5.07	3.41
Tomato	31.82	48.60	22.41	26.24	36.73	17.59	3.78	5.65	2.10

angle in the seed chamber of the seeder should be greater than 48°. Floating speed differences among the vegetable seeds were significant. The floating speed varied from 2.10 $m \cdot s^{-1}$ (tomato) to 6.94 $m \cdot s^{-1}$ (cucumber). Therefore, the airflow velocity of suction and blow devices should be greater than 7.00 $m \cdot s^{-1}$.

Conclusions

The plug precision seeder is the key device used in seed production in nurseries and factories. This study intended to survey the physical properties of vegetable seeds toimprove the precision seeder by optimizing the working parameters. Several factors were considered, such as the relationship between the parameters and the seeds and devices. The final precision seeder could satisfactorily meet the requirements for vegetable production.

Acknowledgements

This study was financially supported by the Special Fund for Agro-scientific Research in the Public Interest (201303014).

References

[1]http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

[2]Lee, J.M., Kubota, C., Tsao, S.J., Bie, Z., Echevarria, P. H., Morra, L. and Oda, M. 2010. Current status of vegetable grafting: Diffusion, grafting techniques, automation. Scientia Horticulturae **127**:93-105.

[3]Gaikwad, B.B. and Sirohi., N.P.S. 2008. Design of a low-cost pneumatic seeder for nursery plug trays. Biosystems Engineering **99**:322-329.

[4]Karayel, D., Barut, Z.B. and Özmerzi, A. 2004. Mathematical modelling of vacuum pressure on a precision seeder. Biosystems Engineering **87**: 437-444.

[5]Zhao, Z., Li, Y., Chen, J. and Xu, L. 2010. Numerical analysis and laboratory testing of seed spacing uniformity performance for vacuum-cylinder precision seeder. Biosystems Engineering **106**:344-351.

[6]Dong, C.W., Luo, X., Hu, B., Li, M.Z. and Huang, L.L. 2008. Design of a semi-automatic tray precision seeding-machine. Journal of Shihezi University (Natural Science) **26**:630-632.

[7]Yang, Y.L., Gu, S., Pan, R. Q. and Wang, X.Y. 2009. Design of the directional precision seeding mechanism for big seeds. J. Agricultural Mechanization Research (12):68-70 (in Chinese with English abstract).

[8]Xia, H.M., Li, Z.W., Niu, J.J. and Lin, X.B. 2008. Dynamic model for metering process for pneumatic roller-type vegetable seeder. Transactions of the CSAE **24**:141-146 (in Chinese with English abstract).

[9]Xing, Z, and Gu, S. 2007. Properties of air suction type vegetable seeder for tray. Research of Agricultural Mechanization (6):129-130.

[10]Zhang, S., Xia, J. and Chen, J. 2007. Study on equipment of vibration air-suction vegetable tray precise seeder. J. Agricultural Mechanization Research (8):101-105.

[11]Xu, D., Song, Y.Q., Xin, M.J. and Guo, Y. 2007. Experimental study on physical and aerodynamic properties of vegetable seed. J. Agricultural Mechanization Research (4):112-114.

[12]Lin, L., Hu, R., Wang, C., Liu, Z.C. and Gao, M. 2010. The development of vacuum adsorption-type precision seeder. Development, Innovation of Machinery and Electrical Products **23**:52-54.