



Performance of a large seed vacuum planter for bare and pelleted onion seeds

Büyük tohumların ekimde kullanılan bir hava emişli hassas ekim makinasının çıplak ve peletle kaplı soğan tohumlarını ekim başarısı

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ABSTRACT

Seed coating, or pelleting, is a technology used to improve seed germination and provide more uniform stands and higher yields. In recent years, the use of coated or pelleted seed has increased in vegetable cultivation. Information on sowing of coated, or pelleted seed, with planters are needed. This research was carried out to determine the performance of a precision vacuum planter designed for large seed for sowing pelleted and bare onion (*Allium cepa* L.) seed. A laboratory experiment was performed to evaluate seed distribution uniformity for forward speeds of 0.5, 1.0, 1.5 and 2.0 m s⁻¹. For the laboratory test using a sticky belt test setup, pelleting of onion seed generally increased seed distribution uniformity of the planter. Optimum forward speed was 1.5 m s⁻¹ for pelleted and 1.0 m s⁻¹ for bare seed. The planter was operated at the forward speed of 1.5 m s⁻¹ for pelleted and 1.0 m s⁻¹ for bare seed for field trials. Pelleting of onion seed decreased percentage emergence from 73.6 to 62.5% for field conditions. Percentage emergence of pelleted seed in the field decreased more than bare seed, but it was considered acceptable for precision sowing with planter as indicated percentage emergence being over 60%.

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ÖZ

Tohumların film veya peletle kaplanması, çimlenmeyi ve dolayısıyla düzenli filiz çıkışı ile verimi arttıran önemli bir teknolojidir. Son yıllarda özellikle sebze tarımında kaplanmış tohumların kullanımı yaygınlaşmaktadır. Bu nedenle kaplanmış tohumların ekim makineleri ile ekimine yönelik bilgiye ihtiyaç duyulmaktadır. Bu araştırma büyük tohumların ekimi için tasarlanmış bir hava emişli hassas ekim makinasının çıplak ve peletle kaplanmış soğan (*Allium cepa* L.) tohumlarının ekim başarısını belirlemek için yapılmıştır. Laboratuvar denemeleri ile 0.5, 1.0, 1.5 ve 2.0 m s⁻¹ ilerleme hızlarında ekim makinasının tohum dağılım düzgünlüğü incelenmiştir. Yapışkan bantlı deneme düzeni kullanılarak yapılan denemelerde, peletle kaplama soğan tohumlarının dağılım düzgünlüğünü iyileştirmiştir. Çıplak tohumlar için optimum ilerleme hızı 1.0 m s⁻¹ iken kaplı tohumlar için 1.5 m s⁻¹ 'dir. Dolayısıyla ekim makinası tarla denemelerinde çıplak soğan tohumlarının ekiminde 1.0 m s⁻¹ ilerleme hızında, kaplı soğan tohumlarının ekiminde ise 1.5 m s⁻¹ ilerleme hızında çalıştırılmıştır. Tohumların peletle kaplanması tarla filiz çıkış oranını %73.6'dan %62.5'e düşürmüştür. Ancak tarla koşulları için önerilen %60 çimlenme oranının üzerinde olduğu için kabul edilebilir olarak değerlendirilmiştir.

1. Introduction

Sowing of seed is a critical process in plant production because the planting process affects the quality and quantity of the crop. Sowing is especially important for vegetables because vegetable seeds are smaller and less hardy than seeds of other crops. Sowing quality is related to physical effects of the planter on the seed and distribution of seed within the soil (Ozmerzi et al. 2002). For this purpose, the horizontal and vertical

distribution of seed in the soil is determined in order to determine the planting efficiency of planter.

The most important feature of a precision planter is placing individual seed in the furrow at a desired spacing. Precision planting is not widely applied in vegetable production. According to a survey conducted to determine problems

experienced in vegetable production, the first concern was planting (Ozmerzi et al. 1992).

Precision vacuum planters should sow a wider range of seed size more uniformly than a mechanical belt planter because holes in the seed plate must be smaller than smallest seed in the seed cluster (Parish and Bracy 1998; Parish and McCoy 1999; Panning et al. 2000; Karayel and Ozmerzi 2001; Ozmerzi et al. 2002; Karayel et al. 2004). Bracy and Parish (1998) compared vacuum and belt type precision planters for sowing quality (seed distribution uniformity within the row) with seed of onion (*Allium cepa* L.), spinach (*Spinacia oleracea* L.), cucumber (*Cucumis sativus* L.), cabbage (*Brassica oleracea* L.) and carrot (*Daucus carota* L.). The miss, multiple, and quality of feed indices of a precision vacuum planter (Gaspardo) with onion seed were 50, 16 and 34%, respectively. Quality of feed index (34%) was too low and precision (21%), miss and multiple indices of precision vacuum planter too high to be acceptable for precision sowing of onion.

Different procedures are applied to protect development of vegetables (Hwang and Sung 1991; Parish 2000; Parish et al. 2002), and increase germination rate with a chemical (Powel and Mathews 1982), or biological agent (Fairley and Draycott 1978; Luchmeah and Cooke 1985; Evans et al. 1993; Stout et al. 1993). Several authors (Maude and Bambridge 1985; Sikhao et al. 2015; Barut 2008; Hara 2013; Hara 2016; Accinelli et al. 2018) reported the effect of pelleting, or coating, on seedling emergence rate, seedling growth, yield, or dust generating potential while sowing in different soils. Coating or pelleting, vegetable seed has been used in agricultural production since the 1960s, and has enabled more precise sowing (Grelliera et al. 1999).

This project was undertaken to evaluate performance of a precision vacuum planter designed for large seed for sowing pelleted onion (*Allium cepa* L.) seed in laboratory and field experiments.

2. Materials and methods

The laboratory experiments involved testing metering uniformity of the planter using bare and pelleted seed, with

different dimensions (Table 1) to determine the optimum forward speed of the planter. The planter was set to space seed as closely to the recommended spacing as possible. To prepare the seed a cylindrical rigid plastic vessel mounted at 30° to a rod reduced to 40 revolution min⁻¹ using a 3-phase electrical engine/motor running on 220 V voltage (Figure 1A) (Haciyusufoglu et al. 2015). Mounting the vessel horizontally at 30° prevented the spilling of seeds during operation. An application apparatus manufactured from glass and a compressor was used to ensure adhesion of coating materials. The plastic line in Figure 1B was attached to compressor and an air valve was used for adjusting flow and regulation of air. A hot air blowpipe was used to dry the seed.

The seed were coated using powdered bentonite, peat, perlite and lime which were passed through a 0.1 mm sieve and mixed at specific ratios to prepare the coating powder. For coating to take place the seed were put into a vessel which rotated (the vessel initially contains only seeds). To cover the seed a liquid adhesion material was sprayed as a thin layer onto the seed rotating in the vessel using a specially designed spraying apparatus (Figure 1B) (Haciyusufoglu et al. 2015). When the thin layer dried slightly the previously sieved coating material, which had been crushed into a powder, was added freely onto the seed in the vessel in a specific amount depending on the amount of seed in the vessel. The seed covered with the adhesive liquid in the rotating vessel was covered. After completion of the first coating process, the seed in the vessel were partially dried using a hot air blowpipe. The seed were again sprayed with the adhesive liquid and partially dried and the powdered coating material was again added. The enlarging diameters of the pelleted seed may not be uniform. To prevent this at intervals during the coating process, pelleted seed were passed through sieves of different mesh sizes to remove those having smaller diameters and they were recoated to attain the desired diameter. The seeds were removed from the vessel and left to dry at room temperature. The capacity of vessel varies between 250-300 g h⁻¹ depending on the seed variety.

A sticky belt test setup was used to determine seed distribution uniformity of the planter. The test stand had a 15 cm wide belt with a 750 cm long horizontal viewing surface.

Table 1. Means and standard errors of the seed dimensions.

Seed	Length (mm)	Thickness (mm)	Width (mm)	Sphericity (%)
Bare onion	1.3 ± 0.011	1.5 ± 0.016	2.3 ± 0.022	32.4 ± 0.45
		Diameter (mm) ^b		
Pelleted onion (2.4 mm) ^a		2.41 ± 0.14		90.85 ± 1.66
Pelleted onion (3.5 mm) ^a		3.52 ± 0.33		91.83 ± 1.75

^aSieve size, ^bMean diameter ± standard error of pelleted onion seed.



(A)



(B)

Figure 1. Equipment used for seed coating process: (A) rotating cylindrical plastic vessel (mounted at 30°) at 40 revolution min⁻¹, (B) liquid adhesion material spraying apparatus.

The planter was mounted on the test stand which utilized an adjustable speed drive unit and a seed metering system and operated at different speeds. Sufficient grease was added to the surface of the belt to catch the seed without rolling or bouncing on the belt surface.

A general purpose, precision vacuum planter (model Sonmezler MD, Sonmezler Farm Machinery, Turkey), designed for large seed, was used for laboratory and field tests. A seed plate (disc) was used in the metering mechanism of planter. The seed plate operates in a vertical plane and requires a vacuum of 300-850 mm of water to select and transfer seed to drop point to furrows (Figure 2).

Vacuum from the holes of the vertical seed plate retain 1 seed in place. The seed is delivered from the rotating vertical seed plate with an air-cut which situated over the furrow opener (under the seed plate). Absence of vacuum allows the seed to drop into the furrow.

Each sowing unit of the planter is mounted on a parallelogram with joint springs so each unit can operate independently. A runner type furrow opener was mounted under the seed metering unit without a seed tube. A press wheel followed the furrow opener to close and compact the furrow and maintain a constant sowing depth for each seed.

The planter was tested over the greased belt at forward speeds of 0.5, 1.0, 1.5 or 2 m s⁻¹ and adjusted to vacuum pressure of 4.0 kPa. Bare or pelleted (dia 2.4 or 3.5 mm) onion seed were used (Table 2). The optimum forward speed for the field test was determined from those tested in the laboratory. Seed spacings were measured over the horizontal viewing surface of greased belt (750 cm). The planter was adjusted to sowing a nominal seed spacing of 110 mm for bare and pelleted onion seed.

Table 2. Test parameters for laboratory experiments.

Class	Level	Value
Speed	4	0.5, 1.0, 1.5, or 2.0 m s ⁻¹
Seed	3	Bare onion seed
		Pelleted onion seed with diameter of 2.4 mm Pelleted onion seeds with diameter of 3.5 mm

The seed distribution uniformity was analyzed using methods described by Kachman and Smith (1995) for laboratory and field experiments. They recommended using miss, multiple, quality of feed and precision indices for evaluating the

uniformity of planter metering rather than mean, standard deviation or coefficient of variation of seed spacings. For this study, miss, multiple, quality of feed indices and precision index of seed distribution were used.

The multiple index is the percentage of seed spacing that are less than, or equal to, half of the adjusted spacing and indicates the percentage of multiple seed drops. The miss index is percentage of seed spacings greater than 1.5 times the adjusted seed spacing and indicates percentage missed seed locations or skips. Quality of feed index is percentage of seed spacings more than half, but no more than 1.5 times, the theoretical spacing. Quality of feed index is 100% minus miss and multiple index and indicates percentage of single seed sowings. Precision index is the coefficient of variation of seed spacings classified as singles after removing spacings consisting of misses and multiples (Bracy and Parish 2001). Practical upper limit of precision index and lower limits of quality of feed index are 29 and 85%, respectively (Kachman and Smith 1995).

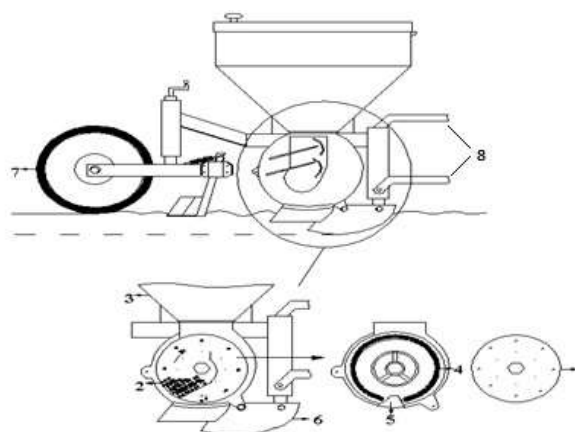
Field experiments were conducted on a clayey loam soil at the Aksu Research and Application Farm at the University of Akdeniz, Antalya, Turkey. Seedbed preparation before seeding operation consisted of plowing to an approximate depth of 35 cm, disking and levelling. Tests were generally conducted at near-optimum soil moisture (15-20%) for seedbed preparation and sowing (Karayel and Ozmerzi 2006).

The field performance of the vacuum planter was evaluated in respect to field emergence rate. The planter is one of the most important factors effective on emergence rate such as the seed quality, physical condition of the soil and environmental factors (Celik et al. 2007; Ozmerzi et al. 2002). The planter was adjusted to a nominal sowing depth of 25 mm for field experiments. After sowing, percentage emergence of bare and pelleted onion seed was determined. Onion seedlings were counted in 25 m of furrow per treatment at 20 days after sowing (Bracy and Parish 2001; Ozmerzi et al. 2002). From these count percentage emergence was calculated. No irrigation was applied in this period.

Field emergence rates of 60 to 70% are normal for vegetables that tolerate a fairly wide range of growing conditions (Barut 2008; Karayel and Ozmerzi 2001; Ozmerzi et al. 1992; Ozmerzi et al. 2002). Therefore, the minimum field emergence rate should be over the 60% for an acceptable precision sowing of vegetables.



Figure 2. Precision vacuum planter designed for large seed. 1- vertical seed plate, 2- seed, 3- seed box, 4- air suction canal, 5- air cut, 6- runner type furrow opener, 7- press wheel, 8- parallelogram connecting rods.



The data were subjected to analysis of variance using the SPSS package (SPSS Inc, Chicago, IL). Where appropriate, if significant, the interaction was used to explain the results. When the interaction was not significant means were separated using Duncan's Multiple Range Test.

3. Results and Discussion

The probability values obtained from results of analysis of variance are presented in Table 3. Seed type has a significant effect on seed distribution uniformity of a precision vacuum planter. According to the statistical test (variance analysis) results, differences between, multiple index, miss index and quality of feed index are significantly important. Analysis of variance was not applied on the precision index values. Because the precision index is the coefficient of variation of seed spacings classified as singles after removing spacings consisting of misses and multiples. Pelleting of onion seeds increased miss index while decreasing multiple index of seed distribution uniformity (Table 4).

Forward speed of precision vacuum planter has a significant effect on parameters of seed distribution uniformity (multiple index, miss index and quality of feed index). The miss and multiple indices of seed distribution uniformity for the forward speeds of 0.5, 1.0, 1.5 and 2.0 m s⁻¹ are given in Table 5. The miss index increased and the multiple index decreased with increasing forward speed of seeder. Increasing the peripheral speed of vertical seed plate with the results of increasing the forward speed of the planter caused the increasing miss index and decreasing the multiple index of seed distribution of bare and pelleted onion seeds. Our results support reports from Karayel and Ozmerzi (2001) who found the negative effect of forward speed on seed distribution uniformity indicators of a precision planter such as multiple, miss and quality of feed indices.

Interaction between seed type and forward speed of planter has a significant impact on the quality of feed index of seed distribution uniformity. Effect of seed type and forward speed interaction on quality of feed index of seed distribution uniformity is presented in Table 6. Precision index values are also presented in Table 7. The quality of feed and precision indices should be evaluated together to determine the optimum forward speed of a planter. Seed distribution uniformities of pelleted onion seeds for all forward speeds were considered acceptable, as indicated by all values of precision index being under 29% and the quality of feed indices being all over 85% for both pelleted seeds (with the diameter of 2.4 and 3.5). The highest precision index was obtained for the forward speed of 0.5 m s⁻¹ and the least precision index occurred when the forwards speeds were 1.0 or 1.5 m s⁻¹. Optimum forward speeds of planter for bare and pelleted seeds are different because of the seed type and forward speed interaction effect. Seed distribution uniformity of the forward speed of 1.5 m s⁻¹ for pelleted seeds and 1.0 m s⁻¹ for bare seeds are better, as indicated precision index is minimum, and quality of feed index is maximum for these forward speeds. Therefore, the planter operated at the forward speed of 1.5 for pelleted and 1.0 m s⁻¹ for bare seeds for field trials.

When the seed distribution uniformity of pelleted and bare onion seeds compared, fewer preciseness, skips or multiple seed drops and higher quality of feed index values occur at any forward speeds when the pelleted seeds is used. Therefore, the pelleting of the onion seeds increase the seed distribution

uniformity of precision vacuum planter designed for large seed. Diameter of pelleting has not a significant effect on seed distribution uniformity.

Similar results were obtained by Barut (2008) with pelleted sesame seeds. When the pelleted sesame seeds used, the precision index of planter was 16.25%, indicating that the planter performance was better than bare sesame seeds used (with precision index of 19.19%). The pelleting sesame seeds with a diameter of 3.5 mm provided better seed distribution uniformity.

Field emergence rates of bare and pelleted onion seeds are presented in Table 8. The percentage emergence of pelleted onion seeds was considered acceptable for field conditions. As indicated, value of percentage emergence was over 60%.

Table 3. Probability values for selected factors.

Seed type	Mean of seed spacings (mm)	Miss index (%)	Multiple index (%)	Quality of feed index (%)
Seed type (S)	0.88	0.03*	0.02*	0.02*
Forward speed (FS)	0.25	0.02*	0.04*	0.03*
S×FS	0.53	0.76	0.11	0.04*

*significant at the 0.05 probability level.

Table 4. Effect of seed type on miss and multiple indices.

Seed type	Miss index (%)	Multiple index (%)
Bare	4.5b ^a	31.4 ^a
Pelleted, 2.4 mm dia	7.8a	6.1 ^b
Pelleted, 3.5 mm dia	8.1a	4.6 ^b

Means followed by same superscript letter within a column are not significantly different at P= 0.05, Duncan's multiple range test.

Table 5. Effect of forward speeds on miss and multiple indices.

Forward speed (m s ⁻¹)	Miss index (%)	Multiple index (%)
0.5	4.8b ^a	23.3 ^a
1.0	5.6b	12.4 ^b
1.5	6.4b	11.2 ^b
2.0	10.4a	9.2 ^b

Means followed by same superscript letter within a column are not significantly different at P= 0.05, Duncan's multiple range test.

Table 6. Effect of seed type and forward speed interaction on quality of feed index of seed distribution uniformity.

Seed type	Forward speed (m s ⁻¹)	Quality of feed index (%)
Bare	0.5	54.1 ^c
	1.0	68.7 ^a
	1.5	67.6 ^b
	2.0	66.1 ^b
Pelleted, 2.4 mm dia	0.5	80.1 ^c
	1.0	87.6 ^b
	1.5	89.9 ^a
	2.0	87.4 ^b
Pelleted, 3.5 mm dia	0.5	82.3 ^c
	1.0	89.7 ^a
	1.5	89.8 ^a
	2.0	87.9 ^b

Data in the interaction analyzed with Least Squares Means and means separated with LSD. Means followed by same superscript letter within a column of seed type are not significantly different at P= 0.05.

Table 7. Effect of seed type and forward speed on precision index of seed distribution uniformity.

Seed type	Forward speed (m s ⁻¹)	Precision index (%)
Bare	0.5	65.2
	1.0	40.1
	1.5	40.8
	2.0	49.7
Pelleted, 2.4 mm dia	0.5	20.3
	1.0	15.3
	1.5	14.8
	2.0	17.5
Pelleted, 3.5 mm dia	0.5	18.5
	1.0	14.8
	1.5	13.9
	2.0	16.5

Table 8. Percent emergences of pelleted and bare onion seeds under laboratory and field conditions.

Seed	Emergence (%)	
	Laboratory	Field
Bare	85.2a ^a	73.6 ^a
Pelleted, 2.4 mm dia	80.8b	65.3 ^b
Pelleted, 3.5 mm dia	79.1b	62.5 ^b

Means followed by same superscript letter within a column are not significantly different at P=0.05, Duncan's multiple range test.

The percent emergence of bare seeds is higher than the pelleted onion seeds. The pelleting of onion seeds decreased percentage of emergence of onion for laboratory and field conditions. Compared to laboratory conditions, percent emergence of pelleted seeds in field decreased more than bare seeds. Therefore, when a large seed vacuum planter used for sowing, seed spacing of pelleted seeds can be reduced to obtain the same onion plant stands of bare seeds per field area. Our results support reports from Barut (2008) who found the negative effect of pelleting on percentage of emergence of sesame seeds.

4. Conclusions

Sowing uniformity of the large seed vacuum planter was affected by pelleting of the onion seeds. Pelleting of onion seeds increased seed distribution uniformity of planter. The planter was tested for bare and pelleted onion seeds for forward speeds of 0.5, 1.0, 1.5 and 2.0 m s⁻¹. Seed type and forward speed of precision vacuum planter have a significant effect on seed distribution uniformity of bare and pelleted seeds. The best seed distribution uniformity was obtained at the forward speed of 1.5 m s⁻¹ for both pelleted seeds (with the diameter of 2.4 and 3.5 mm) and 1.0 m s⁻¹ for bare seeds. The pelleting of onion seeds decreased the percentage of emergence for field conditions. The percentage emergence of pelleted onion seed can be considered acceptable. But reduced seed spacing for pelleted seed can be recommended to obtain the same plant stands of bare onion seeds per field area when a large seed vacuum planter used for sowing.

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