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THE EFFECT OF CULTIVATION METHOD ON SELECTED TRAITS RELATED TO THE SOWING VALUE OF SHALLOT (*Allium cepa* L. var. *ascalonicum* Backer) SEED

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Abstract. In many countries, the traditional method of growing shallots from bulbs is replaced by direct seeding in the field or by planting seedlings. The availability of shallot seed with high parameters of the sowing value is an important condition for growing shallot in larger areas. It is possible thanks to the progress in breeding and introduction into cultivation of new cultivars that produce seed stalks and seed. Therefore, the aim of the present study was to evaluate the sowing value of seed of the true-breeding cultivar 'Toto', when this seed is obtained by planting steckling bulbs (bulb-to-seed method) and by using the seed-to-seed method. This study, conducted in the period 2010–2012, was to evaluate some important characteristics of the seed quality obtained by planting different diameter bulbs (20–60 mm, 4 fractions every 10 mm) in autumn and spring and from seedlings planted in summer (third 10-day period of July and first and third 10-day period August). The quality of shallot seed was evaluated taking into account the following parameters: 1000 seed weight (TSW), germination energy and capacity as well as vigour tests (seedling growth test and seedling growth rate test). Shallot cultivation method had a large effect on 1000 seed weight, but it only slightly affected germination capacity and vigour of seed obtained. Larger seeds were obtained from bulbs, regardless of their planting time, compared to the cultivation method involving planting seedlings in summer. The diameter of bulbs used for planting at autumn planting time proved to be an important factor for TSW, germination energy and the traits determining seed vigour. In the case of this planting time, seed obtained from large bulbs with a diameter of 40–60 mm was distinguished by the best quality. The study did not show such a correlation for seed derived from spring bulb planting.

Key words: shallot seed, bulb planting, seedling planting, 1000 seed weight, germination capacity, vigour tests

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INTRODUCTION

The research on shallot growth, development and yield has allowed researchers to identify the traits that enable this plant to be perfectly adapted to different climatic and soil conditions [Tashiro et al. 1982, Krontal et al. 1998, Getahun and Zelleke 2006, Răduica and Popescu 2010, Brink and Basuki 2012]. It has proved that the high tolerance of shallot to low and high temperature as well as to poorer quality soil is its important characteristic. Due to this, shallot is commonly grown where the cultivation of common onion is unsuccessful [Permadi 1994, Soedomo 1999, Pham et al. 2006, Brink and Basuki 2012]. The large interest of breeders in developing new shallot cultivars results from the demand for this vegetable in commercial trading. Consumers value the seasoning and health-promoting qualities of this onion. Shallot is a rich source of polyphenolic compounds and many other components considered to be antioxidants [Tendaj and Mysiak 2010, Lu et al. 2011].

The availability of shallot seed with high parameters of the sowing value is an important condition for growing shallot in larger areas. Shallot is commonly grown from bulbs obtained by dividing the cluster of the mother plant, but this cultivation method primarily applies to local cultivars that produce seed poorly or do not produce seed at all. Seed of hybrid cultivars (F_1) is available in the market, but its price is high, since breeding hybrids is much more expensive than in the case of true-breeding cultivars [Sumami and Soetiarso 1998, Cohat et al. 2001]. A true-breeding cultivar 'Toto', which was bred in Poland, is now being introduced into cultivation in increasingly larger areas. Therefore, the aim of the present study was to evaluate the sowing value of seed of this cultivar when this seed is obtained by planting steckling bulbs (bulb-to-seed method) and by using the seed-to-seed method.

MATERIAL AND METHODS

Seed of the true-breeding cultivar 'Toto', bred by a Polish seed breeding company, PlantiCo Zielonki, was used in this study.

This seed was obtained by growing shallot at the Felin Experimental Farm of the University of Life Sciences in Lublin (51°18'N, 22°45'E) over the period 2011–2012. The characteristics of seed stalk development and seed yield are presented in the papers by Tendaj and Mysiak [2013a, b], and Tendaj et al. [2013].

To make an evaluation of the sowing value of shallot seed, 100 g seed samples were collected from the yield obtained from each treatment used in three experiments. The method of these experiments is described in the above-cited papers by Tendaj and Mysiak [2013a, b], and Tendaj et al. [2013]. In the first experiment, shallot was grown for seed using the seed-to-seed method by planting seedlings in summer – in the third 10-day period of July, the first 10-day period of August, and the third 10-day period of August in 2010 and 2011. Seedlings were produced in an unheated greenhouse by sowing seed 4 weeks before planned seedling planting in the field. This was a method similar to that given by Voss et al. [2013] for seed-grown onion using the seed-to-seed system.

After plants overwintered in the field, in the second year of cropping (2011 and 2012, respectively), the characteristics of seed stalk development was made and the seed yield was estimated [Tendaj and Mysiak 2013a]. After 50–60 days from seed harvest, a laboratory analysis was performed to investigate the most important parameters of the sowing value.

In the second experiment, the study investigated seed stalk development and shallot seed yield obtained by planting different diameter bulbs (20–30 mm, 31–40 mm, 41–50 mm and 51–60 mm) in autumn. In 2010 and 2011 the bulb planting date was in the first 10-day period of October, whereas the growth and development of shallot plants were observed in the 2011 and 2012 growing seasons [Tendaj and Mysiak 2013b]. Similarly as in the first experiment, the sowing value of seed was evaluated after about 60 days from harvest, i.e. in November.

The third experiment examined the effect of storage temperature of steckling bulbs of different diameter on seed stalk development as well as on shallot seed yield and quality [Tendaj et al. 2013]. The bulb storage temperature was 0–1°C, 4–6°C and 8–10°C, whereas the bulb diameter 20–30 mm, 31–40 mm, 41–50 mm, and 51–60 mm. Seed collected from plants in the treatments where seed had been produced was subjected to laboratory analysis. No seed was obtained by planting small bulbs (20–40 mm in diameter) stored at a temperature of 0–1°C (tab. 3).

The quality of cv. 'Toto' shallot seed was evaluated taking into account the following parameters: 1000 seed weight (TSW), germination energy and capacity as well as vigour tests (seedling growth test and seedling growth rate test).

1000 seed weight (TSW), germination energy and capacity were evaluated following the regulations of the International Seed Testing Association (ISTA, 1995) and the Polish Standard PN-R-65950 (Seeds and seedlings – Seed testing methods, 1994).

The seedling vigour tests (seedling growth test and seedling growth rate test) were carried out following the method described by Hampton and TeKrony [1995] and taking into account the paper by Dąbrowska et al. [2000].

RESULTS

The largest seeds, as expressed by 1000 seed weight, were obtained from the seed stalks of shallot plants grown from autumn-planted bulbs. The average thousand seed weight for these plants was 3.64 g (tab. 2). Plants grown from autumn-planted larger bulbs, i.e. with a diameter of 31–60 mm, were also found to produce seed with significantly higher weight compared to plants grown from small bulbs with a diameter of 20–30 mm.

Shallot plants derived from spring-planted bulbs stored at a temperature of 0–1°C, 4–6°C, and 8–10°C produced seed with lower weight, by 0.24 g on average, compared to those obtained from autumn-planted bulbs with the same size (tab. 3). Plants grown from small bulbs with a diameter of 20–40 and stored at 0–1°C did not produce seed or the amount of seed was so small (2012) that it was not sufficient to provide a sample for laboratory analysis.

By far the smallest seeds were harvested from plants derived from summer-planted seedlings. In this treatment, the average 1000 seed weight was 3.18 g and, compared to plants obtained from autumn bulb planting, it was a decrease of 0.46 g on average, while in relation to those derived from spring bulb planting a decrease of 0.22 g on average (tab. 1, 2, 3).

Table 1. The effect of summer seedling planting dates on shallot seed quality (mean for 2011–2012)

Seedling plantingdate	1000 seed weight (g)	Germination energy (%)	Germination capacity (%)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Radicle length (cm)	Cotyledon length (cm)
Third 10-day period of July	3.20	41.5	75.0	28.2	1.7	4.2	6.0
First 10-day period of August	3.04	46.0	76.0	26.2	1.6	3.9	6.1
Third 10-day period August	3.31	51.0	81.0	25.7	1.5	4.0	5.9
Mean	3.18	46.2	77.3	26.7	1.6	4.0	6.0
$LSD_{0.05}$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

The germination energy and capacity of shallot seed proved to be not very high. Plants grown from autumn-planted bulbs germinated best. The average germination energy of this seed was 48.0–62.0%, depending on the size of bulbs used for planting, while their germination capacity was 76.0–89.5%. As in the case of 1000 seed weight, the larger bulbs were used, the higher was the seed germination capacity. Seed obtained from spring bulb planting showed germination energy at a level of 25.0–56.5%, while the germination capacity was at a level of 57.0–86.0% (tab. 3). On average, regardless of the size of bulbs used for planting, germination energy was lower by 12.7% and germination capacity by 14.7% compared to treatments with autumn bulb planting (tab. 2 and 3).

Seed germination energy in shallot plants grown from summer-planted seedlings was at a similar level to that found in the treatments with spring bulb planting and it was on average 46.1%, i.e. by 1.6% less than in the case of seed obtained from spring-planted bulbs.

The germination capacity of seed harvested from seedling-grown plants was on average 77.3% and was higher by 8% compared to seed obtained from spring bulb planting, but lower by 6.7% relative to seed derived from autumn-planted bulbs.

Regardless of bulb planting time, bulb size (in diameter) did not have a significant effect on the germination capacity of seed obtained. However, germination energy of seed derived from autumn-planted small bulbs with a diameter of 20–30 mm proved to be significantly lower compared to seed obtained from the largest bulbs planted (41–60 mm in diameter).

Table 2. The effect of the size of autumn-planted bulbs on shallot seed quality (mean for 2011–2012)

Bulb size (mm in diam.)	1000 seed weight (g)	Germination energy (%)	Germination capacity (%)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Radicle length (cm)	Cotyledon length (cm)
20–30	3.00	48.0	76.0	27.4	1.6	4.8	6.8
31–40	3.78	55.0	83.0	24.4	1.7	5.1	5.5
41–50	3.99	62.0	87.5	33.3	1.8	5.6	7.1
51–60	3.80	59.5	89.5	30.1	1.8	5.1	6.6
Mean	3.64	56.1	84.0	28.8	1.7	5.2	6.5
$LSD_{0.05}$	0.72	11.2	n.s.	5.7	n.s.	n.s.	1.3

The conducted vigour tests (seedling growth test and seedling growth rate test) complemented the evaluation of the sowing value of shallot seed depending on cultivation method.

Table 3. The effect of storage temperature and bulb size on shallot seed quality from spring bulb planting (mean for 2011–2012)

Storage temperature (°C)	Bulb size (mm in diam.)	1000 seed weight (g)	Germination energy (%)	Germination capacity (%)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Radicle length (cm)	Cotyledon length (cm)
	20–30	–	–	–	–	–	–	–
	31–40	–	–	–	–	–	–	–
0–1°C	41–50	3.51	30.5	62.0	26.7	0.9	3.9	6.4
	51–60	3.34	25.0	59.0	28.3	1.3	4.3	6.2
	mean	3.42	27.7	60.5	27.5	1.1	4.1	6.3
	20–30	3.27	48.5	67.5	23.1	1.1	4.1	5.8
	31–40	3.47	55.0	86.0	20.8	1.2	3.9	5.6
4–6°C	41–50	3.17	40.5	57.0	25.0	1.4	4.0	5.4
	51–60	3.88	44.0	73.5	27.7	1.5	4.6	5.8
	mean	3.45	47.0	71.0	24.1	1.3	4.1	5.6
	20–30	3.57	56.5	82.0	26.6	1.3	5.2	6.1
	31–40	3.52	45.5	76.0	27.3	1.4	5.1	6.4
8–10°C	41–50	3.04	41.5	58.0	25.8	1.2	4.5	5.8
	51–60	3.30	47.5	72.5	28.2	1.3	4.6	6.1
	mean	3.36	47.7	72.1	27.0	1.3	4.8	6.1
Mean		3.40	43.4	69.3	25.9	1.3	4.4	5.9
$LSD_{0.05}$ storage temp.		n.s.	8.6	n.s.	n.s.	n.s.	n.s.	n.s.

The tests performed according to the method described by Hampton and TeKrony [1995] and Dąbrowska et al. [2000] did not show significant differences in fresh and dry weight of shallot seedlings as well as in cotyledon and radicle length depending on cultivation method. After 12 days of growth from the beginning of germination, the average seedling fresh weight was 26.7–28.8 g, while the dry weight was 1.3–1.7 mg. Seedlings grown from seed derived from autumn bulb planting had the greatest length of cotyledon (on average 6.5 cm) and radicle (on average 5.1 cm). On the other hand, seedlings grown from seed obtained from spring-planted bulbs, had the shortest cotyledons (on average 5.9 cm) (tab. 2 and 3).

The average length of seedling radicle was 4.0–5.1 cm. Similarly as in the case of cotyledon length, seedlings grown from seed obtained from autumn-planted bulbs had the longest radicles.

DISCUSSION

In many countries, the traditional method of growing shallots from bulbs is replaced by direct seeding in the field or by planting seedlings [Permadi 1994, Sumami and Soetiarso 1998, Răduica and Popescu 2010, Brink and Basuki 2012]. It is possible thanks to the progress in breeding and introduction into cultivation of new cultivars that produce seed stalks and seed [Getahun et al. 2003, Tabor et al. 2005, Degewione et al. 2011].

The study presented in this paper showed that the quality of seed of the shallot cultivar 'Toto' was dependent on cultivation method as well as on bulb and seedling planting time. As in the case of common onion grown for seed, shallot seeds harvested from plants grown from larger bulbs were larger – they had significantly higher weight and better germination capacity. Many authors indicate that in growing onion and shallot for seed, in addition to the size of steckling bulbs, bulb storage temperature has a significant effect on the quality of seed obtained [Aoba 1960, Hesse et al. 1979, Krontal et al. 2000]. Khokhar et al. [2007] report that with increasing size of onion bulbs stored at a temperature of 5°C for 120 days, the seed yield was higher by 5–12% compared to the treatments where onion bulbs were stored at this temperature only for 90 days. However, there is no unambiguous assessment of the effect of steckling bulbs with different diameters on seed germination capacity of onions. Asaduzzaman et al. [2012] found that onion seed derived from the largest sized bulbs had the highest germination percentage (94.3%), compared to small bulbs with twice lower weight. On the other hand, Morozowska and Hołubowicz [2009] showed that bulb size did not affect 1000 seed weight or germination energy and capacity. In the present study, it was demonstrated that in shallot, regardless of bulb planting time, the largest seeds (with the highest 1000 seed weight) were obtained from the largest bulbs with a diameter of more than 40 mm. But as in the case of common onion, bulb planting time significantly affected the quality of seed. The largest seeds with slightly better germination capacity and better vigour were obtained from autumn-planted bulbs. This is in agreement with the results of studies on both shallot and common onion grown for seed under different climatic conditions [Tashiro et al. 1982, Harikarunakar et al. 2000, Khokhar 2009, El-Helaly and Karam 2012].

The quality of shallot seed harvested from seed-grown plants derived from summer-planted seedlings (which corresponds to the seed-to-seed method) did not differ significantly from the quality of seed obtained from bulb planting. The sowing value of this seed was slightly better compared to seed harvested from plants grown from spring-planted bulbs, but worse in comparison with seed obtained from autumn bulb planting. Nevertheless, shallot seed production using the seed-to-seed method would be possible in regions with a milder climate. This is shown by the results of studies of many researchers [Ruggeri and Branca 1994, Garay and Gomez 1996, El-Helaly and Karam 2012, Tendaj and Mysiak 2013a] and by the present study.

Although the shallot seed yield obtained from plants grown from summer-planted seedlings (third 10-day period of July) proved to be distinctly lower compared to the seed yield derived from autumn bulb planting in the first 10-day period of October [Tendaj and Mysiak 2013a, b], but the quality of this seed was not significantly lower. Shallot seed obtained from summer-planted seedlings was even distinguished by slightly better vigour compared to seed derived from spring bulb planting.

CONCLUSIONS

1. Shallot cultivation method had a large effect on 1000 seed weight, but it only slightly affected germination capacity and vigour of shallot seed. Larger seeds were obtained from bulbs, regardless of their planting time, compared to the cultivation method involving planting seedlings in summer.

2. The diameter of bulbs used for planting at autumn planting time proved to be an important factor for 1000 seed weight, germination energy and the traits determining seed vigour. In the case of this planting time, seed obtained from large bulbs with a diameter of 40–60 mm was distinguished by the best quality. The study did not show such a correlation for seed derived from spring bulb planting.

3. Bulb storage temperature and seedling planting date did not have a significant influence on most traits determining the sowing value of seed obtained.

4. Based on the evaluation of selected parameters of the sowing value of shallot seed, it can be concluded that the best quality of seed is obtained when shallots are grown by planting large bulbs at autumn planting time.

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WPŁYW METODY UPRAWY NA NIEKTÓRE CECHY WARTOŚCI SIEWNEJ NASION SZALOTKI (*Allium cepa* L. var. *ascalonicum* Backer)

Streszczenie. W wielu krajach tradycyjna uprawa szalotki z cebul jest zastępowana uprawą z siewu nasion wprost na pole lub z sadzenia rozsady. Dostępność nasion o wysokich parametrach wartości siewnej jest warunkiem uprawy szalotki na większych powierzchniach. Jest to możliwe dzięki postępowi prac hodowlanych i wdrażaniu do uprawy nowych odmian, które wytwarzają nasiona. Z tego względu celem podjętych badań była ocena wartości siewnej nasion ustalonej odmiany 'Toto' przy ich pozyskiwaniu metodą sadzenia cebul (bulb-to-seed) i metodą bezwysadkową (seed-to-seed). Badania przeprowadzone w latach 2011–2012 obejmowały ocenę wartości siewnej nasion otrzymanych z jesiennego i wiosennego sadzenia cebul o średnicy 20–60 mm (4 wielkości co 10 mm) oraz z letnich terminów sadzenia rozsady (trzecia dekada lipca oraz pierwsza i trzecia dekada sierpnia). Jakość nasion oceniano z uwzględnieniem następujących parametrów: masy 1000 nasion, energii i zdolności kiełkowania, a także wigorowych testów wzrostowych (test wzrostu siewki i test szybkości wzrostu siewki). Metoda uprawy szalotki na nasiona miała duży wpływ na masę 1000 nasion, a niewielki na zdolność kiełkowania i wigor nasion. Dorodniejsze nasiona uzyskano z roślin uprawianych z sadzenia cebul (niezależnie od terminu ich sadzenie) w porównaniu z metodą sadzenia rozsady w letnich terminach. Średnica cebul użytych do sadzenia w jesiennym terminie okazała się istotnym czynnikiem dla masy 1000 nasion, energii kiełkowania oraz cech decydujących o wigorze nasion. Z tego terminu sadzenia cebul najlepszą jakością wyróżniały się nasiona uzyskane z dużych cebul o średnicy 40–60 mm, czego nie wykazano u nasion z wiosennego sadzenia cebul o takiej średnicy.

Słowa kluczowe: nasiona szalotki, sadzenie cebul, sadzenie rozsady, masa 1000 nasion, zdolność kiełkowania, wigorowe testy

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