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INFLUENCE OF SOWING PERIOD AND FERTILIZATION ON YIELD AND QUALITY OF SEEDS OF *Nigella damascena* AND *Nigella sativa*

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ABSTRACT

Background. Representatives of the *Nigella* genus are annual plants with a short vegetation period. The best known species are *Nigella damascena* and *Nigella sativa*. *N. damascena* is a traditional flower species in Croatian flora that is in increasing demand due to its modest agrotechnical demands and its variety of use for ornamental purposes. *N. sativa* has become well known over the past several years for its oil, which is used for medicinal purposes. The increasing demand for its oil is met through import or by the processing of imported "raw material". Both species have a high cultivation potential and the possibility of usage in the pharmaceutical industry and horticulture, but the problem is lack of seed. The objective of this research was to determine achieved yields and seed quality (1000 seed weight, energy, germination and health condition) in two sowing periods with the application of fertilizer.
Material and methods. The field trial was set up in a random block design in four repetitions over two years. The first factor in the trial was the sowing period (spring, autumn), the second factor was fertilization (no fertilizer, nitrogen 30 $kg \cdot ha^{-1}$, phosphorus 30 $kg \cdot ha^{-1}$).
Results. The spring sowing period and fertilization with nitrogen and with phosphorus achieved the highest seed yields. The seed of *N. damascena* cultivated in the autumn sowing period had a higher 1000 seed weight, however, the sowing period and fertilization did not significantly influence the parameters of energy and germination. The seed quality indicators of *N. sativa* in the spring sowing period had significantly higher values than those from the autumn sowing period, and fertilization with phosphorus influenced the 1000 seed weight.
Conclusion. The results indicate that in the researched conditions it is possible to achieve a high yield of quality seed, which could satisfy the demand for the seed of the researched species and create possibilities for the domestic populations of *N. damascena* and for populations of *N. sativa* originating from countries of traditional cultivation.

Key words: agrotechnics, germination capacity, germination energy, medicinal plants, ornamental plants

INTRODUCTION

The genus *Nigella* belongs to the family Ranunculaceae, and is represented by 15 species (Zohary, 1983) that are widespread from the Middle East to Spain (Heiss *et al*., 2011). Genus representatives are annual herbaceous plants a short vegetation period (D'Antuono *et al*., 2002) and pentametric flowers (Padhye *et al*.,

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2008), that after pollination create a fruit in the shape of a capsule with three to seven follicles containing seeds (Sharma *et al*., 2009). The seeds of the majority of this genus are black and tiny, and the name of the genus was derived from these properties, lat. *nigellus* black (Heiss and Oeggl, 2005). The most common species are *Nigella damascena* L. and *Nigella sativa* L.

Nigella damascena (*N. damascena*) was named after the old Syrian town of Damascus, which confirms its eastern Mediterranean origin (Heiss and Oeggl, 2005). It has a large horticultural significance and in numerous regions it is cultivated as an ornamental plant. In the Eastern Mediterranean and North Africa the seed is used as a spice, and due to its mild strawberry-like flavour it was used in the past for the decorating and flavouring of cakes (D'Antuono *et al*., 2002; Heiss and Oeggl, 2005; Sharma *et al*., 2009). This horticultural species has mainly been studied from a morphological aspect, while agrotechnical characteristics and seed quality are poorly researched.

Since ancient times *Nigella sativa* (*N. sativa*) has been known as a medicinal plant, the old Romans named it *Panacea* which means,"cures everything" (Padhye *et al*., 2008), and its medicinal properties are also mentioned in sacred books (Abdolrahimi *et al*., 2012). It originates from arid and semi-arid areas (D'Antuono *et al*., 2002), and it is cultivated in South Europe, Syria, Egypt, Saudi Arabia, Pakistan and Turkey (Toncer and Kizil, 2004). The seeds have high nutritional value because they contain fats, proteins, carbohydrates (Abu-Jdayil, 2002) and carotenes (Naz, 2011). Cold pressing of the seeds gives an oil that promotes reduction of cholesterol and increases blood pressure, body weight and glucose level in the blood. The oil has anti-inflammatory and analgetic properties, and a cytotoxic effect on some types of human tumour cells. The medicinal properties of black cumin have been researched by numerous authors (Al-Hader *et al.*, 1993, Worthen *et al*., 1998; Al-Ghamdi, 2001; Abu-Jdayil, 2002; Moretti *et al*., 2004; Njami *et al*., 2008; Tuncturk *et al.*, 2011; Tuncturk *et al.*, 2012).

Due to its widely distributed cultivation area and the growing demand for medicinal plants, many studies of the agrotechnical characteristics of *N. sativa* have been conducted in the traditional countries of cultivation. The use of mineral fertilizers is universally accepted in the practice of enhancing the yield and quality of aromatic and medicinal plants (Tuncturk *et al*., 2011). Nitrogen is beneficial for plant height, number of branches per plant and the number of capsules per plant, as well as for the seed yield of the *N. sativa* species (Khaled *et* al., 2007; Ozguven and Sekeroglu 2007; Mollafilabi *et al.*, 2010; Tuncturk *et al.*, 2012). Phosphorus has been found to significantly affect the number of capsules, weight of 1000 seeds and seed yield (Ozguven and Sekeroglu, 2007; Tuncturk *et al.*, 2011). Although seeds in general represent a foundation for the survival and development of mankind from its beginnings to the present day (Gradečki-Poštenjak and Poštenjak, 2009), the majority of research related to the influence of agrotechnics on seed yield focused only on the property of the weight of 1000 seeds, whereas other seed quality indicators (germination energy, germination capacity and health properties) have not been researched. One of the more significant factors for successful production is the use of high quality seed, because this is the only way that can ensure the expected advantages (Gradečki-Poštenjak and Poštenjak, 2009).

The increased interest in production of *N. damascena* and *N. sativa* imposes the necessity to research the cultivation capacities of these species. The first step in cultivation is the use of quality seed, and a basic problem is the lack of such seed. Former agronomy research of these species was mostly oriented towards mercantile production (yield and composition of seed) in arid climate conditions, whereas seed production remained almost unresearched. This is the first research of seed yield and quality of *N. damascena* and *N. sativa* in the North-western region of Croatia and it can serve as a foundation for further research into increasing seed quality, which could then form the basis for production of the researched species for nutritional, medicinal and ornamental purposes.

MATERIAL AND METHODS

Field research

The research was conducted at Križevci College of Agriculture, in the north-west part of Croatia, located at 46°01´ N; 16°32´ E, during 2012 and 2013.

According to the Thornthwaite climate classification based on the relative amount of water necessary for potential evaporation and precipitation water, the climate in Križevci is at the border between semi-humid and humid.

The average monthly precipitation was 36 mm higher in 2013 than in 2012, whereas there was no significant difference between annual mean values of temperature Table 1. A cold and wet period was observed in 2013 in January, February and March, which negatively affected the growth of *N. damascena* and *N. sativa* sown in the autumn 2012 period.

Average soil samples were taken using standard methods. The following chemical properties were established: pH in water and 1 M KCl (ISO 10390:2005), hummus content according to Tiurin (ISO 10694: 1995), the phosphorus and potassium available to the plant according to the AL method (ISO 1123: 1994) and overall nitrogen according to Kjeldal (ISO 11261:2004) for each year of research.

Soil type is pseudogley with the following characteristics: texturally light clay of medium capacity of water in all horizons. The soil is porous to slightly porous and moderately plastic. Results of the chemical soil analysis (Table 2) indicate that both localities have soils of similar characteristics, neutral, rich in nitrogen and phosphorus and somewhat deficient in potassium, whereas the soil used for autumn sowing had lower humus content. Two identical experiments were carried out – the first with *N. damascena* and the second with *N. sativa.* Research factors referred to the sowing period (spring and autumn) and fertilization (no fertilization, fertilized with 30 $kg \cdot ha^{-1}$ of nitrogen and fertilized with 30 $kg \cdot ha^{-1}$ of phosphorus). Nitrogen fertilization was done with UREA-a fertilizer, and phosphorus fertilization with TRIPLEX fertilizer. The results for the individual variants of fertilization are presented as the means from sowing in autumn and spring. The experiment was set according to a random block design in four repetitions. The size of the basic experiment unit was 5 × 1 m.

Deep ploughing, cultivation and fertilization were administered prior to sowing. Sowing was administered manually, in the spring sowing period on May 18th, 2012 and in the autumn sowing period on November 16th, 2012. The plants were sown in three rows with 25 cm distance between the rows and 10 cm distance within the rows. Weeds were removed manually, by pulling and digging. The yield components on 20 plants from the middle row were measured on each experiment unit. The measured yield components referred to plant height, number of flowering branches and the number of capsules per plant. In order to determine the number of seeds in the capsule, 20 capsules were cut from each experiment unit. The harvest was undertaken when 90% of capsules had reached maturity (Table 3). In order to determine yield per ha and to test quality indicators of the seed, the capsules from the entire experiment surface were cut. The results for the individual variants for different sowing dates are presented as the means from all studied variants of fertilization.

Table 1. Average monthly temperatures and quantity of precipitation for 2012 and 2013

Average temperatures per month and annual mean value													
year	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	mean
2012	1.9	-2.4	9.2	12.2	16.1	21.5	23.3	23.4	17.6	11.1	8.4	0.8	11.9
2013	0.7	1.4	4.2	12.5	15.8	19.5	22.2	21.3	15.0	12.9	6.6	2.5	11.2
Average quantity of precipitation and annual mean value													
2012	27.5	30.4	2.4	34.6	99.4	65.6	24	6.7	66.6	79.7	93	83.6	51.2
2013	112.9	93.9	132.1	47.1	108.2	44.4	105.4	94.2	117.0	25.9	161.8	4.0	87.2

Table 2. Results of chemical analysis of soil

Location according to sowing period	Depth cm	pH		Organic matter %	N %	AL – method mg·100 g^{-1} of soil	
		H_2O	1M KCL			P_2O_5	K_2O
Spring	0-30	7.25	6.70	2.47	0.18	25.57	12.34
Autumn	0-30	7.28	6.15	1.33	0.07	25.60	11.25

Table 3. Harvest period of *N. sativa* and *N. damascena* according to sowing period

Plant species	Harvest of plants from spring sowing period	Harvest of plants from autumn sowing period
Nigella damascena	22.08.2012	08.08.2013
Nigella sativa	10.08.2012	19.07.2013

Laboratory research

The yield per ha was determined after manual seed cleaning based on weighing the seed with 99% purity. Seed quality analysis was administered in the laboratory according to ISTA international testing methods (Rules Proposals for the International Rules for Seed Testing 2011 Edition), which require a test for the energy and germination capacity of seeds for each plant species. In this research, germination energy and germination capacity of seed were tested with the filter paper method, which was used to interrupt seed dormancy. Each testing unit was tested in four repetitions with 100 seeds in each repetition. A layer of filter paper moistened with a 2% solution of KNO_3 was placed in each Petri dish and 100 seeds were distributed on its surface. The petri dishes containing the seed of *N. damascena* were cooled for five days at 5°C, and were subsequently placed in a dark chamber for 14 days at a temperature of 15°C. After preliminary treatment the seed were placed in a germination chamber at 23°C. The seeds of *N. sativa* were cooled for five days at 5°C, and were subsequently placed in the germination chamber. The temperature in the germination chamber was 23°C, with alternating light and dark every 12 hours. Germination energy of both species was determined after 7 days, and germination capacity after 21 day. Energy and germination of seeds were expressed in percentages as a mean value of normally developed sprouts in all four repetitions. The weight of 1000 seeds was determined by manual counting and weighing on analytical scales. Health properties were tested using the filter paper method. A layer of filter paper moistened with distilled water was placed in a Petri dish and 50 seeds were distributed on it. Each testing unit was tested in four repetitions with 50 seeds in each repetition. Petri dishes with seeds were placed in a germination chamber at 20°C with darkness and ultra-violet light alternating every 12 hours. The incubation period lasted 10 days. After incubation, seed infection with pathogens was assessed by means of examination under a stereo-microscope (Zeiss Stemi 2000) and microscope (Axiostar Zeiss). The evaluation of pathogens was determined based on spores according to Mathur and Kongsdal (2003). The health condition of seed was expressed as a percentage of infection of seed by pathogenic fungi.

By means of variance analysis, separate data was obtained for each plant species. Research results were statistically processed by means of the PC applications SAS for Windows (SAS Institute Inc., Cary, NC, USA), Stat Soft Statistica and Excel for determining variance analysis (ANOVA).

RESULTS

Nigella damascena

Spring sowing resulted in significantly higher seed yield (1012.26 kg·ha^{-1}) than autumn sowing (713.41

kg·ha^{-1}), (Table 4). Values of yield components (number of flowering branches per plant, number of capsules per plant and number of seeds in the capsule) were significantly higher in spring sowing, except for the plant height, where no significant difference was observed between spring and autumn sowing (Table 4). The vegetation cycle is much shorter in the spring sowing; the harvest of these seeds was carried out only 14 days after the harvest of the plants sown in the autumn period (Table 3).

The highest seed yield was achieved on plots fertilized with nitrogen (875.34 kg·ha^{-1}), slightly lower on plots fertilized with phosphorus (872.60 kg·ha^{-1}), while the yield was decreased to a greater extent on plots with no fertilization (740.58 kg·ha^{-1}) (Table 4). Values of the researched yield components, plant height, number of flowering branches per plant, number of capsules per plant and the number of seeds per capsule varied between fertilized and non-fertilized plots. The highest values were achieved on plots fertilized with nitrogen and phosphorus; whereas the values on non-fertilized plots were significantly lower (Table 4).

Both sowing periods resulted in high seed quality. The 1000 seed weight of 2.702 g for the autumn sowing period was significantly higher than the 2.339 g value achieved for the spring sowing period (Table 5). Germination energy increased from 87.58% for the autumn sowing period to 91.25% for the spring sowing period, and germination capacity of seed increased from 88.25 to 93.75% for the same periods, however, there were no significant differences between the two sowing periods (Table 5). The sowing period significantly influenced the health properties of seed. The pathogen which occurred on the seed was *Alternatia alternata*. Infection of seed with this pathogen amounted in the spring sowing to 12%, and in the autumn sowing to 22%.

Fertilization did not significantly influence seed quality. Although the differences of 1000 seed weight between treatments were not statistically significant, the highest 1000 seed weight of 2.606 g was achieved on plots fertilized with phosphorus, and the lowest weight of 2.467 g was achieved on plots fertilized with nitrogen (Table 5). Germination energy varied from 93.50 to 86.88%, and germination capacity from 94.63 to 88.75%.The highest germination values were observed on the non-fertilized plots (Table 5).

Nigella sativa

Spring sowing resulted in a considerably higher seed yield (569.51 kg·ha^{-1}) in comparison to autumn sowing (380.94 kg·ha^{-1}) (Table 6). Values of yield components (number of flowering branches per plant, number of capsules per plant and number of seeds in the capsule) were significantly higher for spring sowing, with the exception of plant height where no significant difference was observed between spring and autumn sowing (Table 6). The vegetative cycle is significantly shorter in spring sowing as this harvest was carried out only 22 days after the harvest of the plants sown in the autumn period (Table 3).

Table 4. Seed yield and yield components of *N. damascena* with reference to fertilization and sowing period

Fertilization/sowing time	Plant height cm	Number of flowering branches per plant	Number of capsules per plant	Number of seeds per capsule	Yield kg·ha^{-1}
Nitrogen (30 kg·ha^{-1})	48.20 a*	22.48 a	22.04 a	82.50 a	875.34 a
Phosphorus (30 kg·ha^{-1})	45.80 a	20.38 a	19.84 a	82.00 a	872.60 b
Non-fertilized	39.09 b	16.80 b	16.26 b	75.88 b	740.58 c
Spring	45.57^{ns}	23.66 a	23.30 a	81.50 a	1012.26 a
Autumn	43.16	16.11 b	15.46 b	78.75 b	713.41 b

* ns – no significant LSD (5%), or P = 0.05

Table 5. Seed quality of *N. damascena* with reference to fertilization and sowing period

Fertilization/sowing time	Weight of 1000 seeds g	Germination energy %	Germination capacity %	*Alternaria* infected seeds %
Nitrogen (30 kg·ha^{-1})	2.467^{ns}*	86.88^{ns}*	88.75^{ns}*	17.00
Phosphorus (30 kg·ha^{-1})	2.606	87.88	89.63	17.00
Non-fertilized	2.488	93.50	94.63	16.75
Spring	2.339 b	91.25^{ns*}	93.75^{ns*}	11.92
Autumn	2.702 a	87.58	88.25·	21.92

* ns – no significant LSD (5%), or P = 0.05

Table 6. Seed yield and yield components of *N. sativa* with reference to fertilization and sowing period

Fertilization/sowing time	Plant height cm	Number of flowering branches per plant	Number of capsules per plant	Number of seeds per capsule	Yield kg·ha^{-1}
Nitrogen (30 kg·ha^{-1})	34.20 a	11.80 a	11.43 a	61.28a	542.01 a
Phosphorus (30 kg·ha^{-1})	31.11 b	10.69 a	10.20 a	56.31b	488.34 a
Non-fertilized	29.00 b	8.04 b	7.75 b	55.63b	395.33 b
Spring	32.34^{ns}*	12.69 a	12.32 a	58.13a	569.51 a
Autumn	30.53	7.66 b	7.27 b	57.35b	380.94 b

* ns – no significant LSD (5%), or P = 0.05

Nitrogen fertilization resulted in the highest seed yield at 542.01 kg·ha^{-1} as well as the highest yield components (plant height, number of flowering branches per plant, number of capsules per plant and number of seeds in the capsule), (Table 6). Fertilization with phosphorus significantly influenced seed yield (488.34 kg·ha^{-1}), the number of flowering branches per plant and the number of capsules per plant, but it had no impact on the plant height and the number of seeds in the capsule (Table 6). A significantly lower seed yield of 395.33 kg·ha^{-1}, as well as lower yield components, was observed on the non-fertilized plots (Table 6).

The sowing period had a significant impact on seed quality indicators. Germination energy of seed in the autumn sowing period amounted to 53.25%, and germination capacity to 56.58%, whereas in the spring sowing period germination energy amounted to 90.67%, and germination capacity to 91.25% (Table 7). The 1000 seed weight of 3.551 g achieved in the spring sowing period was significantly higher than the 3.173 g achieved in the autumn sowing period (Table 7). Infection of seed by *Alternaria alternata* was determined. Infection of the seed in the spring period amounted to 8%, and in the autumn period it measured 12%. Fertilization did not significantly affect seed energy and germination. Germination energy ranged from 66.63 to 75.63%, and germination capacity from 69.25 to 77.50% (Table 7). Although the differences between treatments were not statistically significant, the lowest energy and germination capacity was observed on plots fertilized with phosphorus, and the highest on plots fertilized with nitrogen. Plots fertilized with phosphorus resulted in a 1000 seed weight of 3.514 g, which was significantly higher than the values observed on plots fertilized with nitrogen and on non-fertilized plots (Table 7).

Table 7. Seed quality of *N. sativa* with reference to fertilization and sowing period

Fertilization/sowing time	Weight of 1000 seeds g	Germination energy %	Germination capacity %	*Alternaria* infected seeds %
Nitrogen (30 kg·ha^{-1})	3.270 b	75.63^{ns}*	77.50^{ns}*	10.00
Phosphorus (30 kg·ha^{-1})	3.514 a	66.63	69.25	10.00
Non-fertilized	3.301 b	73.63	75.00	10.00
Spring	3.551 a	90.67 a	91.25 a	8.08
Autumn	3.173 b	53.25 b	56.58 b	11.92

* ns – no significant LSD (5%), or P = 0.05

DISCUSSION

Yield of seeds and its components

Depending on climate conditions both researched species can be sown in spring and in autumn. *N. damascena* is usually sown in spring, but it can also sow itself and grow in autumn or early spring. In some parts of Turkey *N. sativa* is sown in October, November and December (Toncer and Kizil, 2004). The results of this research indicate that yield and yield components are higher when spring sowing is undertaken. Our seed yields from *N. damascena* and *N. sativa* were similar to the yields that D'Antuono *et al*. (2002) obtained from seeds that they had sown in April and May, respectively. In the research of D'Antuono *et al*. (2002) the highest seed yield for both species was achieved with sowing in March, whereas later sowing periods resulted in smaller yields.

Nitrogen fertilization had significant influence on seed yield and yield components for both researched species, which correlates with research carried out by Tuncturk *et al*. (2012), Mollafilabi *et al*. (2009) and Ozguven and Sekeroglu (2007). Our seed yield and plant height of *N. sativa* correlates with the research carried out by Tuncturk *et al*. (2012), although the number of flowering branches per plant, number of capsules per plant, and the number of seeds per capsule was higher in our research. This can be explained by the lower plant density that we used. *N. sativa* is a plant that regulates its own density by producing a larger number of branches. The positive influence of fertilization with phosphorus on the seed yield of *N. sativa* correlates with the research carried out by Tuncturk *et al*. (2012). In our research, phosphorus influenced the increase in the number of branches and capsules per plant, which partly correlates with Tuncturk *et al*. (2012) who found that various quantities of phosphorus influenced only the number of capsules per plant.

Seed quality

High quality *N. damascena* seed was achieved in both sowing periods, whereas with *N. sativa* the seed quality from the autumn sowing period was significantly lower. A high level of precipitation during the seed ripening period (Table 1) resulted in a reduction of the energy and germination capacity of *N. sativa*, and caused an increased percentage of *Alternaria alternata* with both species.

Nitrogen fertilization had no significant influence on seed quality indicators for both researched species. In research conducted by Khaled *et al.* (2007), Mollafilabi *et al*. (2009) and Tuncturk *et al*. (2012), nitrogen fertilization also had no significant impact on the 1000 seed weight, however, the authors did not research the other parameters of seed quality. Phosphorus fertilization significantly influenced the 1000 seed weight for *N. sativa*, which corresponds to research carried out by Tuncturk *et al.* (2011). The 1000 seed weight for *N. sativa* was higher by 1 g in our research in comparison with similar research that had been carried out previously by Mollafilabi *et al.* (2009) and Tuncturk *et al*. (2012). This can be explained by the lower sowing density in our esearch as well as by different seed origin.

CONCLUSIONS

1. Seed yield was significantly higher for spring sowing for both species. Values for seed quality indicators (1000 seed weight, germination energy, germination capacity) of *N. sativa* were significantly higher from the spring than from the autumn sown plants.
2. Infection of seed with the fungus *Alternaria alternata* was lower after spring sowing for both species.
3. Fertilization with nitrogen and phosphorus at the rate of 30 $kg \cdot ha^{-1}$ significantly influenced yield and yield components for both researched species, with the exception of the number of seeds in the capsule of *N. sativa* after fertilization with phosphorus.
4. Fertilization with phosphorus resulted in an increase in 1000 seed weight with *N. sativa*, however, seed germination energy and germination capacity of the researched species were not influenced by fertilization with nitrogen or phosphorus.

LIMITATIONS

Determining the most effective sowing period requires conducting research in several autumn and spring sowing periods. Single doses of nitrogen and phosphorus fertilizer were used and this confirmed the justification of using mineral fertilizers in cultivation of these species, but in order to determine accurate quantities of fertilizer to be used further research needs to be conducted.

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WPŁYW TERMINU SIEWU I NAWOŻENIA NA PLON I JAKOŚĆ NASION *Nigella damascena* i *Nigella sativa*

Streszczenie

Do rodzaju *Nigella* należą roczne rośliny o krótkim okresie wegetacji. Najbardziej znanymi gatunkami są *Nigella damascena* i *Nigella sativa*. *N. damascena* jest tradycyjnym gatunkiem kwiatowym flory Chorwacji, wyróżniającym się rosnącym popytem ze względu na skromne wymagania agrotechniczne i możliwości wykorzystania w celach ozdobnych. *N. sativa* stał się dobrze znany w ciągu ostatnich kilku lat z powodu jego oleju, stosowanego w celach leczniczych. Rosnący popyt na olej jest zaspokajany przez import lub przetwarzanie importowanego surowca. Oba gatunki mają wysoki potencjał uprawowy. Mogą mieć zastosowanie w przemyśle farmaceutycznym i ogrodnictwie, lecz problemem jest brak nasion. Celem badań było określenie potencjału plonowania i jakości nasion (masa 1000 nasion, energia kiełkowania i zdrowotność) w dwóch okresach siewu, w warunkach stosowania nawożenia. Badania polowe przeprowadzono w układzie losowanych bloków, w czterech powtórzeniach w ciągu dwóch lat. Pierwszym czynnikiem w badaniach był okres siewu (wiosna, jesień). Drugim czynnikiem było nawożenie (bez nawozu, azot 30 $kg \cdot ha^{-1}$, fosfor 30 $kg \cdot ha^{-1}$). Wiosenny termin siewu oraz nawożenie azotem i fosforem skutkowało osiąganiem najwyższego plonu nasion. Nasiona zebrane z roślin *N. damascena* z siewu jesiennego miały wyższą masę 1000 nasion niż z roślin z siewu wiosennego, natomiast energia i zdolność kiełkowania nie były zależne od terminu siewu i nawożenia. Wskaźniki jakości nasion *N. sativa* z roślin z siewu w okresie wiosennym miały istotnie wyższe wartości niż te pochodzące z siewu jesiennego. Nawożenie fosforem wpływało pozytywnie na masę 1000 nasion. Uzyskane wyniki wskazują, że w badanych warunkach możliwe jest osiągnięcie wysokiej wydajności i jakości nasion, które spełniają zapotrzebowanie na nasiona badanych gatunków i stworzyć możliwości dla populacji krajowej *N. damascena* i populacji *N. sativa* pochodzących z krajów o tradycyjnej uprawie.

Słowa kluczowe: agrotechnika, energia i zdolność kiełkowania nasion, rośliny lecznicze, rośliny ozdobne