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THE APPLICATION OF TECHNOLOGICAL ELEMENTS IN THE CULTIVATION AND USE OF SEVERAL FORMS OF *Nigella damascena* L. IN THE REPUBLIC OF MOLDOVA

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Abstract

Nowadays, non-traditional edible oils of sesame, flax, mustard, chia etc. are widely used in various industries. Among them, the oil extracted from the seeds of Nigella damascena species, which possesses unique medicinal properties, is in great demand. In our research, we applied methods of individual selection and chose several forms, which differ from the 'Azuriu' cultivar registered in the Catalogue of Plant Varieties and the initial population. One of the selected forms (ND-4) was characterised by higher seed and oil productivity, good adaptability, adequate response to the technological elements applied in Comparative Testing of Varieties, and then it was proposed to the farm that had requested the seeds, where the necessary tests were done. The given form (ND-4), being stable in terms of production of raw material, will be submitted for registration in the Catalogue of Plant Varieties of the Republic of Moldova.

Key words*: seeds, breeding, fatty oil, food, germination, test weight (weight of 1000 seeds), production.*

INTRODUCTION

Modern society is becoming more cautious in choosing food products. Crops and products that have been known for a long time but have been forgotten are now becoming popular again. Non-traditional edible oils of sesame, flax, mustard, chia etc. are widely used in various industries (Kukhareva & Pashina 1986; Lavrov, 1995; Kostadinović Veličkovska et al., 2018; Prokhorov, 2021; Suárez et al., 2021). Among them, the oil extracted from the seeds of the *Nigella* species is in great demand. Over the years, we have been studying some oil-producing species, including love-in-a-mist, the fatty oil of which has unique medicinal properties (Khan, 1999; Korableva & Rakhmetov, 2011; Salehi et al., 2021).

Love-in-a-mist or devil in the bush *Nigella damascene* L.*, Ranunculaceae* family, native to southern Europe, north Africa and southwest Asia has been known and used since ancient times as a spice and medicinal plant in the treatment of various diseases (Kukhareva & Pashina, 1986; Lavrov, 1995; Korableva & Rakhmetov, 2011; Salehi et al., 2021; Prokhorov, 2021; Zaky et al., 2021).

Modern phytotherapy, based on the active ingredients extracted from the seeds of *Nigella.* species, as well as volatile and fatty oils, indicates the following properties: antimicrobial, antiviral, antifungal, anticancer, bronchodilator, blood glucose balancing, energizing, vasoreparative, metabolic, detoxifying, antiallergic, immunostimulatory and aphrodisiac (Gali-Muhtasib et al., 2006; Kazemi, 2014; Mashirova & Orlovskaya, 2012; Prokhorov, 2021). The seeds contain carbohydrates, lipids (35.5-41.6%), proteins, resins, tannins, volatile oil (1.5%), glycosides, alkaloids, amino acids, triterpenes, flavones, saponins, ergostane-type steroids (obtusifoliol), omega 3 and omega 6, essential fatty acids, significant amounts of minerals and vitamins (Kudinov, 1986; Dudcenko et al.,1989; Dauksas et al., 2006; Kudinov, 2007; Sieniawska et al., 2018; Prokhorov, 2021).

MATERIALS AND METHODS

The valuable medicinal and nutritional properties of this species contributed to the initiation of the study on its adaptation, breeding and testing, with the aim of further introduction and implementation of the given species. In our research, we applied methods of individual selection and chose several forms, which differ from the 'Azuriu' cultivar registered in the

Catalogue of Plant Varieties. One of the selected forms (ND-4) was characterised by higher seed and oil productivity, good adaptability, adequate response to the technological elements applied in CCC tests. The given form (ND-4), being stable in terms of production of raw material (seeds), will be submitted for registration in the Catalogue of Plant Varieties of the Republic of Moldova.

For the study, seed samples of two forms of *Nigella damascena* were used, one as a control - 'Azuriu' and the selected form (ND - 4). The seeds were separated according to the test weight (the weight of 1000 seeds) and tested for this index to determine its degree of influence on grain production. The seeds of *Nigella damascena* were passed through a sieve and categorized as follows: I batch - 1.2 mm in diameter (small), II - 1.5 mm (medium), III - 2.0 mm (large), this operation was performed every year, on freshly harvested seeds. We chose the method of propagation by direct sowing in open ground,

according to the scheme (45 cm x 5 cm) at a depth of 1.5-2 cm, always followed by rolling. The optimal time for harvesting the seeds has been determined, considering that they may scatter when ripe, considerably diminishing the yield. Besides, phenological observations, morphological analyzes and biometric measurements were performed during the growing season.

RESULTS AND DISCUSSIONS

During the three-year period when the germination capacity and growth energy of seeds were tested, seed samples were selected (divided in a seed selection machine) according to the test weight (the weight of 1000 seeds), into three categories for each of the tested forms. The small seeds had a low growth energy, namely, 22.4% in the control and 26.2% in the new ND-4 cultivar. In the case of the samples with large seeds, the energy was equal to 33.4 (control) and 30.2%, respectively, but the seeds of medium size had the most considerable value, constituting the largest fraction of the total amount and being characterized by a germination capacity of 42.4 and 46.2% in the given tests (Table 1).

Table 1. The impact of the test weight on the germination capacity of *Nigella damascena* seeds

Tested cultivars	Test weight of seeds, g			Germination capacity, %		
	small	medium	large	small	medium	large
'Azuriu' control cultivar	0.92	1.8	2.2	22.4	42.4	33.4
ND-4, new cultivar	1.2	2.1	2.6	26.2	46.2	30.2

The test weight is also one of the essential characteristics that influences seed productivity. Analyzing batches of seeds with various test weight, we noticed that stronger plants and higher yields are not always obtained from the samples with greater weight of 1000 seeds. The seed fractions that have medium test weight are the most representative and valuable. They represent approximately 57-62% of any batch of seeds, which is also characteristic of the studied forms of *N. damascena*. The small seeds are often underdeveloped, irregularly shaped, and sometimes have an abnormal development in terms of germination capacity. This research was conducted to track the influence of the index - test weight on the seed production potential of plants, which consists of several elements. It has been established that seed productivity is directly correlated with the number of flowers per plant. In the forms of directly correlated with the number of flowers per plant. In the forms of *Nigella* ssp., this index varied between 1 and 30; in the years of the research, there were on average from 14.5 to 29.2 flowers per plant (in the control) and from 22.7 to 34.6 in the ND-4 cultivar. The average number of rudimentary seeds in a pod has been, over the years, from 22.3 ('Azuriu' cultivar) to 26.8 (ND-4). The average number of rudimentary seeds per plant varied over the years within an amplitude from 1873.9 to 2977.9, and the productive potential of a plant was from 4.1 to 10.4 g. Based on the values of the test weight and the average number of plants growing per 1 m^2, the seed production potential per unit area of the ('Azuriu' cultivar reached values of 533.1 g/m^2 and ND-4-910.4 g/m^2. For a species of short, small plants, the values are quite good (Table 2). The actual seed productivity, for several reasons is lower than the calculated potential.

Table 2. Elements of the calculated productive potential of *Nigella damascena* L.

Tested cultivars	Average number: pcs.				Potential seed productivity	
	flowers per plant	pods per plant	rudimentary seeds per pod	rudimentary seeds per plant	plant/g	g/m^2
'Azuriu', control cultivar	14.5	4.9	22.3	1873.9	2.1	533.1
ND-4, new cultivar	21.2	5.8	26.8	2912.6	8.4	910.4

The difference between the number of flowers and the capsules with seeds is not essential, because practically every flower forms seeds. A more considerable difference was observed (Table 3) between the number of rudimentary seeds formed in a pod and the number of normally developed seeds, which also coincides with the data obtained by other researchers - Makrushin et al. (2007), Kuznetsov (2015). The real seed productivity of a plant reached values of 4.5 g in the control cultivar and 6.4 g - in the new variety ND-4. Thus, the actual seed productivity per unit area was equal to 483.3 g in the control cultivar and 594.6 g in the new cultivar ND-4 (Table 3).

Table 3. Actual seed productivity of *Nigella damascena*, average per three years

Tested cultivars	Average number: pcs.				Potential seed productivity	
	capsules per plant	pods per capsule	normal seeds per pod	seeds per plant	per plant, g	g/m^2
'Azuriu', control cultivar	20.2	5.1	16.6	1642.4	4.5	483.3
ND-4, new cultivar	21.2	5.3	20.3	2084.6	6.4	594.6

There are several factors that influence the formation of fully developed seeds from the rudimentary ones. Some of them may be related to morphological features - the location of rudimentary seeds in the ovary, the quality of pollen or its insufficiency, the lack of pollinators, unfavorable growth conditions, the data being confirmed by other authors such as Astafyeva (2008), Chunikhovska (2009), Orlovskaya & Masirova (2012), Margout et al. (2013), Kuznetsov (2015).

The data in Table 4 show that the level of development of actual seeds from the rudimentary ones - the coefficient of seed productivity has changed over the years of testing (Table 4).

Table 4. Seed productivity coefficient of *Nigella damascena* L.

Tested cultivars	Average number: pcs.		Seed productivity coefficient, %	Test weight, g
	Rudimentary seeds per plant, pcs.	Normally developed seeds per plant, pcs.		
'Azuriu', control cultivar	2049.9	1612.7	78.6	2.63
ND-4, new cultivar	3122.8	2517.3	80.6	2.82

The seed productivity coefficient of the control cultivar 'Azuriu' was 84.1 while - of the selected form - 86.6%. In terms of the test weight index, the selected forms in both variants had slightly higher values, from 2.61 to 2.82 g. The germination capacity evaluated under laboratory condition, in two repetitions, was equal to 78% in the control and 80% in new cultivar. The seeds correspond to the quality class I. The growth energy was quite high, reaching values of 65 and 67% within three days from the beginning of germination. The test weight was 2.1-2.3 g, and the number of seeds per gram was 197 pcs. in the control and 201 in the new cultivar (Table 5).

Table 5. Quantitative indices in assessing the quality of *Nigella damascena* seeds, in the 2nd fraction

Tested cultivars	Average values	Germination capacity, %	Growth energy in three days, %	Test weight, g	Number of seeds in 1 g.
'Azuriu', control cultivar	X	78	65	2.1	219
	Sx	5.2	2.7	0.6	1.1
ND-4, new cultivar	X	80	67	2.3	224
	Sx	4.1	2.8	0.7	0.9

Several morphological and biological indices were assessed. The plant height was 64.3 cm in the control cultivar and 65.1 cm in the new cultivar. The number of branches was practically equal to the number of capsules, from 7.6 in the control cultivar to 8.05 in the new cultivar. The duration of the growing season from seedling emergence to seed harvesting was from 86 to 98 days, in different years, being the same for both forms, because sowing and harvesting were done at the same time at seed ripening, so that we haven't noticed any difference.

Table 6. Morphological and productive indices of *Nigella damascena* L., average for three years

Tested cultivars	Average values	Plant height, cm	Number of branches	Number of capsules/plant	Seed productivity, kg/ha	Duration of the growing season, days
'Azuriu', control cultivar	X	64.3	7.6	7.7	531	86-98
	Sx	0.48	0.64	0.57	-	
ND-4, new cultivar	X	65.1	8.0	8.05	572	85-98
	Sx	0.63	0.52	0.53	-	

DL_{05} to seed production constituted 0.03 t/ha

Seed productivity (recalculated per 1 hectare) of both *Nigella damascena* cultivars, for the three-year period, averaged 0.531 t/ha in the control and 0.572 t/ha in the new cultivar, which is with 0.041 t/ha more (Table 6).

CONCLUSIONS

Based on the research conducted and the results obtained, we can conclude that: the selections made in the initial samples allowed us to highlight a form of *Nigella damascena* (DN-4), which under the climatic conditions of our country, achieved a rather high potential productivity, which constituted 80.6-86.6%. The average productivity over three years reached values in the range 446.5-594.6 g/m^2, and recalculated per 1 ha, it was on average for three years 531 kg/ha in the control and 572 kg/ha in the new cultivar, being much higher than the biological potential for productivity, obtained in other neighboring regions.

The seed fractions that have medium test weight are the most representative and valuable. They represent approximately 57-62% of any seed batch, being used for sowing in industrial plantations and testing.

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