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EXPRESSIVENESS OF THE MAIN QUANTITATIVE CHARACTERS OF *RAPHANUS SATIVUS* VAR. *CAUDATUS* ACHIEVED AT PLANT GENETIC RESOURCES BANK BUZAU

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Abstract

PGRB Buzau has a valuable germplasm collection of Raphanus sativus. The bank's specialists have been involved in the conservation and improvement of this species' resources, obtaining two varieties registered in the Official Catalogue of Romanian Cultivated Plants. A large number of genotypes of this species was obtained due to the high degree of entomophily. Within the Bank, a considerable number of genotypes have been obtained, among which one valuable genotype has been biologically isolated from the others, showing genetic stability of the main characters, successfully passing the DUS test. The research undertaken in the present study reflects the expressiveness of the main quantitative characters of the newly obtained genotype. The genotype was evaluated in two growing environments, protected and field, and it was found that both quantitative traits in terms of plant height, height, number of shoots, pod production, pod size and yield per plant were clearly superior (1174 g pods/plant) in protected environments. In the field, production was significantly lower (8.7 g pods/plant) but with much lower cost prices.

Key words: *pod, genotype, expressivity, edible, entomophilous.*

INTRODUCTION

Radish green (*Raphanus sativus* var. *caudatus*) is a small-sized Brassicaceae family that grows as a tuber root and is a vegetable with a short growth period (Hidayat E., 2021). Research on wild vegetable plants and their possible introduction into the human diet for diversification of nutrient intake is important for the genetic conservation, propagation, improvement, and valorisation of these wild genotypes. The Food and Agriculture Organization recognizes the importance of consumption of vegetables (and fruits) as the inadequate consumption of these crops was the cause of 14% gastrointestinal cancer deaths, 11% of ischemic heart disease deaths and 9% of stroke deaths (FAO 2016).

Medicinal plants continue to play an important role in the lives of a significant proportion of the global population (Patel et all., 2021).

Recently, wild vegetable species have started to be prioritised in research and breeding programmes. Many are quite unaware that underutilized vegetables and wild food plants (that can be used as vegetables) can be tapped alongside the more popular vegetables in the market to increase vegetable consumption (Zhang et all., 2021). Very little is known about their use, genetic description, breeding possibilities and conservative selection.

Plants having India inception are *Oryza sativa*, rice; *Eleusine coracana*, African millet; *Cicer arietinum*, chickpea; *Phaseolus aconitifolius*, Mothbean; *Phaseolus calcaratus*, ricebean; *Dolichos biflorus*, Horsegram; *Vigna sinensis*, Asparagus bean; *Solanum melongena*, eggplant; *Raphanus caudatus*, Rats tail radish (Rao D.N., 2017).

Further research on the various wild relatives of cultivated vegetable plants is necessary to ensure food security. These have a superior capacity to adapt to changing climatic conditions and to attacks by various pathogens.

Raphanus sativus contains several domesticated varieties, such as cherry belle radish *(R. sativus* var. *radicula*), black radish (*R. sativus* var. *niger*), rat's tail radish (*R. sativus* var.

caudatus), oilseed radish (*R. sativus* var. *oleiformis*), and the most widely planted cultivar of radish, *R. sativus* var. l*ongipinnatus* (Zhang et al., 2021).
In the West, it was introduced from Java (Indonesia) to England around 1815. It probably began to conquer new territories of the world through trade, at that time reaching America and Europe, where it was cultivated sporadically. In Romania, this species arrived quite late (Vînătoru et al., 2019).
PGRB Buzau has a valuable germplasm collection of *Raphanus sativus*. The bank's specialists have been involved in the conservation and improvement of this species' resources, obtaining two varieties registered in the Official Catalogue of Romanian Cultivated Plants.
As a result of the increasing interest in biodiversity conservation and gastronomic interest for new species, since 2000 a new variety of *Raphanus* has been studied which has not been cultivated in Romania so far, namely *Raphanus sativus* var. *caudatus*.
Edible parts of the plant are represented by the leaves which should be eaten when young, either raw or cooked, presenting a slightly spicy taste. The flowers can also be eaten raw. The most desirable part from the nutritional point of view is the seed-bearing silica.
It is recommended to eat them at an immature stage, before the seeds form, because as the seeds form, the silica seeds turn bitter and spicy.
They can be eaten raw, like common radishes. They can be stored in the refrigerator for about three weeks, frozen or pickled. In addition to other uses, the species can be successfully grown and used in microgreens.
Radish has been reported for the occurrence of flavones, flavonoids, isoflavone, catechins, isocatechins, coumarin lignans and anthocyanins that may contribute to its pharmacological potential (Agil et al., 2006).

MATERIALS AND METHODS

A large number of genotypes were obtained for this species due to the high degree of entomophily. At Bank level, a considerable number of genotypes in various stages of improvement have been obtained, of which 3 genotypes are genetically stabilised. Of these, the G2 genotype showed superiority in terms of genetic stability and yield capacity and was included in this study. In order to ensure the purity of the genotype, it was biologically isolated from the other genotypes in culture, demonstrating genetic stability of the main characters, successfully passing the DUS test.
The research undertaken in the present study shows the expressivity of the main quantitative characters of the newly obtained genotype.
Research on the establishment of the crop by both direct sowing and seedling has been developed.
Sowing in the field was carried out around 15th of March.
Sowing was carried out in 70-hole pallets in cold protected areas around 1st-5th March.
The field crop establishment scheme was as follows: the land was shaped with the L 445 tractor in aggregate with MMS 2.8 with 140 mm spacing, 94 cm at the crown and 70 cm between rows, and 12 cm from the edge of the crown, 46 cm ruler (Figure 1).
Sowing was carried out respecting distances of 70 cm between rows and 30 cm between plants/row.

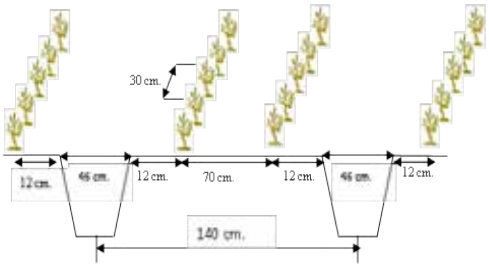

Figure 1. Field crop system

For the cultivation in protected areas, a planting pattern of 70 cm between strips and 35-40 cm between plants/row was used. In cold protected areas the crop is established after 15th of February (Figure 2).

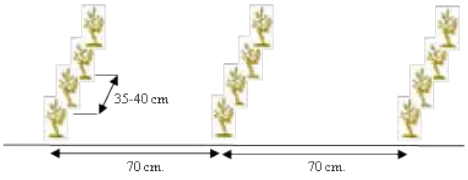

Figure 2. Protected areas crop system

Phenological observations, biometric and laboratory determinations were carried out during the growing season.

RESULTS AND DISCUSSIONS

Harvesting is recommended from the basis of the inflorescence to the apex.
In the open field, harvesting is carried out in stages, from the basis of the plant to the apex, when the pods are juicy and have a size between 3-12 cm, until the milk-wax phenophase is exhausted.
In protected areas, harvesting can be done in stages from 15th of April until 30 May (Figures 3, 4).

Figure 3. Flower and seed pod detail

Figure 4. Seed pods in different ripening stages

For seed production, it is recommended to establish the crop by seedling, with the mention that the seed pods reach maturity after 15th of June (Figure 5).

Figure 5. Fully ripened seed pods

Research has shown that in the soil and climatic conditions of our country, both in protected areas and in the open field, it is not possible to obtain plants with a high production of pods in very cold periods, because the species is entomophilous.
Aside from the fact that the flowers do not tolerate low temperatures below 6 degrees, it should be mentioned that at these temperatures, natural pollinators are absent.
Special attention should be paid to the biological isolation distances from other varieties and also to the seed lots.
After the seeds have reached the wax stage, they must be protected against pests, especially sparrows, as these seed pods are an important food source for them.
High temperatures of over 25 degrees cause the crop to ripen too rapidly.
The quantity of pods/plant decreases, their taste is significantly impaired, they become very bitter and especially the consistency of the pods changes, they lignify prematurely.
The main characteristics of the studied plants are presented in Table 1.

Table 1. Mean values of the main key features studied in field and protected areas

Characteristics	V1 C	CV%	V1 S	CV%
Plant height (cm)	132,8±15,4 [a]	11,6	188±18,7 [b]	9,93
Plant diameter (cm)	43,4±5,9 [a]	13,7	60±8,8 [b]	14,7
Main shoots no.	6±1,41 [a]	23,6	11±1,4 [b]	12,8
No. of pods/shoot	16±2 [a]	12,5	29±4,8 [b]	16,6
Shoot length (cm)	39,2±3,5 [a]	9,04	57±8,2 [b]	14,4
No. of silicva/ plant	102±9,6 [a]	9,4	170±33,4 [b]	19,6
Peduncle length (cm)	29±8 [a]	27,6	47,6±9,3 [b]	19,5

Pod length (mm)	110±17,6 [a]	16	146±34,1 [a]	23,4
Pod diam. (mm)	8,8±1,72 [a]	19,6	14±1,4 [b]	10,1
Pod seed no.	9±1,4 [a]	15,7	14±1,5 [b]	10,1
Pod weight (g)	3,17±1,05 [a]	33,25	5,8±2 [b]	34,2
Pod production/plant (gr)	666±262,2 [a]	39,4	986±257 [a]	26

*letters represent Duncan test results with a 95% confidence interval and p<0.05%

As seen in Table 1, the quantitative characters determined recorded significantly lower values for the crop established in the field in comparison to the one in the protected areas.
This may demonstrate that the species prefers the conditions in protected areas, with the observation that these do not significantly influence seedpod length and seedpod/plant production (Figure 6).

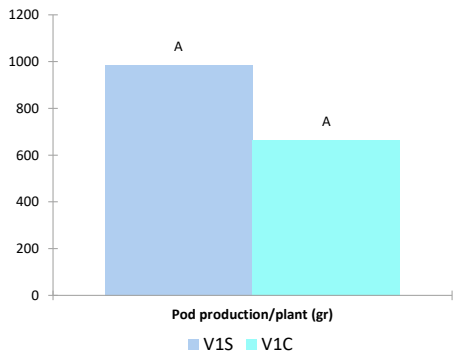

Figure 6. Similarity of pod production/plant for V1S and V1C

Significant differences influenced by the growing environment were observed in terms of plant height, number of shoots, number of seedpods/shoots, and number of seedpod/plant.
An increase of more than 60% was observed in the protected area crop in terms of seedpod diameter and number of seeds in seedpods. (Figure 7).

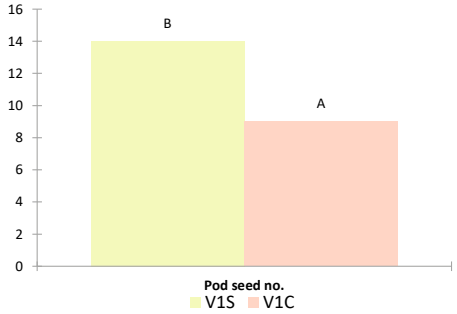

Figure 7. Diferences of pod seed number for V1S and V1C

Determining correlations were made using Matrix of Pearson, as shown in Tables 2 and 3.

Table 2. Matrix of Pearson correlation coefficients for the main quantitative plant traits in V1C

Variables	H	PL	Pl	PD	S	pD	P/s	PS	SL	Pw	P/p
Plant height (cm) H	**1**										
Peduncle length (cm) PL	0,104	**1**									
Pod length (mm) Pl	0,140	**0,991**	**1**								
Plant diameter PD	-0,483	0,749	0,706	**1**							
Main shoots no. S	0,587	0,634	0,643	0,000	**1**						
Pod diam. (mm) pD	0,127	**1,000**	**0,990**	0,730	0,658	**1**					
Pods/shoot P/s	0,234	**0,984**	**0,966**	0,672	0,707	**0,988**	**1**				
Pod seed no. PS	0,257	-0,758	-0,723	**-0,950**	0,000	-0,740	-0,707	**1**			
Shoot.length (cm) SL	0,056	**0,992**	**0,994**	0,736	0,638	**0,991**	**0,959**	-0,718	**1**		
Pod weight (g) Pw	-0,636	0,632	0,641	0,821	0,040	0,614	0,493	-0,657	0,695	**1**	
Pods/plant P/p	0,183	**0,988**	**0,967**	0,725	0,646	**0,990**	**0,997**	-0,763	**0,961**	0,528	**1**

To determine the correlations between the main quantitative characteristics of *Raphanus sativus* var. *caudatus* plants studied under field culture conditions, it can be observed a maximum of 1 obtained by pod diameter and peduncle length, resulting in a close correlation between these two characters. A strong correlation of 0.997 was also observed between pods/plant and pods/shoot.

Table 3. Matrix of Pearson correlation coefficients for the main quantitative plant traits in V1S

Variables	PL	pL	pD	PS	Pw	P/p	H	PD	S	P/s	SL	p/p
Peduncle length (cm) PL	**1**											
Pod length (mm) pL	**0,955**	**1**										
Pod diam. (mm) pD	0,321	0,505	**1**									
Pod seed no. PS	**0,931**	**0,977**	0,600	**1**								
Pod weight (g) Pw	**0,943**	**0,989**	0,584	**0,997**	**1**							
Pods/plant (g) P/p	**0,930**	**0,976**	0,601	**1,000**	**0,997**	**1**						
Plant height (cm) H	**0,925**	**0,971**	0,606	**1,000**	**0,995**	**1,000**	**1**					
Plant diameter (cm) PD	**0,946**	**0,992**	0,578	**0,995**	**1,000**	**0,995**	**0,992**	**1**				
Main shoots no. S	0,595	0,572	-0,300	0,400	0,449	0,395	0,379	0,466	**1**			
Pods/shoot P/s	**0,941**	**0,987**	0,587	**0,998**	**1,000**	**0,998**	**0,996**	**0,999**	0,440	**1**		
Shoot length (cm) SL	**0,943**	**0,989**	0,585	**0,998**	**1,000**	**0,997**	**0,995**	**1,000**	0,447	**1,000**	**1**	
Pods/plant p/p	**0,937**	**0,984**	0,593	**0,999**	**0,999**	**0,999**	**0,998**	**0,998**	0,423	**1,000**	**0,999**	**1**

For protected area cultivation, numerous interdependencies were observed with a maximum value of 1 for the following traits: pods/plant and pod seed number, plant height and pod seed number, plant diameter and pod weight, pods/shoot and pod weight, shoot length and pod weight, shoot length and plant diameter, shoot length and pods/shoot, pods/plant and pods/shoot. These premises lead us to the conclusion that the species thrives very well in the growing conditions offered by cold protected areas.

Figure 8. *Raphanus sativus* var. *caudatus* crop detail

CONCLUSIONS

The research was completed with the successful acclimatization of the species in our country, a new genotype was obtained with expressive distinct phenotype to be registered at ISTIS for patenting and registration.

Its production potential has been evaluated both in protected areas and in the field, concluding that it can be grown with success early spring and late autumn, excluding the hot summer periods.

The cultivation technology of the species has been developed for both protected areas and the field.

The research led to the enrichment and evaluation of the PGRB Buzau germplasm collection with new genotypes, accumulating valuable information in the database of the Buzau Genebank.

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