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## SELECTION OF PERSPECTIVE EARLY MUTANT LINES OF BEAN (*PHASEOLUS VULGARIS* L.) IN DROUGHT CONDITIONS

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### Abstract

In 2020 a field experiment was conducted with mutant lines of common bean from M<sub>4</sub> generations at the Maritsa Vegetable Crops Research Institute, Plovdiv. The aim of the study was to determine the productivity of plants in drought conditions. Twenty four mutant lines were studied in two variants: optimal (non-treated) and reduced (treated) irrigation regimes. A description of the mutant lines was made according to the following features: color: coloring of the flag; beans - length without beak; bean shape in cross section (through the seed); beans-basic coloring; flowering time.

Phenological data were collected for phenophases: budding, flowering, fruit size, consumption and botanical maturity. At consumption maturity, biometric measurements were made of 5 plants per repetition on the following indicators: fresh weight (g) of a plant; number and fresh mass (g) of green beans per plant; length (cm) and width (cm) of beans, total fresh biomass (g).

The highest productivity found among the treated plants in consumption maturity were the early mutant lines M 564-193-9-1-1 and 564-193-9-1-2, followed by M 564-190-1-1-1, M 564-110-1-2, and M 564-191-1-1-2, compared to the parent line L 564 and all the rest of early mutant lines. The treated plants developed the phenophases 7-10 days later than those with optimal watering.

**Keywords:** *Phaseolus vulgaris* L., mutants, morphology, productivity, drought stress.

### INTRODUCTION

Drought stress is the most serious agronomic challenge in growing beans in some areas of the world (Rao, 2014; Rippke et al., 2016). Over the last decade, the duration of rainless periods has increased significantly, resulting in large losses in yields (Dai, 2013). Therefore, there is a need for developing new varieties tolerant to long periods of drought, guaranteeing relatively high yields.

Legumes are widespread and consumed worldwide, providing more than 69 % of the protein and 30 % of the fat needed for human diet. Beans (*Phaseolus vulgaris* L.) are one of the main sources of protein, ranging in content from 60 % to 90 %, depending on the genotype (Koehler, 1987).

Legumes are also used in sustainable

agriculture due to the minimum requirements for fertilization and due to the symbiotic relationship with the soil microorganisms, while increasing soil fertility and reducing the amount of mineral fertilizers in crop rotations (Piha and Munns, 1987; Figueiredo et al., 2008 Olivera et al., 2004).

The aim of the study was to evaluate and select mutant genotypes of beans in drought conditions. Selected mutant genotypes will be used for a subsequent selection and developing varieties tolerant to water deficit which will guarantee a good productivity in the changing climatic conditions.

### MATERIALS AND METHODS

The study was conducted in 2020 (a study conducted in continuation from 2019) at



the Maritsa Vegetable Crops Research Institute, Plovdiv with a bean population of 24 early mutant lines in M<sub>4</sub> generation. They were grown in the following conditions: Control - untreated plants grown in optimal irrigation regime (10 plants in one replication) and Treated plants - with reduced irrigation regime / drought (water deficit) (10 plants in three replications). Watering is done through a drip system. Until the beginning of the budding phase, the plants of both variants are watered with an optimal irrigation rate (30-40 L / m<sup>2</sup>). The treatment of the plants (50 % of all plants) started in the beginning of budding. Plants from the early mutant lines were grown under conditions without watering for 15 days until reaching 30 % of soil humidity (from 16/07 to 31/07). Until the end of the vegetation, an irrigation regime was maintained with 7 days of drying of the treated plants (watering once a week), and the control plants were watered twice a week to maintain optimal soil humidity. A total of 40 plants were selected from the previously selected mutant lines and the parent.

The plants were grown by the technology for the late field production, according to the scheme: 100 + 60 / 5-6 cm and the sowing date, June 15. The amount of fertilizers was determined after the agrochemical analysis of the soil. With the pre-sowing treatment, fertilization was performed with 200 kg / ha triple superphosphate and 160 kg / ha potassium sulfate in the recommended norms, according to a preliminary agrochemical analysis. Ammonium nitrate was applied twice during the growing season at 100 kg / ha: with first hoeing and after 20 days.

Phenotypic observations were made and the dates of the phenophases were taken into account: budding, flowering, knotting, consumption and botanical maturity. The beginning of the phenophase is considered in 25 % of the plants in the crop, and for all plants in 75 %.

A description of the mutant lines was made according to the following features: color: coloring of the flag - white, pinkish white, pink, violet; beans - length without beak - many short, short, medium, long, very long; pod-shape in cross section (through the seed) - narrowly elliptical, elliptical to ovoid, heart-shaped, rounded, octagonal shape; beans-basic coloring - yellow, green, purple; flowering time when at least 50 % of the plants have at least one open flower.

At consumption maturity, biometric measurements were made of 5 plants from repetition according to the following indicators: fresh mass (g) of one plant; number and fresh mass (g) of green pods per plant; length (cm) and width (cm) of pods, total fresh biomass (g).

## RESULTS AND DISCUSSION

Phenotypic reports showed differences in plant development within mutant lines under the different experimental conditions. It was found that the treated plants are delayed in their development and the phenophases budding and flowering occur 7-10 days later compared to those with optimal watering regime (Table 1). The treated plants start the phenophases of knot and consumption maturity about 3 days later, compared to those with optimal watering regime, but botanical maturity occurs about two weeks earlier in some of the mutant lines. This can be explained by the unfavorable growing conditions created due to the 7-day drought period and the combination with dry and rainless weather during the period July-August.

As a natural response of plants in dry weather they shorten their life cycle and reproduce before the drought (Araus et al., 2002). The duration of the vegetation is determined interactively by the genotype and the environment as the main factors that influence the ability of the crop to avoid climatic stresses (Dingkuhn and Asch, 1999).



**Table 1.** Phenological observations of early mutant lines of common beans, average of the two cultivation variants, after treatment of plants

Phenophases	Optimal watering regime *	Drought conditions (treated plants) *
Buttoning		
Beginning	6/07	13/07
All plants	13/07	17/07
Flowering		
Beginning	13/07	17/07
All plants	17/07	20/07
Tie the fruit		
Beginning	20/07	24/07
All plants	24/07	27/07
Consumption maturity		
Beginning	24/07	27/07
All plants	27/07	30/07
Botanical maturity		
Beginning	19/08	3/08
All plants	24/08	19/08

Date of phenological reports

In treated mutant lines, premature leaf drop was observed from the base to the top of the plants in response to the stress factor. A similar reaction was observed in other cultures (DaMatta, 2004).

Description of the mutant lines of beans is presented in Table 2. Segregation is observed on the basis of the color of the flagella. In terms of color and shape of the beans, those without patterns, with a flat-cylindrical shape predominate.

**Table 2.** Description of plants by phenotypic traits.

№	Line	Seed color	Pod	Features of treated plants
1	L 564 - parent	white	green in color, cylindrical in shape	
2	Variety Mastilen 11b	white	green in color, cylindrical in shape	
3	Variety Lodi - standard for drought tolerance	white	green in color, flat in shape	
4	M 564-110-1-2	white	green in color, cylindrical in shape	
5	M 564-110-1A	white	green in color, cylindrical in shape	
6	M 564-175-3-1	pink	green in color, cylindrical in shape	
7	M 564-175-3-1A	pink	green in color, patterned, flat in shape	
8	M 564-190-1-1-1	pink	green in color, patterned, flat in shape	
9	M 564-190-3-3-4 190-1-3	pink	green in color, patterned, flat in shape	
10	M 564-190-3-5	pink	green in color, cylindrical in shape	
11	M 564-190-3-7-1	pink	green in color, cylindrical in shape	
12	M 564-190-3-7-2	pink	green in color, with many patterns cylindrical in shape	
13	M 564-190-3-7-3	violets	green in color, flat-cylindrical in shape	
14	M 564-190-3-7-4	violets	green in color, patterned, cylindrical in shape	
15	M 564-191-1-1-1	mixed - white, pink and purple	50 % of the plants are with green pods, 50% with patterns, flat	stronger plant habit than other mutant lines
16	M 564-191-1-1-2	creamy	green in color, flat-cylindrical in shape	stronger plant habit than other mutant lines
17	M 564-191-1-1-3	dark pink	green in color, patterned, flat in shape	stronger plant habit than other mutant lines

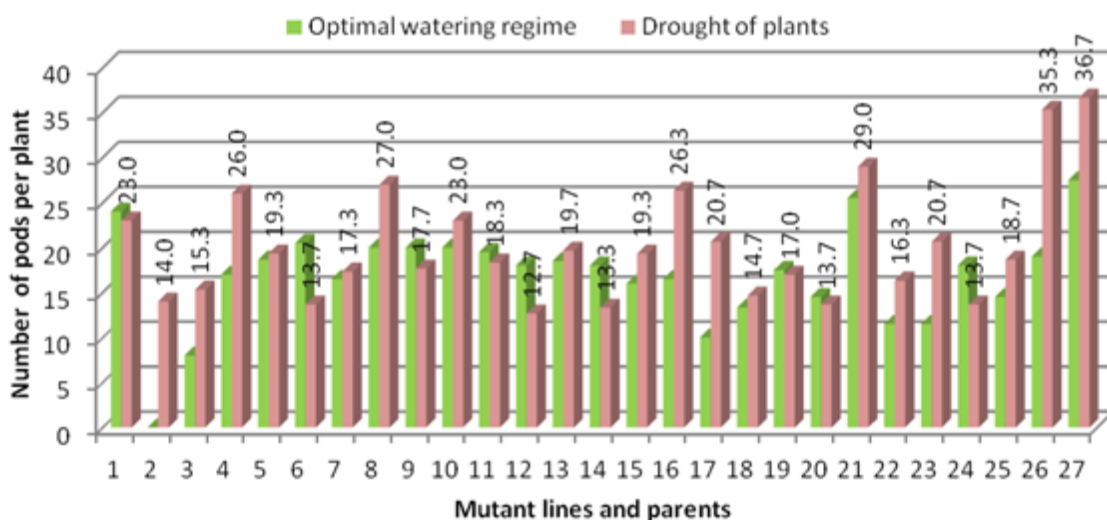


18	M 564-191-1-1-4	light pink	green in color, flat in shape	stronger plant habit than other mutant lines
19	M 564-191-1-1-5	dark pink	green in color, patterned, flat in shape	stronger plant habit than other mutant lines
20	M 564-191-1-1-6	mixed - pink and white	green in color, patterned, flat in shape	taller and with a stronger plant habit than other mutant lines
21	M 564-193-8-1A	mixed - light pink and white	green in color, flat in shape	lower plants and weak habitat compared to other mutant lines
22	M 564-193-8-2	white	green in color, flat-cylindrical in shape	lower plants and weak habitat compared to other mutant lines
23	M 564-193-8-3	pink	green in color, flat in shape	lower plants and weak habitat compared to other mutant lines
24	M 564-193-8-4	white and violets	green in color, flat in shape	lower plants and weak habitat compared to other mutant lines
25	M 564-193-8-5	mixed- white and pink	green in color, flat in shape	lower plants and weak habitat compared to other mutant lines
26	M 564-193-9-1-1	pink	green in color, flat in shape	
27	M 564-193-9-1-2	pale pink	green in color, flat in shape	

The drought tolerance of the mutant lines was assessed by comparing the biometric indicators – the number and the fresh mass of pods per plant (Fig. 1 and Fig. 2). Measurements have shown that the most plants from the studied mutant lines under water-deficit formed a larger number of pods per plant - from 14 to 37 with a fresh weight of 36.0 to 183.8 g, while

the plants under the optimal irrigation regime formed from 8 to 28 pods with a fresh weight of 25.7 to 138.7 g.

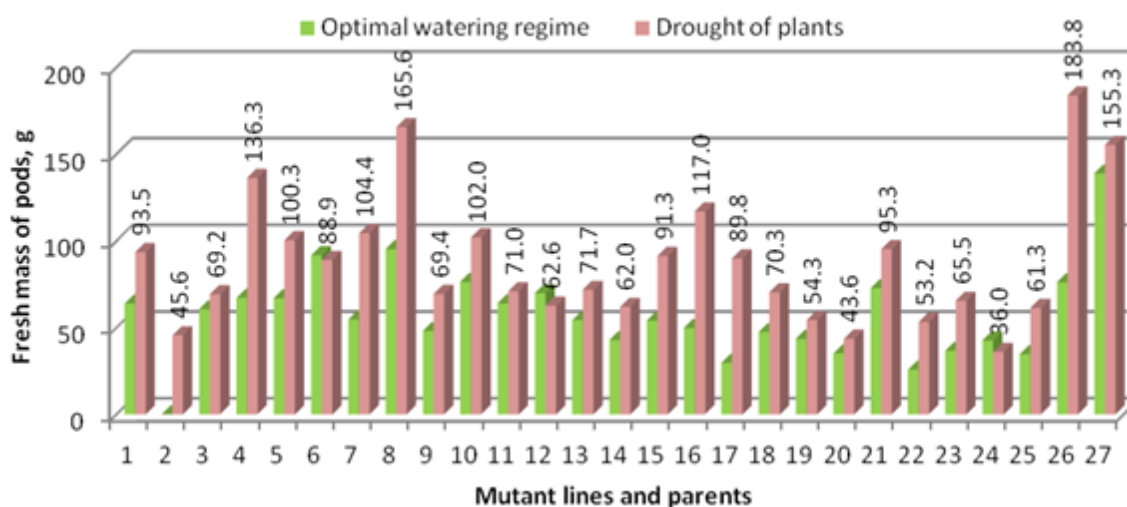
The highest productivity in consumption maturity possessed the treated mutant lines № 26 (M 564-193-9-1-1) and № 27 (M 564-193-9-1-2).



**Figure 1.** Biometric measurements of beans at economic maturity (number of pods per plant) (Line



numbers are presented in Table 2.)



**Figure 2.** Biometric measurements of pods at consumption maturity (fresh mass of pods, g) (Line numbers are presented in Table 2.)

**Table 3.** Biometric measurements of bean pods at consumption maturity in drought regime (treated plants)

№	Morphology of a bean pod		
	Length, cm	Width, cm	Fresh mass, g
1	12,60	10,95	6,66
2	7,87	13,12	4,12
3	11,02	15,84	7,34
4	12,78	11,32	7,58
5	12,77	11,05	7,23
6	13,02	11,69	8,33
7	12,13	11,68	7,90
8	12,76	11,15	8,21
9	10,15	11,65	6,46
10	10,74	11,26	6,59
11	8,76	10,43	5,38
12	11,87	11,59	6,55
13	9,69	10,88	5,50
14	9,24	11,12	6,11
15	12,22	11,87	6,93
16	12,11	13,01	6,37
17	11,85	12,66	6,50
18	13,98	12,83	7,27
19	11,78	12,69	5,96
20	10,57	11,89	5,48
21	11,19	9,39	4,87
22	9,21	10,26	4,71
23	11,17	10,43	4,70
24	9,42	9,88	4,04
25	11,91	9,35	5,10
26	12,71	11,38	7,39
27	12,45	11,25	7,18

Biometric measurements of pods, the major component of the yield, showed a variation in the studied indicators. On the basis of the pod length, the values were in the range from 9.24 cm to 13.98 cm, the width of the pods was in the range from 9.35 mm to 13.01 mm, and the fresh weight of one pod was from 4.04 g to 8, 33 g (Table 3).

The productivity index gives a significant estimate of the percentage of fresh mass of bean pods to the total biomass of the plant (Table 4). This indicator has the highest value of 81.46 % at line 26 (M 564-193-9-1-1), followed by line 8 (M 564-190-1-1-1), line 4 (M 564 -110-1-2), line 7 (M 564-175-3-1A), line 16 (M 564-191-1-1-2), line 10 (M 564-190-3-5), line 21 (M 564-193-8-1A), with an increase of 79.00 %, 73.68 %, 73.50 %, 72.07 %, 71.91 % and 70.86 %, respectively. The highest average bean pod mass of the tested mutant lines compared to the control was in lines 26 (M 564-193-9-1-1), 8 (M 564-190-1-1-1) and 27 (M 564- 193-9-1-2), 132.39 %, 119.29 % and 111.85 %, respectively.



**Table 4.** Productivity index for mutant bean lines in drought conditions

№	Fresh leaf – stem mass, g	Fresh mass of pods, g	Total biomass, g	mass of pods, %	mass of pods / K, %
1	45,33	93,52	138,85	67,35	100,00
2	46,50	45,57	92,07	49,49	32,82
3	46,33	69,19	115,52	59,89	49,83
4	48,67	136,25	184,92	73,68	98,13
5	45,83	100,30	146,13	68,64	72,24
6	47,33	88,94	136,27	65,27	64,05
7	37,63	104,39	142,02	73,50	75,18
8	44,03	165,63	209,66	79,00	119,29
9	44,10	69,43	113,53	61,16	50,00
10	39,83	101,97	141,80	71,91	73,44
11	38,33	70,96	109,29	64,93	51,11
12	47,70	62,60	110,30	56,75	45,08
13	36,50	71,73	108,23	66,28	51,66
14	34,17	61,96	96,13	64,45	44,62
15	49,00	91,33	140,33	65,08	65,78
16	45,33	116,99	162,32	72,07	84,26
17	47,17	89,84	137,01	65,57	64,70
18	54,00	70,34	124,34	56,57	50,66
19	51,83	54,26	106,09	51,15	39,08
20	49,10	43,61	92,71	47,04	31,41
21	39,17	95,27	134,44	70,86	68,61
22	42,17	53,19	95,36	55,78	38,31
23	40,00	65,49	105,49	62,08	47,17
24	31,67	36,03	67,70	53,22	25,95
25	40,00	61,26	101,26	60,50	44,12
26	41,83	183,83	225,66	81,46	132,39
27	78,87	155,31	234,18	66,32	111,85

## CONCLUSIONS

When the mutant bean lines were grown in the same agroclimatic conditions under drought treatment, the early (M<sub>4</sub>) mutant lines are №26 (M 564-193-9-1-1) and №27 (M 564-193-9-1-2), followed by № 8 (M 564-190-1-1), № 4 (M 564-110-1-2) and № 16 M 564-191-1-2), stood out, compared with the parent line №1 (L 564), the other mutants from the experiment and the variety Mastilen 11b according to the biometric measurements of the treated plants in consumption maturity with the highest productivity.

Plants from the early mutant line № 21 (M 564-193-8-1A) formed more bean pods than those of the parent line №1, but they have lower values of length, width and fresh weight of one pod.

Treated plants with the reduced irrigation regime (water deficit) delayed development and phenophases from 7 to 10 days were later than those with the optimal irrigation.

The mutant line № 25 (M 564-193-8-5) differed from all treated early mutant lines and was selected as the earliest one.

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