Scientific Journal of Agricultural Sciences

Print (ISSN 2535-1796) / Online (ISSN 2535-180X)

Selection for Some Economic Characters and Southern Blight Resistance in Dry Bean

Entsar M. E. Abo-Hamda[1], R. A. Arafa[2], Samah F. A. Elgobashy[2], Asmaa M. Shebl[2] and S. M. Kamel[2]

[1]Veg. Res. Depts., Horticultural Res. Inst., Agric. Res. Center, Egypt.
[2]Plant Pathology Res. Inst., Agric. Res. Center, Giza, Egypt.

Citation: Entsar M.E. Abo-Hamda, R.A. Arafa, Samah F.A. Elgobashy, Asmaa M. Shebl and S.M. Kamel. (2023). Selection for Some Economic Characters and Southern Blight Resistance in Dry Bean. Scientific Journal of Agricultural Sciences, 5 (1): 85-106.
https://doi.org/10.21608/sjas.2023.193468.1280

Publisher
Beni-Suef University, Faculty of Agriculture

Received: 12 / 2 / 2023
Accepted: 26 / 3 / 2023

Corresponding author:
Entsar Abo-Hamda

Email: hhhamed246@yahoo.com

ABSTRACT

This experiment was conducted at Barrage Horticultural Research Station (BHRS), ARC, Qaloubia governorate, and Plant Pathology Research Institute, Giza, Egypt during the period from 2021 to 2022. The current study aimed to determine the genetic variability and heritability of dry bean (*Phaseolus vulgaris* L.) genotypes for some economic characters and develop new promising resistant lines to *Sclerotium rolfsii* Sacc, causative of root rot and stem rot. Forty-seven new lines of dry bean developed from previous breeding programs as well as three commercial cultivars, *i.e.*, Giza 6, Karnak and Nebraska were used in this study. The results exhibited that the large portion of phenotypic variance (σ^2p) was due to the genetic variance (σ^2g). Furthermore, estimated broad-sense heritability showed high values (64 to 96%) in all traits, indicating that the observed significant phenotypic differences among the studied genotypes are of genetic nature and there are small environmental effects on the phenotypic variation. Therefore, these characters can be improved through selection based on phenotypic observations in early segregating generations in dry bean. Screening of studied genotypes for *Sclerotium rolfsii* resistance was carried out under controlled conditions. The obtained results showed that genotype D 6 recorded the highest level of resistance displaying the lowest disease severity percentage against *S. rolfsii* infection with 6.7%, followed by genotypes D 40, D 39, D 42 and D 46 with mean disease severity 20%. Furthermore, data revealed that five genotypes were resistant, 10 genotypes were moderately resistant, 13 genotypes were moderately susceptible, 19 genotypes were susceptible and three genotypes were highly susceptible. The selected lines D 30-4 and D 36-2, promising lines could be considered for certification. It had high productivity and good dry yield quality. Meanwhile, the lines D 6 and D 42 are promising lines for resistance to *S. rolfsii* infection with good productivity.

KEYWORDS: Dry bean, *Phaseolus vulgaris*, P.C.V, G.C.V, Heritability, *Sclerotium rolfsii* Resistance

1. INTRODUCTION

Common bean (*Phaseolus vulgaris L*.) is one of the most important source of human dietary proteins and calories (De Ron *et al*, 2017 and McDermott and Wyatt, 2017). According to Cardador-Martínez *et al* (2002), Miklas *et al* (2006) and Reynoso-Camacho *et al* (2006), this crop has a high nutritional value with important protein contents (~22%), minerals (calcium, copper, iron, magnesium, manganese, zinc), dietary fibers, phytonutrients (flavonoids, lignins, phytosterols), antioxidants and vitamins necessary to warrant the food security of people especially in the developing countries. Globally, bean has a socio-economic impact where the harvested area of dry bean is 34801567 ha with productivity 27545942 tonnes. In Egypt, the harvested area of dry bean is 36719 ha with production 144809 tonnes (FAOSTAT, 2020).

Moreover, this crop has more importance in subsistence agro-farming system where it is grown with little external input in varying environments especially in small-scale farms. Therefore, farmers consider bean as a cash crop and dry bean area in recent years was increased. Breeding programs for common beans have focused mainly on maximizing yield and improving resistance to both biotic and abiotic stresses (Araújo *et al*, 2015). Development of high yielding cultivars with resistance to major bean diseases is an important breeding priority to reduce impact of diseases and increase common bean production. Also, Costa *et al* (2010), Wasonga *et al* (2010), Hamed (2012) and Hamed and Muhanna (2017) indicated the possibility of selecting homogenous new common bean lines with high yield.

Globally, soil-borne plant diseases are the most threats and challenges for ecology agricultural production system. Interestingly, damping-off, root rot and wilt can dramatically effect on the global food security due to reduction in productivity and crop quality (Hibar *et al*, 2006). *Sclerotium rolfsii* Sacc. (*Athelia rolfsii* (Curzi) Tu & Kimbrough is a destructive soil-borne plant pathogen that causes southern blight, root, stem and foot rot as well as wilt in the agricultural sector along with various plant families such as legumes, crucifers, cucurbits...etc. The phytopathogenic *S. rolfsii* can attack approximately 500 plant species and causes substantial losses in crop productivity worldwide. The pathogen *S. rolfsii* was detected all over the world; however, it is most common in tropical and subtropical geographical regions (Punja, 1985).

This fungus is a basidiomycete pathogen and well-known polyphagous, ubiquitous, omnivorous. The optimal temperature for symptoms appearance of *S. rolfsii* infection has been reported as 30°C and ranged from 20 to 35°C in the most cropping systems (Aycock, 1966). Furthermore, soil moist and temperature play a vital role to enhance the southern blight development, where remoistening of dried soil motivates sclerotia for initial infection and disease progress. The typical indications of this pathogen are quick wilting and damage plants appearance with brownish lesions at the crown of plant closed to the soil level which later colonized and established around the stem. White mycelium of *S. rolfsii* is one of the main characteristic features in the infested soils, which can be remarked surrounding the plant base either trial pots (artificial inoculation) or open field (natural infection). The hyphae of the pathogen spread aggressively and remain active in the infested soil for a lot of cropping seasons in the form of a small, compact and spherical sclerotia (Kumar *et al*, 2012). Sclerotia can be served as a primary inoculum for *S. rolfsii* and are spread to non-infested regions by different ways like animals, agricultural machines, soil, farmers, water and wind (Kator *et al*, 2015). Yield reduction due to *S. rolfsii* ranging from 10 –90% in natural fields (Grichar and Bosweel, 1987 and Kator *et al*, 2015).

Selection of desirable genotypes is usually based on the genetic variation of agronomic or quantitative traits such as yield and its components. The selection of superior genotypes is proportional to the amount of genetic variability present and the extent to which the characters are inherited (Scarano *et al*, 2014). Therefore, adequate information on the magnitude and type of genetic variability and their corresponding heritability is important in the improvement of yield potential of crops in breeding programs.

The major problem that plays a great role for the lower yield of dry bean in Egypt is the lack of improved cultivars. Therefore, there is need to introduce new improved dry bean cultivars with high productivity and resistance to biotic and abiotic stresses. So, this investigation was initiated with the objective of determination the difference in yield and yield components of some new dry bean genotypes obtained from previous breeding programs, identification of new genetic resources associated with *S. rolfsii* resistance in Egyptian common bean genotypes, determination genetic parameters for yield and some economic characters of dry bean and selection the best performing genotypes in the study area.

2. MATERIALS AND METHODS

This study was conducted during the period from 2021 to 2022 under open field condition at Barrage Hort. Res. Station (BHRS) of Agric. Res. center (ARC), Qaloubia governorate, Egypt. A total of 47 common bean breeder-selected lines in F_8 generation as well as three commercial cultivars namely Giza 6, Karnak and Nebraska (Table 1) were used in this study. The entries promising lines originated from breeding programs of dry bean, Horticultural Research Institute, ARC, Egypt (Abdel-Ati *et al* 2000 and Hamed 2012). These lines were chosen based on earliness, high yield and seeds quality.

The entries were evaluated during the two consecutive summer seasons of 2021 and 2022 and the combined data across the two seasons were calculated. Seeds of the fifty genotypes (forty seven selected lines and three commercial cultivars) were cultivated on first week of March in both two seasons. A randomized complete block design with three replicates was used in this study. In the two seasons, each plot consisted of three rows. Seeds were sown on raised beds with 70 cm row to row spacing and 7 cm plant to plant spacing at a depth of 5 cm. Cultural practices such as irrigation, chemical fertilization and disease and pest control were practiced as commonly followed in the district. Data were taken and recorded on the studied characters on a plot basis using ten individual plants selected randomly from the central row of each plot. The mean of each genotype was used in the statistical analysis. Measurement unit and measurement procedure of each trait are given in Table (2).

Table 1. Source and agro-morphological traits of 50 evaluated genotypes of common bean.

Genotype	Source	Growth habit	Flower Color	Seed color	Seed Shape
D 1	Nebraska X Giza 6	Bushy	White	White	Kidney
D 4	Giza 6 X DB-2-485	Bushy	White	White	Elongated
D 6	Diacole X Nebraska	Bushy	Dark pink	Dark brown with light brown speckled	Elongated
D 7	Contender X Nebraska	Bushy	Light pink	Light brown	Oval
D 7-1	Contender X Nebraska	Bushy	White	White	Oval
D 7-2	Contender X Nebraska	Bushy	White	White	Oval
D 8	Diacole X Nebraska	Bushy	Light pink	Light to dark brown	Kidney
D 9	Diacole X Nebraska	Bushy	Light pink	Light brown	Kidney
D 10	Nebraska X Giza 6	Bushy	White	White	Kidney
D 11	Nebraska X Giza 6	Bushy	White	White	Oval
D 13	Giza 6 X Helda	Trailing	White	White	Oval
D 14	Nebraska X Giza 6	Bushy	White	White	Elongated
D 14-2	Nebraska X Giza 6	Bushy	White	White	Oval
D 14-7	Nebraska X Giza 6	Bushy	White	White	Oval
D 16	Giza 6 X DB-2-485	Bushy	White	White	Elongated
D18	Diacole X Giza 6	Bushy	Dark pink	Purple	Oval
D 20	Diacole X Nebraska	Bushy	Light pink	Brown	Oval
D 21	Diacole X Nebraska	Bushy	Dark pink	Purple	Elongated
D 23	Nebraska X Giza 6	Bushy	White	White	Oval

Follow table 1

D 23-3	Nebraska X Giza 6	Bushy	White	White	Kidney
D 24	Giza 6 X Helda	Trailing	White	White	Oval
D 25	Contender X Nebraska	Bushy	Light pink	Light brown	Oval
D 26	Diacole X Nebraska	Bushy	White	Dark red with white speckled	Oval
D 30	Nebraska X Giza 6	Bushy	White	White	Kidney
D 30-4	Nebraska X Giza 6	Bushy	White	White	Kidney
D 32	Giza 6 X Helda	Bushy	White	White	Elongated
D 33	Diacole X Nebraska	Bushy	Light pink	Light brown with dark brown streaks	Kidney
D 36	Giza 6 X DB-2-485	Bushy	White	White	Elongated
D 36-1	Giza 6 X DB-2-485	Bushy	White	White	Elongated
D 36-2	Giza 6 X DB-2-485	Bushy	White	White	Elongated
D 38	Nebraska X Giza 6	Bushy	White	White	Kidney
D 38-1	Nebraska X Giza 6	Bushy	White	White	Elongated
D 39	Contender X Nebraska	Bushy	Dark pink	Dark brown with light brown speckled	Oval
D 40	Contender X Nebraska	Bushy	Light pink	Light brown	Elongated
D 41	Contender X Nebraska	Bushy	Dark pink	Purple	Elongated
D 42	Contender X Nebraska	Bushy	Light pink	Brown	Oval
D 43	Giza 6 X Helda	Trailing	White	White	Oval
D 44	Contender X Nebraska	Bushy	Light pink	Light brown	Kidney
D 46	Contender X Nebraska	Bushy	Light pink	Dark red with white speckled	Oval
D 48	Diacole X Nebraska	Bushy	Light pink	Dark brown with light brown speckled	Elongated
D 49	Giza 6 X Helda	Bushy	White	White	Oval
D 49-1	Giza 6 X Helda	Trailing	White	White	Oval
D 49-2	Giza 6 X Helda	Trailing	White	White	Oval
D 49-3	Giza 6 X Helda	Trailing	White	White	Kidney
D 51	Giza 6 X Helda	Bushy	White	White	Elongated
D 53	Giza 6 X Helda	Trailing	White	White	Kidney
D 55	Contender X Nebraska	Bushy	Dark pink	Dark brown	Oval
Giza 6	HRI[z]	Bushy	White	White	Oval
Karnak	Landrace	Bushy	White	White	Kidney
Nebraska	HRI	Bushy	White	White	Elongated

HRI[z]: Horticultural Research Institute

Table 2. Observed dry bean quantitative characters, measurement units and procedures

Character	Measurement unit/sampling procedure
Plant length (cm)	The length of the plant from the ground surface to the tip of the main stem recorded in centimeters at physiological maturity.
Number of branches per plant	Number of shoots arising from the main stem counted and recorded at physiological maturity.
Number of days to flowering	Number of days from the date of planting to the date on which 50% of the plants on a plot opened a flower.
Pod length (cm)	Exterior distance of fully matured pod from the pod apex to the peduncle measured in centimeters at physiological maturity from an average of 10 plant within plot centre.
Number of pods per plant	Average number of pods counted at harvest, for 10 plants within plot centre.
Number of seeds per pod	Determined from the average number of seeds per 10 pods per 10 sampled plants.
100- seeds weight (g)	The weight in grams of 100 seeds was randomly taken from each experimental plot using sensitive balance.
Yield per plant	Average seed yield counted at harvest, for 10 plants within plot centre.
Total yield per feddan (ton/feddan)	Seed yield obtained from each plot was used to estimate seed yield (ton) per feddan (4200 m^2).
Protein content (%)	Protein content was determined as total nitrogen content by Kjeldahl method and using coefficient 6.25 for calculation (Anonymous, 2002)

2.1. Sample collection and isolation of *S. rolfsii*

Infected common bean plants with typical symptoms of root rot, stem and foot rot were collected from various fields located at Qaloubiya governorate, Egypt. The collected samples were transferred into kraftpaper bags to the Laboratory of Plant Pathology, Vegetable Diseases Research Department, Plant Pathology Research Institute, Agricultural Research Center (ARC). The infected tissues were washed under running tap water in order to remove the wastes and cut in to small pieces of about 3-4 mm thick, then rinsed in 1 % NaCIO for 5 minutes for surface sterilization. Afterwards, the sterilized pieces were rinsed into in sterilized distilled water and dried between sterilized filter papers (15-mm) at 25°C. Subsequently, the dried plant sections were moved to potato dextrose agar (PDA) plates (90 mm diameter) amended with streptomycin as antibiotic (20 Iu/ml). Petri plates were incubated at 25°C for one week for growing the associated microorganisms.

The isolated fungus was identified based on its cultural and morphological characteristics according to the descriptions of Watanabe (2002). Identification was confirmed in Mycological Research and Disease Survey Department, Plant Pathology Research Institute, Agricultural Research Center, Giza. The inoculated Petri plates with of the pathogen were reserved at incubator for 3-4 weeks for the production and maturation of *S. rolfsii* sclerotia. Then, the plates were kept at 4°C for further trials.

2.2. Inoculum preparation of *S. rolfsii*

Sclerotium rolfsii isolate was reactivated by culturing on fresh Petri dishes of PDA and incubated at 25°C for one week. Barley grains (100 g in 70 mL water) were carefully mixed in a 500-mL Erlenmeyer flasks. The autoclaved Erlenmeyer flasks were inoculated with 5-7 mycelial discs (5 mm) obtained from the actively growth margin of 7-days-old cultures. The inoculated flakes were incubated for two weeks at 25°C in the dark for enhancement of a uniform growth. For homogenous distribution of *S. rolfsii* growth, the flasks were carefully shaken every two days (Mghalu *et al,* 2007 and Yousaf *et al,* 2017).

Furthermore, sterilized barley grains with the same approach were applied as a control.

2.3. Screening of common bean genotypes for *S. rolfsii* resistance

This trial was conducted in the greenhouse of Vegetable Diseases Research Department, Plant Pathology Research Institute, ARC, Giza. A clay soil from the Agricultural Research Station, ARC, Giza governorate and pure sand 1:1 (w/w) was mixed and autoclaved at 121°C for one hour. The inoculum of *S. rolfsii* (barley grains covered by the fungal growth) were added to the sterilized soil, then packed in the prepared plastic pots (25 cm diameter)). Sterilized barley grains (without pathogen) were added to the soil in the control application. Subsequently, 15 common bean seeds of each genotype were sown in three plastic pots (five seeds for each pot). Plastic pots were incubated in the greenhouse at 20–23°C and 12 h photoperiod. The experimental pots were organized in a randomized complete design with three replications. All agricultural practices including irrigation, fertilization, weed remove and elimination...etc were applied according to the recommendations of Vegetable Research Department, Horticultural Research Institute, ARC, Egypt.

2.4. Disease assessment

Interestingly, 15- and 45-days post sowing (DPS) the pre-emergence damping-off and post-emergence damping off were performed, respectively, then the percentage of survived plants were counted according to the following formula: (Shaban and El-Bramawy, 2011).

$$\textbf{Pre}-\textbf{emergence damping off}\ (\%) = \frac{\text{Number of nongerminated seeds}}{\text{Total number of sown seeds}} x100$$

$$\textbf{Post}-\textbf{emergence damping off}\ (\%) = \frac{\text{Number of dead emerged seedlings}}{\text{Total number of sown seeds}} x100$$

$$\textbf{Plant survival}\ (\%) = \frac{\text{Number of survived seedlings}}{\text{Total number of sown seeds}} x100$$

Moreover, disease incidence (DI%) for common bean root rotted plants was recorded at 60 DPS of each individual genotype and calculated using the following formula:

$$\textbf{Disease incidence (DI) \%} = \frac{\text{Number of infected plants}}{\text{Tota number of planted seeds}} \text{x } 100$$

Disease severity assessment of southern blight disease was estimated at a 0-5 scale as described by Abdou *et al* (2001) where, 0 = no disease symptoms; 1 = 1-25% root discoloration; 2 = more than 25-50% root discoloration; 3 = more than 50-75% root discoloration with one leaf blighting; 4 = <75% root discoloration along with more than one leaf blighted; 5= plant with complete death. Disease severity index for all tested common bean genotypes was scored according to Liu *et al* (1995) as follows:

$$DSI = \frac{\sum d}{\text{d max}\, xn} x\ 100$$

Where ($\sum d$) is the disease rating possible, (d max) is the maximum disease rating and (n) is the total number of plants investigated in each replicate.

2.5. Statistical analysis

2.5.1. Analysis of variance

Obtained data were statistically analyzed at each season and combined across seasons after testing the homogeneity of seasons (Gomez and Gomez, 1984) and mean comparisons were based on the Duncan's multiple range test (Steel and Torrie, 1981).

2.5.2. Phenotypic and genotypic coefficient of variation

The estimates of phenotypic and genotypic coefficient of variation were calculated as described by Singh and Chaudhary (1995):

$$PCV\ \% = \sqrt{Vp/MeanX}100$$

$$GCV\ \% = \sqrt{Vg/meanX}\ 100$$

where PCV is phenotypic coefficient of variance, VP is phenotypic variance, GCV is genotypic coefficient of variance, and Vg is genotypic variance. GCV and PCV values were categorized as low (0-10%), moderate (10-20%), and high (20% and above) as indicated

by Subramanian and Menon (1973) and Cherian (2000).

2.5.3. Broad sense heritability

It was estimated as the ratio of total genotypic variance to the phenotypic variance according to Falconer (1981):

$H^2 = Vg/vPX$ 100

where H^2 = % Broad sense heritability. The heritability percentage was categorized as low (0- 30%), moderate (30 – 60%), and high ≥ 60% as described by Johnson *et al* (1955).

3. RESULTS AND DISCUSSION

3.1. Performance of the selected lines

In Egypt, the determinate growth nature of dry bean cultivars is trait that may have been chosen by farmers because they allow for reducing time until harvest which reducing costs and water require. So, selecting structures with a short plant length with more branches of an erect nature with early fruiting and high yield is of great importance. Means of the evaluated selected lines are presented in Tables (3 to 7). Significant differences were observed among the selected lines for all studied traits.

Obtained data on plant length of dry bean genotypes evaluated in the 2021 and 2022 summer plantings are presented in Table (3). During the selection program, the focus was on short-size plants. Combined analysis of both seasons illustrate significant differences for this trait among the evaluated genotypes. Plant length ranged from 32.42 cm to 151.49 cm. The maximum value was recorded by the selected line D 24, while the shortest plants (32.42 cm, 34.27 cm, 36.84 and 37.92) were the lines D 20, D 10, D 51 and D 25, respectively, without significant differences among them. Comparing the selected lines with the check cultivars, a few number of lines (13 lines) were shorter than the three check cultivars with significant differences.

The trait number of branches per plant varied a lot among the evaluated genotypes (Table 3). Among the selected lines, the lines D 46 and D 7-2 possessed the largest number of branches/plant (5.45 and 5.43, respectively) without significant difference between them, while the line D 14-7 showed the lowest mean (2.15) followed by the line D 53 (2.28) with insignificant differences between them. While the check cultivars exhibited medium number of branches (3.23, 3.10 and 3.07) for the cultivars Nebraska, Karnak and Giza 6, respectively.

Selection for early flowering and fruiting is considered the desired goal from the farmers in Egypt. Significant differences were observed among the evaluated genotypes for number of days to flowering character (Table 4). A few number of selected lines reflected a superiority in earliness compared with the check cultivars. The recorded number of days to flowering ranged from 37.67 to 48.50 days for the lines D 20 and D 53, respectively. The results revealed that the line D 20 was the earliest one (37.67 days), when compared to the remainder selected lines as well as the check cultivars followed by the lines D 8 and D 55 (39.83 days) with insignificant differences among them.

Concerning pod length trait, the recorded data reflected a great variation among the genotypes evaluated (Table 4). The selected lines gave pods ranging from 10.31 to 14.97 cm in length. The longest pods were shown by the selected line D 49-1 (14.97 cm) followed by line D 38-1 (14.15 cm), without significant differences between them and significant differences with the three check cultivars Karnak, Nebraska and Giza 6 (13.12, 12.56 and 12.29 cm, respectively).

For the trait number of pods per plant, the results in Table (5) show that the selected line D 7-2 exhibited the highest number (30.17 pods) followed by the line D 36-2 (27.00 pods) without insignificant differences between them, but showed significant differences from the check cultivars Nebraska, Giza 6 and Karnak (14.17, 11.44 and 9.17 pods/plant, respectively). While, the overall mean of the selected lines recorded 13.22 pods per plant, indicating the effectiveness of the selection for improving this trait.

Regarding number of seeds per pod trait, the selected line D 24 showed the highest number (5.65) followed by line D 25 (5.58) without a significant difference between them, while, with significant differences from the three check cultivars. These data indicated that the selection is effective for improving seeds/pod trait.

Significant differences were found among the evaluated genotypes for 100 seeds weight character (Table 6).

Table 3. Mean performance of the evaluated dry bean selected lines and check cultivars for plant length (cm) and number of branches/plant characters at 2021, 2022 and combined across seasons.

Genotype	Plant length (cm)			No. branches/plant		
	2021	2022	Mean	2021	2022	Mean
D 1	46.33 h-q	54.24 j-p	50.29 f-m	2.57 k-p	4.23 f-l	3.40 h-r
D 4	46.67 g-p	49.01 n-u	47.84 h-o	3.80 b-h	4.68 c-i	4.24 d-i
D 6	47.33 g-o	54.00 j-p	50.67 f-m	3.30 e-m	3.43 l-s	3.37 i-r
D 7	41.87 m-u	54.57 j-p	48.22 h-n	3.30 e-m	3.90 i-p	3.60 f-o
D 7-1	45.67 j-r	60.33 f-j	53.00 f-k	3.33 e-l	5.50 a-d	4.42 b-f
D 7-2	45.67 j-r	54.00 j-p	49.83 f-m	4.50 a-d	6.37 a	5.43 a
D 8	41.67 n-v	41.68 u-w	41.67 l-p	2.80 j-p	3.00 p-u	2.90 m-u
D 9	36.33 t-w	44.13 t-w	40.23 m-p	2.40 m-p	3.00 p-u	2.70 o-u
D 10	34.33 u-w	34.21 xy	34.27 p	2.57 k-p	2.83 q-u	2.70 o-u
D 11	37.67 s-w	42.57 t-w	40.12 m-p	2.70 j-p	4.13 f-m	3.42 g-q
D 13	114 b	133.47 b	123.73 b	2.33 n-p	2.67 r-u	2.50 r-u
D 14	49.33 f-n	55.78 i-o	52.55 f-l	2.40 m-p	2.73 q-u	2.57 q-u
D 14-2	53.67 e-i	59.83 g-k	56.75 f-j	4.77 a	5.67 ab	5.22 ab
D 14-7	52.67 e-k	67.33 f	60.00 f	2.10 p	2.20 u	2.15 u
D 16	54 e-h	56.33 h-n	55.17 f-j	3.83 b-g	4.80 b-i	4.32 b-g
D18	40.67 o-v	44.90 r-w	42.78 k-p	3.60 d-j	3.90 i-p	3.75 e-m
D 20	31.27 w	33.58 y	32.42 p	2.63 k-p	3.00 p-u	2.82 n-u
D 21	39.33 p-v	46.01 q-w	42.67 k-p	2.63 k-p	2.88 q-u	2.76 n-u
D 23	45.33 k-s	51.78 l-r	48.55 g-n	3.60 d-j	4.57 d-j	4.08 d-j
D 23-3	46 i-r	51.67 l-s	48.83 g-n	4.70 ab	5.60 a-c	5.15 a-c
D 24	138 a	164.99 a	151.49 a	2.50 l-p	2.80 q-u	2.65 p-u
D 25	36.40 t-w	39.44 w-y	37.92 n-p	2.80 j-p	2.87 q-u	2.83 n-u
D 26	49 f-n	44.23 s-w	46.62 j-o	2.93 g-p	4.20 f-l	3.57 f-o
D 30	56.33 ef	56.22 h-n	56.28 f-j	2.57 k-p	2.69 q-u	2.63 p-u
D 30-4	54.33 e-g	62.33 f-i	58.33 f-h	4.57 a-c	5.00 b-g	4.78 a-d
D 32	49.33 f-n	57.00 h-m	53.17 f-k	4.37 a-d	4.83 b-i	4.60 a-e
D 33	40 o-v	40.88 v-y	40.44 m-p	2.37 n-p	2.53 s-u	2.45 s-u
D 36	49.33 f-n	52.80 k-q	51.07 f-m	2.33 n-p	4.03 g-n	3.18 j-t
D 36-1	53 e-k	62.33 f-i	57.67 f-j	2.17 p	3.03 o-u	2.60 q-u
D 36-2	49.33 f-n	63.43 f-h	56.38 f-j	4.17 a-e	5.03 b-f	4.60 a-e
D 38	50.67 e-l	55.34 i-o	53.00 f-k	2.17 p	3.10 n-u	2.63 p-u
D 38-1	46.33 h-q	62.33 f-i	54.33 f-j	2.73 j-p	4.90 b-h	3.82 e-l
D 39	55.33 ef	63.67 f-h	59.50 fg	2.73 j-p	3.57 k-r	3.15 k-t
D 40	49.67 f-m	48.67 o-u	49.17 f-m	3.10 f-o	3.57 k-r	3.33 i-s
D 41	43.33 l-t	50.00 m-t	46.67 j-o	3.20 f-n	3.53 k-r	3.37 i-r
D 42	38.67 q-w	41.61 u-x	40.14 m-p	4.00 a-f	5.27 b-e	4.63 a-e
D 43	90 c	119.89 c	104.94 cd	2.40 m-p	3.50 k-s	2.95 l-u
D 44	53.33 e-j	58.00 h-l	55.66 f-j	2.90 h-p	4.13 f-m	3.52 f-p
D 46	38.33 r-w	44.78 r-w	41.55 l-p	4.50 a-d	6.40 a	5.45 a
D 48	49.7 f-m	66.17 fg	57.93 f-i	2.77 j-p	4.00 h-o	3.38 h-r
D 49	54.33 e-g	54.91 i-o	54.62 f-j	3.00 g-p	3.90 i-p	3.45 g-q
D 49-1	93.33 c	105.33 d	99.33 d	3.20 f-n	3.93 h-p	3.57 f-o
D 49-2	66 d	78.00 e	72.00 e	3.77 c-i	4.80 b-i	4.28 c-h
D 49-3	73 d	84.33 e	78.67 e	3.20 f-n	4.07 f-n	3.63 f-n
D 51	34 vw	39.68 w-y	36.84 op	3.43 e-k	4.43 e-k	3.93 d-k
D 53	96.33 c	132.01 b	114.17 bc	2.23 op	2.33 tu	2.28 tu
D 55	36 t-w	45.80 q-w	40.90 m-p	2.87 i-p	3.47 k-s	3.12 k-t
Giza 6	57.67 e	59.44 g-k	58.55 f-h	2.73 j-p	3.40 l-s	3.07 k-t
Karnak	56.33 ef	49.34 n-t	52.84 f-k	3.00 g-p	3.20 m-t	3.10 k-t
Nebraska	46.33 h-q	47.24 p-v	46.79 i-o	2.80 j-p	3.67 j-q	3.23 j-s

Table 4. Mean performance of the evaluated dry bean selected lines and check cultivars for number of days to flowering and pod length (cm) characters at 2021, 2022 and combined across seasons.

Genotype	No. days to flowering			Pod length (cm)		
	2021	2022	Mean	2021	2022	Mean
D 1	43.00 d-f	44.67 e-i	43.83 c-i	11.20 j-p	12.83 c-m	12.01 f-o
D 4	40.00 h-m	44.00 f-k	42.00 f-k	10.70 n-p	13.37 b-h	12.03 f-o
D 6	37.67 n	43.33 h-k	40.50 i-l	10.37 p	11.60 j-n	10.98 n-p
D 7	39.00 j-n	43.67 g-k	41.33 h-k	11.67 g-p	11.58 k-n	11.62 j-p
D 7-1	38.67 k-n	44.33 e-j	41.50 h-k	11.73 g-o	12.44 e-n	12.09 f-o
D 7-2	39.00 j-n	44.33 e-j	41.67 g-k	10.67 n-p	10.97 n	10.82 op
D 8	38.33 l-n	41.33 kl	39.83 kl	13.33 a-e	13.83 b-f	13.58 b-e
D 9	39.00 j-n	41.67 j-l	40.33 j-l	8.93 q	11.68 i-n	10.31 p
D 10	40.00 h-m	41.33 kl	40.67 i-l	11.83 f-o	12.58 d-n	12.21 f-n
D 11	39.67 i-n	43.67 g-k	41.67 g-k	10.60 op	11.53 k-n	11.07 n-p
D 13	46.00 a-c	47.00 c-e	46.50 a-e	12.67 c-h	13.47 b-h	13.07 b-i
D 14	40.00 h-m	44.33 e-j	42.17 f-k	11.50 g-p	12.63 d-m	12.07 f-o
D 14-2	41.00 f-j	45.33 d-h	43.17 e-k	11.07 k-p	12.93 b-m	12.00 f-o
D 14-7	41.00 f-j	52.33 a	46.67 a-d	12.00 e-n	11.51 l-n	11.76 i-o
D 16	47.00 ab	47.67 cd	47.33 ab	10.67 n-p	10.97 n	10.82 op
D18	42.33 e-g	43.67 g-k	43.00 f-k	11.60 g-p	12.27 f-n	11.93 g-o
D 20	37.67 n	37.67 m	37.67 l	11.10 k-p	11.52 l-n	11.31 l-p
D 21	42.00 f-h	44.00 f-k	43.00 f-k	10.63 op	11.35 mn	10.99 n-p
D 23	43.00 d-f	44.67 e-i	43.83 c-i	12.40 d-k	13.30 b-i	12.85 b-k
D 23-3	45.00 b-d	45.33 d-h	45.17 a-f	12.00 e-n	12.80 d-m	12.40 d-m
D 24	39.00 j-n	46.67 c-f	42.83 f-k	12.63 c-i	13.07 b-l	12.85 b-k
D 25	39.33 j-n	44.33 e-j	41.83 f-k	12.47 d-j	13.37 b-h	12.92 b-j
D 26	41.67 f-i	43.33 h-k	42.50 f-k	11.33 h-p	11.85 h-n	11.59 k-p
D 30	39.67 i-n	44.33 e-j	42.00 f-k	13.17 a-f	13.24 b-j	13.20 b-g
D 30-4	40.00 h-m	44.67 e-i	42.33 f-k	13.63 a-d	14.50 ab	14.07 a-c
D 32	40.00 h-m	43.67 g-k	41.83 f-k	12.27 e-l	13.00 b-l	12.63 d-l
D 33	39.00 j-n	42.33 i-l	40.67 i-l	14.07 ab	14.15 a-d	14.11 a-c
D 36	39.67 i-n	43.67 g-k	41.67 g-k	11.00 l-p	13.51 b-g	12.25 f-n
D 36-1	41.00 f-j	44.67 e-i	42.83 f-k	10.77 m-p	13.30 b-i	12.03 f-o
D 36-2	42.33 e-g	44.33 e-j	43.33 d-j	10.33 p	12.92 b-m	11.63 j-p
D 38	39.33 j-n	44.00 f-k	41.67 g-k	13.67 a-d	12.94 b-m	13.30 b-f
D 38-1	39.00 j-n	44.33 e-j	41.67 g-k	13.83 a-c	14.47 a-c	14.15 ab
D 39	40.00 h-m	44.67 e-i	42.33 f-k	11.83 f-o	12.33 f-n	12.08 f-o
D 40	40.33 g-l	43.00 h-k	41.67 g-k	12.40 d-k	13.18 b-k	12.79 c-k
D 41	41.00 f-j	44.33 e-j	42.67 f-k	12.83 b-g	13.45 b-h	13.14 b-g
D 42	42.33 e-g	44.67 e-i	43.50 c-j	10.97 l-p	11.87 g-n	11.42 l-p
D 43	38.67 k-n	44.67 e-i	41.67 g-k	10.90 m-p	12.65 d-m	11.78 i-o
D 44	38.00 mn	44.67 e-i	41.33 h-k	11.83 f-o	13.01 b-l	12.42 d-m
D 46	44.33 c-e	44.33 e-j	44.33 b-h	10.67 n-p	11.53 k-n	11.10 m-p
D 48	40.67 g-k	44.33 e-j	42.50 f-k	10.77 m-p	11.53 k-n	11.15 m-p
D 49	39.00 j-n	44.00 f-k	41.50 h-k	12.07 e-m	11.95 g-n	12.01 f-o
D 49-1	41.00 f-j	46.33 c-g	43.67 c-j	14.40 a	15.53 a	14.97 a
D 49-2	41.67 f-i	48.33 c	45.00 b-g	12.57 c-i	13.43 b-h	13.00 b-i
D 49-3	42.00 f-h	51.67 ab	46.83 a-c	11.33 h-p	12.27 f-n	11.80 h-o
D 51	41.00 f-j	42.33 i-l	41.67 g-k	11.37 h-p	12.79 d-m	12.08 f-o
D 53	48.00 a	49.00 bc	48.50 a	13.27 a-e	14.08 a-e	13.67 a-d
D 55	40.00 h-m	39.67 lm	39.83 kl	11.30 i-p	12.47 e-n	11.88 g-o
Giza 6	41.00 f-j	44.33 e-j	42.67 f-k	11.90 f-o	12.68 d-m	12.29 e-n
Karnak	40.00 h-m	43.00 h-k	41.50 h-k	12.83 b-g	13.41 b-h	13.12 b-h
Nebraska	39.00 j-n	42.67 h-k	40.83 i-l	11.77 g-o	13.35 b-h	12.56 d-l

Table 5. Mean performance of the evaluated dry bean selected lines and check cultivars for number of pods/plant and number of seeds/pod characters at 2021, 2022 and combined across seasons.

Genotype	No. pods/plant			No. seeds/pod		
	2021	2022	Mean	2021	2022	Mean
D 1	4.53 n	14.47 l-q	9.50 h-m	4.00 f-l	4.47 b-j	4.23 g-o
D 4	5.27 l-n	12.47 o-s	8.87 i-m	4.20 d-k	4.40 b-j	4.30 g-o
D 6	8.67 g-l	23.33 d-f	16.00 d-j	3.23 k-m	3.40 kl	3.32 pq
D 7	7.30 h-n	10.90 p-u	9.10 h-m	4.90 a-g	5.00 a-f	4.95 a-g
D 7-1	11.50 d-g	22.33 e-g	16.92 c-i	4.00 f-l	4.80 b-g	4.40 d-o
D 7-2	12.33 c-f	48.00 a	30.17 a	4.13 e-k	4.40 b-j	4.27 g-o
D 8	10.33 d-h	10.11 q-v	10.22 g-m	4.53 a-i	4.70 b-i	4.62 c-l
D 9	4.60 n	11.31 o-u	7.96 j-m	3.40 j-m	4.27 d-k	3.83 m-p
D 10	6.57 j-n	7.33 t-v	6.95 lm	3.97 f-l	4.30 c-k	4.13 h-o
D 11	6.67 i-n	8.57 s-v	7.62 k-m	4.33 b-j	4.40 b-j	4.37 e-o
D 13	9.00 f-k	12.00 o-s	10.50 g-m	4.43 a-j	5.27 a-c	4.85 b-h
D 14	8.63 g-l	15.11 k-p	11.87 f-m	4.30 c-j	4.40 b-j	4.35 f-o
D 14-2	18.00 ab	30.50 c	24.25 a-d	4.27 c-k	4.40 b-j	4.33 f-o
D 14-7	15.33 bc	21.00 f-i	18.17 c-g	3.83 h-m	4.00 g-k	3.92 j-p
D 16	9.00 f-k	12.00 o-s	10.50 g-m	4.53 a-i	4.77 b-h	4.65 c-l
D18	10.67 d-h	14.23 l-r	12.45 f-m	5.30 a-c	5.20 a-d	5.25 a-c
D 20	5.73 k-n	5.77 v	5.75 m	4.10 e-l	3.67 jk	3.88 l-p
D 21	10.17 d-h	11.10 p-u	10.63 g-m	4.53 a-i	4.80 b-g	4.67 c-k
D 23	21.00 a	27.00 cd	24.00 a-e	4.57 a-i	4.80 b-g	4.68 c-j
D 23-3	13.53 cd	20.11 f-j	16.82 c-i	4.87 a-h	5.00 a-f	4.93 a-g
D 24	9.80 e-j	17.47 h-m	13.63 f-m	5.43 a	5.87 a	5.65 a
D 25	11.17 d-g	10.57 q-u	10.87 g-m	5.37 ab	5.80 a	5.58 ab
D 26	7.30 h-n	10.11 q-v	8.71 i-m	3.97 f-l	4.13 e-k	4.05 i-p
D 30	7.43 h-n	11.80 o-t	9.62 h-m	4.30 c-j	4.23 d-k	4.27 g-o
D 30-4	20.67 a	28.33 c	24.50 a-c	5.13 a-e	5.20 a-d	5.17 a-d
D 32	9.67 e-j	12.17 o-s	10.92 g-m	3.80 i-m	3.80 h-k	3.80 n-p
D 33	8.13 g-l	7.23 uv	7.68 k-m	5.23 a-d	5.27 a-c	5.25 a-c
D 36	10.23 d-h	17.70 h-l	13.97 f-m	4.50 a-i	5.07 a-e	4.78 c-i
D 36-1	11.33 d-g	22.00 e-h	16.67 c-i	3.07 lm	4.73 b-h	3.90 k-p
D 36-2	15.33 bc	38.67 b	27.00 ab	4.10 e-l	4.70 b-i	4.40 d-o
D 38	8.10 g-m	12.50 o-s	10.30 g-m	4.47 a-i	4.30 c-k	4.38 e-o
D 38-1	12.33 c-f	26.23 c-e	19.28 b-f	2.80 m	2.47 l	2.63 q
D 39	17.67 ab	17.10 i-n	17.38 c-h	4.87 a-h	5.00 a-f	4.93 a-g
D 40	9.93 e-j	11.33 o-u	10.63 g-m	4.67 a-i	4.47 b-j	4.57 c-n
D 41	10.30 d-h	11.67 o-u	10.98 g-m	3.93 g-l	4.00 g-k	3.97 j-p
D 42	13.00 c-e	15.77 j-o	14.38 f-l	4.30 c-j	4.57 b-j	4.43 d-o
D 43	9.10 f-k	13.00 m-s	11.05 f-m	4.33 b-j	4.70 b-i	4.52 c-o
D 44	11.00 d-g	15.66 j-o	13.33 f-m	5.00 a-f	5.27 a-c	5.13 a-e
D 46	9.73 e-j	11.90 o-s	10.82 g-m	5.00 a-f	5.20 a-d	5.10 a-f
D 48	8.93 f-k	19.67 f-j	14.30 f-l	3.70 i-m	4.20 e-k	3.95 j-p
D 49	10.33 d-h	10.67 p-u	10.50 g-m	4.07 f-l	3.73 i-k	3.90 k-p
D 49-1	11.33 d-g	14.00 l-r	12.67 f-m	4.53 a-i	4.80 b-g	4.67 c-k
D 49-2	12.33 c-f	19.33 f-k	15.83 e-k	3.73 i-m	3.83 g-k	3.78 op
D 49-3	10.33 d-h	15.67 j-o	13.00 f-m	4.33 b-j	4.77 b-h	4.55 c-o
D 51	8.87 g-k	12.11 o-s	10.49 g-m	4.47 a-i	4.53 b-j	4.50 c-o
D 53	4.10 n	10.33 q-u	7.22 lm	3.80 i-m	4.07 f-k	3.93 j-p
D 55	4.67 mn	9.80 r-v	7.23 lm	4.43 a-j	5.33 ab	4.88 a-h
Giza 6	10.00 e-j	12.88 n-s	11.44 f-m	4.10 e-l	4.27 d-k	4.18 g-o
Karnak	7.23 h-n	11.11 p-u	9.17 h-m	4.60 a-i	4.60 b-j	4.60 c-m
Nebraska	10.10 d-i	18.23 g-l	14.17 f-l	4.33 b-j	5.00 a-f	4.67 c-k

Table 6. Mean performance of the evaluated dry bean selected lines and check cultivars for 100 seeds weight (g) and yield/plant (g) characters at 2021, 2022 and combined across seasons.

Genotype	100 seeds weight (g)			Yield/plant (g)		
	2021	2022	Mean	2021	2022	Mean
D 1	32.57 l-q	39.75 m-r	36.16 n-r	4.57 st	13.17 j-p	8.87 g-m
D 4	35.33 i-n	38.89 n-r	37.11 l-q	4.27 t	8.38 r-v	6.32 j-m
D 6	43.67 b-f	47.47 c-g	45.57 b-g	9.57 i-o	20.77 d	15.17 d-h
D 7	27.67 qr	32.92 t-w	30.29 u-w	5.43 q-t	7.43 t-x	6.43 i-m
D 7-1	28.00 p-r	31.48 v-x	29.74 u-w	9.77 h-o	18.87 d-f	14.32 e-i
D 7-2	31.67 m-q	41.64 i-o	36.65 l-r	7.67 n-s	36.97 b	22.32 b-d
D 8	32.33 l-q	37.79 p-s	35.06 p-t	11.70 f-k	13.10 j-p	12.40 f-l
D 9	37.33 g-l	38.52 o-r	37.93 k-p	8.87 j-p	8.78 q-v	8.82 g-m
D 10	42.90 b-f	43.67 h-l	43.28 e-j	9.03 i-p	9.73 o-u	9.38 g-m
D 11	36.33 h-m	40.04 l-q	38.19 k-p	7.57 o-s	8.00 s-w	7.78 h-m
D 13	38.30 f-k	40.12 l-q	39.21 j-o	8.40 l-r	11.73 l-s	10.07 g-m
D 14	45.00 a-e	49.05 b-e	47.03 b-e	9.40 i-p	15.43 f-l	12.42 f-l
D 14-2	39.67 e-j	41.05 k-p	40.36 h-m	15.63 cd	25.40 c	20.52 b-e
D 14-7	35.67 h-m	37.05 q-s	36.36 m-r	9.07 i-p	13.93 i-n	11.50 g-m
D 16	24.60 r	27.89 x	26.25 w	4.27 t	4.14 x	4.20 m
D18	40.33 d-i	41.16 k-p	40.75 h-l	8.67 j-q	10.63 n-t	9.65 g-m
D 20	38.27 f-k	41.79 i-o	40.03 i-n	5.33 r-t	4.30 wx	4.82 lm
D 21	43.33 b-f	45.33 e-i	44.33 d-h	13.43 d-g	14.04 i-n	13.74 e-j
D 23	41.00 d-h	44.13 g-k	42.57 g-j	22.67 a	28.11 c	25.39 ab
D 23-3	44.67 a-e	50.23 bc	47.45 b-d	14.33 d-f	25.74 c	20.04 b-f
D 24	29.80 o-r	32.69 t-w	31.25 s-v	10.20 g-o	17.98 d-h	14.09 e-j
D 25	25.67 r	28.09 x	26.88 w	9.00 i-p	9.01 q-v	9.01 g-m
D 26	41.93 c-g	43.37 h-m	42.65 f-j	9.90 h-o	12.04 l-r	10.97 g-m
D 30	43.23 b-f	45.15 f-j	44.19 d-h	9.73 h-o	14.93 g-m	12.33 f-l
D 30-4	44.67 a-e	46.29 d-h	45.48 b-g	18.33 bc	28.03 c	23.18 bc
D 32	45.33 a-d	48.15 b-f	46.74 b-f	11.50 f-l	13.23 j-p	12.37 f-l
D 33	35.37 i-n	38.31 o-r	36.84 l-r	9.83 h-o	9.47 p-v	9.65 g-m
D 36	40.67 d-i	42.61 h-n	41.64 g-k	10.80 g-o	19.02 d-f	14.91 d-h
D 36-1	42.33 c-g	43.13 h-m	42.73 f-j	14.67 d-f	26.30 c	20.48 b-e
D 36-2	44.33 a-e	46.21 d-h	45.27 c-g	21.47 ab	43.43 a	32.45 a
D 38	42.27 c-g	41.45 j-p	41.86 g-k	10.23 g-o	13.43 j-o	11.83 g-m
D 38-1	35.50 i-m	44.21 g-k	39.86 j-n	15.47 c-e	34.70 b	25.08 ab
D 39	33.37 k-p	33.15 t-w	33.26 q-u	10.60 g-o	11.03 n-t	10.82 g-m
D 40	33.43 k-p	36.35 q-t	34.89 p-t	10.70 g-o	12.03 l-r	11.37 g-m
D 41	45.33 a-d	49.81 b-d	47.57 b-d	12.23 e-i	12.50 k-q	12.37 f-l
D 42	27.33 qr	29.72 wx	28.53 vw	14.50 d-f	17.31 d-i	15.91 c-g
D 43	33.30 k-p	32.23 vw	32.76 r-u	11.87 f-j	10.90 n-t	11.38 g-m
D 44	29.93 n-r	32.29 u-w	31.11 t-v	8.53 k-r	14.37 h-n	11.45 g-m
D 46	34.67 j-o	36.03 r-u	35.35 o-s	8.23 m-r	9.00 q-v	8.62 g-m
D 48	44.67 a-e	46.01 e-h	45.34 b-g	10.10 h-o	19.60 de	14.85 d-h
D 49	42.27 c-g	44.00 g-k	43.13 e-j	8.30 l-r	6.80 u-x	7.55 h-m
D 49-1	49.33 a	54.73 a	52.03 a	10.83 g-n	15.91 e-k	13.37 e-k
D 49-2	48.33 ab	50.20 bc	49.27 a-c	5.43 q-t	5.87 v-x	5.65 k-m
D 49-3	43.33 b-f	45.20 f-j	44.27 d-h	11.43 f-m	16.33 e-j	13.88 e-j
D 51	36.33 h-m	38.53 o-r	37.43 l-p	10.47 g-o	11.16 m-t	10.81 g-m
D 53	46.90 a-c	51.93 ab	49.42 ab	6.27 p-t	9.63 o-v	7.95 g-m
D 55	25.00 r	34.19 s-v	29.59 u-w	3.73 t	8.76 q-v	6.25 j-m
Giza 6	39.67 e-j	39.88 l-q	39.77 j-n	7.83 n-r	11.20 m-t	9.52 g-m
Karnak	48.27 ab	49.11 b-e	48.69 a-c	12.83 d-h	12.88 j-p	12.86 e-k
Nebraska	42.37 c-g	45.84 e-h	44.10 d-i	10.57 g-o	18.41 d-g	14.49 d-h

Mean weight of 100 seeds of the evaluated genotypes ranged from 26.25 to 52.03 g. The highest weight of 100 seeds was shown by the selected line D 49-1 (52.03 g) followed by line D 53 and D 49-2 (49.42 and 49.27 g, respectively) without significant differences among them and also with insignificant differences from the check cultivar Karnak (48.69 g), while with significant differences from the check cultivars Nebraska and Giza 6 (44.10 and 39.77 g, respectively). The lowest value of 100 seeds weight was exhibited by lines D 16 and D 25 (26.25 g and 26.88 g, respectively).

Obtained data on dry yield/plant of dry bean genotypes evaluated in 2021 and 2022 summer plantings are presented in Table (6). Combined analysis across seasons show significant differences for this character among the evaluated genotypes. Dry yield/plant of the evaluated genotypes ranged from 4.20 to 32.45 g. The selected line D 36-2, significantly, produced the highest dry yield/plant (32.45 g/plant) among all evaluated genotypes followed by lines D 23 and D 38-1 (25.39 and 25.08 g/plant, respectively) without significant differences among them, while, with significant differences from the check cultivars Nebraska, Karnak and Giza 6 (14.49, 12.86 and 9.52 g/plant, respectively). These data showed that selection was effective for improving yield in dry bean.

Data in Table (7) generally indicate that many of the selected lines produced significantly higher total yield than the check cultivars. Besides, the results reflected significant differences in the total yield/feddan trait. The selected line D 36-2 produced the highest mean value for total yield/plant (1.546 tons), followed by the line D 30-4, where its mean value reached 1.288 tons with insignificant difference between them. While, the three check cultivars Karnak, Nebraska and Giza 6 recorded mean values of total yield/feddan as the weight of 0.873, 0.870, and 0.727 tons, respectively.

Significant differences were observed among the evaluated genotypes for protein content character (Table 7). Mean protein content of the evaluated genotypes ranged from 18.13 to 24.94%. The highest value was produced by the selected line D 7 (24.94 %) followed by line D 1 (24.71 %) without significant differences between them, but with significant differences from the check cultivars Giza 6, Karnak and Nebraska (20.77, 19.43, and 18.71 %, respectively). The lowest value of protein content was exhibited by line D 42 (18.13 %).

These results are in accordance with the findings of Costa *et al* (2010), Wasonga *et al* (2010), Hamed (2012) and Hamed and Muhanna (2017) who indicated the possibility of selecting new common bean lines with high yield.

3.2.Components of variances

Estimates of components of variances, *i.e.,* environmental (σ^2e), genetic (σ^2g), and phenotypic (σ^2p) variance, genotypic (GCV) and phenotypic (PCA) coefficient of variation, GCV/ PCV ratio and broad-sense heritability (BSH) for the studied traits are presented in Table (8).

All studied characters showed low differences between phenotypic and genetic variances (Table 8) indicating that the large portion of the phenotypic variance (σ^2_p) was due to the genetic variance (σ^2_g) and the significant differences among studied dry bean genotypes were of genetic nature.

Estimates of GCV% and PCV%, respectively for the studied traits were 40.75 and 41.63% for plant length, 23.84 and 26.38% for number of branches per plant, 4.59 and 5.73% for number of days to flowering, 7.76 and 9.06% for pod length, 39.57 and 48.17% for number of pods/plant, 12.15 and 14.32% for number of seeds/pod, 16.12 and 16.74% for 100 seeds weight, 43.60 and 51.31% for dry yield/plant, 33.97 and 37.02% for total yield/feddan and 8.48 and 9.57% for protein content (Table 8). Also, the GCV / PCV ratio for the studied traits ranged from 0.80 (number of days to flowering) to 0.98 (plant length). Obtained broad sense heritability values for the studied traits (Table 8) ranged from 64 to 96%, suggesting a relatively high values of heritability (>60%) in all studied characters.

Table 7. Mean performance of the evaluated dry bean selected lines and check cultivars for total yield/fed. (Ton) and protein content (%) characters at 2021, 2022 and combined across seasons.

Genotype	Total yield/feddan (Ton)			Protein content (%)		
	2021	2022	Mean	2021	2022	Mean
D 1	0.443 t-y	0.992 d-h	0.718 i-r	25.08 a	24.33 ab	24.71 ab
D 4	0.234 z	0.421 o-q	0.327 u	21.17 d-i	20.67 d-j	20.92 c-k
D 6	0.848 g-m	1.340 b	1.094 b-e	21.92 b-f	20.50 d-l	21.21 c-g
D 7	0.423 t-y	0.577 l-p	0.500 o-u	24.38 ab	25.50 a	24.94 a
D 7-1	0.392 v-z	0.722 i-m	0.557 n-u	20.00 e-k	19.60 g-o	19.80 e-m
D 7-2	0.367 w-z	1.240 bc	0.803 f-n	19.33 f-k	19.50 h-o	19.42 f-m
D 8	1.072 cd	1.156 b-d	1.114 b-e	21.75 b-g	19.87 f-n	20.81 c-k
D 9	0.743 l-o	0.722 i-m	0.733 h-q	21.67 c-h	20.57 d-j	21.12 c-i
D 10	1.063 c-e	1.148 b-e	1.106 b-e	21.75 b-g	21.20 d-h	21.48 c-e
D 11	0.450 s-y	0.482 n-q	0.466 q-u	20.67 d-k	19.50 h-o	20.08 d-l
D 13	0.427 t-y	0.485 n-q	0.456 r-u	22.75 a-d	21.40 c-g	22.08 cd
D 14	0.833 i-m	0.874 f-i	0.854 e-m	19.25 g-k	18.67 l-o	18.96 k-m
D 14-2	0.523 r-w	0.641 j-o	0.582 n-u	18.58 i-k	18.23 no	18.41 lm
D 14-7	0.573 p-t	0.616 k-p	0.595 m-t	21.67 c-h	20.53 d-k	21.10 c-i
D 16	0.542 q-v	0.539 m-q	0.540 n-u	22.66 a-d	22.00 c-e	22.33 c
D18	0.973 c-j	1.002 d-g	0.988 c-h	18.42 jk	18.67 l-o	18.54 lm
D 20	0.432 t-y	0.446 o-q	0.439 s-u	21.75 b-g	20.27 e-m	21.01 c-j
D 21	0.993 c-i	1.291 b	1.142 b-d	20.67 d-k	19.50 h-o	20.08 d-l
D 23	0.740 l-o	0.760 i-m	0.750 g-o	19.45 f-k	18.70 k-o	19.08 j-m
D 23-3	0.910 d-k	1.033 c-f	0.972 c-i	18.50 jk	18.27 no	18.38 lm
D 24	0.848 g-m	0.924 e-i	0.886 d-k	18.38 k	18.43 m-o	18.41 lm
D 25	0.605 n-s	0.594 l-p	0.600 l-t	24.15 a-c	18.30 no	21.23 c-f
D 26	0.582 o-t	0.617 k-p	0.600 l-t	19.15 g-k	23.20 bc	21.18 c-h
D 30	0.947 c-j	1.149 b-e	1.048 b-f	18.04 k	17.90 o	17.97 m
D 30-4	1.260 b	1.316 b	1.288 ab	18.42 jk	18.10 no	18.26 lm
D 32	0.823 j-m	1.329 b	1.076 b-e	18.40 jk	18.20 no	18.30 lm
D 33	0.897 f-l	0.834 f-k	0.865 e-l	18.43 jk	18.03 no	18.23 lm
D 36	0.483 r-x	0.854 f-j	0.669 j-s	18.35 k	18.17 no	18.26 lm
D 36-1	0.758 k-n	1.251 bc	1.005 c-g	18.45 jk	18.27 no	18.36 lm
D 36-2	1.442 a	1.650 a	1.546 a	19.25 g-k	19.13 i-o	19.19 g-m
D 38	1.037 c-f	1.125 b-e	1.081 b-e	18.38 k	18.47 m-o	18.43 lm
D 38-1	0.742 l-o	1.125 b-e	0.934 d-j	18.50 jk	18.23 no	18.37 lm
D 39	0.560 p-u	0.576 l-p	0.568 n-u	23.08 a-d	21.87 c-e	22.48 c
D 40	0.833 i-m	0.872 f-i	0.853 e-m	19.25 g-k	19.03 j-o	19.14 i-m
D 41	1.008 c-h	1.025 c-f	1.017 c-g	19.17 g-k	19.10 i-o	19.13 i-m
D 42	1.097 c	1.343 b	1.220 bc	18.08 k	18.17 no	18.13 lm
D 43	1.010 c-g	1.160 b-d	1.085 b-e	18.08 k	18.57 m-o	18.33 lm
D 44	0.617 n-r	0.696 i-n	0.657 k-s	19.03 h-k	19.30 i-o	19.17 h-m
D 46	0.567 p-t	0.586 l-p	0.576 n-u	23.17 a-d	22.33 cd	22.75 bc
D 48	0.512 r-w	0.859 f-j	0.686 j-s	21.93 b-f	20.90 d-i	21.42 c-f
D 49	0.478 r-x	0.470 n-q	0.474 p-u	18.47 jk	18.33 no	18.40 lm
D 49-1	0.907 e-k	1.029 c-f	0.968 c-i	22.17 b-e	21.57 c-f	21.87 cd
D 49-2	0.705 m-p	0.769 h-l	0.737 h-p	19.97 e-k	18.83 j-o	19.40 f-m
D 49-3	0.303 yz	0.339 q	0.321 u	18.43 jk	18.53 m-o	18.48 lm
D 51	0.553 p-v	0.621 k-p	0.587 m-u	18.42 jk	18.23 no	18.33 lm
D 53	0.335 x-z	0.404 pq	0.370 tu	19.08 h-k	19.07 i-o	19.08 j-m
D 55	0.402 u-y	0.794 g-l	0.598 m-t	18.48 jk	18.30 no	18.39 lm
Giza 6	0.700 m-q	0.753 i-m	0.727 h-q	21.03 d-j	20.50 d-l	20.77 c-k
Karnak	0.887 f-l	0.860 f-j	0.873 e-k	19.25 g-k	19.60 g-o	19.43 f-m
Nebraska	0.847 h-m	0.893 f-i	0.870 e-k	18.58 i-k	18.83 j-o	18.71 lm

Table 8. Components of variance (σ^2_p, σ^2_g and σ^2_e), genotypic (GCV) and phenotypic (PCA) coefficient of variation and broad sense heritability (BSH%) for some traits of dry bean.

Components	Plant length	Number of branches/ plant	Number of days to flowering	Pod length	Number of pods/ plant	Number of seeds/ pod	Weight of 100 seeds	yield/ plant	Total yield/ fed.	Protein content
σ^2_p	561.76	0.86	5.95	1.24	39.94	0.40	44.20	43.09	0.09	3.62
σ^2_g	538.25	0.70	3.81	0.91	26.95	0.29	40.99	31.10	0.07	2.84
σ^2_e	23.50	0.16	2.14	0.33	12.99	0.11	3.21	11.98	0.02	0.77
GCV%	40.75	23.84	4.59	7.76	39.57	12.15	16.12	43.60	33.97	8.48
PCV%	41.63	26.38	5.73	9.06	48.17	14.32	16.74	51.31	37.02	9.57
GCV/ PCV	0.98	0.90	0.80	0.86	0.82	0.85	0.96	0.85	0.92	0.89
BSH %	96	82	64	73	67	72	93	72	84	79

Generally, the recorded data exhibited that the differences between phenotypic and genotypic variance for all studied traits were low, also the estimated GCV/PCV ratios were high (from 0.80 to 0.98). It means that the large portion of phenotypic variance (σ^2_p) was due to the genetic variance (σ^2_g). Thus, estimated heritability in broad-sense showed high values (from 64 to 96%) for all traits, indicating that the observed significant phenotypic differences among the studied breeding lines are of genetic nature and there are small environmental effects on the phenotypic variation. Therefore, these studied traits can be improved through selection based on phenotypic observations in early segregating generations. These results are confirmed with the findings of Nosser (2011) and Hamed and Muhanna (2017) who indicated that yield, plant length, number of pods/plant and pod length characters were influenced more by genetic than non-genetic factors and the differences between GCV and PCV were narrow with respect to genetic advance. Also, Hamed and Khalil (2010), Nosser (2011) and Hamed and Muhanna (2017) found that broad-sense heritability ranged from moderate to high for the same studied characters and suggested selection for improving these traits, meanwhile, Ejara *et al* (2018) indicated that the PCV values were relatively greater than GCV in magnitude for the traits seed yield and number of primary branches, but was relatively low for plant length and number of seeds per pod.

3.3. Identify new genetic resources associated with *S. rolfsii* resistance in Egyptian common bean genotypes

The causal agent of blighted samples of common bean was isolated and identified as a *Sclerotium rolfsii* Sacc, with clear morphological characteristics (Fig. 1A and B). The pure culture of *S. rolfsii* was utilized in artificial inoculation to evaluate the studied common bean genotypes (Fig. 1C). Soil infestation with *S. rolfsii* revealed significantly reduction in germination of majority common bean genotypes. Poor plants establishment through "damping-off assay, and brownish roots of common bean plants were investigated for all tested common beans genotypes (50 genotypes). Additionally, differences in pre-emergence damping off of common bean genotypes were significant where ranged from 14 seeds with genotypes *i.e.,* D 7-2, D 14, cv. Karnak, D 23-3, D 53 and D 16 to 0 seeds with genotypes *i.e.,* D 39 and D 6.

All emerged plants were investigated for anticipated symptoms. Interestingly, genotype D 6 showed the best survival value (93.33% of total tested plants) under the potential inoculation of *S., rolfsii*, followed by genotypes D 40, D 39, D 42 and D 46 with 80% of total plants (Table 9).

On the other hand, there are significant reduction in number of survival plants up to only one plant with different genotypes. Response of common beans genotypes to *S. rolfsii* under artificial inoculation using whole plant assay was statistically different ($P<0.05$) with one-way analysis of variance (ANOVA) where disease severity ranged from 6.7 to 100% (Table 9).

Fig. 1. Phenotypic characteristics of *Sclerotium rolfsii* isolate from Egyptian common bean field that used in the current study. (A) Fluffy and fibrous mycelia 7 days' post inoculation potato dextrose agar medium; (B) compact mycelia with starting sclerotia formation (blue arrows) 30 days post inoculation potato dextrose agar medium and (C) fungal growth 7 days post inoculation potato dextrose broth medium.

The obtained results showed that genotype D 6 recorded the highest level of resistance displaying the lowest disease severity percentage against *S. rolfsii* infection with 6.7%, followed by genotypes D 40, D 39, D 42 and D 46 with mean disease severity 20%. On the other hand, genotypes D 14-7, D 23-3 and D 7 revealed the highest level of disease severity with 100%, followed by genotypes D 14 and cv. Karnak with 93.5 and 93.6%, respectively. Interestingly, no common bean genotype was immune or highly resistant to *S. rolfsii*.

Common bean genotypes grown in non-infested soil (control) by *S. rolfsii* showed normal growth of the crop (Fig. 2A). Moreover, most of the tested genotypes exhibited disease-like symptoms with various levels of discoloration that observed on roots, crown, cankers and necrotic areas on shoots. The most severe symptoms were tightly related to poor growth of plants. Also, common beans that failed to emerge (pre-emergence damping off) were also examined, and most were found to be rotten and often covered by sclerotia and fungal mycelia of *S. rolfsii* (Fig. 2B). Additionally, other southern blight progress stages like post-emergence damping off, wilting and death were observed on different genotypes of common bean (Fig. 2C-F). Furthermore, data revealed that five genotypes were resistant, 8 genotypes were moderately resistant, 14 genotypes were moderately susceptible, 14 genotypes were susceptible and nine genotypes were highly susceptible (Fig.3). Additionally, the obtained results demonstrated that the susceptible category recorded the highest percentage (38%), followed by moderately susceptible and moderately resistant with 26 and 20%, respectively.

By analyzing the correlation, it was found that there is a positive strong correlation (r=0.898) between both disease severity and disease incidence in this study (Fig. 4A). On the other hand, the disease severity and number of survived plants showed a strong negative correlation (r= -0.952) under controlled conditions (Fig. 4B)

Table 9. Results of damping off, disease incidence and severity of southern blight for 50 dry bean genotypes grown in soil infested with *S. rolfsii* under greenhouse conditions.

Genotype	Damping off%		Root rot %			Response
	Pre-Emergence	Post-Emergence	Survival	DI	DS	
D 1	66.67 e	06.67 e	26.67 i	100.00 a	77.70 e	S
D 4	73.33 d	06.67 e	20.00 j	100.00 a	80.00 d	S
D 6	00.00 n	06.67e	93.33 a	20.00 k	06.70 o	R
D 7	60.00 f	06.67 e	33.33 h	100.00 a	100.00 a	HS
D 7-1	73.33 d	00.00 f	26.67 i	100.00 a	77.70 e	S
D 7-2	93.33 a	00.00 f	06.67 k	100.00 a	93.30 b	HS
D 8	13.33 l	33.33 a	53.33 e	86.71 b	46.70 j	MS
D 9	26.67 j	00.00 f	73.33 c	26.68 j	26.70 n	MR
D 10	80.00 c	00.00 f	20.00 j	100.00 a	80.00 d	S
D 11	46.67 h	13.33 d	40.00 g	66.70 e	60.00 h	MS
D 13	80.00 c	00.00 f	20.00 j	100.00 a	80.00 d	S
D 14	93.33 a	00.00 f	06.67 k	100.00 a	93.50 b	HS
D 14-2	73.33 d	0.000 f	26.67 i	73.37 d	53.30 i	MS
D 14-7	86.67 b	06.67 e	06.67 k	100.00 a	100.00 a	HS
D 16	93.33 a	00.00 f	06.67 k	100.00 a	93.30 b	HS
D18	86.67 b	00.00 f	13.33 j	100.00 a	86.70 c	S
D 20	20.00 k	13.33 d	66.67 d	53.36 f	33.30 l	MR
D 21	26.67 j	26.67 b	46.67 f	86.71 b	53.70 ni	MS
D 23	86.67 b	00.00 f	13.33 j	100.00 a	86.30 c	S
D 23-3	93.33 a	00.00 f	06.67 k	100.00 a	100.00 a	HS
D 24	46.67 h	06.67 e	46.67 f	73.37 d	53.30 i	MS
D 25	66.67 e	00.00 f	33.33 h	80.04 c	66.70 g	MS
D 26	26.67 j	00.00 f	73.33 c	46.69 h	27.60 m	MR
D 30	80.00 c	00.00 f	20.00 j	100.00 a	80.00 d	S
D 30-4	80.00 c	13.33 d	06.67 k	100.00 a	93.30 b	HS
D 32	46.67 h	06.67 e	46.67 f	73.37 d	53.30 i	MS
D 33	26.67 j	00.00 f	73.33 c	46.69 g	27.60 m	MR
D 36	66.67 e	00.00 f	33.33 h	80.04 c	66.70 g	MS
D 36-1	66.67 e	00.00 f	33.33 h	80.04 c	66.70 g	MS
D 36-2	86.67 b	00.00 f	13.33 j	100.00 a	86.70 c	S
D 38	66.67e	00.00 f	33.33 h	80.04 c	66.70 g	MS
D 38-1	86.67 b	00.00 f	13.33 j	100.00 a	86.80 c	S
D 39	00.00 n	20.00 c	80.00 b	40.02 h	20.00 n	R
D 40	13.33 l	06.67 e	80.00 b	33.35 i	20.00 n	R
D 41	40.00 i	00.00 f	60.00 e	66.70 e	40.00 k	MR
D 42	06.67 m	13.33 d	80.00 b	26.68 j	20.00 n	R
D 43	46.67 h	00.00 f	53.33 e	66.70 e	46.70 j	MS
D 44	20.00 k	06.67 e	73.33 c	53.36 f	26.70 m	MR
D 46	06.67 m	13.33 d	80.00 b	33.35 i	20.00 n	R
D 48	20.00 k	13.33 d	66.67 d	53.36 f	33.30 l	MR
D 49	73.33 d	06.67 e	20.00 j	100.00 a	80.00 d	S
D 49-1	80.00 c	00.00 f	20.00 j	100.00 a	80.00 d	S
D 49-2	46.67 h	13.33 d	40.00 g	80.04 c	66.70 g	MS
D 49-3	73.33 d	00.00 f	26.67 i	100.00 a	73.30 f	S
D 51	73.33 d	06.67 e	20.00 j	100.00 a	80.00 d	S
D 53	93.33 a	00.00 f	06.67 k	100.00 a	93.30 b	HS
D 55	26.67 j	06.67 e	66.67 d	53.36 f	33.30 l	MR
Giza 6	40.00 i	13.33 d	46.67 f	53.36 f	53.40 i	MS
Karnak	93.33 a	00.00 f	06.67 k	100.00 a	93.60 b	HS
Nebraska	53.33 g	00.00 f	46.67 f	73.37 d	53.30 i	MS

DI%= Disease incidence; DS%= Disease severity. Response, I= Immune (0%); HR= High Resistance (>0 – 5%); R= Resistant (5- 20%); MR= Moderately resistant (>20- 40%); MS= Moderately susceptible (>40 – 60%); S= Susceptible (>60 – 90%) and HS= Highly susceptible (>90 – 100%).

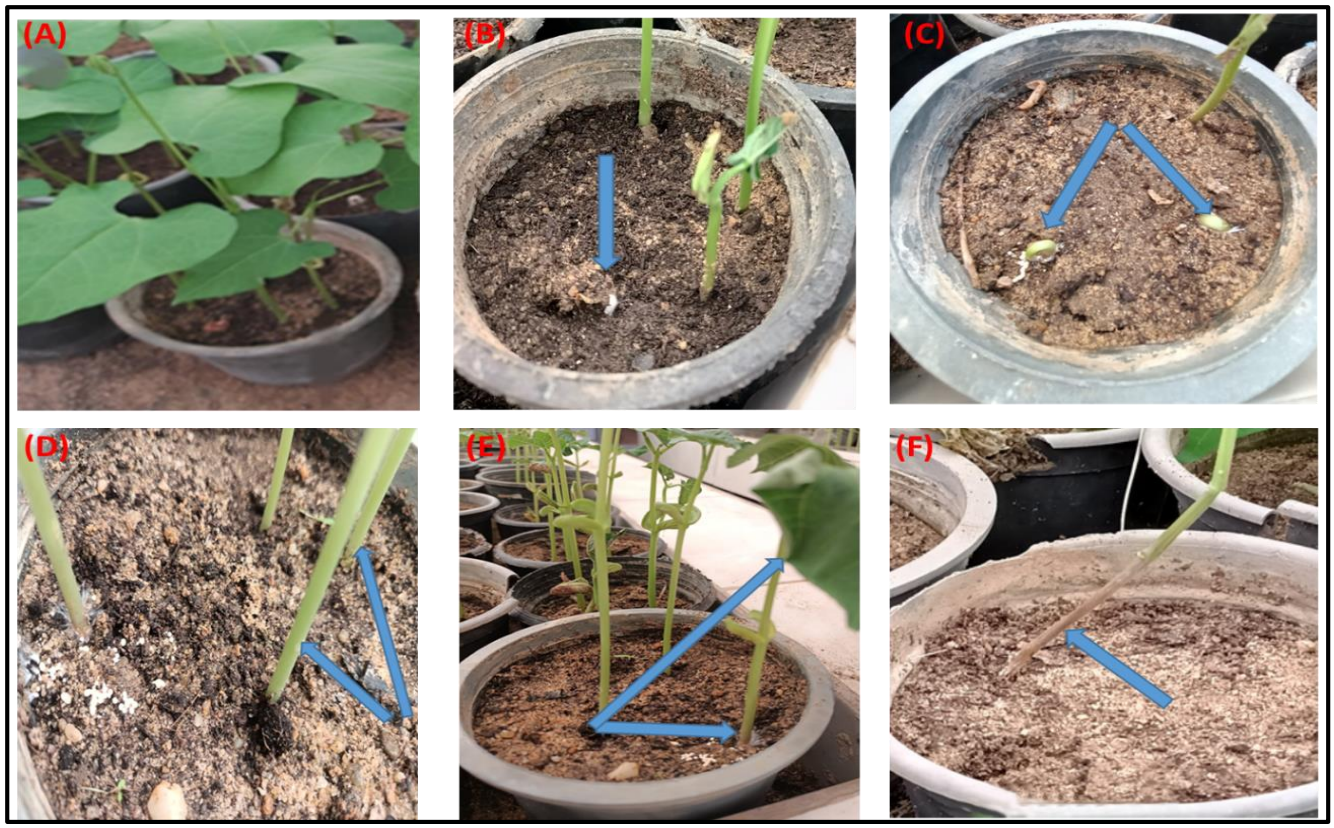

Fig. 2. Diseases symptoms of root rot and stem blight caused by *Sclerotium rolfsii*, on common bean genotypes. (A) control (non-infested soil); (B) Pre-emergence damping off; (C) Post-emergence damping off; (D) Plant survival; (E) stem rot and (F) Death of plants.

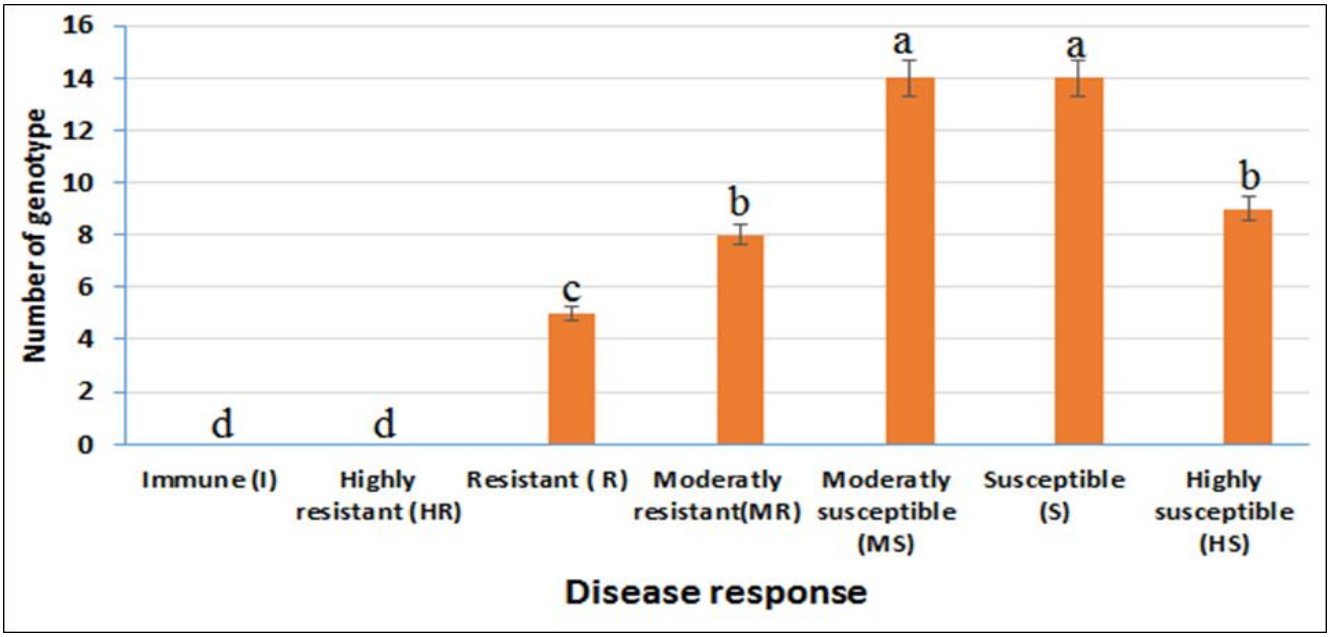

Fig. 3. Disease categories of common bean genotypes (n=50) as a response to virulence isolate of the phytopathogenic fungus, *S. rolfsii.*

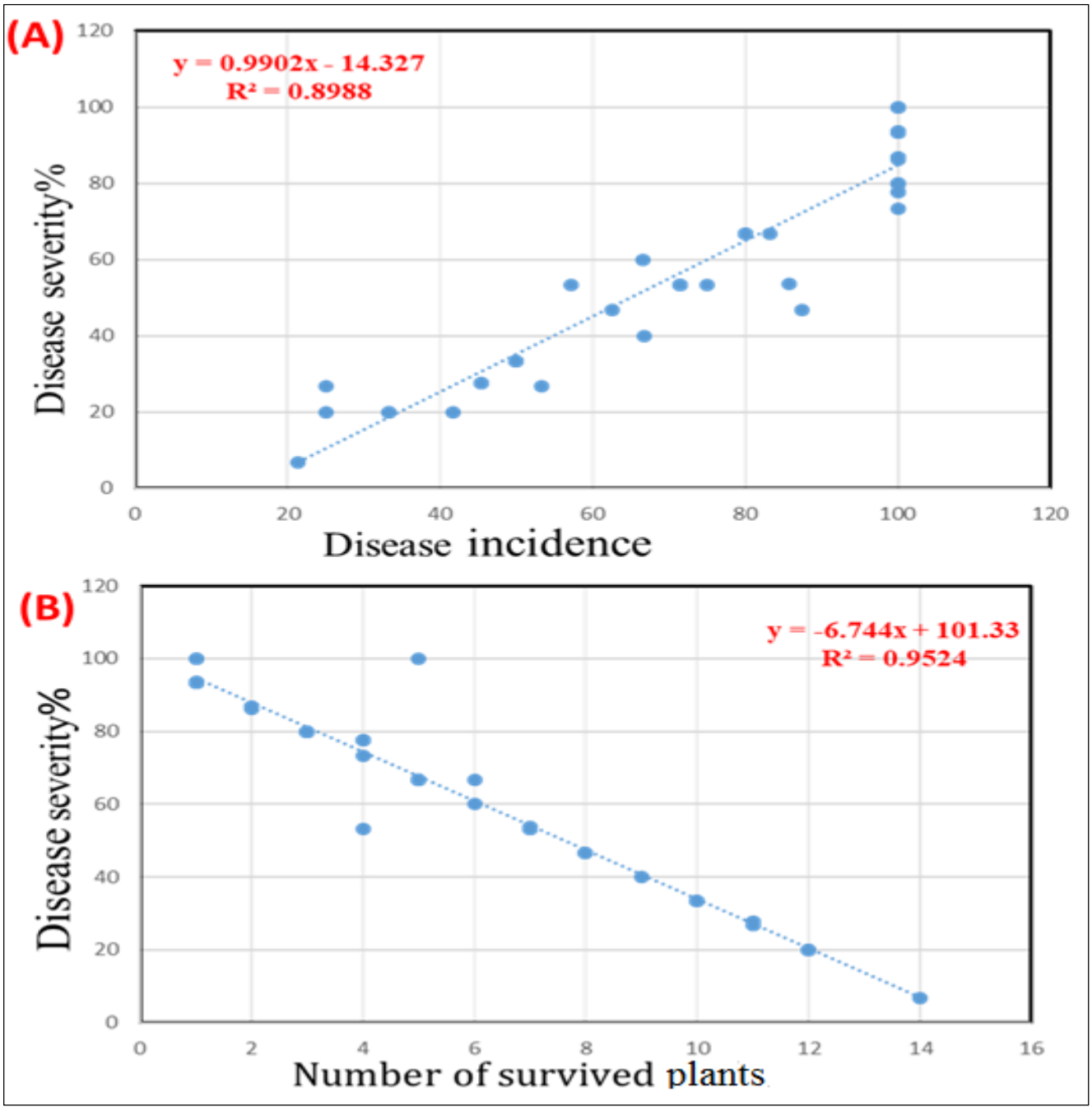

Fig. 4. Relationship between disease severity (DS) and disease incidence (DI) of common bean southern blight as well as number of survived plants in the current study. (A) Correlation coefficient between DS and DI; (B) Correlation coefficient between DS and plant survival.

Disease resistance under controlled conditions with artificial infection is an inseparable part of field resistance (natural infection), where physiological disease resistance/tolerance mechanisms contribute to fungal diseases resistance of common beans (Miklas *et al*, 2001). Interestingly, disease severity offers a good parameter for resistance level measurement to various plant pathogens in different studies (Junaid *et al*, 2014, Li *et al*, 2014 and Wang, 2016). Actually, one of the aims of the current study was to assess the resistance

level and select promising common beans genotypes from a pool of Egyptian germplasm that might confer resistance to *S. rolfsii* in Egypt. The severity of southern blight caused by *S. rolfsii* in common beans was evaluated in the current study that was dramatically different and thus indicates variability in the tested germplasm. Also, the responses of common bean genotypes to southern blight through host-pathogen interactions led to agronomic variations. Greenhouse experiment revealed that pathogenic *S. rolfsii* caused concrete damping-off under favorable environmental conditions particularly with the susceptible genotypes of common bean. This study provides advantageous information to the scientific community in respect of southern blight resistance in common bean population in Egypt. Once a resistant common bean genotypes are identified, it potentially could be utilized in breeding programs of common bean for disease resistance as well as genetic and genomic research especially in the next-generation sequencing era. Furthermore, our findings can contribute in the sustainable agricultural development and global food security particularly in developing countries, where bean assists as a key source of dietary plant proteins as well as mineral nutrition (Worrall *et al*, 2015). Identification of new genetic resources tightly reacted to *S. rolfsii* resistance and/or tolerance offer new insights in successful integrated disease management strategies as well as provide positive socio-economic impacts especially in rural areas. The evaluated resource breeding materials in the current study reflects a better source for common bean improvement in African countries. Even moderately resistance genotypes for *S. rolfsii* could be improved by gene pyramiding and molecular breeding programs according to region preferences. Finally, advanced molecular studies (G x P x E) like epigenetic approach, quantitative trait loci (QTLs) and single nucleotide polymorphism (SNPs) associated with *S. rolfsii* resistance through genome wide association study (GWAS) are needed in the future approach.

4. CONCLUSION

According to the obtained data, we can conclude that selection is effective for improving yield and its components in dry bean. Also, from this selection program, data indicated that lines D 36-2 and D 30-4 gave the highest yield with good characters, meanwhile, lines D 6 and D 42 gave good yield with highest level of resistance displaying the lowest disease severity percentage against *S. rolfsii*. These promising lines could be recommended for certification (after more evaluations). They have high productivity, good yield components and resistance to *S. rolfsii*.

5. REFERENCES

Abdel-Ati KEA, Khereba AH, Faris FS and Hamed AA (2000). Genetic studies on bean (*Phaseolus vulgaris* L.) 2. Inheritance of plant height and seed yield and its components. Egypt. J. Plant Breed. 4: 157-177.

Abdou ES, Abd-Alla HM and Galal AA (2001). Survey of sesame root rot/wilt disease in Minia and their possible control by ascorbic and salicylic acids. J. Agric. Sci. 32(3): 135-152.

Anonymous (2002). Official Methods of Analysis of Association of Official Analytical Chemists, AOAC.17th ed. Gaithersburg MD ed. AOAC, Washington, DC.

Araújo SS, Beebe S, Crespi M, Delbreil B, González EM and Gruber V (2015). Abiotic stress responses in legumes: strategies used to cope with environmental challenges. Crit. Rev. Plant Sci. 34: 237–280.

Aycock R (1966). Stem rot and other disease caused by *Sclerotium rolfsii*. Technical Bulletin No: 174, North Carolina Agricultural Experimental Station, USA, 202 p.

Cardador-Martínez A, Loarca-Piña G and Oomah BD (2002). Antioxidant activity in common beans (*Phaseolus vulgaris* L.). J. Agric. Food. Chem. 50: 6975–6980.

Cherian E (2000). Genetic variability in Capsicum chinense Jacq M.SC. Thesis. Kerala Agricultural University. 213 pp.

Costa MR, Tanure JPM, Arruda KMA, Carneiro JES, Moreira MA and Barros EG (2010). Development and characterization of common black bean lines resistant to anthracnose, rust and angular leaf spot in Brazil. Euphytica, 176 (2): 149-156.

De Ron AM, Sparvoli F, Pueyo JJ and Bazile D (2017). Editorial: protein crops: food and feed for the future. Front. Plant Sci., 8:105.

Ejara E, Mohammed W and Amsalu B (2018). Genetic variability, heritability and expected genetic advance of yield and yield related traits in common bean genotypes (*Phaseolus vulgaris* L.) at Abaya and Yabello, Southern Ethiopia. African J. Biotechnology, 17 (31): 973-980.

Falconer DS (1981). Introduction to quantitative genetics, Longman. 133 Pp.

FAOSTAT (2020). FAOSTAT statistics. Food and Agriculture Organization of the United Nations.

Gomez AK and Gomez AA (1984). Statistical Procedures for Agricultural Research. 2nd edition & Sons Pub., PP.139-153.

Grichar VJ and Bosweel TE (1987). Comparison of Lorsban and Tilt With Terrachlor For Control of Southern Blight on Peanut. Texas. Agric. Exp. Station Pr 4534.

Hamed AA (2012). Developing new dry bean lines by selection. Egypt. J. Plant Breed., 16 (2): 37-48.

Hamed AA and Khalil EMEA (2010). Inheritance of growth habit, time of flowering and yield components in snap beans (*Phaseolus vulgaris* L.). Annals of Agriculture Sciences, Moshtohor, 48 (1): 153-172.

Hamed AA and Muhanna NAS (2017). Breeding for rust resistance and some economic characters in snap bean. Egypt. J. Plant Breed., 21 (2): 339-361.

Hibar K, Daami-Remadi M, Jabnoun-Khiareddine H and El-Mahjoub M (2006). Temperature effect on mycelial growth and on disease incidence of *Fusarium oxysporum*f. sp. *radicis-lycopersici*.*Pl.* Pathol. J., **5**: 233–238.

Johnson HW, Robinson HF and Comstock RE (1955). Estimates of genetic and environmental variability in soyabean. Agron. J., **7:** 314-318.

Junaid JM, Shah TA, Bhat AH, Bhat NA, Dar NA and Ambardar VK (2014). Morphology and status of occurrence of anthracnose of bean (*Phaseolus vulgaris* L.) caused by *Colletotrichum lindemuthianum* (Sacc. And Magn), Scrib in Keshmir valley. The Bioscan, 9 (1): 235–241

Kator L, Z. Y. Hosea ZY and Oche OD (2015). *Sclerotium rolfsii*; Causative organism of southern blight, stem rot, white mold and sclerotia rot disease. Annals of Biological Research, 6 (11): 78-89.

Kumar DP, Anupama PD, Singh RK, Thenmozhi R, Nagasathya A, Thajuddin N and Paneerselvam A (2012). Evaluation of extracellular lytic enzymes from indigenous *Bacillus* isolates. J. Microbiol. Biotechnol., 2: 129–137.

Li YP, You MP and Barbetti MJ (2014). Species of *Pythium* associated with seedling root and hypocotyl disease on common bean (*Phaseolus vulgaris*) in Western Australia. Plant Dis., 98 (9):1241–1247.

Liu L, Kloepper JW and Tuzun S (1995). Introduction of systemic resistance in cucumber against Fusarium wilt by plant growth-promoting rhizobacteria. Phytopathology, 85: 695-698.

McDermott J and Wyatt AJ (2017). The role of pulses in sustainable and healthy food systems. Ann. N. Y. Acad. Sci. 1392, 30–42.

Mghalu JM, Tsuji T, Kubo N, Kubota M and Hyakumachi M (2007). Selective accumulation of *Trichoderma* species in

soils suppressive to radish damping-off disease after repeated inoculations with *Rhizoctonia solani*, binucleate *Rhizoctonia* and *Sclerotium rolfsii*. J. Gen. Plant Pathol., 73: 250–259.

Miklas NP, Kelly JD, Beebe SE and Blair MW (2006). Common bean breeding for resistance against biotic and abiotic stresses: From classical to marker assisted selection breeding. Euphytica, 147 (1-2): 105-131.

Miklas NP, Porter LD, Kelly JD and Myers JR (2001). Characterization of white mold disease avoidance in common bean. Eur. J. Plant Pathol., 135:525–543.

Nosser MA (2011). Development of some new bean lines by selection. Egypt. J. Plant Breed. 15 (4): 51-62.

Punja ZK (1985). The biology, ecology and control of *Sclerotium rolfsii*. Annu. Rev. Phytopathol., 23: 97–127.

Reynoso-Camacho R, Ramos-Gomez M and Loarca-Pina G (2006). Bioactive components in common beans (*Phaseolus vulgaris* L.). Advances in Agricultural and Food Biotechnology, eds R. Guevara-González and I. Torres-Pacheco (Trivandrum: Research Signpost), 217–236.

Scarano D, Rubio F, Ruiz JJ, Rao R and Corrado G (2014). Morphological and genetic diversity among and within common bean (*Phaseolus vulgaris* L.) landraces from the Campania region (Southern Italy). Scientia Horticulturae, 180: 72–78.

Shaban WI and El-Bramawy MA (2011). Impact of dual inoculation with *Rhizobium* and *Trichoderma* on damping-off, root rot diseases and plant growth parameters of some legumes field crop under greenhouse conditions. Int. Res. J. Agric. Sci. Soil Sci., 1 (3): 98-108.

Singh RK and Chaudhary BD (1995). Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India.

Steel, R. C. D. and J. H. Torrie (1981). Principles and Procedures of Statistics. McGrow-Hill, Book Co., Inc., New York, USA. 156 p.

Subramanian SS and Menon M (1973). Heterosis and inbreeding depression in rice. Madras Agricultural Journal 60:1139.

Wang W (2016). QTL analysis and candidate genes identification associated with fusarium root rot resistance in common beans (*Phaseolus vulgaris* L.). M.Sc. Thesis, Michigan State University, Michigan, 115pp.

Wasonga CJ, Pastor-Corrales MA, Porch TG and Griffiths PD (2010). Targeting gene combinations for broad-spectrum rust resistance in heat-tolerant snap beans developed for tropical environments. J. Amer. Soci. Hort. Sci. 135 (6): 521-532.

Watanabe T (2002). *Sclerotium* sp. morphologies of cultured fungi and key species: pictorial atlas of soil and seed fungi, 2nd ed. CRC Press, New York. 504 pp.

Worrall E, Wamonje F, Mukeshimana G, Harvey J and Carr JM (2015). Bean common mosaic virus and bean common mosaic necrosis virus: Relationships, Biology and Prospects for Control. Elsevier, 93: 34-39.

Yousaf A, Wu J, Shakeel Q, Iftikhar Y, Ullah MI, Tahira U, Mubeen M and Dong W (2017). Evaluation of resistance of *Capsicum annum* against *Meloidogyne incognita* and *Sclerotium rolfsii* and their integrated management. PaKistan J. Zool. 49 (5):1671-1682.

الملخص العربي

الإنتخاب لبعض الصفات الإقتصادية والمقاومة لمرض اللفحة الجنوبية فى الفاصوليا الجافة

انتصار مصطفى اسماعيل أبوحمده[١] ورمضان أحمد عرفة[٢] وسماح فوزى أحمد الغباشى[٢] وأسماء محمد شبل[٢] وسعيد محمد كامل[٢]

[١]معهد بحوث البساتين – قسم تربية الخضر – مركز البحوث الزراعية
[٢]معهد بحوث امراض النباتات – قسم بحوث امراض الخضر – مركز البحوث الزراعيه

أجريت هذه الدراسة بمحطة بحوث البساتين بالقناطر الخيرية بمحافظة القليوبيه ومعهد بحوث أمراض النبات التابعين لمركز البحوث الزراعية– مصر خلال الفترة من ٢٠٢١ إلى ٢٠٢٢ بهدف إستنباط بعض السلالات الجديده المبشره من الفاصوليا الجافة والتى تتميز بالمحصول العالى وصفات الجودة المرغوبة بالإضافة الى المقاومة لمرض اللفحة الجنوبية وذلك عن طريق الإنتخاب. تم استخدام سبعة وأربعين سلالة منتخبة من الفاصوليا الجافة فى هذه الدراسة بالإضافة إلى الأصناف التجارية جيزة ٦، والكرنك، ونبراسكا. أشارت النتائج إلى أن معظم التباين الكلى للصفات المدروسة يرجع إلى التباين الوراثى كما أن كفاءة التوريث بمعناها العام كانت عاليه لكل الصفات المدروسه والتى تراوحت من ٦٤ إلى ٩٦% مما يدل على أن الإختلافات المعنويه بين الطرز الوراثية المقيمة تعود إلى التباين الوراثى مع وجود تأثيرات بسيطه للبيئه مما يؤكد أنه يمكن إستنباط سلالات جديدة من الفاصوليا الجافه عن طريق الإنتخاب لتلك الصفات إعتمادا على التباين المظهرى فى الأجيال الإنعزاليه المبكره. تم تقييم الطرز الوراثية للمقاومة لمرض اللفحة الجنوبية وأشارت النتائج إلى أن السلالة D 6 أعطت أفضل مقاومة للمرض حيث أعطت شدة إصابة ٦,٧% تلاها الأصناف D 39 ، وD 40 ، وD 42 ، D 46 حيث أعطوا شدة إصابة ٢٠% فقط. كما أشارت النتائج إلى أن خمسة من التراكيب الوراثية كانت مقاومة للمرض ، وعشرة تراكيب متوسطة المقاومة وثلاثة عشر تركيب متوسط الإصابة وتسعة عشر تركيب حساس للإصابة بينما باقى التراكيب الوراثية (ثلاثة تراكيب) فكانت عالية الحساسية للإصابة. كما أشارت النتائج إلى أن السلالتين D 4–30 ، وD 2–36 تعتبران مبشرتان ويمكن تسجيلهما كاصناف جديده من الفاصوليا الجافه (بعد مزيد من التقييم) لمحصولها المرتفع وصفات الجودة الجيدة. فى حين كانت السلالتين D 6 ، وD 42 سلالتين مبشرتين لمقاومتهما للإصابة بمرض اللفحة الجنوبية بالإضافة لإنتاجيتهما الجيدة.