INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 15, No. 2, p. 1-7, 2019

RESEARCH PAPER OPEN ACCESS

Germination and seedlings characters of some broad bean cultivars as affected by phosphorus fertilization levels

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Article published on August 30, 2019

Key words: Field bean cultivars, Phosphorus fertilization levels, Germination, Seedlings characters

Abstract

Broad bean is the most needed legume crop in Egypt and due to increase field bean production, it was necessary to maximize its productivity in newly cultivated sandy soil as a way of horizontal expansion. A laboratory experiment was carried out after the end of the field experiments in each season under the laboratory conditions of Administration of Examination and Certification of seeds in Dakahlia Governorate, Ministry of Agriculture and Land Reclamation. The purpose of this investigation was to assess seed germination and seedling characters resulted from the field experiment. The results showed that sowing Giza 716 cultivar significantly superior studied cultivars in germination and seedlings parameters and resulted in the highest values of final germination percentage, germination rate, germination index, shoot and root lengths and seedlings vigor index during combined analysis over seasons. Application the highest level of phosphorus fertilization (45 kg P_2O_5/fed) produced the highest values of germination and seedlings parameters, excluding mean germination time during combined analysis over seasons. It can be concluded that fertilizing broad bean Giza 716 cultivar with kg 45 or 30 P_2O_5/fed could be recommend enhancing germination and seedlings characters under the environmental conditions of Dakahlia Governorate, Egypt.

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Introduction

Broad bean (*Vicia faba* L.) is a common staple food in the Egyptian diet, eaten by rich and poor alike. Egyptians eat faba beans in various ways: they may be shelled and then dried, bought dried and then cooked. The most popular way of preparing broad bean in Egypt is by taking the mashed, cooked beans and adding oil, garlic, lemon, salt and cumin to it. The dish is considered the Egyptian national dish.

Chosen the high yielding cultivars is very important to raise crop productivity and quality. Whereas, broad bean cultivars were significantly different in seed quality. Therefore, this study is aiming to evaluate the broad bean cultivars for focusing light on the most promising cultivars that can be used on a large scale at studying area. In this concern, inbred lines have considerable variability in seed chemical composition. The mean carbohydrate content was very high and negatively correlated with seed yield, whereas the average protein content was relatively high and positively correlated with seed yield. Globulin was the significant fractionm followed by albumin. Hudeiba/ 93-S5 and Ed-damar-S5 are useful candidates in broad bean breeding program to terminate the protein deficiency malnutrition and provide healthy and nutritious meal for people living in subtropical areas (Gasim *et al.*, 2015). Improved genotype, Walki was comparable with Hachalu and gave substantially greater seed protein yield than the local cultivar (Kubure *et al.,* 2015). Studied quality characters were significantly influenced by eleven broad bean cultivars (Ibrahim, 2016). Nsovak genotype at hill spacing of 15 cm and fertilizing with 120kg N/ha enhanced seed germination and viability (Kandil *et al.*, 2017). The lowest mean germination time and maximum percentage of coefficient of velocity, tallest shoot and root, weight of fresh shoot, shoot and dry root were obtained from fertilization of phosphate at the rate of 31kg P_2O_5/fed. It could be summarized that seed Giza 111 cultivar recorded the best in seed viability when sown on first May and fertilized with phosphorus fertilizer at the rate of 74.4kg P2O5/ha (Kandil *et al*, 2017). Nubaria1 variety presented the first class in carbohydrate % as compared with other varieties i. e. Nubaria 2, Giza 3 improved, Sakha1 and Sakha 2 (Megawer *et al.*, 2017). Giza 3 variety was the superior and content of the nitrogen, phosphorus and potassium, while Giza 716, later and Nobaria 1 lied in between (Siam *et al.*, 2017). Seed quality characters *i.e.* total carbohydrates, crude protein, minerals (nitrogen, phosphorus, and potassium) content, arginine, lysine were significantly differed due to studied broad bean cultivars i.e. Nubaria 2, Sakha 1, Sakha 3, and Sakha 4 (Abdel-Baky *et al.*, 2019).

Phosphorus fertilizer is second only to nitrogen fertilizer in importance as an essential crop nutrient. Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division (Raghothama and Karthikeyan, 2005). Phosphorus compounds are involved in the transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds such as ATP and ADP for later use in growth and reproduction (Marschner, 1995). An adequate supply of available P in soil is associated with increased root growth, which means roots can explore more soil for nutrients and moisture. Phosphorus is an essential element for crops with greatly decreased uptake from fixation with mineral ions such as aluminum, iron, calcium and magnesium (Feng *et al.*, 2004). Plants can only absorb P as $H_2PO_4^{-1}$ or HPO_4^{-2}, which are mostly present in very low concentrations in the soil (Bhattacharyya and Jha, 2012). A large percentage of P from chemical phosphate fertilizers is not available to plants because at least 70–90% of P that enters the soil is fixed by Fe, Al, and Ca in soils (McBeath *et al.*, 2006). Plant nitrogen content of broad bean was increased by application of 40 kg phosphorus/ha (Adak and Kibritci, 2016). The application of 26.16kg P fed^{-1} produced higher protein percentage in seeds than that obtained for the control treatment (El-Agrodi *et al.,* 2017). Fouda (2017) showed that Soil application of phosphorus fertilizer significantly increased the average values of chemical constituents of broad bean plant as well as available N, P and K of soil after harvesting stage. The highest values recorded with using 75% from recommended dose P-fertilizers (Fouda, 2017). Therefore, the aim of this study was to determine the effect of some broad bean cultivars, phosphorus fertilization levels and their interaction on germination and seedlings characters under the environmental conditions of El-Sinblawin Center, Dakahlia Governorate, Egypt.

Materials and methods

The field experiment were carried out at private field in Toukh El-Aklam Village, El-Sinblawin Center, Dakahlia Governorate, Egypt, during the three unsequent successive winter growing seasons of 2013/2014, 2014/2015 and 2017/2018 to study the effect of some broad bean cultivars, phosphorus fertilization levels and their interaction on germination and seedlings characters.

The field experiments were carried out in split-plot design with three replications. The main-plots were occupied with broad bean cultivars (Sakha 1, Giza 3, Giza 843 and Giza 716). The sub-plots were assigned to phosphorus fertilizer levels (0, 15, 30 and 45kg P_2O_5/fed. Calcium superphosphate (15.5% P_2O_5) was added at the aforementioned rates before the first irrigation (21 days from sowing).

A laboratory experiment was carried out after the end of the field experiments in each season under the laboratory conditions of Administration of Examination and Certification of seeds in Dakahlia Governorate, Ministry of Agriculture and Land Reclamation. The purpose of this investigation was to assess seed quality resulted from the field experiment. Random sample of 400 seeds from each treatment were germinated on top filter paper in sterilized Petri-dishes (14-cm diameter). Each Petri-dish contained-25 seeds, and four Petri-dishes kept close together and incubated at 25ºC and 100% relative humidity, then four replications were used to evaluate every seed test done on each treatment as the rules of International Seed Testing Association (ISTA, 1985).

A- Germination parameters

1- Final germination percentage (FG %). It was expressed by the percentage of seed germinating normally after twelve days in 2014/2015 and 2017/2018 seasons as the following equation:

$$FG\ \% = \frac{\text{Number of normal seedlings}}{\text{Number of total seeds}} \times 100$$

2- Germination rate. It was calculated according following equation as described by Bartlett (1937) in 2014/2015 and 2017/2018 seasons.

$$\text{Germination rate} = \frac{\mathbf{a+(a+b)+\ (a+b+c)+\ \ldots\ldots+(a+b+c+m)}}{\mathbf{n\ (a+b+c+\cdots\ldots+m)}}$$

Where a, b, c and m are number of seedlings emerged at the first count, second count, third count and the final count, respectively and m is the number of counts. 3- Germination index (GI). It was calculated in 2014/2015 and 2017/2018 seasons based on the following equation of Ellis and Roberts (1981):

$$\text{Germination index} = \frac{\mathbf{N_1 + N_2 + N_3 + N_4}}{\mathbf{T_i}}$$

Where N_1, N_2, N_3 and N_4 are number of seedlings emerged at the first, second, third and fourth counts, respectively and T_i is count time. 4- Mean germination time (MGT). It was calculated in 2014/2015 and 2017/2018 seasons based on the following equation of Ellis and Roberts (1981):

$$MGT = \frac{\sum Dn}{\sum n}$$

Where (n) is the number of grains, which were germinated on day, D is number of days counted from the beginning of germination.

B- Seedling parameters

1- Shoot length: Averages of shoot length of the ten seedlings taken by random per each replicate from the seed to the tip of the leaf blade were recorded and expressed in centimeters as the shoot length at the end of standard germination test in 2014/2015 and 2017/2018 seasons.

2- Root length: Averages of root length of ten seedlings taken by random per each replicate from the seed to the tip of the radical and recorded and expressed in centimeters (cm) as the root length at the end of standard germination test in 2014/2015 and 2017/2018 seasons.

3- Seedling vigor index (SVI). It was calculated in 2014/2015 and 2017/2018 seasons according to the formula as suggested by AbdulBaki and Anderson (1973):

$$SVI = \frac{(\text{Shoot length} + \text{Root length}) \times \text{Germination percentage}}{100}$$

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split – plot design of season, then the combined analysis was performed between seasons as published by Gomez and Gomez (1984) by using means of "MSTAT-C" computer software package. Least significant difference (LSD) method was used to test the differences among treatment means at 5 % level of probability as described Snedecor and Cochran (1980).

Results and discussion

A- Cultivars performance

The obtained results in Tables 1 and 2 showed that the four studied cultivars *i.e.* Sakha 1, Giza 3, Giza 843 and Giza 716 were significantly differed in germination parameters (final germination percentage, germination rate and mean germination time) and seedlings parameters (root length and seedlings vigor index) during combined analysis over seasons. While, the differences among studied cultivars did reached level of significance in germination index and shoot length during combined analysis over seasons. Sowing Giza 716 cultivar significantly superior studied cultivars in germination and seedlings parameters and resulted in the highest values of final germination percentage, germination rate, germination index, shoot and root lengths and seedlings vigor index during combined analysis over seasons. Sakha 1 cultivar produced the highest values of mean germination time and the lowest values of final germination percentage, germination rate, germination index, shoot and root lengths and seedlings vigor index during combined analysis over seasons. While, the lowest values of mean germination time were obtained from sowing Giza 843 cultivar in combined analysis over seasons. The former results might be related to genetic factors which resulted from genetic makeup relations for the varieties.

These results are in agreement with those detected by Gasim *et al.* (2015), Megawer *et al.* (2017), Siam *et al.* (2017) and Abdel-Baky *et al.* (2019).

B- Effect of phosphorus fertilization levels

The obtained data revealed that phosphorus fertilization levels (0, 15, 30 and 45kg P_2O_5/fed) significantly affected germination parameters (final germination percentage, germination rate, germination index and mean germination time) and seedlings parameters (shoot and root lengths and seedlings vigor index) during combined analysis over seasons as shown from data presented in Tables 1 and 2.

Table 1. Means of final germination percentage, germination rate, germination index and mean germination time as affected by cultivars, phosphorus fertilization levels and their interaction during combined analysis over seasons.

Characters / Treatments	Final germination (%)	Germination rate	Germination index	Mean germination time (day)
Cultivars (C)				
Sakha 1	79.75	0.683	13.63	5.93
Giza 3	83.75	0.718	14.32	5.57
Giza 843	83.21	0.747	14.18	5.37
Giza 716	86.46	0.757	15.10	5.64
LSD at 5 %	2.41	0.030	NS	0.31
Phosphorus fertilization levels (P)				
Without	78.04	0.701	12.77	5.84
15 kg P_2O_5/fed	83.29	0.720	14.15	5.75
30 kg P_2O_5/fed	85.12	0.739	14.55	5.55
45 kg P_2O_5/fed	86.71	0.745	15.75	5.41
LSD at 5 %	2.61	0.017	1.21	0.18
Interaction (F. test):				
C × P	NS	NS	NS	NS

Table 2. Means of shoot length, root length and seedlings vigor index as affected by cultivars, phosphorus fertilization levels and their interaction during combined analysis over seasons.

Characters / Treatments	Shoot length (cm)	Root length (cm)	Seedlings vigor index
Cultivars (C)			
Sakha 1	29.32	22.37	42.38
Giza 3	30.23	24.91	45.70
Giza 843	30.49	24.20	47.05
Giza 716	32.26	26.44	49.76
LSD at 5 %	NS	0.93	1.54
Phosphorus fertilization levels (P)			
Without	28.45	23.54	40.83
15 kg P_2O_5/fed	30.66	24.29	46.64
30 kg P_2O_5/fed	31.58	25.00	48.02
45 kg P_2O_5/fed	31.59	25.08	49.40
LSD at 5 %	1.07	0.71	2.04
Interaction (F. test):			
C × P	*	*	NS

It can be stated that all studied germination and seedlings parameters were significantly increased as a result of increasing phosphorus fertilizer levels from 0 to, 15, 30 and 45kg P_2O_5/fed and the differences between them were obvious, with exception mean germination time which were decreased by increasing phosphorus fertilizer levels during combined analysis over seasons. Application the highest level of phosphorus fertilization (45kg P_2O_5/fed) produced the highest values of germination and seedlings parameters, excluding mean germination time during combined analysis over seasons. It means that broad bean plants responded to increasing phosphorus fertilizer level was up to 45kg P_2O_5/fed. Fertilizing broad bean plants with 30kg P_2O_5/fed came in the second rank after fertilizing with 45kg P_2O_5/fed with respect to these characters with lowest difference between them, followed by fertilizing with 15kg P_2O_5/fed and lastly broad bean plants growing without phosphorus fertilization (control treatment) during combined analysis over seasons.

The enhancement of germination percentage due to increasing phosphorus fertilization levels may be ascribed to the role of phosphorus in increasing vegetative growth, building up the photosynthetic area of broad bean plants and consequently increased dry matter accumulation and final germination percentage of seeds. These results are in agreement with those detected by Adak and Kibritci (2016), El-Agrodi *et al.* (2017) and Fouda (2017).

C- Effect of interaction

Regarding the effect of interaction, it could be noticed that shoot and root lengths in combined analysis over seasons were significantly influenced by the interaction between broad bean cultivars and phosphorus fertilization levels. The highest values of shoot and root lengths were obtained when mineral fertilization Giza 716 cultivar with 45kg P_2O_5/ fed in combined analysis over seasons as graphically illustrated in Figs. 1 and 2, respectively.

This interaction treatment followed by fertilizing Giza 843 cultivar with 45kg P_2O_5/fed in combined analysis over seasons. On the contrary, the lowest values of shoot and root lengths were resulted from plants of Sakha 1 cultivar growing without phosphorus fertilization in combined analysis over seasons.

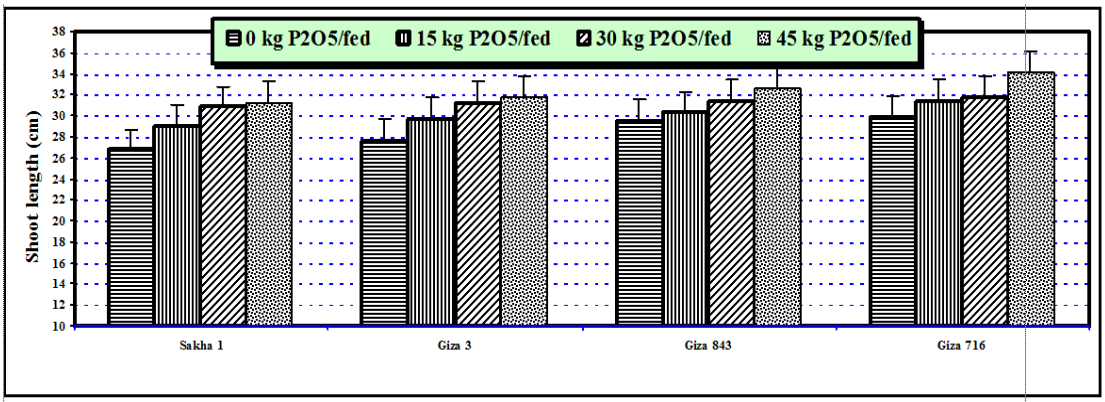

Fig. 1. Means of shoot length (cm) as affected by the interaction between cultivars and phosphorus fertilization levels during combined seasons of 2014/2015 and 2017/2018.

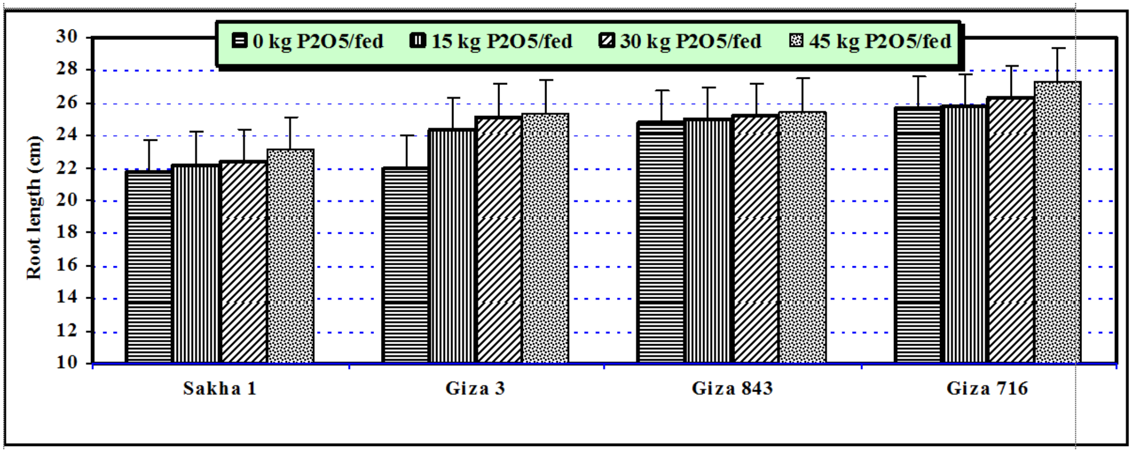

Fig. 2. Means of root length (cm) as affected by the interaction between cultivars and phosphorus fertilization levels during combined seasons of 2014/2015 and 2017/2018.

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