INTRODUCTION

1. INTRODUCTION

Faba bean *(Vicia faba*, L.) is one of the principal food legume crop in Egypt. It is a good source of protein and it is popular in human nutrition in most of Arab countries. As the world population increased a great effect must be done to increase its production per unit area especially in developing countries. Maximizing the productivity of faba bean yield per unit area and improving its quality could be achieved by choosing the suitable agricultural practices such as varieties, plant density and phosphorus fertilization.

Plant density plays a major role in yield improvement of faba bean. In the optimization of seed yield and quality of faba bean, plant distribution is main factor. Uniform and optimum distribution of plants per unit area is one of the factors responsible for increasing faba bean yield.

Phosphatic fertilizer may play an essential role in increasing the productivity of faba bean. Phosphorus is considered the second essential nutrient element for both plants and microorganisms. In spite of the considerable addition of phosphorus to soil, the amount available for plant is usually low. Phosphate dissolving bacteria and soil microorganisms can play an important role in improving plant growth and phosphate up take efficiency by releasing phosphorus from rock or tricalcium phosphate.

Improving the agricultural practices and applying the most appropriate cultural treatments will certainly increase the yield of faba bean per unit area. This is the most easier way for increasing faba bean production. Therefore, the present work was conducted to study the effect of plant density and phosphorus fertilization on growth, yield and its components of two faba bean varieties.

2. REVIEW OF LITERATURE

The available literature for these factors will be reviewed under three topics, i.e. varietal differences, plant density and phosphors fertilization on growth, yield, yield components and nutrients content of faba bean (*Vicia faba L.*).

1. Varietal differences:

Hassan *et al.* (1997) tested three new released varieties namely Giza 461, Giza 716 and Giza Blanca to plant populations and found that Giza Blanca cultivar recorded the highest number of branches, 100-seed weight and seed yield (7.6 ard./fed.). While Giza 716 and Giza 461 cultivars had higher values of number of pods and seed/plant.

Hassan and Hafiz (1998) found that Giza 3 cultivar surpassed both Giza 461 and Giza 716 in plant height, number of pods / plant, seed yields ,biological and straw but Giza 716 cultivar surpassed Giza 461 and Giza3 in the weight of 100-seed.

Ashmawy *et al.* (1998) showed that the tested varieties differed significantly in plant height and number of branches/ plant in both seasons. Giza 461 variety gave the tallest plants followed by Giza 3 and Giza 716 but number of seeds / pod was not significantly affected among varieties.

Hafiz and Abd El-Mottaleb (1998) found that the differences among the three faba bean cultivars, (Giza 3, Giza 461 and Giza 716) in plant height and number of branches/ plant were significant over both seasons. On the other hand there were no significant differences between the three studied cultivars in leaf area/ plant, leaf area index, pods yield/ plant, number of seeds/ pod, seed yield/ plant, shelling percentage, and 100- seed weight in the two growing seasons. The highest pods and seed yields/ plant were recorded by Giza 3, while the highest number of seed/ pod, shelling percentage and 100-seed weight were recorded by Giza 716 .The differences in seed, straw and biological yields/fed, seed protein content and protein yield were significant among the three studied varieties. Giza 3 recorded the highest seed yield/ fad, while the highest value in straw and biological yields/ fad were recorded by Giza 461.

Abd El Aziz and Shalaby (1999) showed that Giza 674 and Yousef El-Sedik varieties gave the highest value of plant height, number of branches, number of leaves, dry weight/plant, LAR, LAI and CGR. They added that Giza 2 cultivar gave the highest number of leaves, dry weight and leaf area /plant. While, Giza 429 cultivar gave the highest value of dry weight, leaf area/ plant, leaf area index and highest value of seed protein % .

Mohamed (2000) recorded that Cairo 375 and Giza 2 varieties did not differ significantly in dry matter of shoots, leaves and reproductive organ as well as / plant at various growth periods. He added that Cairo 375 was superior to Giza 2 in plant height, pods dry weight / plant, plant dry weight, number of pods seeds and seed yield / plant. However, the two varieties were statistically equal in number of branches, number of seeds / pod, seed and harvest index as well as seed, straw and biological yields/fed.

Saad and El-Kholy (2000) showed that Giza blanka significantly surpassed Giza 402 cultivars in number of branches/ plant, dry weight of leaves, 100- seed weight and seed, straw and biological yields/ fed., in addition to the harvest index . On the contrary, Giza 402 significantly overcome Giza Blanka for plant height, number of pods/ plant, number of seeds/pod parameters and percentage of protein in seed.

Bakheit *et al.* (2001) evaluated four faba bean cultivars (Giza2, Giza402, Giza429 and Giza674) at two different soil types of clay loam and sandy calcareous and they reported that Giza 674 gave the highest value of number of pods, seed yield, and seed index in old soil, while Giza 429 gave the highest value of seed yield and seed index in newly reclaimed soil. Comparison between the four commercial cultivars showed that Giza 429 and Giza 674 gave the highest seed yield and heaviest 100-seed weight at both seasons.

Sharaan *et al.* (2003) evaluated four faba bean cultivars (Giza2, Giza429, Giza843 and Misr-1) sown under three (15, 20 and 25 cm between hills).They found that the tested cultivars significantly differed for all studied characters i.e (seeds/ pod, seeds/ plant, seed weight/plant and seed yield/fed).

Ahmed and El-Abagy (2007) reported that Giza Blanka cultivar significantly surpassed Giza 3 cultivar in plant height, number and weight of pods/plant, number of seeds/plant, as well as seed , biological and protein yield/fed. Mean while, Giza 483 cultivar significantly exceeded Giza Blanca in number of branches/plant, straw yield/plant and or per fed and protein % /in seeds.

2. Plant density:

Aguilera-Diaz and Recalde-Manrique (1995) found that increase in plant population density from 10 to 16 plants / m^2 raised seed yield, but a further increase to 21 plants / m^2 did not increase yield significantly.

Shahein *et al.* (1995) recorded that increasing plant density reduced number of branches / plant and seed index the weight of green pods 1000 seeds, and dry seed yields/fed., while, seed weight was heavier with low density.

El Douby *et al.* (1996) indicated that yield components were significantly decreased by increasing plant density from 112.000 or 140.000 to 186.666 plants/fed. Whereas, plant height (in the second season), and seed and biological yields increased in both seasons. The seed yield increased by increasing plant density up to 186.666 plants/fed as compared to 140.000and 112.000 by (19.67 %, 33.56 %) and (18.24, 34.73 %) as well as biological yield by (16.56 %, 32.56 %) and (17.78 5, 26.43 %) in the first and second seasons, respectively.

Ashmawy *et al.* (1998) showed that increasing plant density from 17 to 33 and 50 plants / m^2 increased seed yield / fed by 23.4 % and 25.4 % in the first season, while these increases were 15.1 % and 16.4 % in the second season respectively. In addition, plant height significantly increased by increasing plant density from 17 to 33 and 50 plants / m^2 in both seasons. On the other hand, increasing plant density significantly decreased number of branches, pods and seed yield / plant as well as 100-seed weight in both seasons.

Hassan and Hafiz (1998) showed that decreasing plant spacing from 25 cm. to 15 cm. between hills caused significant increases in plant height and biological, straw and seed yields/fed. While, number of branches/plant, leaf area, leaf area index and number of pods/plant significantly decreased with narrowing planting space between hills within the row.

Abdel Aziz and Shalaby (1999) showed that plant population of 22 plants / m^2 gave highly significant increase in number of leaves, dry weight/plant, CGR, NAR, number of branches, pods and seeds / plant and seed yield per plant. While plant population of 27 plant/m^2 gave a significant increase in dry weight of leaves / plant, LAR and resulted significant increase in 100- seed weight and straw and biological yields/fed.

However, 33 plant/ m^2 gave highly significant increase in leaf area / plant, and leaf area index, seed yield / plant and harvest index, plant height and seed yield (Kg/fed.).

El-Refaey *et al.* (1999) revealed that mean squares of densities were highly significant for number of pods, seeds, seed yield / plant and efficiency in seed yield production/day. This would indicate that these traits responded differently with changing the plant density. On the other hand, insignificant densities mean squares were detected for number of seeds / pod and 100- seed weight.

Hussein *et al.* (1999) reported that faba bean seed and straw yields/ha significantly increased with increasing plant densities from 17 to 22 and 33 plants/ m^2 , and the reverse was true for number of pods, number of seeds and seed yield / plant.

El-Douby *et al.* (2000) reported that yield components of faba bean, i.e. number of branches/plant, number and weight of pods, number and weight of seeds / plant and 100-seed weight were decreased by decreasing the ridge width up to 40 cm, The highest values of seed and biological yields/fed were obtained with a ridge width of 50 cm, while the lowest values were obtained with 80 cm ridge width. Number of branches / plant and 100 - seed weight gave the highest values with planting one plant/ hill at 10 cm between hills on both sides of ridge in both seasons. However, planting two plants hill at 20 cm apart on both sides of ridge recorded the highest values of number and weight of pods seed plant and seed and biological yields whereas planting three plants / hill at 15 cm apart between hills on one side gave the lowest values in both season .

Ibrahem (2000) indicated that planting faba bean with 25 plants /m^2 tended to increase plant height up to 107 and 113 cm, seed yield/fed up to 1.493 and 1.116 ton, straw yield /fed to 3.229 and 3.492 ton and biological yield to 4.722 and 4.608 ton/fed in both seasons, respectively compared with plant densities of 19 and 13 plants/m^2 .On the other hand values of branches number, number of pods and seed yield / plant were higher with plant densities of 19 and 13 plants / m^2. While plant densities did not have significant effect on 100-seed weight.

Mohamed (2000) found that seed yield / fed significantly increased with increasing plant density up to 40plants/m^2. The highest yield/fed (14.63 ardab) was resulted by leaving two plants per/hill spaced 20 cm on both sides of ridges width 50cm (40 plants/m^2). The greatest straw yield was obtained with planting 66.6 and 80.0 plants/m^2. The greatest biological yield / fed were recorded for plant densities over 33.3 plants/m^2 closer ridge spacing (50cm) .

Bakheit *et al.* (2001) showed that the number of branches and pods / plant and 100 seed weight were increased as plant density decreased. While plant height and height to first pod had opposite reaction. He added that plant density of 33 plant / m^2 produced significantly higher yield / fed as compared with other population (22 and 66 plants / m^2). The increase in plant density also caused an increase in plant height which increased straw yield.

Mokhtar (2001) revealed that lower density i.e 88.889 plants/fed. gave significantly the higher number of branches, pods, seeds/pod and seeds/plant, weight of pods, seeds/plant and seed index compared with 133.333 plants/fed. While the reverse was true for seed and straw yields/fed.

Refay (2001) using three plant densities (10,20 and 30 cm. between hills) and found that plant height, biological and seed yields/fed. of faba bean increased with increasing the distance between plants.

Yeeransiri *et al.* (2001) found that growers should consider rates to achieve populations of at least 45 plants / m^2 for improved seed yield.

El-Murshedy *et al.* (2002) indicated that increasing plant density of faba bean from 17 to 40 plants/m^2 caused a significant increase in plant height and straw yield / fed but decreased number of branches / plant, number of pods / plant, number of seeds / pod, 100 - seed weight and seed yield / plant. They added that seed yield / fed increased gradually with increasing plant density up to 33 plants / m^2.

Hussein *et al.* (2002) reported that planting faba bean with 33 plants /m^2 gave higher values of seed and straw yields (5.15 and 3.96 ton/ha., respectively).Regarding to yield components,22 plants/m^2 significantly increased number of pods and seeds as well as seed yield / plant by 18.7, 18.1 and 18.4% respectively compared with 33 plants / m^2 .

Munir and Abdel-Rahman (2002) showed that seed weight / plant, 100-seed weight, number of branches / plant, seeds / pod, pod length and pods / plant, were negatively related to seeding rate. There was a trend for seed weight to decrease with increasing seeding rate. The lowest seeding rate (50 plants / m^2 produced the maximum seed weight plant (15.3 g.). An increase in internodes length, but not in the number of nodes plant. The highest (9.6) and the lowest (6.7) number of pods / plant, was recorded for the lowest (50 plants /m^2) and the highest (100 plants / m^2) seeding rates, respectively. On the other hand, yield was directly related to seeding rate. Seed yield increased as seeding rate increased, with highest yield being obtained at 100 plants / m^2.

Ben Mohamed (2003) found that plant densities (22, 33 and 44 plants / m^2) had a highly significant effect on yield of faba bean and their attributes. Number of branches / plant, plant dry weight number of pod and seeds / plant, number of seed / pod, 100-seed weight and seed yield / plant markedly depressed with increasing plant population density up to 44 plants/m^2. Whereas seed yield/fed was highly significantly increased with seeds of the 7^{th} node of main stem and the seed filling rate in growing seasons. Also, phosphorus fertilizer exerted its favorable of seeds, i.e. increasing the storage capacity of the sink. The well balance between source and sink faba bean plants might contribute much for the increasing dry matter accumulation and seed filling rate under high phosphorus dose compared with low phosphorus dose (0kg P_2O_5 / fed) .

El-Kalla ***et al.*** **(1999)** found that application of phosphorien® significantly increased number of branches/plant and plant height, number of pods/plant, 100-seed weight, seed yield/plant, and seed yield/fed. They added that, applied P rate up to 45 Kg P_2O_5/fed with phosphorein® increased seed protein percentage of faba bean.

Ghizaw ***et al.*** **(1999)** treated faba bean plants with different levels of P as triple super phosphate (0, 23, 46 and 69 Kg P_2O_5/ha). They found a positive linear response of seed yield to applied phosphorus. Application of phosphorus significantly increased plant height, shoot biomass and pods/plant compared to the control.

Amanuel ***et al.*** **(2000)** reported that inoculation with phosphorus bacteria did not cause a significant effect on the seed yield of faba bean at all three locations, and the interaction of inoculation with P application was also non-significant.

Hamissa ***et al.*** **(2000)** showed that the application of phosphate solubilizing bacteria (phosphorein®) significantly increased plant height dry weight / plant and seed yield/fed. of faba bean .

Saad and El-Kholy (2000) reported that plant height, dry weight of leaves and total dry weight of plant were significantly increased by phosphorus fertilizer as a foliar application (32 kg P2O5 /fed. and the foliar application of 0.35 % orthophosphoric acid). Compared with a soil application. Number of branches / plant insignificantly increased with application of phosphorus fertilizers.

Saleh *et al.* (2000) found that inoculation increased number and dry weight of nodules as well as dry weight and N content of shoots by 12.2, 24.8, 31.1 and 25.6%, respectively, compared with un inoculated controls. Inoculation combined with foliar application of P gave the highest increases in seed yield.

Mokhtar (2001) reported that seed yield and yield attributes of faba bean plants significantly affected by P fertilization. He added that, seed yield was increased by adding 31 Kg P_2O_5/fed. by 550 and 340 Kg/fed. compared with those received 15.5 and 23.25 Kg P_2O_5/ fed. respectively. Straw yield followed similar trend.

Zeidan and Abd El-Lateef (2001) indicated that increase phosphorus fertilization level from 24 to 48 kg P_2O_5 /fed. resulted in taller plants with greater number of branch / plant, 100-seed weight, seed yield and biological yield / plant, harvest index, seed yield/fed and protein contents in seeds of faba bean plant, in both seasons. Moreover number of pods and seeds/plant were increased by increasing P level which reflects directly on the yield. This may be due to that phosphorus fertilizer encouraged the vegetative growth plant, flowering and fruiting of both faba bean.

Abdalla (2002) reported that application of the bio-fertilizer (phosphorein®) to faba bean plants increased plant height, number of pods/plant and seed yield/fed.

Munir and Abdel-Rahman (2002) found that faba bean responded well to phosphorus fertilization. They showed that the seed yield, seed weight / plant, 100-seed weight, number seed / pod, plant height, pod length, number of pods/plant and branches/ plant were significantly increased with P application (52.5 kg/ha.) compared with control treatment .

Ahmed *et al.* (2003) studied the effect of a bio-fertilizer (phosphorein®), chemical fertilizers (NPK) and organic manure on the growth and yield of faba bean cv. Giza 614. The results showed positive effects of applied treatments compared with the control particularly on seed and straw yields/fed. They found also that 100-seed weight, seed yield/plant and seed protein yield were the highest with application of both bio and mineral phosphorus fertilizers.

Hamed (2003) found that plant height, pods and seeds weight / plant, seed protein % as well as pod and yield/fed were increased by phosphorus fertilization, while the lowest values for a forenamed traits were obtained in the unfertilized plots. With regard to phosphorein® treatments, inoculating faba bean seeds with phosphate dissolving bacteria (*B.megaterium*). i.e. "phosphorein® " surpassed the uninoculated in plant height, pods and seeds weight/plant, 100-seed weight, pod, seed and protein yields/ fed.

Kanany *et al.* (2004) concluded that inoculating faba bean seeds by P dissolving bacteria significantly increased seed yield/plant.

Koreish *et al.* (2004) reported that inoculation of faba bean plants with phosphate dissolving bacteria Bacillus megaterium (PDB) under farmyard manure and mineral fertilization gave higher dry weight / plant, 100-seed weight and seed yield. Nodulation of faba bean plants was insignificantly affected by mineral fertilization.

Tageldin and Mehasen (2004) found that application of 31.0 kg P_2O_5 /fed increased the total seed yield by 32 % in the first season and by 18 % in the second season relative to the application of 15.5 kg P_2O_5 /fed. The seed yield increased by only 11 % in the first year and by 4 % in the second year by increasing P rate to 46 Kg P_2O_5 / fed.

Mohamed (2005) showed that height number of branches, number of pods/ plant, number of seed / pod, seeds yield / plant and number of seed / plant in both seasons, as well as length of plant and 100- seed weight in the first season were significantly affected by phosphorus sources. The highest values of the previous characters were recorded when faba bean plants fertilizer with triple-super phosphate followed by mono calcium super phosphate in both seasons.

Abdel-Aziz (2007) found that phosphorus rates 45,90 and 130 kg/ha caused a significant increase in plant height, number of branches and leaves/plant, and leaves area/plant, at all growth stages compared with the control, except plant height, and leaves area/plant at branch stage. However, significantly increased in all yield components, at the end of growth.

Ahmed and El-Abagy (2007) observed that application of phosphorein® improved plant growth of faba bean expressed as plant height, number and dry weight of branches, leaves and pods / plant, as well as, LA / plant at 90 and 105 days significantly affected by bio - fertilizer treatment. Meanwhile, the effect on LAI at 90 days and SLW at 90 and 105 days after sowing failed to reach the significant level at 5 %.The addition of mineral phosphorus fertilizer at rate 46.5 Kg / fed P_2O_5 resulted in a significant increase in growth characters of faba bean plants compared with 15.5 and 31 Kg P_2O_5 / fed rates, except, the increase from 31.0 to 46.5 Kg P_2O_5 / fed and no significant increase in (number of leaves / plant and LAI at 90 days and SLW at 90 and 105 days after sowing).Whereas, the effect of the interaction between phosphorein®X P_2O_5 was significant on growth characters (except number of branches at 105 days and on leaves dry weight / plant after 90 days from sowing) as well as on yield and its components.

Mohamed (2007) showed that P application either as mineral or bio-fertilization significantly increased plant height, number of branches, number of pods, pods weight, seed yield/plant, seed, straw and biological yield/fed. and P % in the two successive seasons.

Saleh *et al.* (2008) obtained that combined inoculation with rhizobium and *Bacillus megaterium* did not record significant influence on growth, N and P up take of faba bean plants as compared to inoculation with rhizobium alone.

El-Gizawy and Mehasen (2009) found that adding 30 kg P_2O_5 / fed mixed with phosphate dissolving bacteria (PDB) markedly increased plant height, number of branches, pods, 100-seed weight, seed yield/ plant, seed and straw yields / fed. protein %, N%, P% N and P up take.