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# Response of Faba Bean to Tillage Systems Different Regimes of NPK Fertilization and Plant Interspacing

ALI ISSA NAWAR, AHMAD HUSSEIN AL-FRAIHAT [1]†, HASSAN EL-SAYED KHALIL‡ AND ABDELAZIZ MAHMOUD ABOU EL-ELA‡
*Crop Science Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt*
†*Department of Agricultural Sciences, Al-Shouback University College, Al-Balqa Applied University, Jordan*
‡*Crop Intensification Department, Agriculture Research Centre, Giza, Egypt*
[1]Corresponding author's e-mail: reef-frehat@hotmail.com; drfrehat@yahoo.com

## ABSTRACT

A two-year field study was conducted in winter seasons to investigate the effect of three tillage systems (one, reduced & conventional), three fertilization regimes (P, NP & NPK) and three plant population densities (formed by different hill spacings of 15, 20 & 25 cm among hills) on growth and productivity of faba bean cultivar, Giza 843. Response of number of pods and seed yield per plant, 100-seed weight and seed yield per faddan to tillage systems were significant, where conventional tillage gave higher values for these traits compared to no-and reduced tillage practices. Seed yield per plant, 100-seed weight and seed yield per faddan responded significantly to the fertilization regimes, where NP and NPK produced the highest seed yield per faddan, compared to P fertilization only. Number of pods and seed yield per plant and 100-seed weight significantly increased with increasing the spacings among hills, whereas the intermediate hill spacing of 20 cm produced the highest significant seed yield per faddan. Stepwise regression analysis emphasized the importance of number of pods per plant as an important seed yield component of faba bean. That was further elucidated with the positive and significant correlation between seed yield per plant and number of pods per plant. In conclusion, conventional tillage was superior to both reduced and minimum tillage systems in seed yield and its components. © 2010 Friends Science Publishers

**Key Words:** Faba bean; Tillage; Spacing; 100-seed weight; Seed yield

## INTRODUCTION

Faba bean (*Vicia faba* L.) is the most important legume crop in Egypt. Increasing seed yield potentiality may be attained by the combination of appropriate levels of management decisions of which tillage system, fertilization regime and plant population density are some factors that effect faba bean growing aspects.

Soil plowing and rearrangement with clean surface from preceding crop residues and weeds is a technique, which aims at a creation of better physical conditions for growth. Nevertheless, it causes reversible changes as water loss and organic matter decline. No and minimum tillage are considered as alternative techniques for tilling the soil. Despite no tillage disadvantages, as bulk density and soil compaction, which may negatively influence nutrients uptake with poor performance of root growth (Herridge & Holland, 1992), it is advantageous over conventional tillage in some cases, as conservation tillage (Francis, 1986). To escape from no tillage disadvantages and save time for sowing a crop, reduced tillage may be used as an important alternative (Khalil, 1997; Nawar & Khalil, 2004). Responses of faba bean growth to tillage operation were investigated in different studies. No negative or positive effects of no tillage application on faba bean were reported (Nawar & Khalil, 2004). Besides, EL-Douby and Mohamed (2002) and Nawar and Khalil (2004) observed a tendency for increase in seed yield, 100-seed weight and number of pods/plant of faba bean with tillage, compared to no tillage systems.

The macronutrients, which are essentially supplied as fertilizers and have internal effects on plant growth, are nitrogen, phosphorus and potassium. Data related to the internal effects of N, P and K combined supply on faba bean are limited; however, those regarding the combination of P and N, as a fertilization regime are scarce. Many investigators recommended combination of nitrogen and phosphorus in fertilizing faba bean (EL-Khawaga & Zeiton, 1986; Salem & EL-Nakhlawy, 1987).

Regarding plant density, it is well known that the number of any crop plants/unit area is one of the most important factors determining productivity. Such plant density depends on components of planting method, such as hill spacing. The optimum plant density is a factor, which

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achieves the highest possible crop yield, as recommended by the (Ministry of Agriculture & Land Reclamation, 2004). Divergent studies on the effect of plant density on faba bean traits were conducted by various researchers (Abo-Shetaia, 1990; EL-Habbak & EL-Naggar, 1993; EL-Douby *et al.*, 1996; EL-Douby & Mohamed, 2002), who indicated that increases in plant density decreased numbers of pods and seed yield/plant, as well as 100-seed weight, but increased seed yield/fad insignificantly, compared to the recommended density.

Accordingly, the present investigation was carried out to study the effect of tillage system, fertilization regime and plant density in an attempt to determine the optimum levels of such variables, which achieve the highest possible productivity of faba bean.

## MATERIALS AND METHODS

A two-years field study was conducted during 2006/2007 and 2007/2008 winter seasons at the Agricultural Research Station, Alexandria University, Egypt for the evaluation of faba bean Giza 843 cultivar, with regard to agronomic growth aspects. Soil chemical analysis was applied by using Absorption Flame Emission Spectrophotometer Model (Shimadzu Japan) AA-6200 according to the method described by Al-Alawi and Mandiwana (2007). Results of pH, organic matter, total nitrogen and available inorganic phosphorus were 8.4, 1.3%, 0.02% and 23 ppm, respectively.

A split-split plot design, with three replicates, was used in both the seasons. Tillage systems occupied the main plots, whereas the sub-and sub-sub plots were allocated to fertilization regimes and plant density of 15, 20 and 25 hill spacings, respectively. Tillage systems were conventional (three passes, $T_c$), reduced (cultivation of the soil upper layer using a rotary mower, $T_m$) and zero tillage (direct drilling without preparation, $T_0$). Meanwhile, fertilization regimes were the application of N only ($F_1$), combined application of N and P ($F_2$) and the combination of N, P and K ($F_3$). All these macro-elements were added, according to recommendations, as 15 (starter), 22.5 and 48 kg/fed of N, $P_2O_5$ and $K_2O$, respectively and broadcast on soil surface at the first irrigation (21 days after sowing). Sowing dates were November 15$^{th}$ in both the seasons. Plants were sown in hills, on the two sides of ridges, at spacing of 15, 20 or 25 cm. Each experimental unit (sub-sub plots) was 10.8 $m^2$ (area) of 3 m long and 3.6 m wide (six ridges).

At harvest, the inner four ridges of each faba bean sub-sub plot were harvested to measure seed yield. Representative samples of ten plants, taken at random, were used to calculate plant height (cm), number of pods and tillers/plant, seed yield/plant and 100-seed weight (g). Seed yield was estimated on sub-sub plot basis (kg), then, converted to ardab/fed (one ardab=155 kg, one feddan=0.42 hectare).

Statistical analysis, including analysis of variance, stepwise regression and simple correlation between the studied traits was conducted, according to (Gomez & Gomez, 1984).

## RESULTS

The analysis of variance presented in Table I. Showed significant effects of tillage systems on number of pods and seed yield/plant, as well as 100-seed weight and seed yield/fed. Data further revealed the significant response of seed yields per plant and per feddan, in addition to 100-seed weight, to fertilization regimes. Also the number of pods/plant, seed yield/plant, 100-seed weight and seed yield/fed were significantly influenced by the spacings among hills. No effect of interactions on the studied traits except for fertilization regime and between plants spacings on seed yield/fed was evident. Means of the studied traits, as affected by the three studied factors in both seasons, are presented in Tables II and III. Variations in number of pods/plant, among the three tillage systems were significantly greater for conventional, compared to the two other systems. Increases in pod number were 9.33 and 5.04 pods in the first season, in addition to 11.08 and 5.11 pods in the second season, greater for conventional tillage, compared to Zero and minimum tillage, respectively.

Application of no tillage system produced the least seed yield/plant, which was 0.88 and 1.74 g (in the first season) and 1.32 and 2.42 g in the second season, lower than minimum and conventional tillage, respectively. With regard to 100-seed weight, it had the same trend of seed yield/plant, as influenced by the tillage systems. Both conventional and reduced tillage systems had a significant effect on increasing the 100-seed weight by 1.14 and 1.04 g, in the two winter seasons, respectively. In addition, the conventional tillage surpassed the minimum tillage by 1.04 g, on the average 100-seed weight during the two seasons. Data related to seed yield/fed showed that variations in seed yield among the three tillage systems were significant in both seasons as shown in (Tables II & III). Absolute records for such trait were 100, 77.1 and 87.8% in the first season, corresponding to 100, 0.72% and 81.00% in the second one, for conventional, reduced and minimum tillage, respectively. Combined fertilization with nitrogen and phosphorus, or that in addition to potassium had a significant positive effect on seed yield/plant, 100-seed weight and seed yield/fed in both seasons, except for 100-seed weight in the second season (Tables II & III).

When faba bean was fertilized with phosphorus only, seed yield/plant and 100-seed weight were the lowest. Reductions in seed yield/plant for $F_1$ compared to $F_2$ and $F_3$ were, respectively 0.35 and 0.65 g in the first season and 0.42 and 0.71 g in the second season. Combination of N, P and K was superior to N+P by 0.15 g for seed yield/plant as an average of the two seasons and 1.64 g for 100 seed weight the first season only. Seed yield/fed significantly increased when N was applied in combination with both P

**Table I: Mean squares for the studied characters during 2006/2007 and 2007/2008 seasons**

| S.O.V. | df | Plant height (cm) | | No. of branches/plant | | No. of pods/plant | | Seed yield/plant (g) | | 100-seed weight (g) | | Seed yield/fed (ard/fed)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2006/07 | 2007/08 | 2006/07 | 2007/08 | 2006/07 | 2007/08 | 2006/07 | 2007/08 | 2006/07 | 2007/08 | 2006/07 | 2007/08 |
| Tillage trt. (A) | 2 | NS | NS | NS | NS | * | * | * | * | * | * | * | * |
| Error (a) | 4 | 4.73 | 2.57 | 0.21 | 0.18 | 0.328 | 0.770 | 0.014 | 0.090 | 2.202 | 0.670 | 0.300 | 1.13 |
| Fertilization level(B) | 2 | NS | NS | NS | NS | NS | NS | * | * | * | NS | * | * |
| Error(b) | 12 | 0.713 | 2.88 | 0.17 | 0.14 | 0.451 | 0.400 | 0.042 | 0.026 | 0.865 | 1.29 | 0.178 | 0.228 |
| Planting spacing (C) | 2 | * | * | NS | NS | * | NS | * | * | * | * | * | * |
| Error (C) | 36 | 2.278 | 2.300 | 0.15 | 0.14 | 0.78 | 0.510 | 0.051 | 0.064 | 0.753 | 1.24 | 0.065 | 0.017 |

**Table II: Means of studied characters as affected by tillage managements, fertilization regimes and hill spacing during 2006/2007 season**

| Treatment | Plant height (cm) | No. of branches/plant | No. of pods/plant | Seed yield/plant (g) | 100-seed weight (g) | Seed yield (ard/fed)* |
|---|---|---|---|---|---|---|
| | | | **Tillage level** | | | |
| T0 | 118.00±1.7 | 2.60±0.71 | 24.52±1.03 | 6.65±1.52 | 48.36±1.55 | 6.26±1.53 |
| Tm | 117.95±3.03 | 2.65±0.70 | 28.81±0.71 | 7.53±1.10 | 49.20±1.67 | 7.13±0.95 |
| Tc | 118.93±2.71 | 2.66±0.55 | 33.85±0.71 | 8.39±1.63 | 52.47±1.05 | 8.12±1.51 |
| L.S.D.$_{(0.05)}$ | NS | NS | 0.43 | 0.10 | 1.12 | 0.41 |
| | | | **Fertilization regime** | | | |
| P ($F_1$) | 117.59±1.53 | 2.63±1.52 | 26.65±1.55 | 7.19±1.32 | 48.13±1.51 | 6.87±1.10 |
| NP ($F_2$) | 118.40±2.57 | 2.64±1.35 | 29.07±1.15 | 7.54±0.98 | 50.13±1.71 | 7.13±1.18 |
| NPK ($F_3$) | 118.83±2.25 | 2.67±1.49 | 32.54±1.04 | 7.84±1.54 | 51.77±1.11 | 7.21±1.36 |
| L.S.D.$_{(0.05)}$ | NS | NS | NS | 0.12 | 0.55 | 0.25 |
| ($S_1$) 15 cm | 123.22±3.5 | 2.61±0.32 | 27.26±1.33 | 5.87±0.55 | 48.13±1.2 | 7.21±1.22 |
| ($S_2$) 20 cm | 118.15±2.52 | 2.63±0.28 | 29.67±1.46 | 8.16±0.71 | 50.13±0.95 | 7.57±1.76 |
| ($S_3$) 25 cm | 113.50±3.55 | 2.67±0.19 | 30.33±1.28 | 8.53±0.65 | 51.77±1.05 | 6.63±1.15 |
| L.S.D.$_{(0.05)}$ | 0.83 | NS | 0.49 | 0.13 | 0.48 | 0.14 |

**Table III: Means of studied characters as affected by tillage managements, fertilization regimes and plant spacing during 2007/2008 season**

| Treatment | Plant height (cm) | No. of branches/plant | No. of pods/plant | Seed yield/plant (g) | 100-seed weight (g) | Seed yield (ard/fed)* |
|---|---|---|---|---|---|---|
| | | | **Tillage level** | | | |
| $T_0$ | 123.44±2.56 | 2.70±0.75 | 23.70±1.04 | 7.28±0.95 | 50.22±1.15 | 6.61±0.83 |
| $T_m$ | 122.88±3.12 | 2.73±0.95 | 29.67±1.51 | 8.60±1.05 | 51.38±1.46 | 7.61±0.93 |
| $T_c$ | 123.00±2.86 | 2.77±0.87 | 34.78±1.23 | 9.70±1.10 | 52.02±1.06 | 8.51±0.97 |
| L.S.D.$_{(0.05)}$ | NS | NS | 0.76 | 0.23 | 1.12 | 0.80 |
| | | | **Fertilization regime** | | | |
| P ($F_1$) | 122.37±3.01 | 2.72±0.63 | 26.00±1.05 | 8.16±0.77 | 50.50±1.05 | 7.25±1.01 |
| NP ($F_2$) | 123.07±2.55 | 2.74±0.69 | 29.48±1.15 | 8.58±0.86 | 51.53±1.57 | 7.58±1.05 |
| NPK ($F_3$) | 123.01±2.78 | 2.76±0.77 | 32.67±1.32 | 8.87±0.95 | 51.59±1.66 | 7.91±1.15 |
| L.S.D.$_{(0.05)}$ | NS | NS | NS | 0.12 | NS | 0.28 |
| | | | **Plant spacing** | | | |
| 15 cm | 127.93±3.10 | 2.68±0.65 | 27.15±1.05 | 6.84±0.89 | 49.60±0.97 | 7.53±1.13 |
| 20 cm | 124.07±3.05 | 2.70±0.75 | 30.00±1.15 | 9.17±0.75 | 51.22±1.12 | 8.25±1.63 |
| 25 cm | 117.27±2.25 | 2.85±0.95 | 31.00±1.19 | 9.61±0.96 | 52.83±1.10 | 6.92±0.98 |
| L.S.D.$_{(0.05)}$ | 0.84 | NS | NS | 0.14 | 0.48 | 0.10 |

NS = Not significant
*(one ardab = 155 kg, one feddan= 0.42 hectare)

and K in the two seasons. Increase seed yield in the first season reached 4% and 4.9% for N+P and NPK, respectively compared to P fertilization regime. The respective increases in the second season were 4.6 and 9.1%. The effect of spacing among hills on plant height number of pods/plant, seed yield/plant, 100-seed weight and seed yield/fed was significant and followed the same trend except for number of pods/plant in the second season (Tables II & III).

Regarding plant height, increasing spacing among hills reduced plant height, the tallest plants (127.93 cm) were obtained at the highest plant density at 15 cm between hills, whereas the shortest plants (117.27 cm) were obtained at the lowest plant density at 25 cm among hills.

Both numbers of pods and seed yield/plant were proportionally affected by spaces among hills. Increase in hill spacing from 15 to 20 cm increased number of pods/plant by 2.41 pods in the first season and 2.90 pods in the second season. However, further increases in the same variable, up to 25 cm increased this trait by 3.07 and 2.85 pods in the two successive seasons, respectively. Meanwhile the maximum and minimum seed yield/plant were respectively obtained from 25 and 15 hill spacing, respectively. Among hill interspacing of 20 cm exceeded seed yield/plant than that of 15 cm by 2.31 g as an average of the two seasons, but decreased by 0.40 g compared to 25 cm hill spacing.

Concerning the effect of hill spacing on 100-seed weight data showed a progressive and significant increase in such weight with increasing hill spacing in both seasons. As an average of both seasons, the 20 and 25 cm hill spacing recorded higher values for 100-seed weight, compared to 15 cm hill spacing and amounted to 3.7 and 7.0%, respectively. Seed yield/fed significantly increased with increasing hill spacing from 15 to 20 cm. Further increase in hill spacing to 25 cm, was associated with a significant decline in such yield. An average of both seasons, for 15, 20 and 25 hill spacings, was 7.37, 7.91 and 6.78 ardab/fed, respectively.

Stepwise regression (max R) indicated that the number of pods/plant accounted for 56 and 53% of the variations in seed yield/fad, in both seasons, respectively. However, including the number of branches per plant with that of pods/plant raised the interpretation to 71 and 93%, in the first and second seasons, respectively. The remaining characters showed minor contributions to the interpretation of variations in seed yield. These findings emphasize the importance of number of pods per plant as an important seed yield component in faba bean and the role played by hill spacing, in determining the number of branches developed on the plant, which might have an effect on number of pods and hence, seed yield per plant.

Simple correlation coefficients between pairs of studied characters, in both seasons, are presented in (Table IV). The results revealed that seed yield per plant was positively and significantly correlated with number of branches and pods per plant and 100-seed weight. Seed yield/fad was positively correlated with number of pods per plant, in the two seasons and with number of branches per plant only in the second season.

**Table IV: Simple correlation coefficients between pairs of studied characters in 2006/2007 and 2007/2008 seasons**

| Characters | | No. of pods/ plant | Seed yield/ plant | 100-seed weight | Seed yield/ fad.** |
|---|---|---|---|---|---|
| No. of branches/plant | 2006/07 | 0.79* | 0.81** | 0.85** | 0.36 |
| | 2007/08 | 0.60NS | 0.74* | 0.90** | 0.73* |
| No. of pods/plant | 2006/07 | | 0.73* | 0.80** | 0.75* |
| | 2007/08 | | 0.85* | 0.74* | 0.73* |
| Seed yield/plant | 2006/07 | | | 0.84** | 0.38NS |
| | 2007/08 | | | 0.93** | 0.50NS |
| 100-seed weight | 2006/07 | | | | 0.49NS |
| | 2007/08 | | | | 0.23NS |

* Significantly different at P<0.05 probability; NS, non-significant
** (one ardab = 155 kg, one feddan= 0.42 ha)

## DISCUSSION

Among the essential ingredients affecting any crop growth trait, tillage system (Nawar & Khalil, 2004), fertilization regime and plant population density (Salem & EL-Nakhlawy, 1987) play an important role in that aspect. Conventional tillage reduces the soil mechanical resistance to plant-roots penetration, leading to deeper rooting system, which increases the uptake of growth resources, especially from the soil deeper layers and consequently, increased seed yield. (El-Metwally *et al.,* 1990; Gomma & El Naggar, 1995; El-Douby & Mohamed, 2002), who reported that conventional tillage had a positive effect on faba bean seed yield. Despite seed yield reduction, in case of no tillage-application, such procedure could be effective in critical conditions, as the short-turn period between two consecutive crops (Francis, 1986; Herridge & Holland, 1992).

Data suggested that the balanced application of N, P and K affected the seed yield of faba bean and its yield components either significantly or insignificantly. These results could be due to N acceleration for plant growth, coupled with the enhancement of N and K uptake, which was associated with increases in the increases in the period of reproductive stage and seed yield production (Yagodin, 1984). Khalil *et al.* (2003) the same conclusion in case of sunflower increases in the uptake of growth resources increased photosynthesis and efflux of photoassimilates from leaves to plant economic parts, increasing a single seed weight and seed yield per plant and per land unit area (Yusuf *et al.,* 1989; Zamski & Scaffer, 1996; Nawar & Khalil, 2004).

Increasing plant density, as plants were spaced at 15 cm apart, was associated with an increase in LAI and mutual shading. An increase in mutual shading led to less uptake of growth factors, causing a reduction in photosynthesis and photoassimilates translocation into the plant reproductive parts to decrease pod setting and a single seed weight hence seed yield. Abo-Shetaia (1990) that a higher plant density was associated with greater seed yield. Data showed a compensatory relationship between seed yield and its morphological attributes to emphasize the concept of Wallace and Yan (1985) who reported that plant density was a critical limit that might be associated with seed yield increase, despite a reduction of, at least, one yield component. Data also reached the same conclusions of (El-Habbak & El-Naggar, 1993; EgyptianMinistry of Agriculture & Land Reclamation, 2004).

## CONCLUSION

Increasing Faba bean seed were associated to application of conventional tillage, in case of sufficient time (for land preparation) between two consecutive crops, balanced addition of nitrogen, phosphorus and (potassium at the levels of 15 kg N+22.5 kg $P_2O_5$+48 kg $K_2O$/fed) and a suitable plant population density.

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