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# Effect of Some Agronomic Practices on Ascochyta Blight Severity and Yield of Faba Bean (*Vicia faba* L.) in Tunisia

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## ABSTRACT

**Background:** In Tunisia, faba bean (*Vicia faba* L.) is the first major food legume. The development of faba bean production is facing several biotic constraints. Faba bean Ascochyta blight caused by *Ascochyta fabae* is one of the most destructive diseases of faba bean and can cause significant yield loss under favorable conditions. As only incomplete resistance ABL varieties are available, some agronomic practices should be applied to control and reduce Ascochyta blight incidence wherever possible. Therefore, this work was undertaken to evaluate the effect of spacing row and seed rate on ABL severity, growth and yield of faba bean.

**Methods:** A split-plot design with three replications was adopted to carry out this study during 2018 and 2019 cropping seasons. 'Bachaar' faba bean variety was sown at 40 and 60 cm row spacing and at three seed rates (100, 140 and 200 kg $ha^{-1}$). ABL severity was assessed visually on a 0-9 scale and agro-morphological traits were measured. Analysis of variance was used to analyze the data. Correlations between agronomic traits, row spacing, seed rate and ABL severity were investigated.

**Result:** Results showed that seed rate has a larger effect on yield than row spacing. In both cropping seasons, the highest grain yield was recorded in 60 cm row spacing and 140 kg $ha^{-1}$ seed rate treatment. So, this treatment is recommended for obtaining high yield of faba bean. Most of the variation in disease severity was associated with seed rate (r=0.62). The highest ABL score severity was noted at 200 kg $ha^{-1}$ rate. Over both years, wide row spacing and low seed rate reduced ABL severity. In this study, the small amounts of ABL disease (which reached a score of 5.3 and 4.7 in 2018 and 2019, respectively) had little or no effect on yield.


**Key words:** *Ascochyta fabae*, Faba bean, Row spacing, Seed rate, *Vicia faba* L., Yield.

## INTRODUCTION

Globally, faba bean (*Vicia faba* L.) is cultivated in 2.5 M. ha with a production of 4.5 million tons (FAOSTAT, 2019). As a legume, faba bean enhances the soil fertility by fixing atmospheric nitrogen in a wide range of conditions. Biological nitrogen fixation provides about 80% of the plant's nitrogen needs reaching 160 kg $ha^{-1}$ (Hauggaard *et al.*, 2009). Faba bean serves as a valuable source of proteins (Alshameri *et al.*, 2021) ranging from 24% to 35% (Crépon *et al.,* 2010). The productivity of faba bean is constrained by various abiotic and biotic stresses. Among biotic stresses, Ascochyta blight, caused by *Ascochyta fabae* is one of the most destructive diseases of faba bean in Tunisia and can cause upto 35% yield loss under favorable conditions (Kharrat *et al*. 2006). In the absence of faba bean variety totally resistant to ABL, some methods have been used to control and reduce ABL disease effects. The development of integrated disease management options (application of fungicides, crop rotation, use of resistant varieties, sowing date, row spacing and seeding rate) considerably reduces Ascochyta blight infection and are crucial for it's successful control (Ahmed *et al*., 2016). Furthermore, plant spacing in the field facilitate aeration and light penetration into plant canopy and optimize rate of photosynthesis as confirmed by Ugwuoke *et al*. (2021). Optimum spacing can ensure proper growth of the aerial and underground parts of the plant through efficient utilization of solar radiation, nutrients, water, land as well as air spaces and therefore contribute to the increased yield as confirmed by Malik and Singh, (1996). Lopez-Bellido *et al*. (2005) reported that plant density can affect canopy development, radiation interception, drymatter production and evaporation of water from the soil under the crop, weed competition, the development of fungal and viral diseases, podding and harvesting height and eventually, seed yield. In Tunisia, in the absence of faba bean variety totally resistance to ABL, row spacing and seed rates methods should be used to control and reduce ABL disease effects and help for the disease management of faba bean.

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## MATERIALS AND METHODS

### Experimental procedure

The experiment was conducted on farm field in Beldiya, Bousalem region over 2017/2018 and 2018/2019 cropping seasons under rainfed conditions. The area is situated in Jendouba governorate which is located in the northwest of Tunisia. For both cropping seasons, the maximum and minimum temperatures and rainfall are presented in Fig 1 and Fig 2. The treatments consisted of two raw spacing (40 and 60 cm) and three seed rates (100, 140 and 200 kg $ha^{-1}$). 'Bachaar' faba bean variety, was planted in a in a split-plot design with three replications. Main plots consisted of row spacing and subplots as seed rate. Each row was 4 m long. Ascochyta blight severity (ABL) was assessed visually on a 0-9 scale, where: 0= no infection, 1= 1-9% of foliage area affected per plot, 2= 10-19%, 3= 20-29%, 4= 30-39%, 5= 40-49%, 6= 50-59%, 7= 60-69%, 8= 70-79% and 9= ≥80% of the foliage area affected per plot. At full maturity, plant height (grain yield per ha (GY$ha^{-1}$) and biological yield per ha (BY$ha^{-1}$) were measured.

### Data analysis

Data regarding ABL severity and agro-morphological traits were subjected to ANOVA using statistix 8.1 computer software. Correlations between traits, row spacing, seed rate and ABL severity were investigated using simple correlation coefficients.

## RESULTS AND DISCUSSION

### Impact of row spacing and seed rate on growth and yield of faba bean

### Plant height

In both 2018 and 2019 cropping seasons, the analysis of variance of plant height indicated that seed rate and row spacing had a significant effect on plant height of faba bean (Table 1). Results inferred that plant height increased with increasing seed rate and decreasing row spacing (Table 2). Maximum plant height was recorded under 40 cm row spacing (105.8 and 108.1 cm in 2018 and 2019, respectively) and 200 kg $ha^{-1}$ seed rate (127.7 and 140.7 cm in 2018 and 2019, respectively). The interaction effect of row spacing and seed rate was not significant on plant height of faba bean. The narrowest row spacing (40 cm) and highest seed rate (200 kg $ha^{-1}$) gave significantly taller plants (134.7 and 146 cm, respectively) than the rest of the treatments. The increase in plant densities contribute to the increase of plant height. This was probably due to competition of plants in higher densities for light leading to taller stems, as well as the production of fewer tillers and develop longer internodes resulting in taller plants as confirmed by Singh *et al.* (2013).

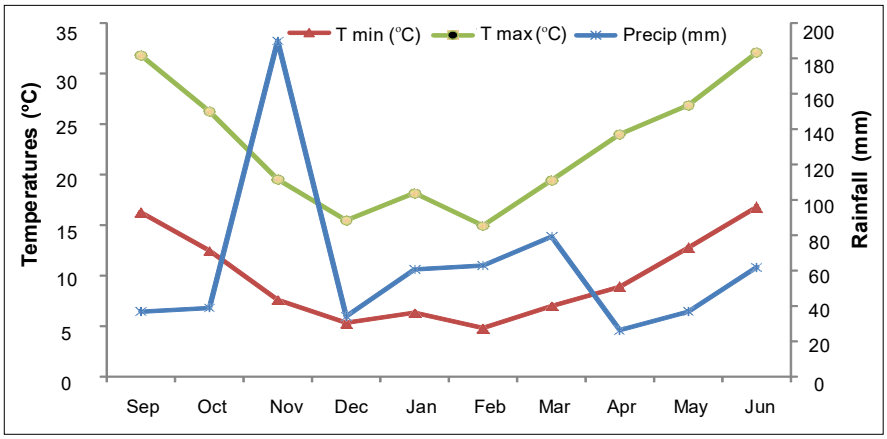


**Fig 1:** The maximum and minimum temperatures and rainfall recorded at Beldiya during 2017-2018 cropping season.

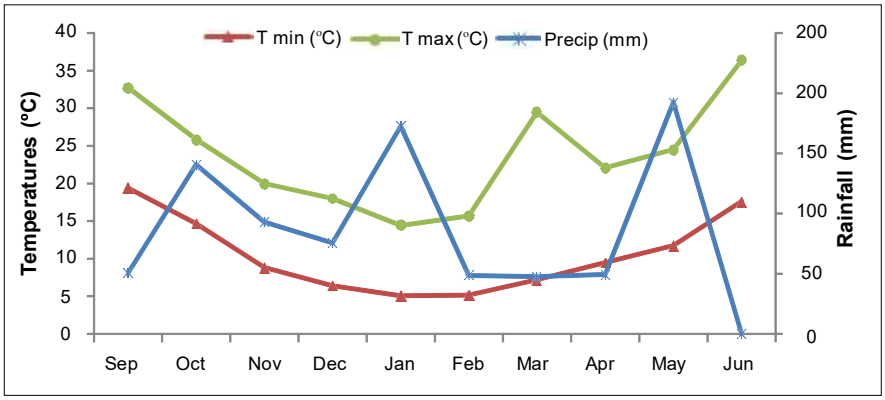


**Fig 2:** The maximum and minimum temperatures and rainfall recorded at Beldiya during 2018-2019 cropping season.

**Biological yield**

Data given in Table 1 indicated that, in the first year, biological yield was influenced by seeding rate only.. But during the second year, both row spacing and seeding rate affected biological yield significantly. During the two years of study,*viz.*, 2018 and 2019 cropping seasons, maximum biological yield was recorded at 140 (with 1952.5 and 2271.5 kg ha$^{-1}$) and 200 kg ha$^{-1}$ seed rate (with 1841.8 and 2079.7 kg ha$^{-1}$), respectively. Over 2018 and 2019, row spacing × seeding rate interaction effects on biological yields were not significant. However, 60cm row spacing and 140 kg ha$^{-1}$ seed rate treatment was found to be the best for faba bean production in terms of biological yield per hectare (Table 2). This combination produced the highest biological yields 2053 and 2313 kg ha$^{-1}$ in 2018 and 2019, respectively. Biological yield was higher in high plant densities compared to low plant densities. This was due to the higher leaf area index which provided a larger surface area for light interception resulting in higher net photosynthesis and might have led to greater biomass per unit area as confirmed by Almaz and Kindie (2017). This result is in line with Al-Rifaee *et al*. (2004) who reported that the drymatter yield of faba bean increased with increasing plant population due to the increase in the number of plants per unit area and the associated increase in plant height. Similarly, biomass yield was justified by number of plant per unit area. Seeding rate also indirectly influences light interception, duration of vegetative growth, weed and disease control and finally grain quality (López-Bellido *et al*. 2005).

**Grain yield**

In both 2018 and 2019 cropping season, the analysis of variance of grain yield resulted in highly significant effects with seed rate (Table1). Analysis of variance did not show any significant effect on grain yield with row spacing and the row spacing × seeding rate interaction. The highest grain yield was registered under 140 kg ha$^{-1}$ seeding rate with 1806.5 and 2014.7 kg ha$^{-1}$ in 2018 and 2019 cropping seasons, respectively. Grain yield was tending to increase with increasing seed rates but at a density higher than optimal, grain yields decreased. Indeed, seed yield responded positively to an increase in seed rate up to about 140 kg ha$^{-1}$ and slightly decreased with 200 kg ha$^{-1}$. Results of Table 3 inferred that the increase in seed rate from 100 to 140 kg ha$^{-1}$ increased grain yield from 1427 to 1806.5 kg ha$^{-1}$ in 2018 and from 1513.2 to 2014.7 kg ha$^{-1}$ in 2019. At 200 kg ha$^{-1}$ seed rate, grain yield decreased significantly. This extrapolation has been reported by Li *et al*. (2015) in corn (*Zea mays* L.) where the amount of drymatter accumulation and harvest index decreased with increasing seeding rate, although seed yield increased until an upper limit is reached and then began to decline. The influence of row spacing × seed rate interaction on seed yield was not significant. However, the highest seed yield (1874 and 2050 kg ha$^{-1}$ registered in 2018 and 2019, respectively) was observed at 60 cm row spacing combined with 140 kg ha$^{-1}$ seed rate treatment. An optimum plant density ensures proper growth of the aerial and underground parts of the plant through efficient utilization of solar radiation, nutrients, land as well as air spaces and water as reported by Malek *et al*. (2012). As plant density per unit area increased there is more plant to plant competition which results in low nutrient partitioning into seeds as compared to straw; as a result there was low seed yield with low seed weights as confirmed by Kissi and Tamiru (2016).

**Table 1:** Analysis of variance with F values of plant height (PH), first pod level (FPL), grain yield (GY), biological yield (BY) and Ascochyta blight severity (ABL) over 2018 and 2019 cropping seasons.

| Year | Source of variation | PH | FPL | GY | BY | ABL |
|---|---|---|---|---|---|---|
| 2017-2018 | Row spacing (RS) | 10000** | 4.23 | 0.82 | 2.56 | 3.57 |
| | Seeding rate (SR) | 18.40** | 22.77** | 6.93* | 7.53* | 11.20** |
| | RS × SR | 0.05 | 0.01 | 0.01 | 0.12 | 1.6 |
| 2018-2019 | Row spacing (RS) | 387.77** | 0.01 | 1.10 | 18.71* | 4 |
| | Seeding rate (SR) | 404.82** | 153.54** | 12.99** | 27.82** | 7.6* |
| | RS × SR | 1.31 | 8.76** | 0.34 | 0.12 | 0.4 |

**Table 2:** Means of plant height (PH) and biological yield (BY) under different row spacing and seeding rate over 2018 and 2019 cropping seasons.

| Year | Row spacing | Plant height (PH) | | | | Biological yields per ha (BY/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Seed rates (kg ha$^{-1}$) | | | | Seed rates (kg ha$^{-1}$) | | | |
| | | 100 | 140 | 180 | Means | 100 | 140 | 180 | Means |
| 2017-2018 | 40 (cm) | 84 | 98.7 | 134.7 | 105.8a | 1322 | 1852 | 1724.3 | 1632.8a |
| | 60 (cm) | 75 | 88.3 | 120.7 | 94.7b | 1643.3 | 2053 | 1959.3 | 1885.2a |
| | Means | 79.5a | 93.5a | 127.7b | - | 1482.7a | 1952.5b | 1841.8b | - |
| 2018-2019 | 40 (cm) | 79.7 | 98.7 | 146 | 108.1a | 1448.7 | 2230 | 2054 | 1910.9a |
| | 60 (cm) | 76 | 89.3 | 135.3 | 100.2b | 1598.3 | 2313 | 2105.3 | 2005.6b |
| | Means | 77.8a | 94b | 140.7c | - | 1523.5a | 2271.5b | 2079.7b | - |

**Table 3:** Means of grain yield (GY) and Ascochyta blight severity (ABL) under different row spacing and seeding rate over 2018 and 2019 cropping seasons.

| Year | Row spacing | Grain yield (GY) | | | | Ascochyta blight severity (ABL score) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Seed rates (kg ha$^{-1}$) | | | | Seed rates (kg ha$^{-1}$) | | | |
| | | 100 | 140 | 180 | Means | 100 | 140 | 180 | Means |
| 2017-2018 | 40 (cm) | 1372.3 | 1739 | 1407.3 | 1506.2a | 3.67 | 4.33 | 6.33 | 4.78a |
| | 60 (cm) | 1481.7 | 1874 | 1553.3 | 1636.3a | 3 | 3.67 | 4.33 | 3.67a |
| | Means | 1427a | 1806.5b | 1480.3a | - | 3.33a | 4a | 5.33b | - |
| 2018-2019 | 40 (cm) | 1543.3 | 1979.3 | 1600.3 | 1707.7a | 3 | 4.33 | 5 | 4.11a |
| | 60 (cm) | 1483 | 2050 | 1696 | 1743a | 3 | 3.67 | 4.33 | 3.67a |
| | Means | 1513.2a | 2014.7b | 1648.2a | - | 3a | 4b | 4.67b | - |

### Impact of row spacing and seeding rate on Ascochyta blight severity

The analysis of variance of ascochyta blight severity showed a significant effect of seed rate in 2018 and 2019 cropping seasons. Over both the years, the effect of row spacing and row spacing × seed rate interaction were not significant (Table 1). Results of Table 3 showed that the increase in seed rate from 100, 140 and 200 kg ha$^{-1}$ increased Ascochyta blight severity. Ascochyta blight severity was lower at 100 kg ha$^{-1}$ seeding rate (mean score of 3.33 and mean score of 3 in 2018 and 2019, respectively), compared to the highest severity of Ascochyta blight (mean score 5.33 and mean score 4.67) that was scored at 200 kg ha$^{-1}$ seed rate. Reduced plant population density could be one tool in a program to manage Ascochyta blight of faba bean. Decreasing disease severity level of faba bean observed with 100 kg ha$^{-1}$ seed rate could be due to proper aeration resulting in decreased humidity level suitable for fungus growth and decreasing plant population also limits the transmission of rust pathogen to the next plant as confirmed by Mengesha and Tesfaye, (2015). Disease incidence and severity tended to increase with increased plant spacing in susceptible cultivars as confirmed by Maasa *et al*. (2006). Tala and Shalaldeh (2006) reported that lowering plant density reduced the risk and pressure of diseases such as chocolate spot and Ascochyta blight. In Tunisia, Ascochyta blight disease is among the major constraint to yield improvement and adoption of the crop by farmers which cause complete yield loss. Since only faba bean are susceptible to Aschochyta blight, cultural practices such as optimum seed rate and row spacing could be able to control this disease as confirmed by Kimurto *et al*. (2013).

### Correlation among disease severity and yield and related traits

The objective of this study was to evaluate the effect of some cultural practices on yield and disease development. The level of association among disease severity and yield and related traits could be helpful for the achievement of the highest yield and determining the suitable row spacing and seed rate to decrease diseases severity. Results showed that Ascochyta blight (ABL) severity was significantly ($p \leq 0.01$) and positively correlated with seed rate (r=0.62) and plant height (r=0.61) (Table 4). It is known that plant diseases impose significant yield losses. In this study, ABL severity was not correlated with grain and biological yields. Consequently, ABL attacks had no negative impact on yields. Our results are consistent with those found by McGrath, (2004), who reported that small amounts of ABL disease have little or no effect on yield and the disease may not be worth controlling. Biological yield was positively correlated with seeding rate (r=0.55), plant height (r=0.35) and grain yield (r=0.87). It is usually not sufficient to determine whether a disease is present or absent. The critical information required is the amount of disease that is present. Disease often has to exceed a certain threshold before it reduces the yield of a crop.

**Table 4:** Coefficients of correlation between ABL severity, plant height (PH), first pod level (FPL), grain yield (GY), biological yield (BY), row spacing and seeding rate.

| | RS | SR | PH | GY | BY |
|---|---|---|---|---|---|
| SR | - | 1 | | | |
| PH | -0.19 | 0.89** | 1 | | |
| GY | 0.16 | 0.15 | -0.05 | 1 | |
| BY | 0.26 | 0.55** | **0.35*** | **0.87**** | 1 |
| ABL | -0.32 | **0.62**** | 0.61** | -0.22 | 0.07 |

## CONCLUSION

The present study demonstrated that besides genetic constitution, row spacing and seed rate also control growth performance of faba bean. Seed rate has a larger effect on yield than row spacing. The highest grain yield was recorded in 60 cm row spacing and 140 kg ha$^{-1}$ seeding rate treatment. So, this treatment is recommended for obtaining high grain yield. In this study, ABL attacks have little or no effect on faba bean yields because the small amounts of disease. However, low seeding rate could reduce the Ascochyta blight severity. Therefore, decreasing density could be one tool to manage Ascochyta blight of faba bean. The choice of row spacing and seed rate should be considered as important components of integrated pest management and reduce Ascochyta blight pressure wherever possible in faba bean. Since this research is done in one location, research works should be carried out for confirmation in different location in the future.

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