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# Response of local landrace of bean to different methods of mycorrhizal applications

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## Abstract

Common bean, *Phaseolus vulgaris* L., is widely harvested by small farmers in the northwest of Spain. Micorrhizae are an important symbiotic relationship between fungi and plant roots. Mycorrhizal fungi enhance growth and development and increase legumes yield. This work was carried out during 2010 and 2011 in the province of León, Spain, under irrigated conditions to determinate the influence of mycorrhizal application method on the yield and yield components of a local landrace of bean (Riñón de León). A randomized block design with four replications was used and the experimental plot area was 11.0 m$^2$. The treatment were: (1) zero application (untreated), (2) mycorrhizal application over seed before sowing, sowing in seedbed and transplant into the soil, (3) mycorrhizal application over seed before sowing and sowing in the soil, (4) mycorrhizal dry application in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it, and (5) mycorrhizal application with water in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it. At maturity four groups of 10 plants with productive pods in each plot were hand harvested. The information collected was dry matter production and the yield and yield components. The data were analysed by conducting an analysis of the variance using SPSS. The comparison of the means which was conducted was based on Tukey test. The plant population density at harvest was not affected by the treatments. However, the yield and the dry matter production were affected by mycorrhizal application. Mycorrhizal application improved yield per plant except with sowing in seedbed, due mainly to increased the number of pods per plant. The treatment (2) provided the low yield, 187.5 g/m$^2$. The biggest yield was obtained by the treatment (5), 430.5 g/m$^2$. Mycorrhizal application improved dry matter production per plant except with sowing in seedbed; roots, leaf-stems and pods (including seeds) increased their dry weight. The treatment (2) provided the low dry matter production (30.5 g/plant). The biggest dry matter production was obtained by the treatment (3) 68.4 g/plant. Harvest index was not affect by the treatments, the yield per plant is influenced by the plant size. Transplant is not favorable for bean production. Although mycorrhizal applications improve the common bean production is not a solution in transplant situations.

**Keywords: bean, mycorrhizal, yield, harvest index**

## 1 Introduction

Common bean (*Phaseolus vulgaris* L.) is widely harvested in northwest Spain, and contributes significantly to the sustainability of traditional cropping systems, because of the predominance of small-scale bean farmers. The socio-economic peculiarities of Province of León (main common bean producing area in Spain) have enabled the maintenance of traditional varieties. Bush bean genotypes, with growth habit type I (Singh, 1982), are growing in popularity due to the convenience of mechanisation and management of the crop and their general suitability for cultivation as a sole crop.

Chemical pesticide use is more and more restricted due to its risks to human health and the environment, as well as other inputs such as fertilizers; so implementation of sustainable agriculture has become imperative in crop production.

The arbuscular mycorrhiza play an important role in the maintenance and stability of the agroecosystem contributing to the fertility, structure and biodiversity of soil. Mycorrhiza are an important symbiotic relationship between fungi and plant roots, and this is one of the most widespread symbioses in natural and cropping systems. They stimulate plant growth (Barea, 1997). Mycorrhiza increase the uptake of plant nutrients that move from soil to plant by diffusion and thus play a critical role in nutrient cycling and eco-system functioning (Kernaghan, 2005). They improve plant growth and facilitate the access to water and nutrients and can positively contribute to nutrient and water use efficiency (Brussaard *et al*., 2007). Among others, they may also help the plant to thrive under polluted conditions (Shetty *et al*., 1994) and contribute to protecting plants from infection by pathogenic fungi and nematodes, (Alarcón *et al.*, 2004).

Mycorrhizal fungi enhance growth and development and increase legumes yield. But legume roots growing in non-sterilized soils become naturally colonized with indigenous arbuscular mycorrhiza, and several authors have expressed scepticism concerning the likelihood of obtaining a significant response to arbuscular mycorrhiza inoculation in the field (Chalk *et al*., 2006). In particular, common bean respond to the mycorrhizal colonization but there are differences between genotypes (Hacisalihoglu *et al*., 2005).

This study evaluated the influence of mycorrhizal application method on the yield and yield components of a local landrace of bean (Riñón de León).

## 2 Materials and methods

Two experiments were carried out in Ribas de la Valduerna [Latitude: 42º18.5’ N; Longitude: 5º57.1’ W; Altitude: 799 m] (León province - Spain), one in 2010 and one in 2011, using a traditional bean landrace and different mycorrhizal application methods. The 2010 plot was a loam with an organic matter content of 2.8% and pH of 6.2. The 2011 plot was a loam with an organic matter content of 1.9% and pH of 6.7. In both cases, the previous crop was winter wheat.

The experiment was a randomised block design with four replicates. A traditional bean landrace (Riñón de León) was used. The cycle (from sowing to harvesting) of this landrace is Medium (100-105 days), it has a Growth habit Type I (Singh, 1982) and its seed is white and of a medium size (1,000-seed weight, 450 g). The treatments were: (1) zero application (untreated), (2) mycorrhizal application over seed before sowing, sowing in seedbed and transplant into the soil, (3) mycorrhizal application over seed before sowing and sowing in the soil, (4) mycorrhizal dry application in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it, and (5) mycorrhizal application with water in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it. A mixed inoculum including two arbuscular mycorrhiza (*Glomus intraradices* and *Glomus mosseae*) in commercial products from ATENS were used.

Conventional tillage was used for land preparation, including mouldboard ploughing and vibrating tine cultivation to prepare a suitable seedbed. In 2010, sowing was carried out on 15 May and in 2011 on 21 of the same month. Before sowing, 250 kg/ha of calcic superphosphate (7.9% P and 20.0% Ca) was applied and soil incorporated. The plots were kept free from weeds by applying Ethalfluralin prior to sowing (dose: 0.0025 $m^3$/ha). The plos were irrigated 5 times, from the third week of June until the first week of August using furrow irrigation system (c. 50 litre/$m^2$ of water were applied at each irrigation). There were no pest and disease incidents.

Forty plants were collected from each plot. Four effective areas in each plot were randomly selected and then, from each of these areas, 10 consecutive plants bearing productive pods were hand-harvested at seed maturity (13 August in 2010 and 17 August in 2011).Each plant was extracted manually with an agricultural tool. Plants were cut at ground level to separate the roots from the stems. Roots, stems with leaves (leaf-stems) and pods including seeds were separated, oven-dried at 80 8C to a constant weight to allow correction of data to absolute dry weight, and weighed. Data were recorded for the following characteristics:

- Dry weight (DW) data: DW data were recorded for the 40 harvested plants and this was used to calculate indices of DW partitioning: root weight ratio (RWR = root DW/total DW); leaf-stem weight ratio (LSWR = leaf-stem DW/total DW); pod weight ratio (PWR = pod DW/total DW); and harvest index (HI = seed DW/total DW).
- Number of pods per plant: this was determined from the 40 harvested plants.
- Number of seeds per pod: this was determined from the 40 harvested plants.
- Dry seed weight (g): this was determined from a sample of 1,000 chickpea seeds.
- Grain production per plant (g/plant) was calculated from the yield components.
- Grain yield (g/m$^2$) was calculated from the yield components and the plant population at harvest.

The data were analyzed by analyses of variance using the routines of SPSS version 15.0.1. Means comparison was based on Tukey test ($P$< 0.01 and $P$< 0.05) (Steel and Torrie, 1986).

## 3 Results an discussions

Practically there were no significant differences between years for registered characters (data not shown). The environmental conditions were similar both years and the characteristics of the fields were not very different.

The plant population density at harvest was not affected by the treatments, although the seedling survival can improve with the mycorrhiza inoculation (Ortas, 2010). The seedling survival was high in all treatments (data not shown).

The dry matter production was affected by the treatments. There were highly significant differences between treatments for total dry matter production (Table 1). The mycorrhiza application improved the plant dry weight versus untreated, except for treatment (2) that provided the lowest total dry weight (30.5 g/plant). This local bean land race did not adapt to the transplant. The results demonstrate the benefits of mycorrhiza fungi application on the growth (Barea, 1997; Hacisalihoglu *et al*., 2005; Gardezi *et al*., 2012; Tajini *et al*., 2012) of this common bean land race, although this response can be different for other genotypes (Hacisalihoglu *et al*., 2005). The biggest total dry weight per plant was obtained by the treatment (3), 68.4 g/plant. Total plant dry weight was highly variable (CV = 34.3%). Mycorrhiza application improved plant growth parameters, all parts increased weight, but biomass partitioning was not affected by mycorrhiza application (data not shown), similar results were obtained by Tajini *et al*. (2012).

The number of pods per plant was the only yield component affected by the different treatments (Table 2). A highly significant difference was observed for number of pods per plant between mycorrhiza application methods. According to Safapour *et al*. (2011) and Gardezi *et al*. (2012) the highest numbers of pods per plant were produced with mycorrhiza application, without seedbed. The mycorrhiza application allowed the number of pods per plant to increase. No differences were detected between application methods. Pods per plant was highly variable yield component compared to seeds per pod and 1,000-seed weight, which were relatively less variable.

As growth, yield characteristics were strongly affected by mycorrhiza application. Highly significant differences were observed for plant production and for seed yield (Table 2). The treatment (2) produced the lowest plant production 17.7 g/plant and the lowest seed yield (187.5 g/m$^2$). The highest yield was obtained with mycorrhizal application with water in the seed row directly onto the soil during sowing after placing the seed on the soil but before burying it (430.5 g/m$^2$), although there not significant differences with other application methods. The results show that when no seedbed is carried out the mycorrhiza applications increase the seed yield (Ramana *et al*., 2010; Safapour *et al*., 2011; Gardezi *et al*., 2012) due mainly to an increase in the number of pods per plant, the way application has not influence. The increased yield was the result of an increased number of pods per plant (Valenciano *et al*., 2007), pods per plant is closely related with final seed yield.

There was no difference between treatments for harvest index, the increase in yield was accompanied to the same extent by an increase in total dry matter production. Harvest index was lowly variable (CV = 7.4%). The yield per plant is influenced by plant size or/and plant biomass (Scully & Wallace, 1990).

## 4 Conclusions

The mycorrhizal application under field conditions improved the growth and yield of local bean landrace, due to increase in pods per plant. There were no differences between methods used. The transplant was not favorable for the local bean landrace used (Riñón de León).

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*Table 1. Dry weight (DW) production at maturity of the treatment with an indication of significance and their coefficient of variation (CV) according to analysis of variance in experiment soils.*

| | **Root DW (g/plant)** | **Leaf-stem DW (g/plant)** | **Pod DW (g/plant)** | **Total DW[a] (g/plant)** |
|---|---|---|---|---|
| Application method [c] | NS[b] | NS | $p \leq 0.05$ | $p \leq 0.01$ |
| (1) | 3.4 | 15.1 | 82.0 | 43.5 |
| (2) | 2.9 | 19.3 | 77.3 | 30.5 |
| (3) | 2.7 | 18.2 | 79.1 | 68.4 |
| (4) | 2.5 | 17.4 | 80.1 | 67.7 |
| (5) | 2.6 | 17.2 | 80.2 | 67.4 |
| CV (%) | 28.4 | 20.5 | 5.4 | 34.3 |

[a] DW: dry weight. [b] NS: not significant.

[c] Treatments: (1) zero application (untreated), (2) mycorrhizal application over seed before sowing, sowing in seedbed and transplant into the soil, (3) mycorrhizal application over seed before sowing and sowing in the soil, (4) mycorrhizal dry application in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it, and (5) mycorrhizal application with water in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it.

*Table 2. Mean yield components and seed yield of the treatment with an indication of significance and their coefficient of variation (CV) according to analysis of variance in experiment soils.*

| | ***Yield components*** | | | **Plant production (g/plant)** | **Yield (g/m²)** | **Harvest Index** |
|---|---|---|---|---|---|---|
| | Pods/plant | Seeds/ pod | 1000-seed weight (g) | | | |
| Application method [c] | $p \leq 0.01$ | NS[b] | NS | $p \leq 0.01$ | $p \leq 0.01$ | NS |
| (1) | 15.5 | 4.05 | 417.3 | 26.0 | 283.9 | 59.8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (2) | 10.8 | 3.91 | 398.9 | 17.7 | 187.5 | 56.0 |
| (3) | 20.6 | 4.21 | 434.1 | 37.9 | 396.0 | 55.3 |
| (4) | 21.2 | 4.53 | 417.8 | 40.1 | 395.1 | 59.1 |
| (5) | 21.3 | 4.44 | 420.1 | 39.9 | 430.5 | 58.9 |
| CV (%) | 28.7 | 8.5 | 8.4 | 35.4 | 39.9 | 7.4 |

[a] DW: dry weight. [b] NS: not significant.

[c] Treatments: (1) zero application (untreated), (2) mycorrhizal application over seed before sowing, sowing in seedbed and transplant into the soil, (3) mycorrhizal application over seed before sowing and sowing in the soil, (4) mycorrhizal dry application in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it, and (5) mycorrhizal application with water in the seed row directly on the soil during sowing-after placing the seed on the soil but before burying it.