FIELD PERFORMANCE OF COMMON BEAN (*PHASEOLUS VULGARIS* L.) UNDER MYCORRHIZAL INOCULATION AND PHOSPHORUS LEVEL APPLICATION IN KASHUSHA, EASTERN DR CONGO
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ABSTRACT

The positive effects of arbuscular mycorrhizal fungi (AMF) on yield and phosphorus uptake have already been widely studied. However, the response of common bean (*Phaseolus vulgaris* L) to mycorrhizal inoculation under phosphorus supply conditions is still poorly documented in South-Kivu, where the use of fungal biofertilizers is not yet tested. This study was initiated to assess the effect of AMF inoculation and increasing phosphorus doses on common bean performance and yield in South Kivu to reduce phosphate input. The study was conducted during the A 2021 cropping season at the experimental field of the "Université Evangélique en Afrique" at Kashusha, Kabare territory. A split-plot design was used to compare two levels of mycorrhizal inoculation (with and without inoculation) with three rates of increasing phosphorus (0, 30, 60 and 120 kg P ha^{-1}). Growth, yield and mycorrhizal colonization parameters were recorded. Inoculation with *R. irregularis* significantly improved root mycorrhization rate, biomass, yield and harvest index (HI) of bean at 0 kg P ha^{-1} and 30 kg P ha^{-1}. The performance of bean plants inoculated with *R. irregularis*, in terms of collar diameter, aboveground biomass, total biomass, yield and HI at 30 kg P ha^{-1}, was superior to those non-inoculated and inoculated plants at the doses of 60 kg P ha^{-1} and 120 kg P ha^{-1}, suggesting the potential of AMF in reducing phosphate fertilizer input. The results indicate that P levels significantly affected the mycorrhization rate of bean. The application of 60 and 120 kg P ha^{-1} drastically reduced the mycorrhization rate confirming the influence of inorganic P on the establishment of mycorrhizal symbiosis. Therefore, the responses induced by AMF were also dependent on the applied P dose. Mycorrhizal inoculation with *R. irregularis* could be an important lever to boost bean yield and ensure phosphate fertilizer saving in ferralitic soils of Kashusha.

Keywords: *Phaseolus vulgaris L.*, Arbuscular mycorrhizal fungi, Phosphorus nutrition, South-Kivu

INTRODUCTION

Land degradation and declining soil fertility are the major constraints to crop productivity, especially for legumes. Common bean is more dependent on macronutrient availability in the soil, especially phosphorus, which determines its performance and yield. In terms of nutrient uptake, beans consume more phosphorus than other nutrients (Chekanai *et al.,* 2018). It was also demonstrated that a significant increase in yield was obtained with increasing doses of phosphate fertilizers on common bean. Thus, under phosphorus deficiency conditions, plants remain weak, and deformation of organ development occurs as a result of defective cell division (Liang *et al.,* 2022). According to Chekanai *et al.* (2018), phosphorus supply in legumes can doubles the biomass production and consequently increase the bean yield. In addition, soil microorganisms, such as arbuscular mycorrhizal fungi (AMF), play an important role in improving plant mineral nutrition and nutrient cycling in the soil. Accordingly, they are actively involved in phosphorus absorption and solubilization in different agro systems (Veresoglou *et al.,* 2012). On common bean, it has been shown that AMFs contribute effectively to yield improvement by enhancing pod development and productivity (Chekanai *et al.,* 2018). Therefore, inoculation with efficient strains of AMF could enhance phosphorus use efficiency and biological nitrogen fixation on bean and thus, ensure phosphate fertilizer savings. However, the response of common bean (*Phaseolus vulgaris* L) to mycorrhizal inoculation under phosphorus supply conditions is still poorly documented in South-Kivu province where the use of fungal biofertilizers is not yet tested. Furthermore, the optimal phosphorus dose to combine with AMF inoculation for successful bean performance is not yet determined. Based on the above background, this study was initiated to determine the effect of AMF inoculation and increasing doses of phosphorus on common bean performance in South-Kivu to reduce phosphate input.

MATERIALS AND METHODS

The study site was located at the experimental field of the "Université Evangélique en Afrique" at Kashusha in the territory of Kabare. The study was conducted during the A cropping season (2021) as a split-plot design to compare two levels of mycorrhizal inoculation (with and without inoculation with AMF *Rhizophagus irregularis* strain), and three increasing phosphorus doses (0, 30, 60 and 120 P kg ha^{-1}, corresponding to D_0, D_1, D_2, and D_3 respectively). The combination of factors resulted in a total of eight treatments which were randomly arranged as a bloc. Inoculation was placed on large plots while phosphorus doses were assigned to small plots. The treatments tested in this study are described as follows; T1: Myc+D_0, T2: Myc+D_1, T3: Myc+D_2, T4: Myc+D_3, T5: NonMyc+D_0, T6: NonMyc+ D_1, T7: NonMyc +D_2, T8: NonMyc+D_3. Phosphorus was applied as Triple Superphosphate (TSP). The optimal rate of 60 P_2O_5 kg ha^{-1} was considered as a reference rate from which the other rates were established (Chuma *et al.,* 2022). A localized application of fertilizer was made in each plot according to the different treatments studied. Mycorrhizal inoculum was applied to the plots at the same time as the fertilization using 20 g of soil inoculum per hole, containing AMF concentration of 10 spores g^{-1} soil. For fertilized and inoculated treatments, the inoculum was placed just above the fertilizer in direct contact with the seed while being separated from the fertilizer by a small amount of soil. Sowing was done at 40 cm × 20 cm to maintain a density of 60 plants ha^{-1} on all the elementary plots. After three months, the plants were harvested, and the different parameters were measured.

Growth parameters were measured 1 month before the physiological maturity, and a week before harvest. These include plant height, collar diameter, leaf area and aboveground and root biomass. While yield parameters were evaluated during harvesting time (number of pods, number of grains per pod, 100-seed weight, harvest index and yield). Mycorrhizal colonization under the different treatments under study was assessed according to the method of Trouvelot *et al.* as described by Ndeko *et al.* (2022). A portion of the roots (~2g) was retained for this purpose.

RESULTS AND DISCUSSIONS

Mycorrhizal colonization under treatments application

In the control treatment, bean plants showed low mycorrhization regardless of the applied phosphorus rate. By contrast, in plants inoculated with *R. irregularis*, mycorrhizal inoculation significantly increased root colonization and a significant interaction between the factors was observed as attested by the two-way ANOVA test (Table 1). The result indicated that P levels drastically reduced the mycorrhizal colonization rate (mycorrhization frequency and intensity) at the rate of 60 and 120 kg of P. In addition, fertilizer application rate has negative effects on the mycorrhizal colonization, arbuscule and vesicle formation in agro systems (Tanwar *et al.,* 2013).

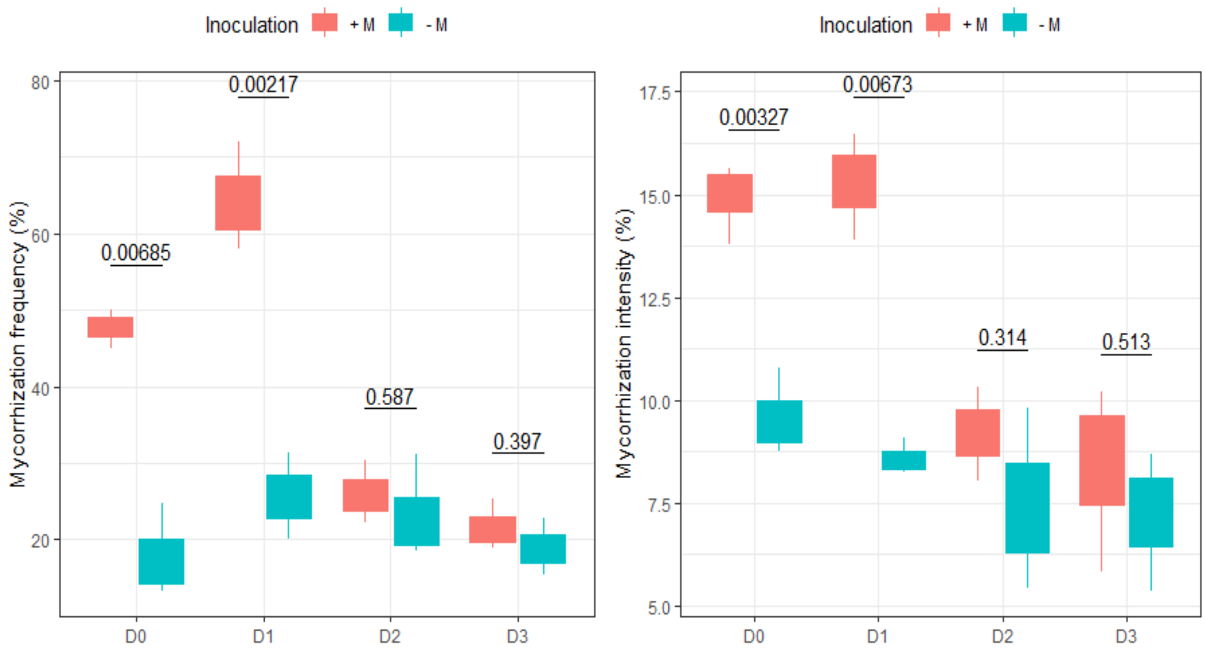

Fig. 1. Arbuscular Mycorrhizal Fungal (AMF) colonized root length in percent of the total root length (mycorrhizal frequency and mycorrhizal intensity). The plants were supplied with triple superphosphate at three fertilization levels: 0, 30, 60 and 120 P kg ha^{-1}.

Effect of mycorrhizal inoculation and P fertilizer application rate on growth of common bean

The relationship between growth parameters and treatments were plotted in the Fig. 1. The results showed that mycorrhizal inoculation significantly improved plant growth at the rate of 0 and 30 kg P ha^{-1} (Table 1). The performance of inoculated plants, in terms of collar diameter, aboveground biomass and total biomass at the dose of 30 kg P ha^{-1}, was superior compared to non-inoculated plants and inoculated plants at the doses of 60 and 120 kg P ha^{-1}. However, the leaf area was not affected by the mycorrhizal inoculation regardless the P dose applied. These results suggest that mycorrhizal inoculation has a potential role in improvement of common bean growth and ensuring phosphate fertilizer input.

Effect of mycorrhizal inoculation and P Fertilizer application rate on grain yield of bean

Compared to non-inoculated plants, mycorrhizal inoculation increased bean yield and harvest index at the rate of 0 and 30 kg P ha^{-1} (Fig. 2). But at the rate of 60 and 120 kg P ha^{-1}, mycorrhizal efficiency decreased with P level application. *R. irregularis* mycorrhizal inoculations increased bean yield, even at the high P level application (60 kg P ha^{-1}), the grain yield is higher than in non-inoculated treatments but not statistically different. In most legumes, mycorrhizal inoculation increases nutrient uptake and biofortification and consequently crop yield (Liang *et al.,* 2022). The lack of the effects of mycorrhizal inoculation in the other treatments may be linked to the suppression of mycorrhizal development at a height P supply.

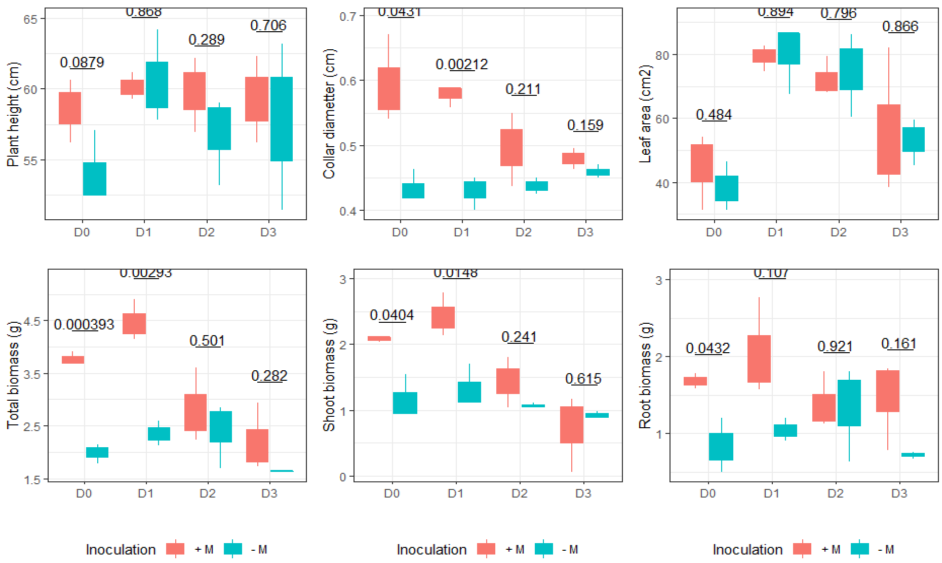

Fig. 2. Plant height, collar diameter, leaf area, total biomass, shoot biomass and root biomass of common bean under mycorrhizal inoculation (+M and –M) and phosphorus doses application (D_0=0, D_1=30, D_2=60 and D_3=120 kg P ha^{-1}).

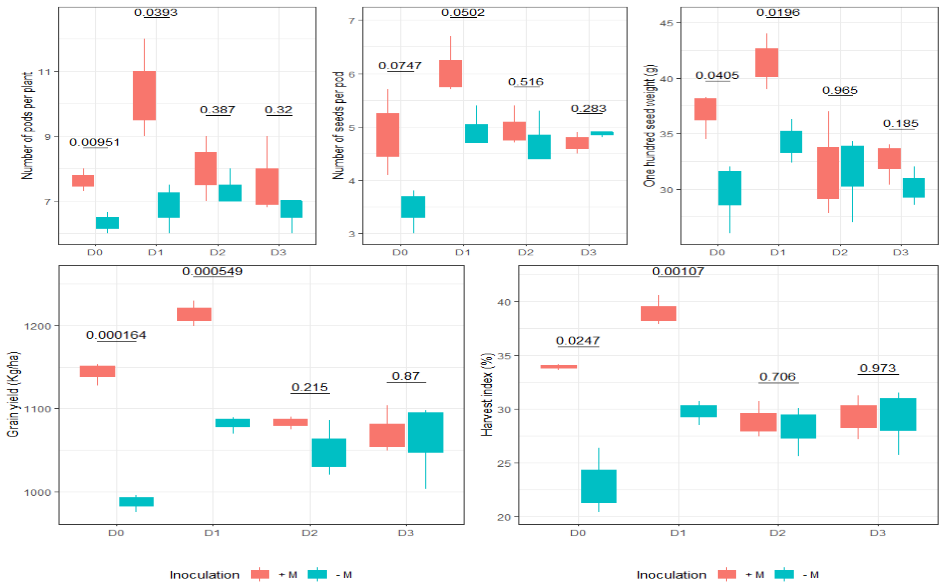

Fig. 3. Bean yield parameters (number of pods per plant, number of seeds per pod, one hundred weight, average grain yield and harvest index) as affected by *R. irregularis* mycorrhizal inoculation and phosphorus levels application.

CONCLUSIONS

The result revealed that mycorrhizal inoculation increased common bean growth and yield, especially at low phosphorus application and in the control treatments. Mycorrhizal inoculation with *R. irregularis* strain could be an important lever to boost bean yield and ensure phosphate fertilizer saving in ferralitic soils of Kashusha.

Table 1. Analysis of variance for plant growth and yield parameters of mycorrhizal (+AM) and non-mycorrhizal (−AM) bean plants grown under different phosphorus fertilization levels (0, 30, 60 and 120 kg P ha^{-1}).

Indicators	**P doses (df=3)**		**AMF (df=1)**		**P doses*AMF (df=3)**	
	F	***P*-value**	***F***	***P*-value**	***F***	***P*-value**
Mycorrhizal colonization						
Frequency (%)	8.03	*0.002*	133	*< 0,001*	7.39	*0.003*
Intensity (%)	5.59	*0.008*	7.4	*0.015*	1.48	*0.26*
Growth parameters						
Aboveground biomass	13.45	*0.000*	49.91	*< 0,001*	8.44	*0.001*
Belowground biomass	0.69	*0.57*	68.7	*< 0,001*	1.03	*0.4*
Total Biomass	20.38	*< 0,001*	309.24	*< 0,001*	18.04	*< 0,001*
Plant heigh	5.75	*0.007*	12.19	*0.003*	2.18	*0.12*
Collar diameter	3.93	*0.028*	14.91	*0.001*	5.44	*0.009*
Leaf area	12.9	*0.000*	0.13	*0.71*	0.15	*0.92*
Yield and yield components						
NGP	5.8	*0.007*	30.57	*< 0,001*	0.59	*0.62*
NGG	7.57	*0.002*	11.57	*0.004*	3.59	*0.037*
P100	16.17	*< 0,001*	21.56	*< 0,001*	1.8	*0.18*
Yield (Kg/ha)	12.07	*0.000*	166.77	*< 0,001*	2.27	*0.12*
IR	0.64	*0.59*	4.68	*0.046*	0.95	*0.43*

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