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Research Application Summary

Integrated management of *Orobanche crenata* in faba bean in Ethiopia

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Abstract

Broomrape (*Orobanche crenata*) is a major constraint to faba bean (*Vicia faba*) production particularly in northern Ethiopia. Few resistant faba bean varieties are capable of reducing the level of damage from *O. crenata* infestation in faba bean. There is therefore a need to enhance the level of productivity of resistant varieties through the adoption of management options that can be used in combating the parasitic weed problem in Tigray. Thus, the study was conducted July to December 2015 with the objective of evaluating the synergistic effect of host plant resistance, bio-inoculant (*Rhizobium legimunosarum*) and a bio-control agent (*Trichoderma harzanium*) on the severity of *O. crenata* and seed and biomass yield of faba bean varieties. Four faba bean varieties including one resistant variety and a local check, and a bio-inoculant (*Rhizobium legimunosarum*) and a bio-control agent (*Trichoderma harzanium*) were applied singly or in combination to treated plots. Un-inoculated plots with neither of the inoculants were considered as control. The experiment was arranged in randomized complete block design with three replications. Data were collected from each plot and included days to *Orobanche* emergence, faba bean seed and biomass yield, number of emerged *Orobanche* shoots per m^2, *O. crenata* biomass per plot, days to crop maturity and thousand seed weight. Bio-inoculation with *R. leguminosarum* and *T. harzanium* singly or in combination resulted in significant grain yield improvements in faba bean. The faba bean grain yield for the different treatments of the *Orobanche* resistant variety "Hashenge", inoculated with both *R. leguminosarum* and *T. harzanium*, had yield advantage of 1012%, 527%, and 727% over Walkie, Moti and the local variety, respectively. Variety Hashenge treated with both inoculants had yield advantage of 29% over the control, uninoculated Hashenge, but only 13 and 9% yield advantage over the same variety singly treated with *T. harzanium* and *R. leguminosarum*, respectively. The yield difference between the *Trichoderma harzianum*+ *Rhizobium* treated and untreated showed significant yield differences of 36%, 44%, and 55% for varieties Walkie, Moti and the local variety. The current study has demonstrated that the combination of the right resistance type with the application of both *R. leguminosarum* and *T. harzanium* can improve plant growth and both biomass and seed yield of faba bean.

Key words: Bioinoculants, *Rhizobium legimunosarum,* synergistic effect, *Trichoderma harzanium*

Résumé

Orobanche crenata est une contrainte majeure pour la production du *Vicia faba*, dans le nord Éthiopie. Peu de variétés résistantes du haricot *Vicia faba* sont capables de modérer de dégâts causés par l'infestation par *O. crenata*. Il y a donc un besoin d'améliorer le niveau de productivité des variétés résistantes à travers des options de gestion pouvant permettre de lutter contre les mauvaises herbes parasites. La présente étude a été menée de Juillet à Décembre 2015 afin d'évaluer l'effet synergétique de la résistance des plantes hôtes, du bio-inoculant *(Rhizobium legimunosarum*) et un agent de bio-contrôle (*Trichoderma harzanium*) sur la gravité de *O. crenata*, les semences et le rendement en biomasse des variétés étudiées. Quatre variétés de haricots Vicia faba, dont une résistante et une locale, un bio-inoculant (*Rhizobium legimunosarum*) et un agent de bio-contrôle (*Trichoderma harzanium*) ont été appliqués isolément ou en combinaison avec des parcelles traitées. Les parcelles non inoculées ont été considérées comme témoin. L'expérience a été réalisée suivant un dispositif de blocs aléatoires complets avec trois répétitions. Les données ont été obtenues dans chaque parcelle et ont compris le nombre des jours pour l'émergence de *O. crenata*, les semences et le rendement en biomasse du haricot Vicia faba, la densité des pousses de *O. crenata* par m^2, la biomasse de *O. crenata* par parcelle, le nombre de jours à maturation et le poids de mille graines. L'inoculation du *R. leguminosarum* et **T. harzanium** isolément ou en combinaison a entraîné des améliorations significatives en rendement du haricot Vicia faba. Le rendement en grains pour les différents traitements de la variété résistante "Hashenge", inoculé à la fois avec *R. leguminosarum* et *T. harzanium*, avait un avantage de 1012%, 527% et 727% par rapport à Walkie, Moti et la variété locale, respectivement. La variété Hashenge traitée avec les deux inoculants avait un avantage de rendement de 29% par rapport au contrôle, Hachenge non inoculé, mais seulement un avantage de rendement de 13 et 9% par rapport la même variété traitée individuellement avec *T. harzanium* et *R. leguminosarum*, respectivement. La différence de rendement entre *Trichoderma harzianum* + *Rhizobium* traité et non traité a montré des valeurs significatives de 36%, 44% et 55% pour les variétés Walkie, Moti et la variété locale. La présente étude a démontré que la combinaison du type de résistance approprié avec l'application de *R. leguminosarum* et *T. harzanium* peut améliorer la croissance des plantes, la biomasse et le rendement en semences du haricot Vicia faba.

Mots clés: Bio-inoculant, R*hizobium legimunosarum*, effet synergique, *Trichoderma harzanium*

Introduction

Faba bean (*Vicia faba*) which is grown in the cooler medium to high altitude areas in Ethiopia takes the largest share of the area under pulse production occupying close to 574,060 ha of land with annual production of about 943,964 tones (CSA, 2013). It provides the much needed protein supplement to the diet of rural households, which otherwise includes mainly cereal or root crops. Faba bean has been considered as a meat extender or

substitute due to its high protein content (20-41 %) (Crépona *et al.,* 2010) and its haulm is an important source of livestock feed. The importance of faba bean as a rotation crop and its role in improving soil health through atmospheric nitrogen fixation is well recognized by Ethiopian farmers (Sahile *et al.,* 2008). In the cooler highlands, where other pulse crop types are least cultivated, it is the major and sometimes the only legume rotation crop planted following cereals every two to three years.

The productivity of faba bean, however, has remained far below its potential due to a number of factors including the low grain yielding potential of indigenous cultivars and their susceptibility to biotic and abiotic stresses (Mussa *et al.,* 2008; Sahile *et al.,* 2008). Fungal diseases such as chocolate spot and Fusarium root rots, and the parasitic weed Broomrape (*Orobanche crenata*), where it exists, are known to severely limit faba bean production.

In areas of severe *O. crenata* infestation, such as the Southern Zone of Tigray where total crop losses due to *O. crenata* in faba bean are most frequent (Abebe *et al.,* 2014), the parasitic weed problem is forcing farmers to stop cultivating the legume crop. The removal of faba bean from the production system severely affects nutrition of poorer households since this may be the only or major source of household protein rich nutrition (Crépona *et al.,* 2010; Haas *et al.,* 2010) and impacts livestock production as faba bean straw is a good source of feed. Besides, the absence of a legume rotation crop in *O. crenata* infested areas is affecting the traditional organic soil fertility management system and forcing farmers to depend on chemical fertilisers.

Attempts to deal with the *O. crenata* problem through the use of chemical herbicides and manual weeding were not effective in reducing the parasitic weed population in faba bean fields and curbing its further distribution (Kiros and Mulubrhan, 2005). Resistant varieties such as the recently released variety "Hashenge" developed from screening nurseries in the area have shown remarkable level of resistance to the parasitic weed with substantial improvements in faba bean seed yield (Teklay *et al.,* 2013). Further improvements in the management of the parasitic weed problem could be achieved by the adoption of an integrated management approach that employs different control options. The use of beneficial microorganisms including bio-inoculants and bio-control agents is known to enhance the level of host resistance and result in improved yields in field pea (Mabrouk *et al.,* 2007). Therefore, this study was conducted with the objective of evaluating the level of synergistic effect resulting from the combined use of host plant resistance, *R. leguminosarum* and *T. harzanium* on faba bean productivity.

Literature Review

Faba bean production in Ethiopia is constrained by both biotic and abiotic factors. Of the biotic factor, diseases are a major constraint (Berhanu *et al.,* 2003; Nigussie *et al.,* 2008; Teshome and Tegegn, 2013; Abebe *et al.,* 2014). Globally, chocolate spot disease of faba

bean caused by *Botrytis fabae* remains one of the most important diseases which cause great annual losses and sometimes complete crop failures (Koike, 1998). In Ethiopia, chocolate spot is considered to be the most important and destructive disease causing serious damage to the crop and consequent decrease of the seed yield, up to 61% on susceptible cultivars (Dereje and Beniwal, 1987).

The use of resistant cultivars is the most economical and effective method of disease control (Gevens and Vallad, undated). The beneficial effect of *Rhizobium* spp. has been a main focus in terms of biological nitrogen fixation but reports reveal that *Rhizobium* spp. can be used to control soil-borne pathogens of legume crops when used as seed dressing (Bardin *et al.,* 2004; Baraka *et al.,* 2009). Trichoderma has long been known as effective antagonists against soil-borne plant pathogenic fungi (Kumar and Mukerji, 1996).

Mabrouk *et al.* (2007) showed that symbiosis with some *Rhizobium leguminosarum* strains could induce in pea both better development and lower susceptibility to *O. crenata.* Induced resistance in the nodulated peas was characterized by a low activity of the root exudates in triggering *Orobanche* seed germination and by the induction of necrosis of most of the *Orobanche* seedlings and tubercles before and after attachment to host roots, respectively. Similarly, growth promoting rhizobacteria can elicit plant defense mechanisms against fungal pathogens through a number of structural and biochemical responses. This suggests that treatment with selected endophytic bacteria could precondition plants to defend themselves against pathogen attack (Kloepper *et al.,* 1993; Tuzun, 1995). Among the *R. leguminosarum* strains tested, the P.SOM strain was the most efficient in both promoting pea growth and eliciting resistance to *O. crenata* (Mabrouk *et al.,* 2007).

Materials and Methods

This study was conducted on soils with known history of severe *O. crenata* infestation (Kiros and Mulubrhan, 2005). The treatments were faba bean varieties and a bio-inoculant (*Rhizobium leguminosarum*) and a bio-control agent (*Trichoderma harzianum*). The sorghum (*Sorghum bicolor*) varieties were Hashenge, an improved variety with known resistance to *O. crenata*, Walki and Moti, improved varieties, and a local susceptible cultivar. The treatments using the bio-inoculant and bio-control agent were as follows: *Rhizobium,* and *trichderma, Rhizobium* + *Trichoderma*, and uninoculated control. The experiment was established in 2015 and arranged in factorial RCBD with three replications. Each plot measured 4m^2. The rate of inoculation for *R. leguminosarum* was 0.48 gram (108cfu/ml) while for *T. harzianum* was 5x106 conidia/ml (Mokhtar *et al.,* 2009) which were used to inoculate the seeds individually or in combination. Plots receiving *T. harzanium* singly or in combination with *R. leguminosarum* were sprayed with 95 ml spore suspension (5x106 conidia/ml) of the *T. harzianum*, five times at 15 days interval and starting from 15 days after faba bean seedlings emergence following the method of Mokhtar *et al.* (2009). Data on number of emerging *Orobanche* shoots, *Orobanche* dry biomass, and faba bean biomass and seed yield were recorded from each plot. Data were analyzed using Genstat.

Results and discussion

The findings showed that both variety and bio-inoculation with *Rhizobium* and *Trichoderma* singly or in combination resulted in significant grain yield improvements in faba bean. The faba bean grain yield comparisons for the different treatments of the *Orobnache* resistant variety "Hashenge" inoculated with both *R. leguminosarum* and *T. harzanium*, had yield advantage of 1012%, 527%, and 727% over Walkie, Moti and the local variety, respectively (Fig 1). Variety Hashenge treated with both inoculants had yield advantage of 29% over the control, uninoculated Hashenge, but only 13 and 9% yield advantage over the *T. harzanium* and *R. leguminosarum* treatments, respectively.

There were significant yield differences between the *Trichoderma harzianum+ Rhizobium* treated and untreated control, being 36%, 44%, and 55% for varieties Walkie, Moti and the local variety (Fig. 1).

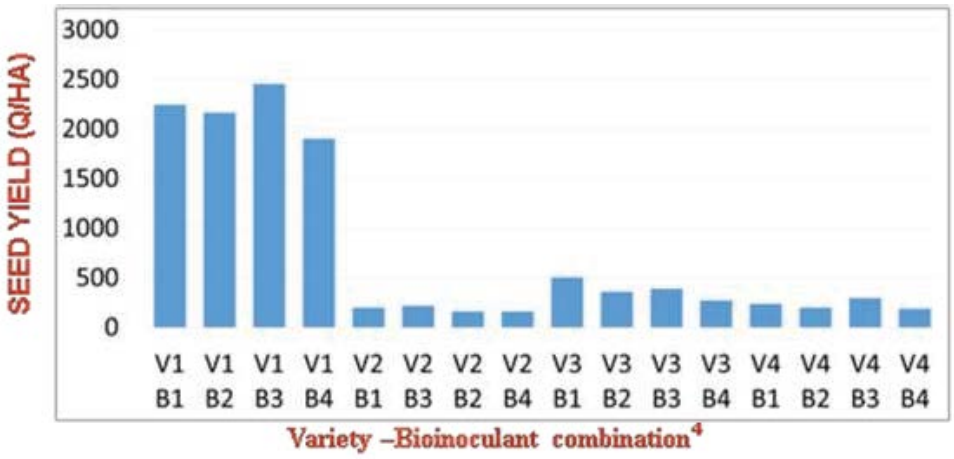

Figure 1. Mean seed yield of faba bean varieties under different treatments (V1= Hashenge; V2 = Walkie, V3 = Moti, and V4 = local variety; B1 = *T. Harzanium,* B2 = *R. leguminosarum*, B3 = *T. Harzanium + R. leguminosarum* and B4 = uninoculated control)

The number of *O. crenata* shoots recorded was higher in the control plots than in rest of the treatments with the least number in the resistant variety Hashenge. For most varieties, except Hashenge, the least *Orobanche* count was recorded in the *T. harzanium + R. leguminosarum* plots (Fig. 2).

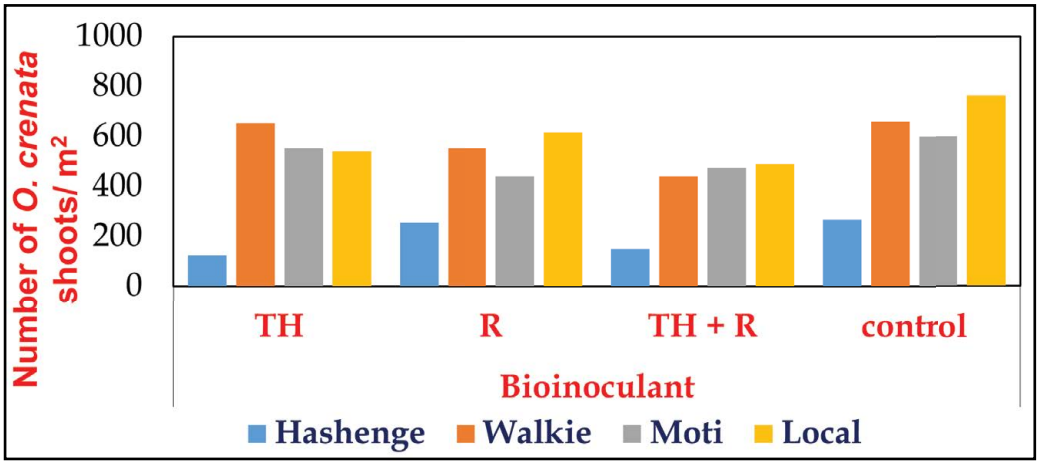

Figure 2. Mean *O. crenata* shoot count/m^2 of faba bean varieties under different treatments

(TH = *T. Harzanium*; R = *R. leguminosarum*, TH +R = *T. Harzanium* + *R. leguminosarum*, Control = uninoculated)

The level of host plant resistance to *O. crenata* seems to have contributed to different faba bean grain and dry biomass production. The *O. crenata* resistant variety had significantly higher seed and biomass yield (data not shown) and lower *Orobanche* shoots per unit area as well as *Orobanche* dry biomass (data not shown). Further the contribution of dual application of *R. leguminosarum* and *T. harzanium* to faba bean was found to be substantially high as compared to in the un-inoculated control (Figure 1). Similar findings were reported by Mabrouk *et al*. (2007) who demonstrated that with the application of some strains of *R. leguminosarum*, there was both better development and lower susceptibility to *O. crenata* in field pea.

Conclusion

Results of this study demonstrate that the combination of the right resistance faba bean type with the application of both *R. leguminosarum* and *T. harzanium* can improve both biomass and seed yield of faba bean. Thus there is a need to give more focus on *O. crenata* resistance variety development and integrate the use of both *R. leguminosarum* and *T. harzanium* for enhanced growth and increased grain and biomass yield in faba bean.

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