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Research Application Summary

Legumes yield response to *Rhizobium* inoculation in Ethiopia: A review

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Abstract

Ethiopia has been known as the homeland and domestication centre of several crop plants. Area unsuitability, un-productiveness, diseases, and insect pests are the most legume crop yield-limiting factors. However, leguminous plants have capacity for nitrogen-fixing symbiosis when established with gram-negative *Rhizobia* and then, incorporates atmospheric nitrogen to soil. Commercially many different species of *Rhizobium* have been prepared. To improve soil fertility, inoculating with *Rhizobium* before planting leads to substantial yield increase. There are a number of *Rhizobium* inoculation experiments for different legumes in Ethiopia. Conversely, they are not organized, to access easily. Therefore this review was undertaken to assemble yield response of legumes to *Rhizobium* inoculants in Ethiopia. Yield response of common bean, soya bean, chickpea, faba bean and lentils to *Rhizobium* inoculation were collected and summarized.

Key words: Ethiopia, legumes, *Rhizobium*, yield response.

Résumé

L'Éthiopie est connue comme étant la patrie et le centre de domestication de plusieurs plantes cultivées. L'inadéquation de la zone de production, la non-productivité, les maladies et les insectes nuisibles sont les facteurs qui limitent le plus le rendement des cultures de légumineuses. Cependant, les légumineuses ont la capacité symbiotique fixatrice d'azote lorsqu'elles sont établies par des *Rhizobiums* à Gram négatif, puis incorporent l'azote atmosphérique au sol. Dans le commerce, de nombreuses espèces différentes de *Rhizobium* sont disponibles. Pour améliorer la fertilité du sol, l'inoculation de Rhizobium avant la plantation entraîne une augmentation substantielle du rendement. Il existe un certain nombre d'expérimentations d'inoculation au *Rhizobium* sur des différentes légumineuses en Ethiopie. En revanche, les résultats de ces expérimentations ne sont pas structurés, pour y accéder facilement. Par conséquent, cette revue était entreprise pour recueillir l'incidence sur le rendement des légumineuses de l'apport d'inoculant au *Rhizobium* en Éthiopie. Les rendements obtenu du haricot, du soja, du pois chiche, de la fève et des lentilles à l'inoculation de *Rhizobium* ont été recueillies et résumées

Mots clés : Éthiopie, légumineuses, *Rhizobium*, l'incidence du rendement

Introduction

Ethiopia is known as the homeland for domestication of several crop plants and is among the top pulse producing countries in the world. Pulses occupy 9.7% and 12.6% of the country's total grain production and total area of private peasant holdings, respectively (CSA, 2018), and they are the are the second most important constituent in the national diet, providing protein source and important dietary supplement to cereal consumption (IFPRI, 2010). Pulses are used primarily for making an Ethiopian stew “wot”, which is sometimes served as a chief dish. Pulses have been used for many years in crop rotation practices. The major varieties of pulses grown in Ethiopia are faba bean, chickpea, field pea, red haricot beans, white haricot beans, lentils, grass pea and soya beans (Mulugeta, 2010; CSA, 2018).

Pulses play an important role in the Ethiopian export sector. Pulses are third in bringing the country’s foreign currency, with a contribution of about 6.3% of the total export earnings after coffee (26.0%) and oilseeds (24.6%). In 2008/2009, the export revenue from pulses dropped by 36.8% as compared to its previous year despite the price increase in the international market. The 2009/2010 export volume and revenue earned from pulses however increased by 70 percent and 64 percent, respectively (Mulugeta, 2010).

In Ethiopia area unsuitability, unproductiveness, diseases, and insect pests are the most legume crop yield-limiting factors. Soil infertility problem is worsened by the increasing population, overgrazing, over-cultivation of sloppy areas and land fragmentation (Barry and Jonfa, 2005). Production continuity of cultivated land is the result of supplying essential nutrients to keep balance in forms of production output and input. Soil fertility is key for sustainable production, environmental and ecosystem balance (Tamene *et al.*, 2017). As a result of long term cultivation, nitrogen deficiency is a problem (Beteru, 1999). Nitrogen depletion can be addressed by addition of inorganic and/or organic fertilizers (Hungria and Vargas, 2000). Organic fertilizers increase productivity and play a role in reducing environment pollution (Bohlool *et al*., 1992). Leguminous plants have capacity for nitrogen-fixing symbiosis establishment with gram-negative *Rhizobia* and then, incorporates atmospheric nitrogen to soil (Nogales *et al*., 2002; Bekere *et al*., 2013).

Rhizobia species can inject atmospheric nitrogen in symbiotic association with legumes and certain non-legumes like Parasponia and Tremma. They normally enter the root hairs, multiply there and form nodules (Erker *et al*., 2014). The plant helps the bacteria by forming a protective arena and supplying it with energy (Erker *et al*., 2014). The amount of nitrogen fixed varies with the strain of *Rhizobium*, the plant species and environmental conditions. Different legumes require different strains of Rhizobia. Therefore this paper reviews yield response of selected legumes to *Rhizobium* in Ethiopia

Selected Case studies of inoculation with *Rhizobia*

Yield response of common bean (*Phaseolus vulgaris* L.) to *Rhizobium* inoculant. A *Rhizobium* inoculation experiment for common bean was conducted at Galaaicha, Melkassa ARC, Hawassa and Mizan-Teferi (Assefa, 2017; Girma *et al*., 2017; Tarekegn and Serawit, 2017; Tarekegn *et al*., 2017), on clay loam, sandy loam, and clay sandy loam soils, respectively. Results indicated that the yield of common bean was significantly increased due to *Rhizobium* inoculation (strain *B-429*). The authors also report that the highest and lowest common bean grain yield as influenced by *Rhizobium* inoculant was 179% at Hawassa and 35 % at Melkassa ARC, respectively, over the non-inoculated (Table 1). Another experiment conducted at Gurumo Koysha of Boloso Sore Woreda, Southern Ethiopia on sandy clay loam soils showed significant ($P<0.05$) difference among inoculated and un-inoculated common beans. Maximum seed yield was recorded from plots treated with *Rhizobium* strain *BH129* over un-inoculated ones (Habete and Buraka, 2016).

Table 1. Yield response of common bean to *Rhizobium* inoculation (Strain *B-429*)

Site	Yield kg ha^{-1}			Reference
	Control	Inoculant	Increment (%)	
Hawassa	1400	2500	179	Tarekegn and Serawit , 2017
Galalicha	1340	1970	48	Tarekegn *et al*,, 2017
Mizan-Teferi	581.7	1190.6	204	Girma *et al*., 2017
Melkassa ARC	1514	2349	35	Assefa, 2017

Yield response of Soya bean (*Glycine max* L. Merill) to *Rhizobium* inoculants. An experiment was conducted on a saline soil containing high soil nitrogen (N) in Shinille area, Somali region, Ethiopia by Aregaw (2014) to examine the efficacy of exotic and locally isolated *Bradyrhizobium* spp. in the area. Accordingly, the author reported that inoculation with an elite isolate of *Bradyrhizobium* spp. improved the yield of the soybean in saline soils. Another experiment conducted by Solomon *et al*. (2012) at Bako in West Shoa Ethiopia obtained a 53.2% yield increment due to inoculation with *Bradyrhizobium japonicum* (TAL 379) over the un-inoculated controls.

Yield response of chickpea (*Cicer arietinum* L.) to *Rhizobium* inoculants. An experiment was conducted by Wolde-Meskel *et al*. (2018) at Damote and Adaa on eutric vertisol and humic nitisols soils, respectively, while Tena *et al*. (2016) conducted a similar study in south Ethiopia at Ele Kebelle in Damote-Gale with clay textural soil to investigate impacts of *Mesorhizobium* inoculation on growth and yield of chickpea. The result obtained indicated that chickpea yield without inoculation was very low calling for inoculation with *Mesorhizobial*. The authors indicated that inoculation with *Mesorhizobium* resulted in significantly higher chickpea yield by 128, 102 %, 117%, 138.5% in 2012, 2013 and 2014, and 2015 cropping years in Damote (South Ethiopia) and Adaa (Table 2). Also, 28-50% and 49-60% yield increment were observed in pot and field experiments at Ele Kebelle.

Table 2. Yield response of chickpea (*Cicer arietinum* L.) to innoculation with rhizobium year

Year	Sites					
	Damote (South Ethiopia)			Adaa (Central Ethiopia)		
	Un-inoculated	Inoculated	Increment (%)	Un-inoculated	Inoculated	Increment (%)
2012	1593	2043	128			
2013	1747	1796	102			
2014				1937	2272	117
2015				1693	2348	138.5

Source: Wolde-Meskel *et al*., 2018

Response of other legumes to *Rhizobium* inoculants. According to Woldekiros (2018) *Rhizobium* inoculation significantly improved grain yield of faba beans (*Vicia fabae*) at Alicho Wuriro highlands but Zerihun (2014) reported that inoculating faba bean with *Rhizobium* strains failed to create significant increase in yields. However, another investigation at Ada'a district indicatesd that *Rhizobium* gave the highest seed yeild over yeilds of the un-inoculated lentils (*Lens culinaris* Medikus) (Feleke *et al*., 2019)

Conclusion

Rhizobium inoculation experiments have been conducted in Ethiopia for different legumes. These include studies on response of common bean, chickpea, soya bean, faba bean and lentil to innoculation with *rhizobium*. The results showed that rhizobia inoculants increasd yield of legumes as reported by different authors in this paper. However, no researches no research seemsto have done for legumes, i.e., *Viz*. grass pea, fenugreek nor mung bean in Ethiopia. Therefore, further studies should ne done with these crops.

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