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Review on the Production Practices and Impacts of Bio-Fertilizers on Legume Production in Ethiopia

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Abstract

Even though there is progress in production and productivity of agricultural produces, food insecurity and per capita calorie consumption in the world has not registered a significant improvement. Thus, adoption and diffusion of nutritious crops may be regarded as a good option for rural smallholder farmers. This paper reviews various articles and documents on production practice and impact of bio-fertilizer on legume production in Ethiopia. The production practice and impact of bio-fertilizer in legume production is of great significance in particular to developing countries due to their large dependence on agricultural practice for livelihoods and their lack of infrastructure for adaptation when compared to developed countries. Impact and production practice affected by Training, Extension, Availability, Pricing and coordination and the quality of the up-take of bio-fertilizers may be compromised by other factors including unresolved disease and seed issues as well as changing weather patterns. Despite the fact that production and practice is challenged by the above listed problems it brought tremendous impact on farmers that are practicing. It increase yield of the legumes, soil fertility, income and yield of cereal that fellow in next cropping season.

Keywords: Impact; Legumes; Bio fertilizer; Inoculant

Introduction

There have been a report that Legumes like faba bean and soybean is able to fix 20kg-60 kg N under tropical environments, but these amounts are significant for the succeeding cereal to meet the N requirement for economically attractive mean yields [1]. Farmers have been seeking ways to produce more food from the same field [2]. The incentives to intensify production increase as populations grow and land-holdings are progressively subdivided. In Ethiopia a recent report states that in the last decade land holdings have declined by an average of 1.4% per year or 14% in total (Surveys). In response, farmers have innovated: the area of fallow is reduced; the use of fertilizers has increased [3]; the area planted to high yielding cereals has expanded; and the area planted to legumes has decreased [4]. As the area of arable land planted to legumes has reduced, farmers have become increasingly interested in boosting legume yields [5]. There are several ways to do this, such as using organic and inorganic fertilizers, using improved seed, or applying bio-fertilizers (Thilakarathna and Raizada) [6].

Bio-fertilizers are composed of a simple, milled peat/lignite base that is used to carry Rhizobia bacteria (AKLDP). At the time of planting, bio-fertilizers are usually mixed with a sugar solution in which the seed is soaked. The sugar solution ensures the bio-fertilizer adheres to the coating of the seed and that the Rhizobia quickly colonize the interior of the plant after germination. Rhizobia-based bio-fertilizers increase the rate of root nodule formation in legumes and as a result, increase the rate of fixation of atmospheric nitrogen (N_2). This fixed nitrogen is transformed into a more useable form of nitrogen (N) that supports plant growth and productivity. Critically, bio-fertilizers do not contain any chemicals that are harmful to the living soil. Once the legume is harvested, the root nodule breaks down and releases the Rhizobia and nitrogen back into the soil. The Rhizobia can persist in the soil or can re-infect legume plants that are planted in following years (K. Mulongoy) the same way, the nitrogen released into the soil after harvest can subsequently be used by other crops known as 'follow-on' crops, and this typically results in higher yields [7].

The organization called "N_2 Africa" reported in Ethiopia, faba bean is the crop that has the highest absolute production, and the largest area cultivated. Ethiopia is also the second largest producer of faba bean in the world (after China) [7]. Common bean and chickpea are also major legumes, with both a production of more than 200,000 MT grain. On the world market, Ethiopia ranks 6th in chickpea production and 14th in production of common bean [6]. Among African countries, Ethiopia is the largest producer of both chickpea and common bean (ICRISAT, Ronner).

In total, the area cultivated with the selected legumes is more than 1 million ha. Production per ha is low and far below the potential production of e.g. 2.9 t/ha for chickpea and 4 t/ha for common bean and faba bean.

Literature Review

The term bio fertilizer or called 'microbial inoculants' can be generally defined as a preparation containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulytic microorganisms used for application of seed, soil or composting areas with the objective of increasing the numbers of such microorganisms and accelerate certain microbial process to augment the extent of the availability of nutrients in a form which can assimilated by plant. In large sense, the term may be used to include all organic resources (manure) forplant growth which is rendered in an available form for plant absorption through microorganisms or plant associations or interactions. The knowledge of applied microbial inoculums is long history which passes from generation to generation of farmers. It started with culture of small scale compost production that has evidently proved the ability of biofertilizer. This is recognize when the cultures accelerate the decomposition of organics residues and agricultural by-products through various processes and gives healthy harvest of crops [8]. In Malaysia, industrial scale microbial inoculants are started in the late 1940's and peaking up in 1970's taking guide by Brady rhizobium

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inoculation on legumes.

Legumes

The family Fabaceae (earlier known as Leguminosae) comprises more than 600 genera and about 18,000 species of cultivated plants. It is the second largest family after Poaceae (earlier known as Gramineae), in terms of food and vege protein source, and of fodder. The sub-family Papilionoideae consists of 480 genera and about 12,000 species, of which only a few species are cultivated for human nutrition. Endowed with excellent food and fodder qualities, these crops also restore soil fertility by scavenging atmospheric nitrogen, adding organic matter, enhancing phosphorus availability, and improving physical, chemical and biological properties of the soil. Hence, they occupy an indispensable position in various cereal-based cropping systems in marginal and sub-marginal lands, where they sustain intensive agriculture and farming systems adopted by small and marginal farmers.

Why bio fertilizer

Government research institute, the Malaysian Rubber Board (MRB) had been conducting research on Rhizobium inoculums for Agricultural production is constrained by population pressure, declining soil fertility and unpredic and erratic is posing a serious threat to food production, a symptom rainfall. Gradual depletion of N from African soils for lack of appropriate soil management.

Assessment findings

The field assessment that has been conducted by Menagesha biotechnology Industry in collaboration with agricultural research institute reported that, the despite a long history of research on bio-fertilizers in Ethiopia dating back to the early 1980s, commercially available bio-fertilizers did not become available for farmers until 2010. Subsequently, the National Soil Laboratory (NSL), other research centers and some development projects have started to market and distribute bio-fertilizers. Therefore, Rhizobia inoculated seed is available to some extent in Ethiopia for faba bean, chickpeas, lentils, field pea, haricot bean, soybean and mung bean. District officials estimated average land holdings of 2.5ha in Arsi zone and 2.0ha in East Shewa zone; average family size was estimated to be six persons. Land holding averages are however rather misleading as district officials also reported a growing number of landless households, estimated at approaching 50% in some PAs. However, it was also difficult to assess the size of farm holdings accurately as used different descriptions of their land and that these were approximations e.g. Kert-the stretch of a farmer's stride and 'timad' – the area a pair of oxen can plough in a day. As a result, the field assessment was not able to accurately assess yield per area. Cereals continue to dominate arable cropping with a mix of wheat for bread and barley in Arsi zone and wheat for bread and pasta, and teff in East Shewa zone. Faba bean and field peas are also gown in Arsi zone and chickpeas and lentils in East Shewa zone. It was not possible to estimate trends in the planting area of pulses in Arsi and East Shewa zones, but national-level CSA 2014/2015 production data indicates that the area planted to pulses in Ethiopia is in overall decline. In the last 5 years the area planted to faba bean, field pea, grass pea and lentils has fallen by 18%, 16%, 19% and 21% respectively. In contrast, the area planted to chickpea has increased by 4% in the same period. The FGDs confirmed that farmers planted other crops including teff, linseed and mustard. Crops are used for both home consumption and sale, with farmers reporting sales of up to 60% of faba bean in Arsi zone and 80% of chickpeas in East Shewa zone. Typically, legumes are sold for higher prices than cereals. This price differential enables farmers to sell legumes and buy back larger volumes of cereals. This trade increases the availability of calories at household level. Aware of the importance of soil fertility, and soil borne pests and diseases, farmers routinely practice rotations. In Arsi zone commonly used rotations included: cereals, pulses, oilseeds and cereals; cereals, pulses, cereals and cereals; and cereals, pulses, cereals and fallow. In contrast, rotations in East Shewa zone included wheat, pulses, teff and pulses and wheat, pulses, teff and pulses. Over the last decade, population increase has resulted in increased pressure on land holdings and a decline in the size of farm-holdings. While data is not available for the study area, IFPRI (2015) estimate that at the national level average holding size has declined by 14% in the period 2005 to 2015. This decline in holding size has resulted in many farmers abandoning the traditional practice of 'fallowing in favor of an increase in the application rates of inorganic fertilizer. Fertilizer is used not only on cereal crops, but increasingly for legumes and oilseeds in Arsi zone.

Discussion

Impact on livelihood

The profitability benefit of bio fertilizer can be deduced from bio-fertilizer benefit-cost analysis, which is based on the ratio of the obtainable value of benefit compared to the actual cost of the inoculum at a particular time. An enterprise will be profi when the benefit to cost ratio exceeds 1 after discounting the gross cost and benefit. According to Mulongoy, Gianinazzi, Roger, and Dommergues, yield increases have the potential to improve food security and increase household income, assuming that the cost of adopting new technologies does not out-weigh potential gains. However, the field assessment confirmed that the costs of using bio-fertilizer were minimal as the cost per packet – adequate for a quarter hectare – is Eth birr 55 with an additional Eth birr 8 for sugar that is mixed with the bio-fertilizer to ensure that it 'sticks' to the seed. Farmers also reported that the additional labor required to prepare the bio fertilizer with water and sugar was less than 'the time taken to clean the soil from the wings of the plough at the end of each furrow and therefore negligible.

The report reviled that the field assessment interviewed relatively small numbers of farmers and relied on farmer-reported yields. However, a conservative estimate was that yield increases could result in an additional Eth birr 5-10,000/ ha over two years i.e. from increased faba bean yields in the first year and follow on wheat or barley yields in the second year. Farmers also reported other benefits: increased size and plumpness or good seeds of faba bean resulting in higher sale prices, soil fertility increased as more organic matter of plants at ground-level leaving roots and nodules in the soil supporting a transition away from 'fallowing' and supporting an increase in 'productive farm holding size reduced use of fertilizer. In addition, women reported that good faba beans are easier to cook resulting in reduced firewood/biomass use. Legumes have an important role in household nutrition, in particular of poorer households who are less able to access animal sourced proteins; legumes are prepared in sauces or shiro-wot and snacks. Therefore, the full economic benefit of the use of bio-fertilizers is substantially more than the Eth birr 5-10,000/ha associated with productivity increases alone.

Conclusion

Faba bean – there were high levels of farmer confidence in the use of bio-fertilizers to increase faba bean yields and the yields of follow-on cereal crops. Chickpeas - the benefits associated with bio-fertilizers for chickpeas were more variable, and in some PAs, difficult to assess due to poor seed, and erratic and poor rainfall. Other benefits associated with the use of bio-fertilizers were widely reported-reduced fertilizer use, improved soil fertility, more efficient use of biomass for cooking good

seed fava beans. The benefits of use of bio-fertilizer use extend beyond increased yields and income to include improved dietary diversity, and reduced workload for women. Despite the benefits, there are multiple barriers to the wider up-take of bio-fertilizers e.g. inadequate extension, availability, pricing and coordination issues, and the urgent need for the appropriate regulation and quality control.

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