9 Impact of Biofertilizer on Crop Yield of Isabgol (*Plantago ovata*) and Senna (*Cassia alexandrina*)

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Contents

Abstract

Isabgol (*Plantago ovata* Forssk.) is an important cash crop in western part of Rajasthan during Rabi season, making India top ranked in its production. It is widely used in Ayurveda due to its laxative property. Senna (*Cassia alexandrina* Mill.) is perennial undershrubs whose leaves and seed both have medicinal importance. Due to the low level of soil health, inadequate agricultural input, the uncertainty of rain, and no other source of irrigation in Rajasthan, the introduction of biofertilizers to improve the productivity of both the medicinal crops was studied. The biofertilizers used were *Serendipita indica* a culturable arbuscular mycorrhiza, which is able to increase biomass and yield of crop plants and to induce local and systemic resistance to fungal diseases and tolerance to abiotic stress, and *Azotobacter* sp. a free-living nitrogen fixer, individually as well as in combination. The results showed that *S. indica* performed better than all the other treatments. The mean yield in Isabgol seed and husk, respectively, increased to 57% and 33% in *S. indica*-treated seeds followed by 36% and 14% in consortia of the fungus and bacterium and 23% and 4% in *Azotobacter* sp.-treated seeds as compared to control. Similarly, mean yield of Senna seeds was maximum in

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S. indica-treated seeds (39.69 g), followed by consortia (20.04 g) and *Azotobacter* (19.16 g) as compared to control (16.30 g).

Keywords
Cassia alexandrina · *Plantago ovata* · *Serendipita indica*

9.1 Introduction

Isabgol is an annual irrigated crop of rabi season which takes 4 months in the field to complete its cycle. India is the largest producer as well as exporter of Isabgol in the world (Jat et al. 2015). The main Isabgol-producing states in India are Gujarat and Rajasthan. Similarly, Senna is a valuable plant drug and used in Ayurveda for the treatment of constipation (Morales et al. 2009; Seethapathy et al. 2015). Due to the excessive use of chemical fertilizers and pesticides/fungicides, there has been the acute demand for sustainable production of crops by using organic methods. The soil health has been deteriorated resulting in low productivity of agricultural and horticultural plants, and now it is getting difficult to produce crops without using chemicals, which is beyond the reach of poor and marginal farmers of rural areas. Moreover, there is the harmful impact of synthetic chemicals. Such kind of problems can be overcome by using plant growth-promoting microorganism. These microbes are attaining importance worldwide. The beneficial microbes not only play an important role in increasing soil fertility but they also enhance growth and vigor of the plant and help in the value addition and productivity of economically important plants. Moreover, they also protect them from other harmful microbes. The production of plant growth hormones has been suggested as one of the mechanisms by which these biofertilizers stimulate growth. There are many species of fungus and bacteria which makes the nutrient in the soil available to plants. Arbuscular mycorrhiza colonizes the root of the diverse plants and extends the hyphae far away into the soil. Their main role is to mobilize phosphorus to the plant. *S. indica* is also one of the AM fungi which primarily supplies phosphate to the plant and also produces novel new plant growth hormone PYK-10. Similarly, the nitrogen supply is maintained by free-living nitrogen-fixing bacteria like *Azotobacter*, *Azospirillum*, and symbiotic nitrogen fixers like *Rhizobium*. The main aim is to develop a consortium of these microbes which are compatible and can help in rejuvenating the soil also along with providing nutrients to the plants. In this study, the effect of *S. indica* alone and in combination with *Azotobacter* was studied for Senna and Isabgol so that a package of practice for these species could be developed.

9.2 Material and Methods

9.2.1 Preparation of Liquid Cultures

The mass cultivation of *S.indica* was carried out in batch culture in shaking flasks. Special focus was given to minimize the expensive nutrients and to grow them exclusively on composite energy source Jaggery. The focus was on the excessive production of chlamydospores for better formulation, storage, and transfer to the field at room temperature compatible with *P. indica* nitrogen-fixing *Azotobacter* sp. which was also grown in batch culture. The CFU count of the bacteria was optimized to 10^9 mL^{-1}.

9.2.2 Preparation of Field Beds

A total of 12 beds having the size of 400 square meters were first flooded, and then the next day, the same was dug to soften the soil texture for easy seed germination. These fields were then labeled according to the treatment with three replications for each treatment.

9.2.3 Seed Treatment

Seeds of Isabgol and Senna were presoaked overnight in the batch cultures prepared as mentioned above. The viable seeds of these plants were treated separately with the liquid cultures of *S. indica*, *Azotobacter* sp., and their combination. In addition to this, some seeds of both plants were soaked only in-plane distilled water without any bioagent that was used as a control.

9.2.4 Seed Sowing and Experimental Design

The experimental design adopted in the present investigation was a randomized block design (RBD) with three replications for each treatment (four treatments). Therefore, the beds prepared above were distributed randomly for a different combination of treatment. The presoaked seeds that seem to be fully imbibed were then broadcasted in the beds as their respective treatment after which these were covered with a small layer of soil. These field beds were then left for 5–6 days without water for the proper germination of seedlings.

9.2.5 Maintenance of Beds and Data Collection

Once the seeds were germinated properly, the plots were watered periodically. Thinning was performed when the seedlings got an adequate length. Row-to-row and plant-to-plant spacing for Senna was kept 45 × 30 cm, while for Isabgol, it was 30 × 5 cm. The crop was maintained for nearly 4 months, while for Senna, the duration was 6 months; thereafter, the yield data was recorded. The standard error of means and coefficient of variance was calculated for yield data as described by Gupta et al. (2001).

9.2.6 Results

In the present investigation, the mean yield in Isabgol (*Plantago ovata*) seed and husk, respectively, increased to 57% and 33% g/plant in *S. indica*-treated seeds followed by 36% and 14% in consortia of the fungus and bacterium and 23% and 4% in *Azotobacter*-treated seeds as compared to control. Similarly, mean yield of Senna seeds was maximum in *S. indica* -treated seeds (39.69 g), followed by consortia (20.04 g) and *Azotobacter* (19.16 g) as compared to control (16.30 g) (Fig. 9.1).

9.2.7 Discussion

Fertilizers are known to play an essential role in many crop productions in agricultural systems (Singh et al., 2012, but scientific research is little about the interactive effects of various fertilizers on yield and seed capabilities of medicinal plants. The effects of mycorrhizal fungi *S. indica* and free-living nitrogen fixer *Azotobacter* individually and in combination on yield component and seed capabilities of Isabgol (*Plantago ovate*) and Senna (*Cassia alexandrina* Mill.) were studied in the present investigation. The application of fertilizers is one of the primary methods for improving the availability of soil nutrients to plants. Fertilizing can change rates of plant growth, maturity time, size of plant parts, the phytochemical content of plants (Mevi-Schütz et al. 2003), and seed capabilities. The heavy use of chemical fertilizers has created a variety of economic, environmental, ecological, and social problems. Furthermore, the increasing costs of chemical inputs have left farmers helpless, resulting to decreasing seed quality of certain crops and resulting in the fall of commodity prices and consequently reducing farm income (Khadem et al. 2010; Tung and Fernandez 2007). In such situation, the present study can be proved as a milestone because in this investigation not only the global threat of chemical fertilizer use was prevented but also the methods used for the application of biofertilizers were also farmer friendly (cheap). The bioagents used in the study not only provide important soil nutrients such as nitrogen and phosphorous; additionally, using it as fertilizer can be an important disposal method, which was also suggested by many previous studies (Taheri et al. 2011; Madison et al. 1995). It was observed that *S. indica* has performed better for Senna as well as Isabgol in all the treatments. The germination percent was 98%; moreover, the flowering was also recorded 15 days earlier to the control in the case of *S. indica*-treated seeds of Senna and Isabgol. The fungus is able to increase biomass and yield of crop plants and to induce local and systemic resistance to fungal diseases, and tolerance to abiotic

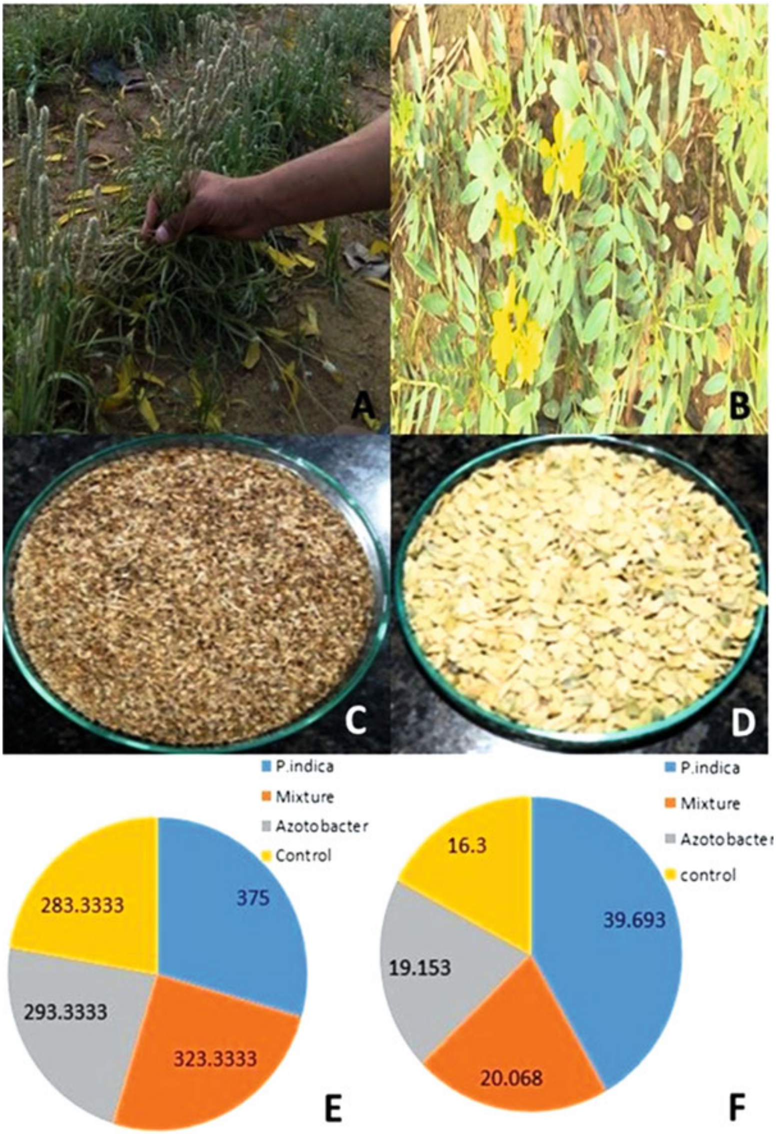

Fig. 9.1 (**a**) Isabgol tillers, (**b**) flowering of Senna, (**c**) seeds of Senna, (**d**) flowering of Senna, (**e**) pie-chart showing yield data (gm/bed) of Senna, (**f**) Isabgol crop after biofertilizer treatment

stress has been suggested by many workers (Stein et al. 2008; Varma et al. 2012). The dual inoculation of AM fungi and *Azotobacter* was found to be the best in the reduction of cadmium stress and promotion of growth parameters (Haneef et al. 2014). Similarly increased overall health of Isabgol plant was observed in light of nitrogen-based fertilizers (Maheshwari et al. 2000).

Fig. 9.2 A view of the morphology of the fungus indicating typical autofluorescent pear-shaped spores. A view of the SEM of the spore. (C.F. Varma et al. 2013)

In the present investigation, seeds treated with *S. indica* sowed the maximum yield in both the Isabgol and Senna followed by the treatment of consortium (*S. indica* + *Azotobacter*) and the seeds coated with the formulation of *Azotobacter* strains only. The result suggests that *S. indica* can be alone used as potential biofertilizer for increasing yield and productivity of crops. The fungus has shown strong growth promotion activity with a broad range of plants tested so far (Waller et al. 2005). Its advantage lies in its ease of cultivation on synthetic media. Due to ease of culture as compared to other AM fungi, this fungus could be used as a model organism for the study of beneficial plant-microbe interactions and a new tool for improving plant production systems (Varma et al. 1999). An overall view of Serendipita indica (*S. indica*), commercially called as "ROOTONIC," is given in Fig. 9.2.

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