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Research Article

Soybean Bio-fertilizer Technology Promoting Through Cluster Based Demonization in the Mima Learning Watershed from Assosa Western Ethiopia

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Abstract

Soil fertility depletion and soil acidity are critical problems for soybean production in western Ethiopia. Therefore, a cluster based biofertilizer technology was demonstrated to improve the depleted soil fertility on Nitisols of Assosa Agricultural Research Centre during 2022 to 2024 cropping season to investigate the response of soybean yield to biofertilizer. The treatment consists of: farmers practice (100 kg NPS ha^{-1}) and biofertilizer plus 100 kg NPS ha^{-1}. Multidisciplinary team had given participatory training from the composed of Soil fertility researcher, soybean breeder and agricultural extension and communication for the selected participates. The training was delivered for different stake holders and farmers on agronomic management of soybean production techniques and management, cluster based bio fertilizer technology demonstration approach. Around 830 packets of bio-fertilizer are distributed for the farmers in last four years cropping season. In order to evaluate the performance share the lesson with different stakeholders' field day and experience sharing were organized in the fields of beneficiary farmers. In the field day and experience sharing famers, development agents (DAs), experts, heads of agricultural and rural development office, researchers were participated. The cluster based demonstrated biofertilizer technology was compared with farmers practice and the field data recorded and analyzed by descriptive statics. The participant farmers and different stake holders preferred biofertilizer plus NPS fertilizer during the field day and experience sharing. The application of recommended NPS plus inoculation was higher in seed yield of maize by 14% compared to the application of recommended NPS fertilizers alone. The yield advantage relative to NPS alone indicating the depletion of the soil microorganism and its strong response to bio fertilizer application.

Keywords

Biofertilizer, Cluster, Yield Advantage, Demonstration, NPS Fertilizer, Soil Microorganism

1. Background

Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in Ethiopia. Continuous nutrient depletion and low soil fertility have not only led to the development of integrated soil fertility management technologies that offer the potential for improving soil fertility in Africa [1], but almost simultaneously caused extensive studies on nutrient balance in various African farming systems. The application of bio-fertilizers has been recognized

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as an effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil Cation Exchange Capacity (CEC) and increasing crop yields [2].

Rhizobia is one of the dominant symbiotic nitrogen fixing bacteria with legumes but a number of factors leads to poor nodulation and nitrogen fixation in legumes. The application of biofertilizer Biological nitrogen fixation (BNF) and mineral soil or N fertilizers are the main sources for meeting the N requirement of high-yielding soybean varieties. Application of biofertilizers along with inorganic fertilizers into the soil leads to increase in productivity of the crop and sustain the soil health for longer period [3]. BNF is an effective and efficient source of N supply to plants under favorable atmospheric and environmental conditions [4]. More than 50–83% of the necessary N requirement for soybean can be derived from BNF [5] by symbiotic association with either the genus Bradyrhizobium or Sinorhizobium. Inoculation with compatible and effective rhizobia may be necessary to optimize the nitrogen fixation and hence legume grain yields, where a low population of native rhizobial strains predominates [6]. Therefore, evaluation and identification of appropriate and effective rhizobial strains are crucial to enhance nitrogen fixation and yield of soybean. Therefore, the piece of research work was to verify the promising performance of elite soybean rhizobial inoculants interaction with different nutrient inputs on grain and biomass yield.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at the Assosa Agricultural Research Center which is located in Assosa District in the Benishangul-Gumuz Regional State. The Benishangul-Gumuz Regional State is located in the western part of Ethiopia between 9° 30' to 11° 39" N and 34° 20' to 36° 30" E covering a total land area of 50,000 square kilometers (km^2). The Assosa District is characterized by hot to warm moist lowland plain with a uni-modal rainfall pattern. The rainy season starts at the end of April and lasts at the end of October with a maximum of June, July, August and September. The total annual average (2010-2015) rainfall is 1316 mm. The Mima water shade covers an area of 510 hectare and the Mima water shade is one of the main streams draining into Afa River. The water shade is found at the distance of 24kms from Assosa town on the way to Addis Ababa through Bambasi District of Benishangul Gumuz Regional State. It is bordered by Amba 16 kebele to west and Jematsa kebele to east direction. Mima water shade is bounded by longitudes 34°39’ east and latitudes 9°55’ south. The central point of the water shade is transversed by Longitude 34°40’ East and Latitude 9°56’S.

2.2. Experimental Design

The soybean genotype used for this study was provided by the Asossa Agricultural Research Center, Ethiopia, which has been approved to be superior under Asossa field conditions. One soybean genotype, which was late maturing (Belsa 95), was used for the field experiment. Rhizobial isolates, MAR 1495 isolate and SB12 isolate were used as inoculants. Non-inoculated plot or cluster planted as farmers practice for compare the difference between inoculated and non-inoculated. These isolates were obtained from Holleta Agricultural Research Center. Preparation of the RI followed [7] whereas application of both types of inoculants was stick to Stacey *et al*., [8]. The rate and time of application of the phosphate sources will be 46 kg P_2O_5 ha^{-1} and banded at planting, respectively. The rate of the rhizobial biofertilizer will be 500g ha^{-1}.

Locally adapted soybean variety seeds of *Belesa-95* planted at 60kg/ha rate, inter-row spacing of 60 cm, and within row spacing of 5 cm. The remaining agronomic management was applied uniformly to all plots according to the local recommendations. Phosphatic fertilizers drilled along the cropping rows at planting.

2.3. Site and Farmers Selection

The current study was conducted Mima learnining watershed of Asossa zone where soybean is dominantly produced. The farmers were selected by office of agriculture and rural development of respective kebeles. Farmers were trained before how they can be used to bio-fertilize. A total of 870 packets of bio-fertilizer were distributed to farmers during three last cropping seasons. A total of 204 male and 47 female beneficiary farmers were participated on bio-fertilizer cluster. As part of the intervention activities, training on bio-fertilizer technology were given to farmers, DAs and experts. Finally, in order to evaluate the performance share the lesson with different stakeholders’ field day and experience sharing were organized at regional level in the fields of beneficiary farmers. In the field day and experience sharing famers, development agents (DAs), experts, heads of agricultural and rural development office, researchers were participated. The demo and trial execution kebeles/villages were differently selected.

2.4. Plant Data Collection and Analysis

Central row plants were used for data collection. Growth-indicating parameters such as plant height, number of seeds per pod number of pods per plant and grain yield were collected. The grain yield was adjusted at 11.5% grain moisture content. All the above ground biomass from 2sq,m sub plot area (random quadrant) were harvested and weighed to get the field biomass weight and converted to hectare bases (kg/ha). The biomass was then be threshed, winnowed and all harvested grains are collected into a sack, weighed (adjusted to 11.5%moisture) and converted in to hectare bases

(kg/ha). 1000 grains will be randomly sampled from each treatment and weighed.

2.5. Field Day

In the field day and experience sharing farmers, development agents (DAs), experts, heads of agricultural and rural development office and researchers were participated. Finally, to evaluate the performance and final outputs of the vermicompost and share the lessons with different stakeholders' field days were organized in the fields of beneficiary farmers. On the field days farmers, development agents (DAs), experts, heads of the agricultural and rural development office, woreda administrators, researchers from Asossa Agricultural Research Center and other stakeholders from Bambasi.

2.6. Data Analysis

The collected agronomic data was analyzed using descriptive statistics and excel. The grain yield and fruit weight data were analyzed using excel and presented using figures.

$$\text{Yield advantage\%} = \frac{\text{Yield advantage of fertilized} - \text{Negative control of N}}{\text{Negative control of N}} \times 100$$

Yield advantage of the demonstrated varieties was calculated using.

3. Result and Discussion

3.1. Farmers Training

The training was delivered for farmers and different stake holders both practical and theoretically on the bio-fertilizer technology. The Asossa Agricultural Research Centre multi-disciplinary team had given participatory training from the composed of Soil fertility researcher, soybean breeder and agricultural extension and communication for the selected participates. The training will be conducted by keeping all WHO standards, by keeping our distance, by using sanitizer and mouth coverage to protect corona virus (COVID-19) at the field during the COVID-19 break out.

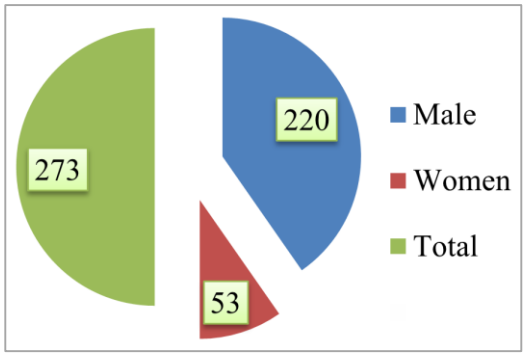

Figure 1. *Number of farmers participated on training during these three years.*

Only the trainers are going to the kebele for giving training for the farmers. For the participatory and accurate organic soil fertility management the concerned stake holders and farmers awareness created. The training was delivered for different stake holders and farmers on agronomic management of soybean production techniques and management, cluster based bio fertilizer technology demonstration approach.

Figure 2. *Practical and theoretical training of farmers on bio-fertilizer and soybean improved technology.*

3.2. Farmers Field Day

As part of the intervention activities, training on vermcompost and earth worm was given to farmers, DAs and experts. Totally around 830 packets of bio-fertilizer are distributed for the farmers in last four years cropping season. Finally, in order to evaluate the performance share the lesson with different stakeholders' field day and experience sharing were organized in the fields of beneficiary farmers. In the field day and experience sharing famers, development agents (DAs), experts, heads of agricultural and rural development office,

researchers were participated. On the day of field day, the Benishangul-Gumuz Regional State Property Party Head said confirmed CALM (climate action through land scape management) P4R had play great role on the e region of farmer economy. During 2019/2020 cropping season around 43.5 hectors of land were covered by bio fertilizer technology and 115 farmers were participated on the cluster based technology demonstration.

Table 1. List of participant on the day of field day during 2019/2020 cropping season.

Farmers			Researchers			Asossa and Bambasi Wereda experts, Agricultural office head, Weredas administration and development agents			Regional agricultural office head, experts and property party head		
Male	Women	Total	Male	Women	Total	Male	Women	Total	Male	women	Total
130	115	245	20	7	27	10	7	17	7	4	11

Figure 3. Farmers and different stake holders field day and experience sharing during 2020/21 cropping season.

The availability of seed of improved varieties is among the major bottlenecks for increasing of crop productivity in Ethiopia particularly in Benishan-gul Gumuz regional state. For solving this bottleneck of crop production we cooperated women and youth farmers as community based seed multiplication in Mima learning watershed as super imposed activity while we demonstrated biofertilizer technology for iproving soil fertility and increase the microbial activity in the watershed. Additionally the physical and biological soil and water conservation were integrated with of soil fertility management technology (biofertilizer cluster). On the other hand we have been cooperated women and youth farmers on sorghum and soybean seed multiplication while conserving soil and water and, improve soil fertility in the learning Mima watershed. Lastly cluster based demonstrated biofertilizer technology was compared with farmers practice and the field data recorded and analyzed by descriptive statics. The participant farmers and different stake holders preferred biofertilizer plus NPS fertilizer during the field day and experience sharing.

Table 2. List of participant on the day of field day during 2020/2021 cropping season.

Farmers			Researchers			Asossa and Bambasi Wereda experts, Agricultural office head, Weredas administration and development agents			Regional agricultural office head, experts, NGO's and property party head		
Male	Women	Total	Male	Women	Total	Male	women	Total	Male	women	Total
150	90	240	10	4	14	12	5	17	15	6	21

Figure 4. Farmers and different stake holders field day and experience sharing during 2021/22 cropping season.

Field day is a method of motivating people to adopt new technologies through arranging expriance sharing among stake holders under field condition. Besides the field day was conducted at physiological growth stage for three consequence years in Mima learning water shed. Totally 703 (520 farmers, 76 researchers, 49 Asossa and Bambasi Wereda experts, Agricultural office head, Weredas administration and development agents and 58 Regional agricultural office head, experts, NGO's, BGRS president, BGRS deputy president, BGRS agriculture college and BGRS prosperity head were participated on the field day for last three consequence years. The BGRS president had participated on the field day and he appreciated and encouraged the team. Regional property party head and the deputy president are also participated on the field. Regional agriculture and NRM office head had gave direction on how others watershed or regional projects shall be learned from the Mima learning watershed. For media coverage, Ethiopia broadcasting corporation (etv), Benishangul Gumuz mass media, F M radio and regional agriculture and Natural resource communication were reported the program for media coverage.

Table 3. List of participant on the day of field day during 2022/2023 cropping season.

Farmers			Researchers			Asossa and Bambasi Wereda experts, Agricultural office head, Weredas administration and development agents			Regional agricultural office head, experts, NGO's, BGRS president, BGRS deputy president, BGRS agriculture college and BGRS prosperity head		
Male	**Women**	**Total**	**Male**	**Women**	**Total**	**Male**	**Women**	**Total**	**Male**	**women**	**Total**
25	10	35	30	5	35	8	7	15	18	8	26

Figure 5. Farmers and different stake holders field day and experience sharing during 2022/23 cropping season.

3.3. Effect of Bio-fertilizer Inoculant on Seed Yield of Soybean

The maximum amount of seed yield (1541.73 kg ha-1) was obtained under application of recommended TSP+ Inoculant. The application of recommended NPS plus inoculation was higher in seed yield of maize by 14% compared to the application of recommended NPS fertilizers alone. The yield advantage relative to NPS alone indicating the depletion of the soil microorganism and its strong response to bio fertilizer application. In line with [9] reported that combined application of rhizobia inoculation and phosphorous application resulted in 21% increased grain yield. This is an indication that the integrated use of organic and inorganic nutrient sources of fertilizers was advantageous over the use of inorganic fertilizer alone and also results in synergy and improved synchronization of nutrient release and uptake by the

crop. Combined application of both organic and inorganic sources to take care of maize nutrition more effectively leads to better productivity [10].

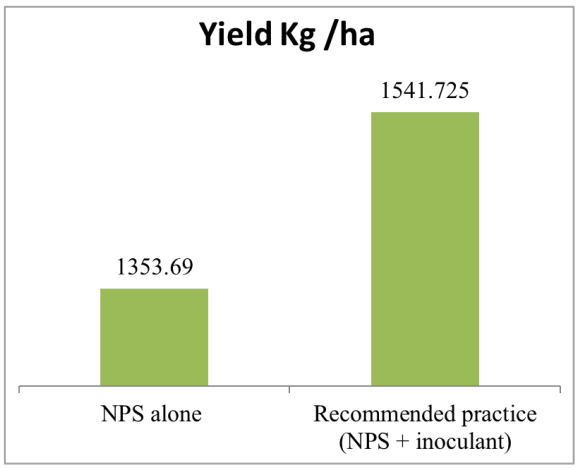

Figure 6. *Effect of bio fertilizer inoculant on seed yield of soybean.*

The participant farmers of both kebeles (Amba16 and Jamatsa) ranked the NPS alone at 2nd level, means they were strongly disagree with the NPS alone plot. On the other hand the farmer the farmers had strongly agreed with the plot that received recommended local practice (NPS + inoculant) they scaled as 1st level. This is may be the contribution of micro-organisms that by their microbial activity improve the nutrient availability of plants. The application of integrate inorganic and organic fertilizer (biofertilizers) are highly recommended for natural and eco-friendly farming practices that maintain the soil structure and bio-diversity.

4. Recommendation and Conclusion

The most possible causes of this decline soil fertility depletion and the continuous use of the traditional fertilizer, which have limited the yield and crop quality. Therefore this experiment was designed for the purpose of demonstrated combination application of the biofertilizer and NPS, and their combination) for soybean under field condition of Asossa District. Accordingly, the study revealed that application of NPS plus inoculation as the best fertilizer combination for soybean production at Assosa area accordingly farmers perception and the yield data recorded. Application of rhizobium inoculation alone also increased seed yield of soybean might be medium level of ppmP (phosphorous availability) of the study area during experimentation. It can be recommended NPS plus inoculation fertilizer combination to increase productivity and sustainability of soybean for study area and similar agro-ecology with its area.

Abbreviations

CALM	Climate Action Through Land Scape Management
P4R	Program for Result
DA	Developmental Agents

Conflicts of Interest

The authors declare no conflicts of interest.

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