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From Farmer Training to Field Demonstration: Participatory Bioameliorant Innovation for Enhancing Waxy Maize Productivity on Sandy Soil in North Lombok, Indonesia

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Abstract:- Sandy soils in North Lombok are characterized by low organic matter, limited nutrient availability, and poor water-holding capacity, which constrain waxy maize productivity. This study evaluated a participatory bioameliorant-based intervention implemented through farmer training, hands-on practice, and field demonstration. Bioameliorant application markedly improved crop growth and yield compared with the control. Plant height and leaf number increased by approximately 27% and 44%, respectively, while shoot and root biomass also increased substantially. Dry ear yield reached 19 t ha^{-1} in the demonstration plot, compared with 5 t ha^{-1} in the control, representing an increase of about 280%. Stover biomass also rose from 5.5 to 54 t ha^{-1}. These results indicate that bioameliorant application can effectively improve crop performance on sandy soils while strengthening farmers' practical understanding of the technology. Wider adoption is recommended through continued extension, farmer training, local bioameliorant production, and further multi-season and multi-location evaluation to confirm its consistency and scalability under resource-limited smallholder farming conditions in the region.

Keywords: *Bioameliorant; Waxy Maize; Sandy Soil; Farmer Training; Field Demonstration.*

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I. INTRODUCTION

Dryland areas represent an important resource for agricultural development in Indonesia. Of approximately 148 million ha of dryland, about 76.22 million ha are considered suitable for agriculture. In West Nusa Tenggara (NTB), dryland covers around 84% of the province, equivalent to approximately 1.8 million ha, although only about 31% of the total area, or 0.6 million ha, has prospects for productive agriculture [1]. In North Lombok, approximately 38,000 ha of dryland are available, but only about 30% are currently utilized for productive food crop cultivation, including maize [2].

The sandy soils in this region, however, impose major limitations on crop productivity. They are dominated by 69% sand, 29% silt, and only 2% clay, resulting in low water- and nutrient-holding capacities. Although the soil reaction is relatively favorable, with a pH (H_2O) of 6.97, fertility remains low, as indicated by very low total nitrogen (0.067%), low available phosphorus (13.82 ppm), very low available potassium (57.22 ppm), and very low organic carbon content (1.21%). These conditions reduce fertilizer-use efficiency and increase nutrient losses through leaching, making low organic matter and limited nutrient availability major constraints to crop production [3–5].

Waxy maize (*Zea mays* var. *ceratina*) is one of the promising crops for development in this area because of its relatively high economic value and its potential to support local food diversification. Its starch contains more than 90% amylopectin, which contributes to its characteristic sticky texture, distinctive taste, and high consumer preference for both fresh consumption and processed products [7]. Nevertheless, waxy maize production by the Loang Landak Farmer Group in Sumur Mual Hamlet remains constrained by low soil fertility, dependence on inorganic fertilizers, and low

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fertilizer-use efficiency. At the same time, approximately 4 tons of cattle manure are generated each month from surrounding livestock activities, but much of this resource remains underutilized because of limited farmer knowledge, skills, and processing technology [8,9]. Farmers also commonly sell waxy maize in fresh form to intermediary traders, resulting in low added value and high dependence on market price fluctuations [10,11].

A promising strategy for addressing these constraints is the application of bioameliorants produced from locally available cattle manure and enriched with arbuscular mycorrhizal fungi. Organic amendments such as manure and compost can improve soil physical, chemical, and biological properties, increase water retention, enhance soil organic matter, and improve nutrient-use efficiency. Mycorrhizal fungi can further increase the effective nutrient-absorbing area of roots, enhance phosphorus uptake, improve drought tolerance, and stimulate soil biological activity. The combined use of organic bioameliorants and mycorrhizal inoculation therefore offers strong potential for improving sandy soil quality, increasing crop productivity, and reducing dependence on inorganic fertilizers [3,12–14].

However, successful adoption of this technology depends not only on its agronomic effectiveness but also on farmers' understanding, participation, and practical skills. Therefore, the intervention was implemented through socialization, extension activities, farmer training, hands-on field practice, and a demonstration plot using a participatory andragogical approach. Farmers were actively involved in identifying field problems, preparing and applying bioameliorants, observing crop responses, and evaluating the technology under actual farming conditions. Accordingly, this study aimed to evaluate participatory bioameliorant-based innovation through farmer training and field demonstration as a strategy for enhancing waxy maize productivity on sandy soil in North Lombok, Indonesia, while promoting the use of local organic resources and more sustainable dryland farming practices.

II. MATERIALS AND METHODS

The extension and demonstration plot activities were conducted from August to October 2026 in Sumur Mual Hamlet, Pemenang Barat Village, Pemenang District, North Lombok Regency, Indonesia, with the "Loang Landak" Farmer Group as the main target participants. The community engagement activities were implemented through training and hands-on field practice using a participatory andragogical approach based on adult education principles. The program began with extension sessions and group discussions, consisting of approximately 20% theoretical instruction, focusing on the benefits of mycorrhiza-enriched bioameliorants derived from cattle manure waste for improving the fertility of sandy soils and increasing waxy maize productivity. This was followed by approximately 80% practical field activities, including bioameliorant preparation, field application, waxy maize cultivation, and activity evaluation.

The innovation was implemented through a demonstration plot using an action research approach consisting of six plots, each measuring 5 m × 5 m. The bioameliorant was formulated from 25% compost, 25% cattle manure, 25% rice husk charcoal, and 25% mycorrhizal biofertilizer, and was applied at planting at approximately 20 g per planting hole [3]. Inorganic fertilizers were applied at half of the recommended rate, consisting of 175 kg ha^{-1} urea and 125 kg ha^{-1} Phonska compound fertilizer. Waxy maize was planted at a spacing of 60 × 30 cm. Crop management included irrigation, weed control, and pest management using organic pesticides.

Growth and yield observations were conducted on 10 plants randomly selected from each plot. The observed parameters included plant height at 45 days after planting (cm), number of leaves at 45 days after planting (leaves $plant^{-1}$), shoot fresh weight at 45 days after planting (g $plant^{-1}$), root fresh weight at 45 days after planting (g $plant^{-1}$), shoot dry weight at 45 days after planting (g $plant^{-1}$), and root dry weight at 45 days after planting (g $plant^{-1}$). Yield-related parameters measured at 70 days after planting included dry ear weight per 25 m^2 plot (kg $plot^{-1}$), stover biomass per 25 m^2 plot (kg $plot^{-1}$), dry ear yield (t ha^{-1}), and stover biomass yield (t ha^{-1}). In addition, farmers' understanding of the extension materials and the introduced bioameliorant technology was evaluated as part of the participatory learning process.

III. RESULTS AND DISCUSSION

The implementation of the training and demonstration plot activities under the *Impactful Professor Program*, through a participatory bioameliorant innovation aimed at improving waxy maize productivity on sandy soil in Sumur Mual, Pemenang Barat, North Lombok, Indonesia, received a high level of enthusiasm from members of the Loang Landak Farmer Group. Participant attendance reached approximately 95% of the invited members, indicating strong farmer interest in the introduced technology. During the instructional sessions, participants were introduced to the concept of bioameliorants, the benefits of utilizing cattle manure waste enriched with mycorrhizal fungi, and its role in improving soil fertility and enhancing the growth and yield of waxy maize on sandy soils. Pre-test results showed that the participants' initial level of knowledge was relatively low, with an average score of approximately 45%. After completing the full series of activities, the average post-test score increased to about 90%, indicating that the training materials were well understood and substantially improved farmers' knowledge and technical capacity.

Interaction during the training sessions was highly dynamic. Participants did not merely receive information passively but actively engaged in discussions on various technical aspects of bioameliorant production, including material composition, fermentation procedures, mycorrhizal inoculation, and application strategies for waxy maize cultivation on sandy soils. Farmers also shared their experiences regarding several production constraints, such as low soil organic matter content, limited water availability, and a high dependence on inorganic fertilizers. These discussions

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served as a collaborative learning process that strengthened participants' understanding while enabling the implementation team to provide solutions that were relevant to the local agroecosystem conditions [15].

The hands-on field practice was the most highly appreciated component of the program because it provided participants with direct experience in producing and applying bioameliorants based on mycorrhiza-enriched cattle manure waste. Under the guidance of the implementation team, participants practiced each stage of the process, including raw material preparation, mixing and fermentation, mycorrhizal inoculation, and bioameliorant application to waxy maize in the demonstration plot (Figure 1). Final evaluation results showed that more than 90% of participants expressed their willingness to adopt the technology on their own farms because it was considered practical, locally resource-based, and potentially effective in increasing productivity while improving soil quality in a sustainable manner. The high level of participation and commitment demonstrated throughout the activities indicates that the program successfully strengthened farmers' technical competence, increased their confidence in adopting environmentally friendly agricultural innovations, and reinforced the self-reliance of the farmer group in supporting sustainable waxy maize production systems (Figure 2).



Fig 1 Mixing, Fermentation and Packaging Process of Mycorrhiza-Enriched Bioameliorant



Fig 2 Farmer Participation in Extension Activities

The waxy maize demonstration plot was established as one of the technology implementation activities under the *Impactful Professor Program* through Participatory Bioameliorant Innovation for Enhancing Waxy Maize Productivity on Sandy Soil. The demonstration plot was carried out participatively with members of the Loang Landak Farmer Group under intensive guidance from the Impactful Professor Team of the University of Mataram. The activity aimed to directly demonstrate the benefits of applying bioameliorants enriched with mycorrhizal biofertilizer for improving the quality of sandy soil and sustainably enhancing waxy maize growth and productivity. Through a practice-based learning approach, farmers were able to observe each stage of technology application and directly compare the performance of plants treated with bioameliorant with those cultivated under conventional practices [16].

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The bioameliorant applied in the demonstration plot consisted of 25% compost, 25% cattle manure, 25% rice husk charcoal, and 25% mycorrhizal biofertilizer. The same bioameliorant formulation was applied uniformly to all plants across the six plots, resulting in relatively consistent responses among the plots. All stages of the activity, including land preparation, soil tillage, bioameliorant preparation and application, waxy maize planting, and crop maintenance, were conducted jointly by the farmers under direct supervision of the implementation team. The active involvement of farmers at each stage served as an effective learning process for improving their technical skills and strengthening their understanding of the use of locally available resources as value-added agricultural inputs [17].

During the crop growth period, regular assistance was provided through field monitoring and technical consultation on fertilization, soil moisture management, environmentally friendly pest control, and crop growth evaluation. Field observations showed that bioameliorant application resulted in better plant performance than the untreated control. Plants in the bioameliorant-treated plots exhibited more uniform growth, greener leaves, stronger stems, and better ear development. These responses indicate that the bioameliorant improved nutrient availability, enhanced soil biological activity, and created a more favorable root-zone environment for waxy maize growth [18].

The successful implementation of the demonstration plot provided farmers with clear evidence that bioameliorant technology is practical, economical, and potentially effective for sustainably improving the productivity of sandy soils. In addition to promoting better crop growth, the technology also contributed to soil fertility improvement through increased organic matter inputs and enhanced activity of beneficial soil microorganisms. The visible performance of the demonstration plot strengthened farmers' confidence in the technology, and most participants expressed their willingness to adopt and further develop the innovation on their own farms. Thus, the demonstration plot functioned not only as a means of technology validation but also as an empowerment tool for strengthening the capacity of the farmer group to implement more productive, efficient, and sustainable waxy maize cultivation systems [19]. The visual appearance of the waxy maize demonstration plot is presented in Figure 3.



Fig 3 Waxy Maize Demonstration Plot with Mycorrhiza-Enriched Bioameliorant Application

As shown in Table 1, bioameliorant application in the demonstration plots consistently improved waxy maize growth and yield compared with the control. Plant height increased by approximately 27%, number of leaves by 44%, shoot fresh weight by 416%, root fresh weight by 250%, shoot dry weight by 752%, and root dry weight by 40%. Dry ear yield increased from 5 to 19 t ha^{-1}, representing an increase of approximately 280%. These improvements can be attributed to the role of organic materials in enhancing the physical, chemical, and biological properties of the soil, increasing water-holding capacity, improving nutrient availability, and reducing nutrient losses through leaching, particularly in sandy soils with inherently low water- and nutrient-retention capacities [20]. In addition, arbuscular mycorrhizal fungi in the bioameliorant can extend the effective nutrient-absorbing area of roots, improve nutrient uptake, particularly phosphorus, enhance water-use efficiency, and increase plant tolerance to environmental stress, thereby supporting greater biomass accumulation and crop yield [18,21,22]. Therefore, the substantial differences in growth and yield between the bioameliorant-treated and control plots not only demonstrate the agronomic potential of the technology for increasing waxy maize productivity on sandy soils but also provide clear field evidence that can be directly observed by farmers, thereby strengthening the participatory learning process through field demonstration.

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Table 1 Mean Growth and Yield of Waxy Maize in Bioameliorant-Treated Demonstration and Control Plots on Sandy Soil in North Lombok

Parameter	Demonstration Plot	Control	Increase (%)
Plant height at 45 days after planting (cm)	160	126	27
Number of leaves at 45 days after planting (leaves/plant)	13	9	44
Shoot fresh weight at 45 days after planting (g/plant)	801	155	416
Root fresh weight at 45 days after planting (g/plant)	84	24	250
Shoot dry weight at 45 days after planting (g/plant)	460	54	752
Root dry weight at 45 days after planting (g/plant)	21	15	40
Dry ear weight at harvest at 70 days after planting (kg/25 m^2 plot)	52	14	271
Stover biomass at 70 days after planting (kg/25 m^2 plot)	150	15	900
Dry ear yield at harvest (t/ha)	19	5	280
Stover biomass (t/ha)	54	5.5	881

Harvesting was conducted at 70 days after planting, when approximately 85% of the ears and leaves had dried. The harvest was carried out jointly by the Impactful Professor Team and members of the farmer group using 5 m × 5 m sampling plots. The ears were separated from the stalks and placed in labeled plastic bags, while the harvested stover was collected separately. Both ear and stover weights were then measured. This procedure provided data on dry ear weight and dry stover biomass per harvest plot, as presented in Figure 4.



Fig 4 Waxy Maize Harvesting with Members of the Farmer Group

IV. CONCLUSION

The application of bioameliorant technology through farmer training and field demonstration substantially improved the growth performance and productivity of waxy maize on sandy soil in North Lombok. Dry ear yield increased from 5 t ha^{-1} in the control to 19 t ha^{-1} in the demonstration plot, representing an increase of approximately 280%, accompanied by marked improvements in vegetative growth and plant biomass. These findings confirm that bioameliorant application is an effective and feasible technology for addressing low soil fertility and the limited productive capacity of sandy soils. The participatory approach, implemented through farmer training and demonstration plots, also played an important role in strengthening farmers' knowledge, practical skills, and confidence in adopting bioameliorant-based innovations sustainably. Based on the outcomes of the Impactful Professor Program, wider application of bioameliorant technology at the farm scale is recommended, supported by continuous extension assistance, training in locally based bioameliorant production, and further evaluation across different seasons and locations to verify the consistency of its effectiveness and strengthen its potential for broader farmer adoption.

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