



Innovation Characteristic and Crop Management of Zinc Biofortified Rice in Jember Regency

Luh Putu Suciati*, Ummi Sholikhah, Ahmad Zainuddin, Illia Seldon Magfiroh, Intan Kartika Setyawati, Rena Yunita Rahman, Nur Widodo

Faculty of Agriculture, University of Jember, Jl. Kalimantan 37, Jember, East Java, Indonesia
suciati.faperta@unej.ac.id

Abstract. The introduction of zinc biofortified rice varieties requires comprehensive and thorough efforts. This study aims to analyze the character of the use of Inpari Nutrizinc rice seeds. The research method used is the scoring method and Likert scale. The research location is in 4 (four) districts of rice centers and at the same time the location of zinc biofortified rice seed assistance in Jember Regency. The sample used was 40 farmers. The results showed that (1) nutrizinc rice is suitable for implementation related to land suitability is very high, but still faces constraints of farmers' openness to innovation that varies greatly (33% high and 35% low) and the level of independent capital and sufficient for land only 55% of farmers are able to independently capitalize. (2) Zinc biofortified rice seed innovation faces challenges related to low relative profitability, compatibility related to low productivity expectations. Supporting aspects are no significant differences with other varieties, easy to observe and easy to try; (3) Management of zinc biofortified rice farming is good in the aspect of the habit of using superior varieties, quality seeds, land cultivation, irrigation and post-harvest. Management aspects need to be improved related to pest control, harvesting, and grain marketing.

Keywords: Biofortified rice, Inpari rice, Zinc.

1. Introduction

Rice contains minerals that function for the growth and development of several vital organs [1]–[3]. One of the micro mineral content in rice is zinc. Zinc plays a role in the activation and synthesis of growth hormones, maintaining immunity, as an antioxidant, taste function, and stabilization of cell membranes. Zinc deficiency in children can cause abnormal growth, diarrhea and decreased immune function. Zinc consumption in children can stimulate appetite and increase energy intake. The need for zinc needs to be met by children during growth [4].

Efforts to increase zinc (Zn) content in rice to increase added value, nutrition and public health have been carried out in Indonesia through biofortification to increase zinc (Zn) content in rice [1], [4], [5]. The development of Nutrizinc fortified rice requires comprehensive handling from upstream to downstream [6], [7]. The main reason for the need for research related to the characteristics of the agricultural system in the development of Nutrizinc biofortified rice is the acceleration of the adoption of new superior varieties so that they can be cultivated by farmers and their products consumed by the community.

Currently, not all farmers are able to adopt the technology recommended by the Center for Rice Research. Although agronomically, the cultivation procedures and the use of agricultural production facilities for Inpari IR nutri zinc rice are not much different from other types of rice varieties [8]–[13], not all rice farmers receive clear information regarding this new type of variety. The potential Zn content in this variety can reach 34.51 ppm, with an average Zn content of 29.54 ppm. Inpari IR Nutrizinc belongs to the cere group, with an upright plant shape. Plant age is quite early, can be harvested \pm 115 days. Inpari IR Nutrizinc has a slender grain shape, and when harvested it is quite easy because it has a moderate level of loss and moderate friability. It has a fluffy rice texture with amylose content of 16.60%, this texture is suitable for most Indonesians. Potential productivity if done optimally can reach 9.98 tons/hectare, with an average yield of 6.21 tons/hectare. Efforts to increase the productivity of superior rice varieties require site-specific soil management, planting, fertilization and control of pest organisms.

The adoption of location-specific superior varieties has been proven to increase rice production and farmers' income. The development of Inpari IR Nutrizinc rice cultivation nationally was released in 2019 and in 2022 was applied in Jember Regency and expanded to 5,000 hectares in 2023 [1]. The development of Nutrizinc rice planting in Jember Regency in 2022 through rice seed assistance for 320 hectares of land in 14 selected locations according to agroecosystem characteristics. The development of Inpari IR Nutri Zinc rice requires research related to integrated agricultural systems so that production results are optimal and can be absorbed by the market and according to the target of reducing zinc deficiency to prevent stunting and energy deficiency in pregnant women.

Research related to the development of Inpari IR Nutri Zinc rice in various regions of Indonesia and other countries has been conducted, such as [1,4,5,14-16]. This research focuses on formulating an integrated farming system for Nutrizinc biofortified rice in various agroecologies. Specifically, the specific objectives in the

application of 7 (seven) components of crop management namely superior varieties, quality seeds, planting systems, irrigation, fertilization characteristics, weed control, pests and plant diseases, harvest and post-harvest in Jember Regency.

2. Research Method

The research was conducted in four sub-districts, namely Kaliwates, Mumbulsari, Rambipuji and Kalisat, based on agroecological differences and the category of zinc fortified rice centers. The sample of farmers used in this study was 40 people. Data analysis using Likert scale scoring analysis of the characteristics of the use of zinc biofortified rice seeds, the nature of innovation and the application of integrated farming systems on zinc biofortified rice with a category of 5 (five) scale very low, low, medium, high to very high. Attribute identification and measurement methods are described in Table 1.

Table 1. Characteristics of the use of Zinc Biofortified rice seeds

1. Suitability to land	<ol style="list-style-type: none"> 1. Very low, because the land topography is not suitable 2. Low suitability regarding topography & irrigation 3. Quite high: 50% compliance with water adequacy and topographic suitability 4. Height: suitable and requires little effort to improve the land 5. high suitability: sufficient water & suitable land slope
2. Cosmopolitan	<ol style="list-style-type: none"> 1. Never participated in counseling and training activities 2. I have attended counseling and farmer group meetings, but not regularly 3. Quite high: often comes to counseling and farmer group meetings 4. High: intense interaction at extension and farmer group meetings 5. Very high: very intense interaction, always present at extension & fellow farmers
3. Availability of capital	<ol style="list-style-type: none"> 1. Loan capital 2. Own capital and loans 3. Own capital but limited 4. Independent capital and sufficient for land 5. Independent and sufficient capital for rice cultivation

Indicators for the characteristics of zinc biofortified rice innovation are based on 5 (five) indicators, namely relative advantage, compatibility, complexity, triability, observability based on the character of adoption of an innovation. Explanation of each attribute in table 2.

Table 2. Nature of Innovation Adoption of Zinc Biofortified Rice Seed Planting Innovation

1. Relative advantage	<ol style="list-style-type: none"> 1. Very low profit (no profit) 2. Profit is lower than the yield of other varieties 3. The benefits are the same as other types of rice 4. High profits (20 – 50% higher than normal rice yields)
2. compatibility	<ol style="list-style-type: none"> 5. Very high profits >100% 1. very low compared to expectations for increased productivity 2. Productivity levels are lower than other types of rice 3. not much different from the productivity of previous varieties planted by farmers 4. According to the need for slightly higher productivity
3. complexity	<ol style="list-style-type: none"> 5. very suitable to the needs of farmers 1. very complicated application 2. complicated application 3. applications like other rice seeds 4. Application is easier than other rice seed applications
4. triability	<ol style="list-style-type: none"> 5. very easy application 1. application is very different compared to ordinary rice seeds 2. There is a slight difference in the application of ordinary rice seeds 3. the same as applying ordinary rice seeds 4. Application is easier than other rice seed applications 5. Application is very easy compared to other rice varieties
5. observability	<ol style="list-style-type: none"> 1. it is very complicated to observe the development of seeds 2. complicated to observe to observe seed development 3. quite easy to observe 4. easy to observe 5. very easy to observe

The farming management application for a new variety uses 7 (seven) component indicators, namely:

Table 3. Application of Farming Management Components in Zinc Biofortified Rice

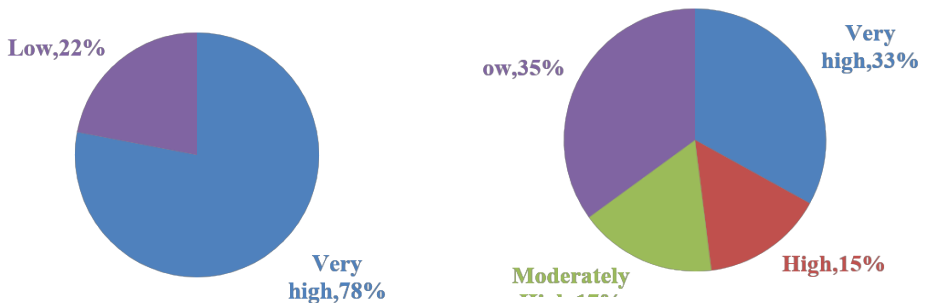
1. paddy varieties	<ol style="list-style-type: none"> 1. Do not use superior varieties 2. Application of superior varieties is only 1 MT per year 3. Application of superior varieties on 50% of land 4. Application of superior varieties to 75% of land 5. Application of superior varieties on all land
2. Use of quality seeds	<ol style="list-style-type: none"> 1. non-certified local seed application 2. application of superior seeds on 50% of the land, the rest is non-certified local seeds 3. application of 50% superior seeds 50% certified local seeds 4. 70% superior seeds and 30% certified local seeds
3. Application of land processing	<ol style="list-style-type: none"> 5. Certified superior seeds from breeders 1. Tablea planting system 2. Intercropping system 3. Legowo row planting system 4. Semi-organic planting system 5. Organic growing system
4. Water system	<ol style="list-style-type: none"> 1. Water requirements are twice as high as other superior rice varieties 2. Water requirements are 50% more than 3. Water requirements are the same as other superior rice varieties 4. Less water requirement 5. Water requirements are very economical
5. Fertilization system	<ol style="list-style-type: none"> 1. Fertilizer use exceeds standards 2. Fertilizer use is high compared to standard 3. Use of fertilizer according to standards 4. Use less fertilizer than standard 5. Fertilizer use is very little compared to standard
	<ul style="list-style-type: none"> ● N fertilizer (urea): 200-250kg, ● Fertilizer P (SP36): 100-150 kg, K ● Fertilizer (KCl):75-100 kg
6. OPT control	<ol style="list-style-type: none"> 1. Pest control is very complex beyond standards 2. Pest control is more frequent than standard 3. OPT control is in accordance with other rice varieties 4. Less pest control than other rice varieties 5. OPT control is very low compared to other rice varieties
7. Nutrizinc rice harvest	<ol style="list-style-type: none"> 1. manual with ani-ani 2. manual with a scythe 3. portable thresher/stationary thresher 4. semi-modern: serrated sickle
8. Post-harvest nutrizinc rice	<ol style="list-style-type: none"> 1. Shelter without bottom, threshing with human power, drying on the ground 2. Shelters use woven bamboo mats, threshing using human power, drying using plastic mats

<p>9. Nutrizinc rice grain marketing *)</p>	<ol style="list-style-type: none"> 3. Shelter using mats, threshing with experienced human power, drying with tarpaulin 4. The shelter uses a tarpaulin base, threshing using experienced human power and machines, drying using a drying machine 5. Using a tarpaulin base, threshing using a machine, drying using a tarpaulin 1. Not sold on the market/can only be consumed alone 2. Difficult to market, only marketed to one particular party at a standard price 3. Quite easy: it can be marketed to various parties at standard prices 4. Easy: marketed to all parties at standard prices 5. Very easy: Can be marketed to all parties at a high price
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3. Results and Discussion

3.1 Characterization of Zinc Biofortified Rice Seed Use in Jember Regency

The introduction of a new variety will depend on the suitability of the agroecosystem, as well as the application of zinc biofortified rice. The results of interviews and discussions with farmers provide information that the suitability of nutrizinc rice with 78% land is very high. This result is in accordance with the research of Pebriandi et al. (2021) [4] which showed that nutrizinc rice has land suitability in several regions in Indonesia such as Kalimantan, Java, and Sumatra. The introduction of new varieties needs to consider farmers' cosmopolitan (Farmers' openness to innovation through counseling and interaction with fellow farmers) varies greatly (33% high and 35% low). Farmers' openness to innovation will facilitate the introduction and adoption of an innovation, especially rice seeds. These results are in accordance with the research of [16]–[18]. Differences in farmer acceptance and communication methods need to be considered. The financial aspect is that not all farmers have independent and sufficient capital availability for land, only 55% are financially independent. Ownership of financial capital independently will increase the level of use of zinc biofortified rice seeds. **Fig 1.** below provides information on the character of zinc biofortified rice seed use in Jember Regency.



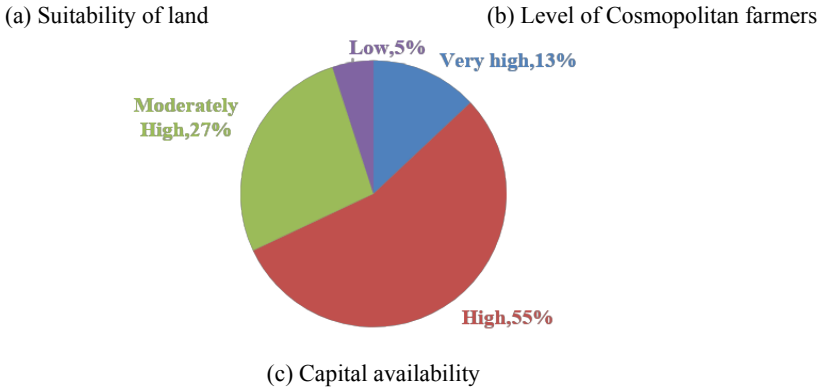


Figure 1. Character of zinc biofortified rice seed use in Jember Regency

Most farmers in Jember Regency are of the opinion that the use of zinc biofortified rice seeds has a high level of land suitability in Jember Regency. This land suitability can be seen that zinc biofortified rice can be adopted in several areas in Jember and produce relatively high productivity of around 4-5 tons/ha. While rice cultivation using other varieties can produce 6-7 tons/ha. This will certainly have implications for farmers' income. When viewed based on the level of cosmopolitan farmers against zinc biofortified Inpari seeds, most of them are still low at 35%. Farmers with very high and high cosmopolitan levels are 15% and 33%, respectively. The level of cosmopolitan farmers is still very dependent on the mindset of farmers and the existence of counseling to farmers. Farmers who receive incentive counseling tend to have a high level of openness. In addition, most farmers have a high level of capital availability at 55%. The availability of capital will encourage farmers to adopt the zinc biofortified rice seeds. This is because farmers are not worried about the losses that will befall farmers if the adoption of the new seeds fails. Broadly speaking, farmers in Jember Regency can accept zinc biofortified rice seeds suggested by the government.

3.2 Nature of Zinc Biofortified Rice Innovation in Jember Regency

The successful implementation of zinc biofortified rice depends on the acceptance of farmers which is assessed using 5 indicators that can be seen in Table 4:

1. Relative profit is considered low by most farmers. As much as 42% rated low (Profit lower than the yield of other varieties), and farmers who rated quite high at 30% (Profit equal to other types of rice). The survey results show that the profit of zinc biofortified rice still has a low level of profit compared to other varieties. The average profit obtained by farmers has a difference of 30% lower than farmers with other varieties.
2. Compatibility is the degree to which Inpari nutrizinc seeds are suitable for productivity improvement needs. The results showed that 40% considered low (the level of productivity is lower than other types of rice, 32% considered quite high (not much different from the productivity of previous varieties planted by

farmers). Most farmers assess that the production of zinc bio-certified rice seeds still has lower productivity compared to the varieties commonly planted by farmers. This result is in accordance with the research of Setiani et al. (2022) [14], which states that the productivity of nutrizinc rice is still relatively lower than other varieties. This low productivity can have implications for the low interest of farmers to produce these seeds.

3. Complexity is the degree of ease of application of Inpari nutrizinc seeds. The results imply that 72% of farmers rated it quite high (application like other rice seeds) and 25% of farmers rated it very high (easy in application). When viewed from the level of complexity, this zinc biofertilized rice seed has the same level of complexity as other rice seeds, making it easy to adopt or apply. This result is reinforced by the research of Qamar et al. (2018)[19] and Singh et al. (2014)[11] which showed that nutrizinc rice seeds are easy to apply.
4. The triability variable is the degree of ease of trying Inpari nutrizinc seeds. This study showed that 72% of farmers gave a fairly high assessment (the same as the application of ordinary rice seeds), and as many as 25% of farmers answered that there was a difference with the seeds of commonly planted varieties. Based on this description, it is known that farmers in Jember Regency are willing to try the Inpari biofertilized zinc rice seeds. This is because the seeds are seeds subsidized by the government, and farmers are curious about the results of the new seeds.
5. The assessment of the observability of nutrizinc rice seeds was mostly considered easy to observe (80%), and 20% answered very easy to observe. This concludes that nutrizinc rice seeds have characteristics that are easy to observe and can be seen. This research is in line with the research of Rao et al. (2020) [3] which showed that nutrizinc rice is easy to observe related to its growth and development.

Table 4. Farmers' Perception of Zinc Biofortified Rice Innovation

Innovation criteria	attribute	Relative advantage	Compatibility	Complexity	Triability	Observability
1 = Very low		5%	0%	0%	0%	0%
2 = Low		43%	40%	0%	25%	0%
3 = Moderately high		30%	33%	73%	73%	0%
4 = High		23%	28%	3%	3%	80%
5 = Very high		0%	0%	25%	0%	20%

3.3 Application of Nine Components of Crop Management in Inpari Nutrizinc in Jember Regency

Farm management is an important aspect to achieve the goal of implementing new rice varieties. In this study, the assessment of the application of the seven components of crop management used the Ministry of Agriculture's concept of farming components. The concept relates to the application of integrated crop management which includes (Refer to **Fig. 2**):

1. Farmers use superior varieties. The use of rice seeds with the Inpari Nutrizinc variety is an advantage for farmers. This is because the Inpari Nutrizinc variety

is one of the superior varieties [14]. This variety is classified as superior because it is a crossbred seed that produces rice that contains high zinc. Based on the results of the study, it shows that the majority of farmers or 95% of farmers consider that they have implemented the use of superior varieties.

2. The second component is the use of quality seeds. Farmers consider that the Inpari nutrizinc seed assistance helps farmers obtain quality seeds. Half of the respondent farmers consider that the use of nutrizinc rice seeds is a quality seed. Inpari nutrizinc rice seeds are government-assisted seeds given to farmers.
3. Farmers provide basic fertilization of agricultural land using organic fertilizers and if needed, they can be mixed with urea fertilizers. The fertilization system carried out by farmers is considered standard by farmers. This is because farmers have applied fertilizer in accordance with the recommendations of the extension workers. Most farmers have also used organic fertilizers which are strongly recommended by extension workers. Balanced fertilization of paddy fields is done twice during the growing season. The first and second fertilization is given when the plants are 15 and 45 days after planting. Research by Serebrennikov et al (2020) [20] showed that a good fertilization is 2 times during the growing season.
4. Farmers' land management has mostly been carried out in accordance with extension advice. Farmers use the 2:1, 4:1 jajar legowo spacing system, and a small proportion still apply the tegel planting system. However, 70 percent of the farmers already use the jajar legowo system.
5. Irrigation systems of respondent farmers are good. The irrigation system used is technical irrigation. However, the results of farmers' perceptions related to the irrigation system used are in a fairly high category. This shows that farmers who use technical irrigation systems are still not satisfied. This condition is due to the existing irrigation system in the countryside is still not well built. Irrigation systems in rural areas, especially in Jember, still need to be improved to support farming activities in the countryside.
6. Farmers' perceptions related to the management of Plant Disturbing Organisms (PEST) are diverse. There are farmers who think that the management of plant pest organisms is still not optimal. Most farmers still use chemical pesticides to reduce the risks caused by pests and plant diseases. Some farmers consider that the pest and disease control system is quite good and even very good. This is because these farmers have implemented management of plant pest organism management with integrated control using natural enemies or using vegetable pesticides.
7. Harvesting nutrizinc rice is mostly done using manual harvesting tools such as sickles or ani-ani [21]. However, some farmers have also used harvesting machines, namely combine harvesters. 90% of farmers rate nutrizinc rice harvesting as high and good.
8. Post-harvest handling of nutrizinc rice by farmers is considered very good. The harvested nutrizinc rice is dried and then milled into rice. This is done like processing other types of rice into rice. Therefore, the assessment related to post-harvest activities is considered very good.
9. Marketing of nutrizinc rice production is still very limited. People are not familiar with nutrizinc rice, which has many health benefits. Most farmers sell

their nutrizinc rice at the same price as other rice varieties. Therefore, farmers consider that the marketing of nutrizinc rice still needs to be improved and the price received by farmers is different from the price of rice with conventional varieties.

The results show that the application of good management is in the aspect of using superior seeds and quality seeds and land management (jajar legowo). While the standard is the irrigation system and fertilization. OPT control is still not optimized. Likewise, the post-harvest and marketing aspects of zinc biofortified rice grain. At the time of its application, farmers are expected to coordinate with their respective farmer groups, because the application of integrated crop management (PTT) will be better if applied jointly by farmers. The role of farmer groups is very large in supporting the success of the integrated crop management program.

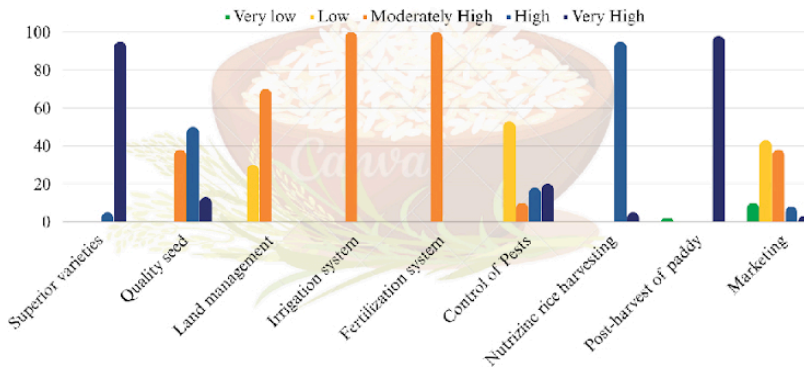


Figure 2. Application of the Nine Components of Crop Management on Inpari Nutrizinc in Jember Regency

4. Conclusion

The nutrizinc rice is suitable for implementation related to land suitability is very high), but still faces obstacles of farmer openness to innovation which varies greatly (33% high and 35% low) and the level of independent and sufficient capital for land only 55% of farmers are able to independently capitalize. Zinc biofortified rice seed innovation faces challenges related to low relative profitability, compatibility related to low productivity expectations. Supporting aspects are no significant difference with other varieties, easy to observe and easy to try. Management of zinc biofortified rice farming is good in aspects of the habit of using superior varieties, quality seeds, land

management, irrigation and post-harvest. Management aspects need to be improved related to pest control, harvesting, and grain marketing.

Suggestions for the development of the use of zinc biofortified rice seeds need to be done comprehensively not only by providing seed assistance, but education related to fertilization that supports the maintenance of zinc elements. The marketing aspect is the attractiveness of using a variety so that education must also be carried out to rice mills and introduction to consumers at a certain period of time.

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