Farmers’ response towards the introduction of NASA 29, a double-ear maize variety developed by IAARD

Nuning A. Subekti, Rizky P. Ramadhan, Dedi Nugraha, Bhakti Priatmojo, Putu Wardana, Made Oka Adnyana

Indonesian Center for Food Crops Research and Development
Jalan Merdeka 147 Bogor 16111

Email: argosubekti@yahoo.com

Abstract. Development and dissemination of NASA 29 has been carried out on a massive scale by the Ministry of Agriculture, especially the Indonesian Agency for Agricultural Research and Development (IAARD). Year 2014-2018 Agricultural Research and Development Performance listed NASA 29 as the most widely cultivated IAARD maize varieties in that period. This is particularly supported by the use of NASA 29 as a superior variety in national-scale agricultural programs. In the long run, it is necessary to ensure the continuing use of NASA 29 independently by farmers. This study aims to determine the response of farmers to the performance of NASA 29 which was introduced by IAARD. The study was conducted using survey approach (ex-ante and ex-post) to cooperative farmers in the NASA 29 development area during 2017-2018 in 4 districts of 3 provinces, namely Lamongan (East Java), East Lombok (West Nusa Tenggara), Sumbawa (West Nusa Tenggara), and Berau (East Kalimantan). The parameters explored in the survey included characteristics and responses of farmers to NASA 29 attributes. The data collected were analysed descriptively and NASA 29’s performance was measured using Importance and Performance Analysis (IPA) and Customer Satisfaction Index (CSI) measurements. The results showed that the average level of NASA 29 attribute performance was 3.86 on a 5.00 scale. This shows that the response of farmers to the performance of NASA 29 attributes is in the “quite satisfied” category. While the average value of the importance level of NASA 29 attributes to farmers is 3.84 from a scale of 5.00. This shows that according to farmers, these attributes are “quite important” to them. Overall, the response of farmers to NASA 29 attribute levels exceeded farmers’ expectations. However, to maximize the satisfaction of farmers, users need to improve the performance of each of these attributes. Farmer satisfaction with NASA 29’s performance is indicated by a CSI value of 77.28%. This value indicates that overall farmers were “quite satisfied” with the performance of the NASA 29 attributes. Improved performance of each attribute can be done at a minimum of 2.72% points so that the assessment of farmer users can be improved to be “satisfied” with the NASA 29 attributes. Further identified NASA 29 performance improvements need to be prioritized on attributes related to production costs that are still not considered efficient and affordable.

1. Introduction

Maize is among the four strategic commodities that receive special attention in the blueprint of the ASEAN Economic Community (AEC). The AEC’s food blueprint aims to enhance food security and sovereignty of maize, rice, soybeans and cassava in the ASEAN region. Indonesia in 2015 is the region’s largest maize producer [1]. However, Indonesian maize consumption continues to outpace
domestic maize production, resulting in a deficit. However, USDA in 2019 reported that maize production in Indonesia in 2019-2020 is forecast to reach 13.3 million tonnes, up from 12.6 million the previous year, as government incentives to expand production continue to yield results [2].

Indonesian Agency of Agricultural Research and Development (IAARD) is a ministerial research body under Ministry of Agriculture acknowledged to be one of the most significant contributors of agricultural innovations in the country. Through research from various aspects, IAARD has produced numerous agricultural innovations. The adoption of those innovations, however, needs to be accelerated, because there are still many technologies that have not been sustainably used by users. One of the innovations that plays an important role in increasing food crop production is high yielding variety. IAARD has released hundreds of food crops varieties, including maize varieties, yet, only a small part of the varieties was used and developed intensively by farmers over a long period of time.

In recent years interest in the use of hybrid maize varieties has significantly increased. The superiority of yield from hybrid maize over open-pollinated varieties (OPVs) is the main attracting factor. Many evidences demonstrate the agronomic superiority of maize hybrids over OPVs in intensive monoculture and integration systems such as agroforestry [3]. Kutka in 2011 stated that OPVs were and are sometimes useful for providing low priced seeds and dependable yields to farmers, although they usually yield less than well adapted hybrid cultivars when those are available [4].

Related to the extended use of hybrid maize varieties, in 2018 The Indonesian Ministry of Agriculture has declared to increase maize production by 40.5% until 2025 and, to achieve this goal it will distribute 40% of the total demand for hybrid maize seeds. The Ministry also stated that the seeds will be distributed to farmers using “seeds with lower productivity”.

NASA 29 is a hybrid maize variety released at the end of 2017 and specifically named by President Joko Widodo. This variety is a double-eared maize with yield potential reaches 13.5tha\(^{-1}\). It possesses a good resistance to an array of maize diseases such as downy mildew, rust, and blight. Yield potential of NASA 29 was reported to equal to several existing varieties such as DK-959 and BISI-2, even higher than PAC-339 and NK-33 [5]. Revenue Cost Ratio and Benefit Cost Ratio showed that NASA 29 was the highest among other varieties and in terms of farmers’ preferences, ear size and yield potential of NASA 29 were better than commercial varieties. Therefore, it is convincing that this variety has a good prospect to be developed in the future. The present study aims to evaluate farmers assessment to the performance of NASA 29.

2. Materials and Methods

Research Location
This research was conducted in 4 districts: East Lombok and Sumbawa (West Nusa Tenggara), Lamongan (East Java) and Berau (East Kalimantan). The activity has been carried out in two years from 2017 to 2018. Type of research was a survey research, that is widely used in quantitative research which uses tools as the main instrument for collecting data [6].
Data collection technique
Data collected in this study include primary data and secondary data. Primary data obtained through interviews (surveys). Survey data are collected with the help of structured questionnaires that are designed according to research interests. Secondary data was collected from various sources related to research topics, for example from national bureau of statistics (BPS), national/international research institutes, scientific publications, including communication with expert sources. Respondents from this research were selected purposively, based on the experience of farmers who had planted NASA 29 in several research/dissemination projects carried out by IAARD.

Data Analysis
Importance and Performance Analysis (IPA). IPA is used to analyse the level of farmers' preferences and satisfaction with NASA 29 attributes. The initial step of the analysis is to measure the importance and performance of NASA 29. The level of importance and performance in this study uses a Likert Scale. The level of importance consists of: Very Important, Important, Ordinary, Not Important, and Very Not Important, rated 5, 4, 3, 2, and 1, respectively. Likewise, the level of performance consist of: Very Not Good, Not Good, Ordinary, Good, and Very Good, rated 1, 2, 3, 4, and 5, respectively. Each attribute is positioned in a diagram, where the average score of performance appraisal (Xi) indicates the position of an attribute on the X axis, while the position of the attribute on the Y axis is indicated by the average score of the attribute importance (Yi) with the formula:

\[
\bar{X} = \frac{\sum X_i}{n} \text{ dan } \bar{Y} = \frac{\sum Y_i}{n} \quad \ldots (1)
\]

where,

\( X_i \) = Average level of performance score
\( Y_i \) = Average score of importance/expectation
\( n \) = Total number of respondent
Furthermore, the formula for describing the Cartesian Diagram is:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{K}$$

and

$$\bar{Y} = \frac{\sum_{i=1}^{n} y_i}{K}$$

… (2)

where,

$$\bar{X} = \text{The average of the average score of the performance level or customer satisfaction of all attributes}$$

$$\bar{Y} = \text{The average of the average score of the level of performance or customer satisfaction of all attributes}$$

$$\bar{x}_1 = \text{The average score of the level of performance or customer satisfaction of all attributes}$$

$$\bar{y}_1 = \text{The average score of the level of performance or customer satisfaction of all attributes}$$

$$K = \text{the number of attributes that affect customer satisfaction}$$

Performance and expectations are grouped into four according to the number of quadrants in Figure 2.

**Figure 2. Level of importance and performance [7]**

1. Top priority (quadrant I). Attributes that are in quadrant I have a high enough level of importance but have below average or unsatisfactory performance. Thus, the performance of the attributes that are in quadrant I must be improved in order to satisfy consumers.
2. Maintain performance (quadrant II). The attribute in quadrant II becomes the strength of the product because it has a high level of importance and performance. All attributes must be maintained because these attributes are the advantages of the product.
3. Low priority (quadrant III). Attributes in quadrant III have a relatively low level of importance and performance. Improved performance of the attributes included in quadrant III should be done after the performance of the attributes in quadrant I have been increased to match consumer expectations. Improved performance of attributes in quadrant III is considered not important by consumers.
4. Excessive (quadrant IV). Attributes in quadrant IV have relatively good performance but with a low level of importance. Performance attributes in quadrant IV are considered excessive by consumers, so investment should be diverted to increase the performance of attributes in quadrant I.

Customer Satisfaction Index (CSI). CSI is an analytical tool to determine the level of overall customer satisfaction by considering the importance of the attributes measured. Therefore, CSI is used to analyse the level of farmer satisfaction with NASA 29 attributes. CSI measurement methods include the following stages [8]:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{K}$$

$$\bar{Y} = \frac{\sum_{i=1}^{n} y_i}{K}$$

where,

$$\bar{x}_1 = \text{The average score of the level of performance or customer satisfaction of all attributes}$$

$$\bar{y}_1 = \text{The average score of the level of performance or customer satisfaction of all attributes}$$

$$K = \text{the number of attributes that affect customer satisfaction}$$
(1) Weighting Factors (WF)

The way to calculate WF is to change the mean value of the importance or mean important score (MIS) of each attribute to a number (%) of the total value of the average importance for all attributes tested, with the formula:

\[ WF = \frac{MIS_i}{\text{Total MIS}} \times 100\% \]  \( \ldots (3) \)

where,
\[ MIS_i = \text{MIS atribut ke-i} \]

(2) Weighted Score (WS)

How to calculate WS is the multiplication value between the average level of performance or satisfaction or Mean Satisfaction Score (MSS) of each attribute with the WF of each attribute, with the formula:

\[ WS = \text{MSS} \times WF \]  \( \ldots (4) \)

(3) Weighted Average Total (WAT)

How to calculate WAT is by adding the WS of all attributes, using the formula:

\[ WAT = WS_1 + WS_2 + \cdots + WS_k \]  \( \ldots (5) \)

where,
\[ K = \text{total attributes} \]

(4) Costumer Satisfaction Index (CSI)

How to calculate CSI, WAT divided by Highest Scale (HS) or the maximum scale used then multiplied by 100%, with the formula:

\[ CSI = \frac{WAT}{\text{HS}} \times 100\% \]  \( \ldots (6) \)

Overall level of satisfaction of respondents can be seen from the level of satisfaction criteria. The highest satisfaction is achieved if CSI shows 100%. The range of satisfaction ranges from 0 - 100%. To create a numerical linear scale, it is necessary to calculate the scale range (RS), using the formula:

\[ RS = \frac{m-n}{b} \]  \( \ldots (7) \)

where,
\[ m = \text{Highest score} \]
\[ n = \text{Lowest score} \]
\[ b = \text{Classes/Category} \]

3. Results and Discussion

3.1. Respondents Characteristics

Characteristics of farmer respondents include gender, age, level of education, farming experience, and average monthly income. Variable characteristics of respondents is a factor that can influence respondents' decisions in adopting superior hybrid maize varieties[9]. The characteristics of respondent farmers illustrate the situation of farmers that can influence the response of farmers in adopting a new technology 10]. The characteristics of the 60 respondent farmers can be seen in Table 1.
Table 1. Characteristics of respondent farmers.

| Profile                  | Category | Total | Percentage | Average |
|--------------------------|----------|-------|------------|---------|
| Gender                   | Male     | 49    | 81.67      |         |
|                          | Female   | 11    | 18.33      |         |
| Age (years old)          | <20      | 1     | 1.67       | 48.65   |
|                          | 20-29    | 2     | 3.33       |         |
|                          | 30-39    | 6     | 10.00      |         |
|                          | >39      | 51    | 85.00      |         |
| Level of education (years of school) | 0      | 7     | 11.67     | 7.62    |
|                          | <7       | 25    | 41.67      |         |
|                          | 7-12     | 24    | 40.00      |         |
|                          | >12      | 4     | 6.67       |         |
| Farming experience (years) | <10    | 10    | 16.67     | 22.65   |
|                          | 10-19    | 14    | 23.33      |         |
|                          | 20-29    | 19    | 31.67      |         |
|                          | 30-39    | 6     | 10.00      |         |
|                          | >39      | 11    | 18.33      |         |
| Average monthly income (Rp) | <500,000 | 7     | 11.67     |         |
|                          | 500,000-999,999 | 6    | 10.00     |         |
|                          | 1,000,000-1,499,999 | 16  | 26.67     |         |
|                          | 1,500,000-1,999,999 | 8   | 13.33     |         |
|                          | 2,000,000-2,499,999 | 9   | 15.00     |         |
|                          | >2,499,999 | 14  | 23.33     |         |

As many as 85% of respondents farmers belongs to elder age group. The number of respondent farmers who are at productive age, is expected to be able to improve the performance of NASA’s 29 hybrid maize farming and increase the adoption and diffusion of new technologies owned by the Indonesian Agricultural Research Agency[11]. The experience of farmers' maize farming (60.00%) for more than 20 years, is expected to increase the interest of farmers to adopt NASA 29 technology because of the advantages they have, including double ears with a frequency of 70% [12], full seed filling, ear relatively small and hard, high yield and more sturdy stems[13].

Formal education attended by farmers is elementary, junior high, high school and university. Most of the respondent farmers (41.67%) had formal education until graduating from elementary school. Only a small proportion (6.67%) have more than high school education. Considering at the level of formal education and experience owned by farmers in conducting hybrid maize farming, the respondent farmers' knowledge in running hybrid maize farming does not originate from formal education, but rather comes from experience gained from generation to generation, in addition to technical training organized by farmer groups or extension agent.

3.2. Importance and Performance Analysis (IPA)

Based on Table 2, it is known that the average value of the performance level of NASA 29 hybrid corn attributes is 3.86 from a scale of 5.00. This shows that the response of farmers to the performance of NASA 29 hybrid corn attributes is in the quite satisfied category. While the average value of the importance level of NASA maize 29 attributes is 3.84 from a scale of 5.00. This shows that according to farmer respondents, these attributes are quite important for farmers. Overall, the response of farmers to NASA 29 hybrid corn attribute levels exceeded farmers' expectations. However, to maximize the satisfaction of farmers, users need to improve the performance of each of these attributes. This is because, consumer satisfaction is a function of perception of performance and expectations [14].
Table 2. Conformity levels between expectations and performance of NASA 29 hybrid maize attributes.

| No. | Attributes                                  | Xj  | Yj  | TKj          | Rank |
|-----|--------------------------------------------|-----|-----|--------------|------|
| 1.  | High productivity                          | 4.33| 4.30| 100.54       | 4    |
| 2.  | Pests and diseases resistance              | 4.05| 4.16| 97.21        | 5    |
| 3.  | Efficient and affordable production costs  | 3.19| 4.00| 79.65        | 6    |
| 4.  | Early maturity                             | 3.81| 3.42| 111.56       | 2    |
| 5.  | Ease of agricultural practices             | 3.77| 3.60| 104.52       | 3    |
| 6.  | High selling price                         | 4.00| 3.53| 113.16       | 1    |
| Total|                                           | 23.14| 23.02|              |      |
| Average|                                       | 3.86| 3.84|              |      |

where,

- $X_j$ : Average Performance Level
- $Y_j$ : Average Expectation or Importance
- $TK_j$ : Level of Conformity between Performance Level and Expectation or Importance Level

Based on the suitability level, it can be seen that the attributes of NASA 29 hybrid maize which have the highest suitability value are the attribute of high output selling price (Var. 06), early maturity of harvest (Var. 04), ease of cultivation (Var. 05) and high productivity (Var. 05). The results showed the high selling price of the crop had the highest suitability value. This means that the selling price of NASA-29 according to farmers' perceptions has exceeded the level of price expectations desired by farmers. According to Raharto et al. in 2015, two main factors that determine the rate of adoption of a technology are the high level of production and the selling price of products [15].

The next level of performance attribute with the highest suitability level according to the respondent farmers is the early harvest age of NASA-29. Azrai in 2013, mentions the classification of corn according to age in broad outline divided into two groups, namely the early harvest age that can be harvested <95 DAP and the harvest age in which can be harvested at > 95 HST [16]. While NASA-29 has a harvest age of 100 DAP [13] which means it is not included in the classification of early maturing corn. However, farmers think that the harvest age of NASA-29 is quite satisfying compared to other corn.

The third attribute that has a high degree of suitability is the ease of conducting NASA-29 cultivation. The farmers' respondents thought that how to do NASA-29 hybrid corn cultivation was quite easy to do. This can be seen from the average value of the performance level of 3.77 on a scale of 5.00. Ease of conducting cultivation is one of the dominant factors affecting farmers' interest in using hybrid corn seeds [17].

NASA-29's high productivity level attribute has exceeded the average level of farmers' expectations. According to respondents, the high productivity of NASA-29 was partly due to the presence of two cobs on the NASA 29 plantations, so this attracted farmers to adopt NASA-29. This is consistent with research conducted by Bahtiar et al. in 2018 [5] which states that farmers' preferences are very good for the potential yield of NASA 29 compared to other varieties of corn. High productivity is one of the main factors in attracting farmers' desire to adopt a new variety [10]. Development and dissemination need to be done more massively in several locations of corn production centers.

The prioritization of the improvement of NASA 29 hybrid corn attribute performance is done by using a Cartesian diagram divided into four quadrants of NASA 29 hybrid corn performance improvement attributes. The division of the Cartesian diagram is done by making the intersection of the X-axis (the assessment of the level of performance attributes) with the Y-axis (the evaluation of the importance level attributes). The midpoints of each X and Y axis are determined based on the average rating of the performance level attribute (X axis) and level of importance (Y axis).
Figure 3. Cartesian diagram of NASA 29 hybrid corn attributes

Based on Figure 3, it is known that each attribute is divided as follows:

1. Quadrant I (top priority)
   This quadrant is an area containing NASA 29 hybrid corn attributes that are considered important by user farmers, but the level of performance is not in line with what is expected. Performance attributes that are in quadrant I must be improved and made the main priority that must be improved to increase user farmer satisfaction. These attributes are the production costs that are still considered inefficient and affordable (Var. 03).

2. Quadrant II (maintain performance)
   In quadrant II there are assessment attributes that are considered important by the user farmers and have a level of performance that is already considered good by the user farmers. Thus, the attributes in quadrant II can be maintained and expected to be a supporting factor for the satisfaction of farmers users. As for the attributes that are in quadrant II, namely 1) the attributes of high productivity (Var. 01) and 2) resistance to pests and diseases (Var. 02).

3. Quadrant III (low priority)
   Quadrant III shows the attributes that are considered by the respondent farmers to have a low level of importance, so they have less effect on the level of consumer satisfaction with NASA 29. Although it has not been a priority for improvement to increase consumer satisfaction, the attributes in this quadrant need to be observed and considered, because it can affect the sustainability of farmers in using NASA 29. The attributes included in quadrant III, namely 1) the attribute of early maturity (Var. 04) and 2) ease of cultivation (Var. 05).

4. Quadrant IV (excessive)
   In quadrant IV, there are valuation attributes that have a level of performance that is considered excessive and exceeds the level of expectation and interests of the user farmers, namely the attribute of the high price of the harvest (Var. 06). As a new technological innovation product introduced to farmers, it turns out to have a high selling price for crops. Further research is needed regarding the factors that influence the high selling prices of new innovation hybrid NASA 29 corn products.
3.3. Customer Satisfaction Index (CSI)

The Customer Satisfaction Index (CSI) measurement is used to determine the level of overall user satisfaction by considering the importance of attributes on NASA 29 hybrid maize. Botthe in 1996 states that CSI measurements provide user satisfaction data at a certain time span so that regular evaluations can be carried out to improve user satisfaction with a product [18].

Based on Table 3, the CSI value of 77.28% was obtained. This value indicates that overall user farmers are quite satisfied with the performance attributes of NASA 29 hybrid maize. Increasing the performance of each attribute can be done at a minimum of 2.72% points so that the assessment of farmer users can be said to be satisfied with NASA 29 attributes. Priority is given to attributes related to production costs that are still not considered efficient and affordable.

Table 3. Customer satisfaction index to NASA 29 based on six main attributes.

| Attributes                     | Mean Importance Score (MIS) | Weighting Factors (WF) | Mean Satisfaction Score (MSS) | Weight Score (WS) |
|-------------------------------|-----------------------------|------------------------|-------------------------------|-------------------|
| High productivity             | 4.30                        | 0.19                   | 4.33                          | 0.81              |
| Pests and diseases resistance | 4.16                        | 0.18                   | 4.05                          | 0.73              |
| Efficient and affordable      | 4.00                        | 0.17                   | 3.19                          | 0.55              |
| production costs              |                             |                        |                               |                   |
| Early maturity                | 3.42                        | 0.15                   | 3.81                          | 0.57              |
| Ease of                      | 3.60                        | 0.16                   | 3.77                          | 0.59              |
| agricultural practices        |                             |                        |                               |                   |
| High selling price            | 3.53                        | 0.15                   | 4.00                          | 0.61              |
| Total                         | 23.02                       | 1.00                   | 23.14                         | 3.86              |
| Weight Average Total (WAT)    |                             |                        |                               | 3.86              |
| CSI (%)                       |                             |                        |                               | 77.28             |

Market demand for seeds produced by farmers (seed growers) needs to be continuously created. Local government must make efforts to connect farmers to business partners of seed users, provide farmers access to capital support, and for the initial stages of this development the local government needs to prioritize the takeover of the seeds produced for further distribution. Affordability of the price of production inputs supporting the seeds propagation can be done by making efforts to get farmers closer to the production input providers. In addition to being able to cut production transportation costs, inputs also provide farmers with greater access to superior pest control products to increase the production of seeds they produce. Improvement of the ease of seed production can be pursued by increasing the capacity of seed farmers. In this case the role of intense mentoring by research institutes and seed inspection and certification body is absolutely necessary.

The sustainability of the supply of NASA 29 seeds in particular and IAARD’s newly released varieties in general, where seed is one of the most important components of an agricultural technology innovation package, is absolutely necessary to ensure the down streaming of the varieties. This is operationally possible through 2 (two) seed production system schemes: (1) corporation-based seed production system at the farmer level, by and for farmers (independent corporate farmer institutions), and (2) partnership seed production systems involving farmer institutions as plasma with business partners (private companies, village-owned business entity, or national-level business entity) as the core that are desired and agreed upon by both parties, mutually benefiting, and with proportional risk sharing.
4. Conclusions
The results showed that the average level of NASA 29 attribute performance was 3.86 on a 5.00 scale. This shows that the response of farmers to the performance of NASA 29 attributes is in the “quite satisfied” category. While the average value of the importance level of NASA 29 attributes to farmers is 3.84 from a scale of 5.00. This shows that according to farmers, these attributes are “quite important” to them. Overall, the response of farmers to NASA 29 attribute levels exceeded farmers' expectations. However, to maximize the satisfaction of farmers, users need to improve the performance of each of these attributes. Farmer satisfaction with NASA 29’s performance is indicated by a CSI value of 77.28%. This value indicates that overall farmers were “quite satisfied” with the performance of the NASA 29 attributes. Improved performance of each attribute can be done at a minimum of 2.72% points so that the assessment of farmer users can be improved to be “satisfied” with the NASA 29 attributes. Further identified NASA 29 performance improvements need to be prioritized on attributes related to production costs that are still not considered efficient and affordable.

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