IIAJ INTERNATIONAL INTEGRATED AGRICULTURAL JOURNAL

Volume 01 Number 01
May 2025
p-ISSN: 3124-7865
e-ISSN: 3124-8179

Application of sustainable agriculture in potato cultivation in highland vegetable farmers, Batu, Malang

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Abstract:
Sustainable agriculture is an agricultural system that considers the environment and the use of natural materials and can make agriculture an organic farming system. This study, which is used as a forum for community service for farmers, aims to determine the response of the application of Lemuru Fish Amino Acid, Sp-36 Application, and Humic Acid to potato yields. This activity began from February to May 2025 in the fields of highland vegetable farmers, Sumber Berantas, Bumiaji, Batu, Malang. The application of Lemuru Fish Amino Acid was carried out using a drip system, using a dose of 30 ml / l, and an interval of 1 week once starting from 21 days after planting (DAP) to 14 days before harvest. The addition of sp-36 fertilizer was given at the beginning only with 6 g / plant sausage by digging, and the application of Humic Acid with a dose of 50 g / l, using two methods if high rainfall was carried out by a sprinkling system and if high rainfall was carried out by a drip system. The parameters observed included the total number of tubers and the total weight of the tubers. The results of this study showed that the application of Lemuru Fish Amino Acid had a very significant effect on production results with results of 6.95 for the total number of tubers, and 83 for the total number of tubers. Thus, the use of organic materials and ecological methods such as this has great potential to support sustainable and productive organic farming.

Article info:
Submitted:
24-06-2025
Revised:
30-06-2025
Accepted:
30-06-2025

Keywords:
potato; sustainable agriculture; lemuru fish amino acid; humic acid; additional fertilizer

DOI: https://doi.org/10.53713/iiaj.v1i1.383

INTRODUCTION

National development aims to improve the standard of living of the community, so that it can always create resilience and welfare for the Indonesian people, both physically and spiritually. Efforts to achieve community welfare are carried out through various development programs in all sectors throughout the territory of the Republic of Indonesia (Fadlina et al., 2013).

Sustainable agriculture is a way of managing natural resources and changing technology and institutions so that human needs can be met continuously for present and future generations. Organic farming is considered a sustainable farming method, beneficial to both the environment and humans, and provides opportunities for farmers to increase income and well-being. This farming technique focuses on the utilization of natural resources and avoids the use of synthetic chemicals. The main difference between organic farming and conventional farming lies in the optimal use of organic materials and minimal use of synthetic materials, which in turn provides added value to consumers. Consumers benefit from organic farming in the form of safe food with high nutritional content (Mayrowani, 2016).

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p-ISSN: 3124-7865
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Like other developing countries, the main sector of Indonesia's economy is agriculture. Therefore, efforts to build Indonesia are always related to the development of the agricultural sector. The agricultural sector still has an important position in the country's economy. The importance of the role of agriculture is evident from its clear contribution to capital formation, provision of food, raw materials for industry, animal feed, and bioenergy. In addition, agriculture also provides employment, brings in foreign exchange for the country, generates income, and helps protect the environment through sustainable agricultural practices.

Based on the evaluation results regarding the development of agriculture that has been carried out so far, there are many basic issues that need to be addressed and require careful and appropriate handling. Currently, the agricultural sector in Indonesia faces various challenges because of past agricultural practices known as the "green revolution." The cultural heritage of the implementation of the green revolution program has caused farmers to become dependent on imported seeds, growth regulators, fertilizers, and chemical pesticides, which are relatively expensive, thus increasing the cost of agricultural production. This situation is not comparable to the selling price of agricultural products, which is generally low at the farmer level. The largest potato-producing area in Indonesia is East Java, and one of the places is Sumber Brantas Village, located in Bumiaji District, Batu City. In this area, there has been a decline in potato production, with a decline reaching 18.34% between 2019 and 2020 (BPS, 2021b).

So, in this problem, there is an alternative for sustainable agriculture that can face the challenges of globalization and the current trend of consumer agriculture and the world market, where agriculture is now starting to be sensitive and concerned about agricultural products that are free from chemical residues, as well as caring about the health of the environment and consumers.

METHOD

This activity was carried out from February to May in the highland vegetable farmers, Bumiaji, Batu City. The materials used in the service to farmers, in the cultivation of Lembang Kembang variety potatoes, Lemuru fish Amino Acid, Sp 36 fertilizer, and Humic Acid. The methods used in the implementation are direct practice, interviews, discussions, documentation, case studies, and literature studies.

Land preparation

Land preparation activities begin with spraying herbicides, land processing, harrowing, or making planting grooves. Spraying of herbicides is carried out 14 days before land processing. Land processing is carried out using a hand rotary using a wide pattern and a narrow pattern to make it looser and can turn the soil perfectly. Making planting grooves or harrowing is done by hoeing with a depth of 15-20 cm. Pulled straight using a Kenco so that it is neat and straight with a bed width of 55 cm and a bed length of 20 cm.

Planting

Planting is done on the farmer's land, which begins with the application of basic fertilizer and the provision of insecticides to protect tubers from attacks by white grub pests. Then, in planting the tubers, the tubers are first taken from the storage warehouse and sorted out the damaged ones and those that are still good, then planted with a distance between tubers of 20-25 cm, then covered again with a thickness of 20 cm. In this cultivation, the use of potato seeds uses the variety (Lembang Kembang) LK G3 because this variety is a variety that is often used by farmers in the area. In this

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p-ISSN: 3124-7865
e-ISSN: 3124-8179

study, the use of tubers involved only 8 tubers because this devotion was carried out on a small scale, and the availability of land was inadequate.

Lemuru Fish Amino Acid Application

The application of lemuru fish amino acid uses a drip system, with a concentration of 30 ml/liter, which is applied at 21 HST and stops application 14 days before harvest with an interval of 1 week. The application starts from mixing the Lemuru Fish Amino Acid material with water and then applied to the plant area.

Sp 36 Application

In addition, Sp 36 fertilizer is applied at the beginning of the plant together with planting. The use of Sp 36 requires a dose of 6 g / plant. The application is done by digging in the planting area. In the application of this fertilizer, only once is done; the rest is maintenance and identification.

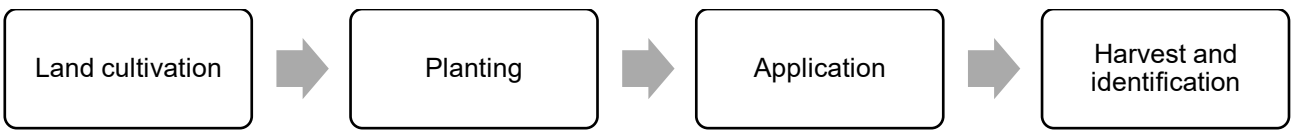
Humic Acid Applications

The addition of Humic Acid in potato cultivation is done with a time interval of 1 week. The dose required in this service is 50 g/liter. With the application method adjusting to environmental conditions, if rainfall is high, the application uses a sprinkling system; if rainfall is low or humidity is low, then the application uses a drip system.

Observation Parameters

In this service, the parameters observed include the Total Number of Bulbs and Total Weight of Bulbs, where the observation uses a calculation method and digital scales, the observation is carried out at the end after harvest. The variables were chosen because of the conditions and constraints faced by farmers, namely the final goal, production results, so this was chosen so that the final results can be seen.

Here is a simple summary of the initial process to data collection carried out in community service activities for farmers in the potato cultivation process, with the aim of increasing potato productivity.



RESULT

Lemuru Fish Amino Acid Application

In the application of Lemuru Fish Amino Acids, it is compared with potato cultivation without the addition of amino acids (owned by farmers). Which obtained very significant results, which are shown in the table below.

Table 1. Observation Data on Total Number of Bulbs

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Number of Bulbs (seeds)	83	52

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e-ISSN: 3124-8179

Based on the results of the study, treatment with the application of amino acids from lemuru fish showed a better number of tubers, reaching 83 tubers, compared to the farmer's treatment or no treatment. Karamina & Fikrinda (2016) noted that the use of POC can affect the number of tubers produced. The application of POC, which has streptomycetes microorganisms at the highest concentration, has been shown to be more effective in increasing the variable number of tubers than the control. This is thought to be related to the size of the seeds used, which affects the number of tubers formed.

Table 2. Observation Data on Total Tuber Weight

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Weight of Bulbs (kg)	6.95	4.5

According to research conducted by (Agustina, 2022), Nutrition is an important element for plants. Plants need various nutrients to grow well. The availability of nutrients will affect the quality of plants, including their growth, development, and yields. The nutrients needed by plants are divided into two categories, namely macronutrients and micronutrients. Increasing the amount of organic matter in the soil can reduce soil density, so that plant roots can grow well. Research on potato plants shows that the provision of liquid organic fertilizer has a positive impact on the weight of wet tubers, in line with the development and increase in the number of leaves. Plants whose nutrient needs are well met will increase growth because they better support the metabolic process. Higher leaf chlorophyll levels will better support plant metabolic processes including the photosynthesis process, so that more photosynthate is produced (Ditio et al., 2023) In the study conducted, the addition of amino acid ingredients from lemuru fish resulted in a total tuber weight of 6.95 kg, compared to farmers who were not treated (control).

Cultivation with SP-36 Fertilizer

One of the efforts to increase potato plant productivity is through optimizing the availability of nutrients through fertilization. Fertilization plays an important role in cultivation because it aims to support growth and increase yields. Lack of fertilizer can result in plants not getting enough nutrients from the soil (Salori & Barunawati, 2018). One of the important nutrients for plants is phosphorus (P), which can be provided through fertilization, for example, with SP-36 fertilizer, which is commonly used by farmers. Phosphorus is classified as a macro nutrient because it is needed in large quantities (Margenda, 2020). The role of phosphorus is vital for plants, especially in supporting growth and production processes. Phosphorus deficiency can cause stunted growth, delayed flowering, delayed harvest, and the seeds produced have low vigor (Sulistyaningrum, 2022). SP-36 fertilizer contains 36% P_2O_5 and functions to stimulate root growth at the beginning of growth, flower and seed formation, increase the conversion of flowers to seeds, strengthen plant resistance to pests and diseases, and improve soil fertility (Margenda, 2020). SP-36 fertilizer contains 36% P_2O_5 and functions to stimulate root growth in the early phase, support flower and seed formation, increase flower to seed conversion, strengthen plant resistance to pests and diseases, and help improve soil fertility conditions (Margenda, 2020). This fertilization is carried out once, at the same time as planting time. The application method is to place the fertilizer on the side of the potato plant carefully so as not to come into direct contact with the tubers, because it can cause the seeds to rot (Prayana, 2017). The use of SP-36 fertilizer with a dose of 6 grams per plant has been shown to significantly increase potato growth and production (Sembiring et al., 2015).

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Table 3. Observation Data on Total Number of Bulbs

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Number of Bulbs (seeds)	63	52

Potato plants require macro and micro nutrients to support their growth. Among these nutrients, phosphorus (P) is one of the most important in tuber formation and increasing yields (Budizaksono et al., 2023). Phosphorus can be obtained from natural availability in the soil or through fertilization. Fertilization itself is a method of adding macro nutrients to the soil, assuming that other nutrients are sufficient, for example, through the use of chicken manure and dolomite lime (Sutrisna & Surdianto, 2014). However, potato cultivation practices by the community in Sumberbrantas Village generally still do not apply basic fertilizers during the initial planting. Based on the table above, the potato harvest from farmers' land that was not treated with SP-36 basic fertilizer produced 52 tubers, while those given SP-36 fertilizer during the initial planting produced 63 tubers.

Table 4. Observation Data on Total Tuber Weight

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Weight of Bulbs (kg)	5	4.5

Research by Sembiring et al. (2015) also showed that the use of SP-36 fertilizer can increase the number and size of tubers compared to plants that are not given phosphorus fertilizer. The provision of phosphorus fertilizer can increase the absorption of nutrients, which ultimately has a positive effect on the growth and production of potatoes at harvest. In addition, potato plants that are given phosphorus fertilizer show better vegetative development, marked by wider leaf size compared to plants that do not receive fertilizer, which tend to have smaller leaves. Based on the table above, the addition of Sp 36 has an effect compared to the control, which is 5 kg.

Humic Acid Fertilizer Application

Humic acid fertilizer application is done through two methods, namely by spreading it directly on the soil surface and by pouring it (mixed with water and then watered). According to Marpaung et al. (2016), humic acid functions as a soil conditioner because it can increase the content of organic matter, which plays a role in improving soil fertility. The pouring method is considered effective because organic fertilizer is more easily dissolved and quickly absorbed by plants, so that plant nutrient needs can be met more. The selection of application methods is adjusted to environmental conditions; in the rainy season, humic acid should be applied by sprinkling, while when rainfall is low, the pouring method is more recommended because it can also replace the function of watering.

Table 5. Observation Data on Total Number of Bulbs

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Number of Bulbs (seeds)	69	52

Based on the observation results shown in the table above, the application of Humic Acid showed a result of 69 seeds; therefore, the application of Humic Acid influences the tubers produced compared to those of farmers without treatment.

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Table 6. Observation Data on Total Tuber Weight

Observation Variables	Lemuru Fish Amino Acid Application	No Treatment (Farmer Owned)
Total Weight of Bulbs (kg)	5	4.5

Based on the table above, the Total Tuber Weight variable shows a result of 5 kg in the application of humic acid, while farmers without treatment showed a result of 4.5 kg. Bertham et al. (2023) stated that humic acid is an environmentally friendly material that can be used to increase soil fertility, especially in vegetable cultivation. During the growth phase, potato plants treated with humic acid showed faster growth, with wider and greener leaves.

DISCUSSION

The application of Amino Acid lemuru fish with a dose of 30 ml / l with a drip application system has been proven to affect the results of the tubers produced. With the presence of these two variables, the application of Amino Acid Lemuru Fish on the Total Number of Tubers produced 83 tubers and a Total Weight of Tubers of 6.95 kg, where the application of amino acid lemuru curls is more effective than the farmer's control in terms of production results. Only in its application must be regular with a time interval of 1 week, which means the effectiveness of the activity, or the time of the activity must be routine.

Based on the benefits and several amino acid contents of lemuru fish that affect plant growth, including Glutamic acid has a carbon compound that plays an important role in the process of photosynthesis to build organic elements, including oxygen that supports the formation of organic elements from the soil transported by the roots and from the air absorbed by the leaves, hydrogen which functions as a source of energy for building organic elements for plants, namely in the form of water absorbed by plants, nitrogen which functions as the formation of chlorophyll and can increase microorganisms, and sodium functions as the formation of stomata on leaves (Kusuma, 2019).

The addition of Sp 36 fertilizer to potato cultivation aims to increase the availability of nutrients in the soil with the aim of producing large tubers and abundant yields. According to Table 3, the total number of tubers produced was 63, and the total weight of the tubers was 5 kg. Potato plants require macro and micronutrients. The nutrient that has the most influence on potato productivity, especially in tuber formation, is the P element (Budizaksono et al., 2023). This nutrient is obtained from the soil (which is already available) and through fertilization. Fertilization is one way to add macro nutrients to the soil, with the hope that other nutrients are already in the soil and can be obtained through the provision of chicken manure and dolomite (Sutrisna and Surdianto, 2014).

The Sumber Berantas Village community generally cultivates potatoes without using basic fertilizers at the beginning of planting. From the results of the research that has been conducted, the results of the potato harvest belonging to farmers without SP 36 basic fertilizer treatment obtained 51 tubers equivalent to 4.5 kg, while the results of the potato harvest with SP 36 fertilizer application treatment at the beginning of planting obtained 63 tubers equivalent to 5 kg. Based on research by Sembiring et al. (2015), the use of SP 36 fertilizer can increase the number of tubers, and the size of the tubers compared to those without fertilizer. So that the provision of p fertilizer can increase the absorption of nutrients, which has an impact on the growth and production of potatoes when harvested. In addition, the vegetative growth of potato plants with the use of this fertilizer tends to have wider leaves compared to those without the fertilizer, which tends to have smaller leaves.

Application of humic acid fertilizer is done by two methods: the first is by sprinkling, and the second is by pouring (mixed with water). According to Marpaung et al (2016), humic acid has a role

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as a soil conditioner by increasing soil organic matter, which will improve soil fertility. With the pouring method, which explains that the use of organic fertilizer will be easily dissolved and easily absorbed by plants, so that plants are faster in obtaining and meeting their nutrient needs (Karamina and Fikrinda, 2016). Both methods are carried out by adjusting environmental conditions. If rainfall is high, then the application of humic acid needs to be sprinkled, while for low rainfall, humic acid is applied with the pouring technique while watering the plants. Based on the data in tables 5 and 6, the two variables are the number of 69 tubers, and the total weight of the tubers is 5 kg. When compared to those of farmers, the results are different.

Humic acid has the main function of improving soil properties such as chemistry, biology, and physical properties. It can also increase plant oxidation. The addition of humic acid to the soil can increase the number of microorganisms in the soil. This can happen because humic acid has organic material that functions as a source of food for soil microorganisms, so that microorganisms can reproduce and help increase soil fertility. Currently, humic acid has been used as a fertilizer supplement that can increase fertilizer utilization and increase plant growth (Turan et al, 2011). The structure of humic acid consists of a mixture of aliphatic and aromatic organic compounds, among which are indicated by the presence of active carboxylic acid and quinoid groups.

Overall, the application of lemuru fish amino acids in a sustainable farming system for potato cultivation is a reference in developing agriculture that produces products free from chemical residues, which in community service research for farmers in Sumber Berantas village can increase maximum and very effective production results, organic farming that advances environmental health and consumer health is a renewable technology in an organic and sustainable farming system.

Table 7. Summary data of all treatments

Treatment (dose)	Total number of tubers (seeds/tuber)	Total weight of tubers (kg)
Control (no treatment)	52	4.5
Lemuru Fish Amino Acids (30 ml/l)	83	6.95
Sp-36 Fertilizer (100 kg/ha)	63	4.9
Humic Acid (50 g/ml)	69	5.6

Based on the table above, the application of Lemuru Fish Amino Acid showed very good results compared to all existing treatments, with a dose of 30 ml/l by pouring it obtained very significant results on both variables, and this began to be glanced at by farmers on how to make Lemuru Fish Amino Acid and how to apply it to cultivated potato plants, especially for consumption potatoes.

The existing documentation starts from the introduction at the potato seed development site and directs application in the field or to farmers.

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Figure 1. Documentation of Community Service Activities for Farmers

CONCLUSION

The addition of Lemuru Fish Amino Acid, sp-36, and Humic Acid to potato cultivation can increase potato production, support sustainable agriculture, and support the balance of the ecosystem on the land, creating products free of chemical residues. However, what can be recommended is the application of Lemuru Fish Amino Acid, as the two existing variables all have a real effect and produce significant results.

ACKNOWLEDGMENTS

The author would like to express his deepest gratitude to the Highland Vegetable Farmers, Sumber Berantas, Bumiaji, Batu, Malang. Those who have given permission, facilities, and opportunities to carry out this activity well. Thanks are also conveyed to the field supervisors who have guided, given direction, and shared knowledge during the activity process. The author also expresses appreciation and deep gratitude to the supervisor for the guidance, motivation, and direction given from the beginning until the completion of this scientific work.

CONFLICTS THAT MAY OCCUR

Conflicts of interest that may occur in the implementation of sustainable agriculture, which must pay attention to environmental balance, will lead to a counter, and the emergence of regulations that will be binding, which will cause a prolonged conflict between industry and farmers. Conflicts can occur when there is no harmony in the rules or policy support for the use of local organic materials in organic agricultural certification programs. The possibility that will occur is the availability of materials where the lemuru fish is needed while the village is far from the fish auction because of the very large needs, and will compete with other consumers who are made as side dishes, and Humic Acid which is truly original is only available in China if the needs are large then it will be difficult.

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p-ISSN: 3124-7865
e-ISSN: 3124-8179

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