Gunung Djati Conference Series, Volume 66 (2026)
Proceedings of the International Conference on Perennial Crops
ISSN : 2774-6585
Website : https://conferences.uinsgd.ac.id/

EFFECTIVENESS OF ORGANIC FERTILIZERS IN INCREASING THE YIELD OF LOCAL SWEET POTATO VARIETIES IN ACIDIC DRYLANDS OF NORTH SUMATRA

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ABSTRACT

This study aims to evaluate the effectiveness of various organic fertilizers in increasing the yields of local sweet potato varieties in the acidic drylands of North Sumatra. The experiment was conducted using a systematic tillage method with 100 cm x 25 cm plant spacing. Organic fertilizers were applied at a dose of 5 t ha^{-1}, supplemented with inorganic fertilizers (200 kg NPK and 150 kg Urea). Maintenance included three rounds of weeding, hilling, and vine turning, with harvesting conducted 3.5 months after planting. Farming analysis results revealed that goat manure (O1) yielded the highest average of 25,733 kg/ha, generating an income of IDR 60,372,000 ha^{-1} with a B/C ratio of 1.42. Rice husk compost (O2) followed with 24,821 kg ha^{-1} (B/C ratio 1.46), while oil palm empty fruit bunches (O3) and the control group without organic fertilizer (O4) produced lower yields of 16,487 kg ha^{-1} and 14,906 kg ha^{-1}, respectively. Among the tested varieties, V3 achieved the highest average yield (20,740 kg ha^{1}) compared to V2 (20,685 kg ha^{-1}) and V1 (20,191 kg ha^{-1}). The study concludes that the application of goat manure and rice husk compost significantly enhances sweet potato productivity in acidic drylands, increasing farmers' income by up to 91.27%. Furthermore, these organic amendments are recommended to improve soil structure in compacted acidic dryland areas.

Key words: Acidic, Dryland, Fertilizer, Organic, Sweet potato.

INTRODUCTION

Dry lands generally have low fertility and low organic matter content. Acidic drylands have a low pH (< 5.5), limited availability of macronutrients such as N, P, and K, as well as high Al and

Fe content that can inhibit plant growth; this condition will worsen if land utilization is not accompanied by the application of organic matter (Abdurachman *et al*., 2008).

Organic fertilizers play a role in improving the physical, chemical, and biological fertility of the soil, as well as enhancing the efficiency of inorganic fertilizer use. The quality and composition of organic fertilizers vary depending on the raw materials of the compost and its manufacturing process (Hartatik *et al*., 2015).

Goat manure is an organic fertilizer that is widely available in the environment, especially in areas where many farmers raise these animals, and it has a high nutrient content. It contains 2.10% N, 0.66% P_2O_5, 1.97 K_2O, 1.64% Ca, 0.60% Mg, 2.33 ppm Mn, and 90.8 ppm Zn (Samekto, 2006), making it highly suitable for soil application to enhance fertility. According to Hartatik & Widowati (2006), its application can significantly improve soil quality.

The use of organic fertilizers is an alternative that can be chosen to reduce farming operation costs. Its availability is also quite abundant around us; besides being easy to obtain, the cost is also quite cheap. Organic fertilizers available around us include livestock manures such as chicken, goat, and cow manure, as well as other green manures.

Sweet potato (*Ipomoea batatas* L.) is a local food commodity that plays an important role in food diversification in Indonesia, particularly in North Sumatra. Local sweet potato varieties generally possess high yield potential and good adaptation to the local environment. However, sweet potato production in dry land is somewhat lower compared to fertile land. The use of organic fertilizers can be an environmentally friendly solution to improve the physical, chemical, and biological properties of the soil, increase nutrient availability, and support crop productivity.

Various types of organic fertilizers, such as manure, compost, and green manure, have different characteristics and nutrient contents. Therefore, it is important to conduct research to determine the effectiveness of each type of organic fertilizer in increasing sweet potato yields in acidic drylands. To fulfill nutrient availability in the soil, utilizing organic fertilizers available in the farmers' environment is highly appropriate. Organic matter is one of the keys to increasing soil fertility (Islami *et al*., 2011).

Rice husk compost is an organic fertilizer made by decomposing plant and animal residues with the help of living organisms. In addition to providing nutrients for plants, compost can improve the physical, chemical, and biological structure of the soil. Physically, compost increases the soil's ability to store water as a reserve during droughts (Sukartono *et al*., 2011). Masulili *et al*. (2010) stated that the use of organic matter can improve the properties of acid soils, namely increasing soil organic matter content, soil Cation Exchange Capacity (CEC), the soil's ability to store available water, and lowering Al solubility as well as soil strength. With these improvements in soil properties, sweet potato plant growth can be improved.

The use of organic fertilizer in sufficiently high doses can provide nutrients for plants. In addition, organic fertilization offers other benefits, such as improving soil structure; organic fertilizers can bind nutrients that are easily lost and assist in providing soil nutrients, thereby increasing fertilization efficiency (Kresnatita *et al*., 2013).

Organic fertilization derived from agricultural and livestock waste, along with the implementation of crop rotation systems, is a combined technique considered capable of maintaining land fertility (Abbasi *et al*., 2015). According to Mohammad *et al*. (2012), crop rotation is a cropping pattern that involves planting different types of crops across several growing seasons with the aim of breaking pest cycles and maintaining soil fertility. The selection of rotated crops should ideally come from different families, such as planting legumes in the first growing season.

Palm oil waste is a byproduct obtained from palm oil production in the form of solid and liquid waste. Solid waste that can be used as organic matter for plants includes oil palm empty fruit bunches (EFB/Tankos) and solids. Palm oil waste can contribute nutrients to plants and act as an ameliorant to improve soil quality (Oktaviani *et al*., 2020). Astralyna (2009) stated that the application of oil palm empty fruit bunch compost can improve soil quality physically, chemically, and biologically, thereby increasing nutrients in the soil.

Acidic drylands in North Sumatra have extensive potential for the development of alternative food crops like sweet potatoes. However, unfavorable soil chemical conditions (low pH, high aluminum saturation, and low nutrient availability) represent major limiting factors impacting low productivity. Intensification efforts through continuous use of inorganic fertilizers can degrade soil quality and cause environmental degradation in the long run.

Organic fertilizer serves as an environmentally friendly and sustainable alternative to improve soil fertility, increase nutrient availability, enhance soil structure, and support soil microorganism activities. The use of organic fertilizers can also increase cation exchange capacity (CEC), reduce Al and Fe toxicity, and increase the pH of acid soils.

Furthermore, local sweet potato varieties have the advantage of good adaptation to the local environment and high yield potential if supported by proper soil fertility management. The utilization of organic fertilizers is expected to support the productivity of local sweet potato varieties, strengthen local food security, and support the increase of farmers' income.

Based on these conditions, research on the effectiveness of several types of organic fertilizers in increasing sweet potato yields in the acidic drylands of North Sumatra is highly necessary. The results of this study can later be used as recommendations for more efficient, sustainable, and environmentally friendly sweet potato cultivation technologies.

This study aims to identify the types of organic matter that can increase yields for several local sweet potato varieties while determining which specific varieties achieve the highest productivity under different organic fertilizer applications in the acidic drylands of North Sumatra.

MATERIALS AND METHODS

The research was conducted on farmers' dry land in Pasar Miring Village, Deli Serdang, North Sumatra. The required materials included: sweet potato cuttings of 3 varieties (Sungai Putih Orange, Sungai Putih Ungu, and Pasar Sembilan Ungu), 3 types of organic fertilizers (goat manure, rice husk, and oil palm empty fruit bunches), hoes, measuring tapes, small label signs, stakes, raffia strings, scales, gunny sacks, sample bags, and writing utensils.

Activity implementation: The soil was perfectly tilled, and then beds/ridges were prepared with a distance of 1 m between bed axes. The planting spacing was 100 cm x 25 cm, and organic fertilizer was applied during the preparation of beds/ridges according to its dose of 5 t ha^{-1}. Inorganic fertilization consisted of 200 kg NPK (PHONSKA) + 150 kg Urea. Fertilizer was applied twice: first, 10 days after planting for the full dose of Phonska fertilizer, and 45 days after planting for the full dose of Urea. Weeding was performed 3 times; during weeding, hilling up and vine turning were also carried out.

The experimental design used was a factorial Randomized Block Design (RBD) replicated three times. Factor I (3 sweet potato varieties): 1) V1 = Sungai Putih Orange, 2) V2 = Sungai Putih Ungu, and 3) V3 = Pasar Sembilan Ungu. Factor II (types of organic matter): 1) O1 = Goat manure, 2) O2 = Rice husk compost, 3) O3 = Oil palm empty fruit bunches (tankos), and 4) O4 = without organic matter (Control).

Observed parameters: 1) Large tuber weight (kg plant^{-1}), 2) Small tuber weight (kg plant^{-1}), 3) Large tuber yield (kg ha^{-1}), 4) Small tuber yield (kg ha^{-1}), 5) Harvest Index (%), and farming analysis.

RESULTS AND DISCUSSION

The results of the initial soil analysis conducted at the Soil Laboratory of the North Sumatera Center for Application of Agricultural Modernization (BRMP) showed that the soil organic content at the research location (acidic dryland) was quite low, with Organic C at only 0.67%, total N at only 0.10%, P-Bray I at 21.00 ppm, exchangeable K (K-dd) at 0.54 me 100 g^{-1}, and a pH of 5.97 (Table 1). The low organic C in the research field implies that adding organic fertilizer will improve the physical properties of the soil, making it looser so that soil microbiology can develop well, which is expected to effectively support sweet potato development.

After the sweet potatoes were harvested, the soil from each organic fertilization treatment was re-analyzed at the BRMP North Sumatra Soil Laboratory to evaluate the residual organic fertilization effect. The application of Goat Manure increased soil organic matter from 0.67% to 1.03%, which was higher than the Rice Husk Compost treatment that only increased from 0.67% to 0.82%. Meanwhile, the organic fertilizer from oil palm empty fruit bunches increased organic C from 0.67% to 0.77%. Without organic fertilizer, the soil analysis remained at 0.67% (Table 2). To further increase Organic C in acidic drylands soils, the organic fertilizer dosage can be raised. According to Samekto (2006), goat manure contains 2.10% N, 0.66% P_2O_5, 1.97% K_2O, 1.64% Ca, 0.60% Mg, 2.33 ppm Mn, and 90.8 ppm Zn. Supported by Hartatik & Widowati (2006), goat manure is highly beneficial when applied to soil to improve fertility.

Among the four organic fertilizer treatments (goat manure, rice husk compost, oil palm empty fruit bunches, and without organic fertilizer), goat manure yielded higher results compared to rice husk compost and empty fruit bunches. The application of goat manure (O1) on V2 variety gave the highest yield of 26,281 kg, compared to V3 at 25,681 kg and V1 which only produced 25,238 kg of large tubers. The average yield of the three varieties under goat manure application was 25,733 kg (Table 3). This shows that goat manure applications can increase sweet potato yields in acidic dryland.

Acidic dryland is usually quite compact; with goat manure application, the soil becomes loose, its fertility increases, and soil microorganisms become more active, creating fertile ground where tubers can develop better. This aligns with Hartatik & Widowati (2006), who noted that goat manure is excellent for soil application to enhance fertility.

Organic fertilizer from rice husk compost also performed better than oil palm empty fruit bunch compost. Variety (V3) yielded 25,635 kg ha^{-1} of large tubers, V1 yielded 25,569 kg ha^{-1}, and V2 yielded 23,259 kg ha^{-1}. Across the three varieties, rice husk compost application resulted in an average yield of 24,821 kg ha^{-1}. According to Sukartono *et al*. (2011), rice husk compost is an organic fertilizer made by decomposing plant residues with the help of living organisms. Besides providing nutrients, it improves physical, chemical, and biological soil structures. Physically, compost increases the soil's capacity to retain water as a reserve during drought, making the soil loose and fertile, thereby increasing sweet potato yields in dry land.

Organic fertilizer from oil palm empty fruit bunches produced lower yields than goat manure and rice husk compost, where V1 yielded 17,703 kg, another trial of (or V2) yielded 17,667 kg, and V3 yielded 14,721 kg. The lower performance of empty fruit bunch compost is presumably because its organic matter decomposes slowly due to its stringy/fibrous texture, making it harder to break down in the soil, which renders it less effective in boosting sweet potato yields. The treatment without organic fertilization (O4) showed the lowest yields compared to organic treatments: V1 yielded 12,256 kg, V2 yielded 15,536 kg, and V3 yielded 16,925 kg (Table 3).

Across all four organic fertilization levels, the average yield of variety V3 was 20,740 kg, which was higher than V2 (20,685 kg) and V1 (20,191 kg ha^{-1}). Differences in yield among varieties are influenced not only by genetics but also heavily by the growing environment (the type of organic fertilizer applied).

Regarding the weight of small tubers per hectare among the four organic treatments, the highest average was found in the treatment without organic fertilizer (O4) at 8,519 kg, followed by O1 (8,136 kg), O2 (7,492 kg), and O3 (6,831 kg ha^{-1}). Small tubers cannot be sold in the market except for animal feed. The high weight of small tubers in the unfertilized treatment occurred because without organic matter, the soil remained compact, preventing optimal tuber development, meaning small tubers failed to grow into large ones.

For large tuber weight per plant, treatment O1 yielded the heaviest at 0.64 kg, higher than O2 (0.62 kg plant^{-1}), O3 (0.42 kg plant^{-1}), and O4 (0.37 kg plant^{-1}). A heavier tuber weight per plant tends to translate to a higher overall yield per hectare, and vice versa.

Small tuber weight per plant did not show significant differences across organic fertilizer treatments or varieties. The produced small tubers do not influence consumable yields as they have no commercial value and are typically used as livestock feed.

The Harvest Index is the ratio of total tuber weight divided by the total weight of tubers plus shoots, multiplied by 100%. Heavier tubers lead to a higher harvest index, unless accompanied by extremely high shoot weight, which reduces the index. In fertile soils, higher tuber yields are usually followed by high shoot growth. Conversely, less fertile soil leads to fewer tubers and lighter shoot weight. Typically, a harvest index above 50% indicates that the produced tubers are heavier than the shoots.

Farming analysis results from the four organic treatments show that Goat Manure (O1) reached an average yield of 25,733 kg, farmer income of Rp 60,372,000 ha^{-1}, and a B/C ratio of 1.42%. Rice husk organic fertilizer (O2) average 24,821 kg, with an income of Rp 59,224,000 and a B/C ratio of 1.46%. Oil Palm Empty Fruit Bunches (O3) average 16,487 kg with an income of Rp 35,388,000 ha^{-1} and a B/C ratio of 1.14%. Meanwhile, without organic fertilizer (O4), the average yield was 14,906 kg, with an income of Rp 31,564,000 ha^{-1} and a B/C ratio of 1.12% (Table 4).

In acidic dryland lowlands, sweet potato yields are lower compared to those in fertile lands. However, the application of goat manure can significantly increase yields and farmer income from Rp 31,564,000 to Rp 60,372,000, representing a substantial increase of 91.27%. Meanwhile, the application of rice husk compost increases farmer income from Rp 31,564,000 to Rp 59,224,000, raising earnings by 87.63%. In contrast, oil palm empty fruit bunches only increase farmer income from Rp 31,564,000 to Rp 35,388,000, yielding a minor growth of just 12.11%.

CONCLUSION

Based on the results of this organic fertilizer research, the following conclusions can be drawn: goat manure and rice husk compost successfully increased:

1. Soil organic matter from 0.67% to 1.03% and 0.82%, resulting in a looser soil structure and higher microorganism populations, making the crops more fertile.
2. Average tuber yields, reaching 25,733 kg ha^{-1} and 24,821 kg ha^{-1} respectively, compared to only 14,906 kg ha^{-1} without organic fertilization.
3. Farmer income, reaching Rp 60,372,000 (noted as Rp 60,122,000 in text summary) and Rp 59,224,000 (noted as Rp 58,974,000 in text summary), compared to only Rp 31,564,000 (noted as Rp 31,314,000 in text summary) without fertilization.
4. Out of the three varieties tested across the four organic fertilization levels, the average yield of was 20,740 kg, which was higher compared to (20,685 kg) and (20,191 kg ha^{-1}).

To improve soil structure in dense, dry, acid soils, organic fertilizers such as goat manure and rice husk compost can be applied.

ACKNOWLEDGEMENT

The authors would like to extend their special thanks to the Soil Laboratory of the North Sumatra Center for Application of Agricultural Modernization (BRMP) for conducting the vital soil chemical analyses required for this research. The authors also highly appreciate the local farmers in Pasar Miring Village, Deli Serdang, North Sumatra, for providing the experimental dryland area and assisting in the successful implementation of the fieldwork.

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Table 1. Initial Soil Analysis Results at the BRMP North Sumatra Laboratory (Before Organic Fertilizer Application).

No.	Type of Analysis	Value	Test Method
1.	Organic C (%)	0.67	IK 0.1.5.0 (Spectrophotometry)
2.	Total N (%)	0.10	IK 0.1.6.0 (Kjeldahl)
3.	P-Bray I (ppm P)	21.00	IK 01.7.0 (Spectrophotometry)
4.	Exch. K / K-dd (me 100 g^{-1})	0.54	IK 0.1.8.0 (AAS)
5.	pH	5.97	IK 0.1.3.0 (Electrometry)

Table 2. Soil Organic C and Ph Analysis Results After Harvest.

No	Sample Code	Type of Analysis	
		Organic C (%)	pH
1	Sample 01 Goat Manure	1.03	5.77
2	Sample 02 Rice Husk	0.82	5.58
3	Sample 03 Empty Fruit Bunches (EFB)	0.77	5.78
4	Without Organic Matter (control)	0,67	5,60
	Test Method	IK 0.1.5.0 (Spectrophotometry)	IK.0.1.0.3 (Electrometry)

Table 3. Yield of Large Tubers, Small Tubers, Large/Small Tuber Weight Per Plant, and Harvest Index (%).

Treatment	Large Tuber Yield (kg ha^{-1})	Small Tuber Yield (kg ha^{-1})	Large Tuber Weight Plant^{-1} (kg)	Small Tuber Weight Plant^{-1} (kg)	Harvest Index (%)
O1V1	25.238	8.640	0,63	0,24	52,29
O1V2	26.281	7.978	0,66	0,20	49,83
O1V3	25.681	7.789	0,64	0,20	51,55
O2V1	25.569	6.994	0,64	0,16	50,66
O2V2	23.259	6.808	0,58	0,17	50,20
O2V3	25.635	8.673	0,64	0,19	50,75
O3V1	17.703	7.214	0,44	0,18	49,22
O3V2	17.667	6.490	0,46	0,16	49,59
O3V3	14.721	6.788	0,37	0,17	51,54
O4V1	12.256	8.133	0,31	0,21	49,59
O4V2	15.536	8.498	0,39	0,21	50,47
O4V3	16.925	8.928	0,42	0,22	49,87

Table 4. Farming Analysis.

Description	Goat Manure (O1)	Rice Husk (O2)	EFB (O3)	Without organic (O4)
A. YIELD kg ha^{-1}	**25.733**	**24.821**	**16.487**	**14.906**
Price @Rp 4000 kg^{-1}	102.932.000	99.284.000	65.948.000	59.624.000
B. COSTS				
Cuttings (40.000 @Rp. 200)	8.000.000	8.000.000	8.000.000	8.000.000
Land preparation	2.000.000	2.000.000	2.000.000	2.000.000
Preparing Ridges	2.500.000	2.500.000	2.500.000	2.500.000
Planting	1.200.000	1.200.000	1.200.000	1.200.000
Organic fertilizer (5000 kg)	12.500.000	10.000.000	1.500.000	0
PHONSKA (200 kg)	600.000	600.000	600.000	600.000
Urea (150 kg)	360.000	360.000	360.000	360.000
Furadan 3G (20 kg)	250.000	250.000	250.000	250.000
Weeding/Hilling up	2.000.000	2.000.000	2.000.000	2.000.000
Fertilization labor	400.000	400.000	400.000	400.000
Harvesting/Transport	4.000.000	4.000.000	3.000.000	2.000.000

Land lease	9.000.000	9.000.000	9.000.000	9.000.000
Total Costs (B)	**42.560.000**	**40.060.000**	**30.560.000**	**28.060.000**
C. INCOME (Rp)	**60.372.000**	**59.224.000**	**35.388.000**	**31.564.000**
D. B/C Ratio	**1,42**	**1,46**	**1,14**	**1,12**