Improvement of Some Soil Physical Properties with Cover Crops and Various Soil Cultivation in Upland Rice Cultivation

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Abstract- The problem that often occurs in Indonesia is the decline in productivity of agricultural land caused by planting monoculture crops. Therefore, efforts are needed to improve and maintain the organic matter and physical properties of the soil through the use of cover crops that are easily found in various fields, such as *Arachis pintoi* and *Asystasia gangetica*. The aim of the study was to determine the effect of tillage and cover crops in improving soil physical properties and upland rice yields. This research was conducted in the experimental garden of the Faculty of Agriculture, Islamic University of North Sumatra, Johor Building, Medan at an altitude of ± 25 m above sea level, and flat topography. The research method used a factorial randomized block design with three replications with tillage and cover crops as treatment. The results showed that Minimum and maximum tillage with cover crop *A. gangetica* was able to improve soil physical properties, namely bulk density, soil particles and soil porosity. However, it has not been able to increase the yield of upland rice.

Index Terms- *A. gangetica*, *A. pintoi*, weed

I. Introduction

Paddy is a rice-producing crop that is consumed by most of the Indonesian people. However, rice production is still low so that it does not meet the needs of the Indonesian people. The low production is estimated to occur due to a decrease in harvested area, a decrease in harvested area due to land conversion and declining land productivity. Therefore, it is necessary to use dry land in Indonesia to be an alternative for rice cultivation. However, the problem with dry land is that it is easily degraded into critical land. The main causes of land degradation are erosion by water and carbon emissions, nutrient leaching, and a decrease in soil organic matter content[1].

In the field of agriculture, soil is defined as a medium for plant growth, the state of a soil will affect the quality of plant life that grows on it. Plants can grow and are able to give good results if they grow on soil that is strong enough to support the erection of plants, does not have a layer that inhibits root development, good aeration, acidity around neutral, does not have high salt solubility and sufficient availability of nutrients and water in favorable conditions balanced[2].

Intensive land management will certainly require high costs in addition to accelerating soil damage. In addition, in general, when land preparation is carried out, the land is open. The soil is crushed by the tiller so that the soil aggregate has low stability. If it rains at that time, the soil is easily destroyed and transported with surface water (erosion). In the long term, continuous tillage results in compaction of the lower soil layer, which can inhibit root growth. To overcome the damage caused by tillage, minimum tillage can be an option[3].

Soil tillage is a land preparation activity for plant cultivation. Intensive tillage is a tillage system that is carried out twice to loosen the soil so that plant roots can grow well and the soil surface is clean without weeds. Minimum tillage is done by scraping weeds that are on the surface of the soil without intensively cultivating the soil and without tillage is done by making a hole to place the seeds[1].

According to Sofyan[4] tillage can increase the porosity. Therefore, to increase the porosity of the soil, the action that needs to be done is to add organic matter or carry out soil processing. Cover crops function as an addition to organic matter to the agroecosystem[5;6], improve soil health, and increase soil organic carbon[7;5]. To be able to be used as a ground cover plant, a plant must meet several

requirements as a ground cover plant, including being easy to propagate, quickly covering the land, producing a lot of leaves and branches, being able to grow in soil conditions with low fertility levels, being able to adapt to the environment and being able to adapt to the environment. little competition in nutrient uptake, adding soil organic matter through fallen stems, twigs and dead leaves[8].
Asytasia gangetica (L.) T. Anderson is an annual weed that grows creeping to form a very thick thicket. Flowering and seed production occur throughout the year[9]. In shaded areas, *Asytasia gangetica* will grow to form more vegetative organs, whereas in open areas it will produce more flowers and seeds[9]. This weed is able to grow well in tropical and subtropical areas, has good tolerance to various types of soil and can be found up to an altitude of 500 meters above sea level [10;9]. The results of Chozin et al.[11] showed that the biomulch treatment of *A. pintoi* 70 and 49 days before planting was able to increase the components of growth and production of tomato fruit. Sumiahadi[12] also stated that the use of *A. pintoi* biomulch could reduce the rate of erosion by more than 70% compared to the treatment without mulch with weeding in maize.

Based on the description above, proper tillage and combined with various ground covers are expected to improve soil physical properties, plant organic matter and upland rice yields.

II. RESEARCH METHODS

The research was carried out at Kebun Percobaan, Faculty of Agriculture, Universitas Islam Sumatera Utara, Gedung Johor, Medan, North Sumatra with an altitude of ± 25 m above sea level. Analysis of soil physical properties was carried out at the Soil Science Laboratory, Faculty of Agriculture, Universitas Islam Sumatera Utara, Gedung Johor, Medan.

The research method used a factorial randomized block design with three replications and two treatment factors. The first factor is: Cover crop (A) which consists of 3 levels, namely: no cover crops (control) (A0), *Asystasia gangetica* (A1) and *Arachis pintoi* (A2). The second factor is: Soil tillage (P) which consists of 3 levels, namely: No tillage (P0), Minimum tillage (P1), Maximum tillage (P2).

The experimental land was made in the form of plots measuring 2 m x 2 m with a height of approximately 30 cm. Planting cover crops using cuttings 15 cm long and planted 3 weeks before planting upland rice with a spacing of 20 cm x 20 cm. Upland rice before being planted in the field, the seeds are soaked for 24 hours, then drained, then sown in sprout tubs and watered every morning and evening for 14 days. After that, it is planted with a spacing of 25 cm x 25 cm by planting 2 rice seeds with planting holes.

Basic fertilizers are given at the time of planting rice according to the recommended dose, namely Urea 250 kg/ha, KCl 125 kg/ha, and SP-36 150 kg/ha. Urea was given 2 times, i.e. 1/2 part at the time of upland rice planting and another 1/2 part at 4 weeks after planting (MST). Fertilizer is applied in an array and covered with a little soil.

The physical properties of the soil observed were: bulk density, soil density, and soil porosity. Observational data were analyzed statistically using the F test and continued with the 5% LSD test if the observations showed a significant effect. Data processing was carried out using Minitab 19 software.

III. RESULTS OR FINDING

The results of analysis of variance showed that tillage, cover crops and the interaction between the two treatments had a significant effect on the bulk density of the soil (Table 1).

Table 1: Bulk density (g/cm^3) of soil with cover crop treatment and tillage

Treatment	Soil Tillage (P)			Average (A)
	No tillage (P_0)	Minimum tillage (P_1)	Maximum tillage (P_2)	
Cover Crop (A)				
Without cover crop (A_0)	1.49a	1.40ab	1.32ab	1.40a
A. gangetica (A_1)	1.37ab	1.14c	1.23bc	1.24b
A. pintoi (A_2)	1.26b	1.19bc	1.14c	1.19c
Average (P)	1.37a	1.24b	1.23c	

Note: The numbers in the same column and row followed by different notations show significant differences at the 5% level based on LSD test.
Average: The number in each mean followed by a different notation shows a significant difference at the 5% level based on LSD test.

Table 1 shows that tillage and cover crops have a significant effect on soil bulk density. Bulk density ranged from 1.14-1.49 g/cm^3. The density of the soil in the results of this study is still in the range of mineral soil density, which is 0.8-1.4 g/cm^3[13].

The interaction between minimum tillage with cover crop *A. pintoii* (P1A1) and maximum tillage with cover crop *A. gangetica* (P2A2) resulted in the lowest soil density compared to the treatment interactions. This is due to tillage causes the soil to become more friable while the presence of cover crops is able to contribute organic matter. In line with the results of the research by Widodo and Kusuma[14] which showed that the addition of organic matter was able to reduce the density of the soil. Hanafiah[15] states that organic matter serves to improve soil structure to crumbs. Further, Muyassir et al.[16] stated that the addition of organic matter can reduce the density of the soil. The difference in the value of soil density is due to the process of improving the physical properties of the soil related to the decomposers that break down organic matter. Indriani[17] explains that the amount of organic matter contained in the soil affects changes in soil density where the more organic matter, the lower the density compared to soils that have low organic matter. In addition, decomposers in changes in organic matter will also cause the soil to become most crumbly. In line with the statement of Muyassir et al.[16] which states that the decrease in soil density as a result of the decomposition of various sources of organic matter into soil organic matter so as to reduce the weight of the soil volume, the solid structure becomes crumbs so that the soil is easier to cultivate.

The results of analysis of variance showed that tillage, cover crops and the interaction between the two treatments had a significant effect on soil particle density (Table 2).

Table 2: Particle density (g/cm^3) soil with cover crop treatment and tillage

Treatment	Soil Tillage (P)			Average (A)
	No tillage (P_0)	Minimum tillage (P_1)	Maximum tillage (P_2)	
Cover Crop (A)				
Without cover crop (A_0)	2.31a	2.15ab	2.10ab	2.19a
A. gangetica (A_1)	2.12ab	1.98bc	1.89c	2.00b
A. pintoi (A_2)	1.96bc	1.86c	1.91c	1.91c
Average (P)	2.13a	2.00b	1.97c	

Note: The numbers in the same column and row followed by different notations show significant differences at the 5% level based on LSD test.
Average: The number in each mean followed by a different notation shows a significant difference at the 5% level based on LSD test.

According to Hakim et al.[18], generally the particle density of mineral soil is 2.65 g/cm^3. However, the high and low density of soil particles is influenced by tillage and soil organic matter content. Tillage causes the soil to become most loose, which can be seen in lower soil density (Table 1), while cover crops cause the addition of soil organic matter. Hardjowigeno[13] stated that organic matter has a smaller weight than other mineral solids in the same volume, the amount of organic matter in the soil clearly affects grain density. As a result, surface soils usually have a much smaller grain density than subsoil. Top soil that contains a lot of organic matter, the grain density decreases to 2.4 g/cm^3 or even lower than that value. In addition to these two factors, another factor is water content. The better the water content of a soil, the more organic and mineral content of the soil, so that the particle density value is low.

The results of analysis of variance showed that tillage, cover crops and the interaction between the two treatments had a significant effect on soil porosity (Table 3).

Table 3: Porosity (%) of soil with cover crop treatment and tillage

Treatment	Soil Tillage (P)			Average (A)
	No tillage (P_0)	Minimum tillage (P_1)	Maximum tillage (P_2)	
Cover Crop (A)				
Without cover crop (A_0)	35.66cd	34.71d	37.44c	35.94b
A. gangetica (A_1)	35.66cd	42.29a	35.20cd	37.72a
A. pintoi (A_2)	35.77cd	36.39cd	40.21ab	37.46ab
Average (P)	35.70b	37.80a	37.62ab	

Note: The numbers in the same column and row followed by different notations show significant differences at the 5% level based on Duncan's test.
Average: The number in each mean followed by a different notation shows a significant difference at the 5% level based on Duncan's test.

Table 3 shows that the interaction between tillage and cover crops has a significant effect on soil porosity. The highest soil porosity was obtained at the interaction of minimum tillage with *A. pintoi* (P1A1) and maximum tillage with *A. gangetica* (P2A2), which were 42.29% and 40.21%, respectively. This is due to the interaction of these treatments having a low bulk density (Table 1) so that it has high soil porosity. Wiskandar[19] stated that the decrease in the bulk density will increase the porosity of the soil. Porosity is an indicator of soil fertility. Poor soil porosity is caused by low organic matter content, poor soil structure and texture[20].

The results of analysis of variance showed that tillage, cover crops and the interaction between the two treatments had no significant effect on dry grain production per hectare (Table 4).

Table 4: Production of dry grain (t/ha) upland rice with cover crop treatment and tillage

Treatment	Soil Tillage (P)			Average (A)
	No tillage (P_0)	Minimum tillage (P_1)	Maximum tillage (P_2)	
Cover Crop (A)				
Without cover crop (A_0)	6.64	7.34	5.69	6.56
A. gangetica (A_1)	6.20	6.30	5.52	6.01
A. pintoi (A_2)	6.08	6.41	6.46	6.32

Average (P)	6.31	6.69	5.89

Note: The numbers in the same column and row followed by different notations show significant differences at the 5% level based on Duncan's test.
Average: The number in each mean followed by a different notation shows a significant difference at the 5% level based on Duncan's test

Table 4 shows that grain production per hectare was not affected by tillage, cover crops and the interaction between the two treatments. This is in line with the results of Birnadi's[21] research which showed that tillage had no significant effect on soybean production. Rachman et al.[22], stated that the effect of tillage on crop yields varies depending on soil conditions and the environment. Tillage sometimes increases, does not change or even decrease crop yields.

The treatment of cover crops also had no significant effect on grain production per hectare (Table 4). This indicated that the use of cover crops *A. gangetica* and *A. pintoi* did not cause competition with upland rice plants, which was seen from the production of grain that was not significantly different from that without cover crops. In addition, according to Asbur et al.[23], the use of cover crops is more influential in reducing the rate of soil erosion, increasing soil fertility, and suppressing weed growth. This is in line with the research results of Asbur et al.[7; 23; 24; 25] which showed that cover crops were able to reduce the rate of erosion, loss of soil nutrients, as well as improve soil chemical properties and suppress weed growth.

IV. CONCLUSION

Minimum and maximum tillage with cover crop *A. gangetica* was able to improve soil physical properties, namely bulk density, soil particles and soil porosity. However, it has not been able to increase the yield of upland rice.

REFERENCES

[1] M. Utomo, *Tanpa Olah Tanah: Teknologi Pengolahan Pertanian Lahan Kering*. Bandar Lampung: Lembaga Penelitian Universitas Lampung, 110p, 2012.

[2] D. Rahardjo, R. Zulhidiani, *Buku Ajar Hubungan Tanah, Air dan Tanaman*. Banjarbaru: Fakultas Pertanian Universitas Lambung Mangkurat, 2022.

[3] C. E. Nita, B. Siswanto, W. H. Utomo, “Pengaruh pengolahan tanah dan pemberian bahan organik (blotong dan abu ketel) terhadap porositas tanah dan pertumbuhan tanaman tebu pada Ultisol, *Jurnal Tanah dan Sumberdaya Lahan*, vol. 2, no. 1, pp. 119-127, 2015.

[4] M. Sofyan, “Pengaruh Pengolahan Tanah Konservasi terhadap Sifat Fisik dan Hidrologi Tanah,” Thesis, Institut Pertanian Bogor. Bogor, 2011.

[5] Y. Asbur, M. Ariyanti, “Peran konservasi tanah terhadap cadangan karbon tanah, bahan organik, dan pertumbuhan kelapa sawit (*Elaeis guineensis Jacq*.),” *Jurnal Kultivasi*, vol. 16, no. 3, pp. 402-411, 2017.

[6] C. J. Nevins, C. Nakatsu, S. Armstrong, “Characterization of microbial community response to cover crop residue decomposition,” *Soil Biology and Biochemistry*, vol. 127, pp. 39-49, 2018.

[7] Y. Asbur, S. Yahya, K. Murtilaksono, Sudradjat, E. S. Sutarta, “Peran tanaman penutup tanah terhadap neraca hara N, P, dan K di perkebunan kelapa sawit menghasilkan di Lampung Selatan,” *J. Pen. Kelapa Sawit*, vol. 23, no. 2, pp. 53-60, 2015.

[8] S. Arsyad, “Konservasi Tanah dan Air,” Revisi ke3, Bogor: IPB Press, 316p, 2010.

[9] H. Prawiratama, “Organisme Pengganggu Tanaman *Asystasia gangetica* (L) subsp. micrantha (Nees),” Medan: Pusat penelitian kelapa sawit, vol. G-0001, 2011.

[10] CRC, “Weed management guide: *Asystasia gangetica* ssp.micrantha,” in: *alert list for environtmental weeds (ed.)*, Australia: CRC for Australian Weed Management, 2003.

[11] M. A. Chozin, J. G. Kartika, R. Baharudin, “Penggunaan kacang hias (*Arachis pintoi*) sebagai biomulsa pada budidaya tanaman tomat (*Lycopersicon esculentum* M.),” *J. Hort. Indonesia*, vol. 4, pp.168-174, 2014.

[12] A. Sumiahadi, “Keefektifan biomulsa Arachis pintoi Karp. & Greg. untuk konservasi tanah dan pengendalian gulma pada pertanaman jagung di lahan kering,” M.S. Thesis, Sekolah Pascasarjana, Institut Pertanian Bogor, Bogor, 2014.

[13] S. Hardjowigeno, *Ilmu Tanah*, Jakarta: Akademika Pressindo, 2010.

[14] K. H. Widodo, Z. Kusuma Z, “Pengaruh kompos terhadap sifat fisik tanah dan pertumbuhan tanaman jagung di Inceptisol,” *Jurnal Tanah dan Sumberdaya Lahan*, vol. 5, no. 2, pp. 959-967, 2018.

[15] K. A. Hanafiah, *Dasar-Dasar Ilmu Tanah*, Jakarta: Rajawali Pers, 2013.

[16] Muyassir, Sufardi, I. Saputra I, “Perubahan sifat fisika Inceptisol akibat perbedaan jenis dan dosis pupuk organik.” *Lentera*, vol. 12, no. 1, pp. 1-8, 2012.

[17] Y. H. Indriani, *Membuat Kompos Secara Kilat*, Jakarta: Penebar Swadaya, 2007.

[18] N. Hakim, et al., *Dasar-Dasar Ilmu Tanah*, Lampung: Universitas Lampung. 488p, 1986.

[19] Wiskandar, “Pemanfaatan Pupuk Kandang untuk Memperbaiki Sifat Fisik Tanah di Lahan Kritis yang telah di Teras.” Kongres Pertanian Nasional VII, vol. 31, 2002.

[20] I. Anastasia, M. Izatti, S. W. A. Suedy, “Pengaruh pemberian kombinasi pupuk organik padat dan organik cair terhadap porositas tanah dan pertumbuhan tanaman bayam (*Amarantus tricolor* L.),” *Jurnal Biologi*, vol. 3, no. 2, pp. 1-10, 2014.

[21] S. Birnadi, “Pengaruh pengolahan tanah dan pupuk organik bokashi terhadap pertumbuhan dan hasil tanaman kedelai (*Glycine max* L.) kultivar Wilis,” *Jurnal Istek*, vol. 8, no. 1, pp. 29-46, 2014.

[22] A. Rachman, A. Dariah, E. Husen. (2021, Nov. 08). *Lahan Kering, Berlereng* [Online]. Available: https://balittanah.litbang.pertanian.go.id/ind/dokumentasi/buku/lahankering/berlereng8.pdf

[23] Y. Asbur, R. D. H. Rambe, Y. Purwaningrum, D. Kusbiantoro, “Potensi beberapa gulma sebagai tanaman penutup tanah di perkebunan kelapa sawit menghasilkan.” *J. Pen. Kelapa Sawit*, vol. 26, pp.113-128, 2018.

[24] Y. Asbur, S. Yahya. K. Murtilaksono, Sudradjat, E. S. Sutarta, The roles *Asystasia gangetica* (L.) Anderson and ridge terrace in reducing soil erosion and nutrient losses in oil palm plantation in South Lampung, Indonesia,” *J. Trop. Crop Sci.*, vol. 3, pp. 49-55, 2016.

[25] Y. Asbur, Y. Purwaningrum, M. Ariyanti, M. S. Rahayu. 2017. Soil Conservation Techniques by Vegetative and Mechanical in Oil Palm Plantation Age of 18 Years. Proceedings of the 7th AIC-ICMR on Health and Life Sciences. The 7th Annual International Conference (AIC) Syiah Kuala University and The 6th

International Conference on Multidisciplinary Research (ICMR) in conjunction with the International Conference on Electrical Engineering and Informatics (ICELTICs) 2017, October 18-20, 2017, Banda Aceh, Indonesia: 399-404.

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