SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin
ISSN: 2088-9038, e-ISSN: 2549-9645
Homepage: http://jurnal.umj.ac.id/index.php/sintek

ANALYSIS OF THE VERTICAL AND HORIZONTAL TYPE CULTIVATOR CLAW ON THE PERFORMANCE TEST OF THE POWER WEEDER MACHINE

Angger Bagus Prasetiyo[1,*], Kartinasari Ayuhikmatin Sekarjati[2]

[1]Department of Mechanical Engineering, Faculty of Industrial Technology, Institut Teknologi Nasional Yogyakarta, Yogyakarta, 55281, Indonesia

[2]Department of Industrial Technology, Faculty of Vocational Studies, Institut Sains & Teknologi AKPRIND, Yogyakarta, 55222, Indonesia

[*]E-mail: angger.bagus@itny.ac.id

Accepted: 17-10-2023 Revised: 15-01-2023 Approved: 01-06-2024

ABSTRACT

Weeds account for approximately 40–65% of rice production losses and affect 15–42% of arable land. If not managed promptly, crop yields could be drastically reduced. Traditional weed control methods, including manual weeding, chemical, semi-mechanical, and mechanical techniques, vary in effectiveness and efficiency. Conventional chemical and semi-mechanical methods are often less effective, costly, time-consuming, and environmentally detrimental. Thus, mechanical weed control presents a superior alternative. This study aims to compare the performance of power weeder machines equipped with vertical and horizontal cultivator claws in terms of weeding time, tool efficiency, and plant damage. The experiment was conducted on 30-day-old rice plants, with each test performed four times over a 1 x 6 meter area, maintaining a muck depth of 20 cm between rice plants. The power weeder machines were equipped with eight claws per unit, a 1.5 HP drive motor, and operated on a mix of oil and petrol fuel. Results indicate that the vertical-type cultivator claw achieved a work efficiency of 72.42%, while the horizontal-type cultivator claw achieved 86.04%. Weeding effectiveness was 93.10% for horizontal claws and 94.77% for vertical claws. Post-weeding, the horizontal cultivator claws caused 14.13% damage to rice plants, compared to 5.73% for vertical claws. Given its high weeding efficiency and minimal plant damage, the vertical type claw cultivator is highly recommended.

Keywords: Horizontal Cultivator Claw; Vertical Cultivator Claw; Power Weeder Machine.

ABSTRAK

Gulma menyumbang sekitar 40-65% dari kerugian produksi padi dan mempengaruhi 15-42% dari lahan pertanian. Jika tidak segera ditangani, hasil panen dapat berkurang secara drastis. Metode pengendalian gulma tradisional, termasuk penyiangan manual, kimiawi, semi-mekanis, dan mekanis, memiliki tingkat efektivitas dan efisiensi yang berbeda-beda. Metode kimia dan semi-mekanis konvensional sering kali kurang efektif, mahal, memakan waktu, dan merugikan lingkungan. Oleh karena itu, pengendalian gulma secara mekanis merupakan alternatif yang lebih unggul. Penelitian ini bertujuan untuk membandingkan kinerja mesin penyiang listrik yang dilengkapi dengan cakar pembudidaya vertikal dan horizontal dalam hal waktu penyiangan, efisiensi alat, dan kerusakan tanaman. Percobaan dilakukan pada tanaman padi berumur 30 hari, dengan masing-masing pengujian dilakukan sebanyak empat kali pada lahan seluas 1 x 6 meter, dengan mempertahankan kedalaman gulma 20 cm di antara tanaman padi. Mesin penyiang listrik dilengkapi dengan delapan cakar per unit, motor penggerak 1,5 HP, dan dioperasikan dengan bahan bakar campuran oli dan bensin. Hasil penelitian menunjukkan bahwa cakar penyiang tipe vertikal mencapai efisiensi kerja 72,42%, sedangkan cakar penyiang tipe horizontal mencapai 86,04%. Efektivitas penyiangan mencapai 93,10% untuk cakar horisontal dan 94,77% untuk cakar vertikal. Pasca penyiangan, cakar pembudidaya horizontal menyebabkan 14,13% kerusakan pada tanaman padi, dibandingkan dengan 5,73% untuk cakar vertikal. Dengan efisiensi penyiangan yang tinggi dan kerusakan tanaman yang minimal, kultivator cakar tipe vertikal sangat direkomendasikan.

Kata Kunci: *Cakar Kultivator Horisontal; Cakar Kultivator Vertikal; Mesin Penyiang Listrik.*

1. Introduction

One of the food crops that is grown all over the world is rice. Among them is Indonesia, which will produce 31.33 million tonnes of rice overall in 2020, making it the world's third-largest producer after India [1]. According to information from the Central Java Province's Agriculture and Plantation Service, the Purworejo Regency Government produced 273294.19 tons of rice per year, with a harvested area of roughly 49844, 53 hectares [2].

Broadleaf weeds, puzzle weeds, and grass weeds are obstacles that rice farmers must deal with since they can attack from the time of planting until the rice harvest [3].

Weed attacks throughout the range from 15 to 42%, and they significantly reduce rice output by 40 to 65% [4], [5]. Weeds dominate the paddy field ecology and compete with it for nutrients, light, water, fertilizer, and space, which lowers the quality of the rice [6-8]. If not managed, weeds can lower crop production and, if unmanaged, can eliminate crops [9]. Figure 1 depicts a general representation of the health of one of the farmers in Persidi Hamlet, Mlaran Village, Gebang District, Purworejo Regency, Central Java).

Figure 1. The state of the rice fields

Figure 2 illustrates the traditional (manual pulling) [10], [11], chemical, semi-mechanical, and mechanical weed control techniques that were developed [12]. A significant portion of the expenses associated with agricultural production is related to weed management. More than 33% of farmers' expenses go toward weeding [13]. Weeding is done to make the soil surface looser and boost the soil's ability to absorb water [14]. Farmers face challenges related to the method of retraction by hand, and semi-mechanical (basic equipment), including operational costs, processing time, the number of personnel, and less clean weeding outcomes [15]. The benefits of mechanical weeding include not harming the environment, raising soil temperature, enhancing rice quality, ensuring rice safety, and decreasing labour by between 50% and 75%. [16], [17] and 65% time savings compared to hand weeding, as well as 60% lower weeding expenditures [18]. Additionally, mechanical weed management can maintain a clear soil surface, improving air intake [17].

The effectiveness of weeding weeds in particular is a reason for concern because the tool's operation is influenced by the tool's shape, quantity, and angle of inclination of the claws [19]. The results of mechanical weeding were 0.0547 ha/hour, field efficiency of 49.37 %, crop damage rate of 7.7 %, and weeds that were not weeded at 3.12 % [20]. A land area of 1 m^2 can be finished in 10-15 minutes [21].

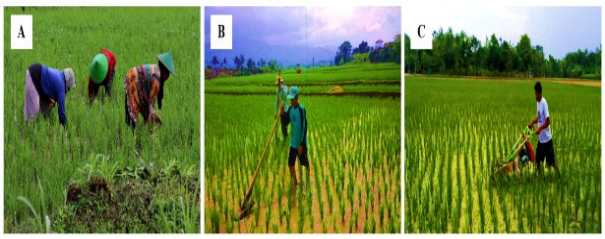

Figure 2. (a) Manual, (b) Semi-mechanical, and (c) Mechanical weeding techniques

The cultivator claw is one of the primary parts of the weeding machine. In designing the claw, efficiency, effectiveness, and strength factors were taken into account so that it could perform as intended. According to prior research, the shape of the claws accounts for 65% of the success rate for weeding; however, once the claws' number and shape were modified, the success rate rose to 78%, an increase of 13% between the two sets of data [22].

Researchers designed a claw cultivator with the goal of improving weeding success rates, work effectiveness, and time efficiency. This study is to examine vertical and horizontal cultivator claws on power weeder machine performance tests, which include weeding time, tool efficiency, and degree of plant damage, based on the aforementioned issues. Thus, this study can broaden readers' perspectives and serve as a resource for academics creating new instruments to facilitate farmers' management of rice weeds.

2. Methods

Research Plan, Location, Materials, and Tools

The ergonomic design principles incorporated into the proposed weed-weeding machine prioritize comfort,

safety, flexibility, and convenience for farmers. These principles are applied during the manufacturing process to ensure ease of movement, particularly concerning the replacement and transportation of components. The production of the weeding machines took place at the Manufacturing Laboratory of the Yogyakarta National Institute of Technology, within the Mechanical Engineering Study Program, Faculty of Industrial Technology. Testing of the cultivator claws was conducted in the rice fields of Persidi Hamlet, Mlaran Village, Gebang District, Purworejo Regency, Central Java. Data collection involved the use of weeding machines, cultivator claws, stopwatches, measuring tapes, stakes, and raffia rope. Table 1 provides the general specifications of the equipment used.

Table 1. Details of the field-used weeding equipment

Description	Type Cultivator	
	Vertical	Horizontal
Driving Power (HP)	1.5	1.5
Engine Speed (rpm)	33.27	33.27
Transmission type	Worm and wheel-type gear	Worm and wheel-type gear
Number of Blades	8	8
Fuel	Mixed gasoline	Mixed gasoline

Research and Testing Phases

The vertical and horizontal cultivator claws are the two types of claws used in the machine test. The total number of weeds and rice plants in each observation plot was then determined. The setting up of weeding tools and weed testing comes next. Table 2 displays all of the parameters that were used. When the rice is 3–4 weeks post-planting and there is about 30 cm between each Legowo type rice plant, the weeding process is completed [22]. In rice fields designed in the Legowo style, the muck is 20 cm deep [23].

Table 2. Study Criteria

Description	Value
Rice Plant Age	30 days
Rice Plant Height	25cm - 30cm
Distance Between	30 cm
Rice Mud Depth	20 cm
Types of Rice Plants	Legowo
Engine Speed	2.02 m/s
Data Retrieval Length	6 m
Data Capture Width	1 m
Radius	3.56 rad/s

Effective Field Capacity

The effectiveness of the tool, the effectiveness of weeding, and the degree of plant damage are among the data collected during the testing of the weeding machine. The following equation can be used to determine work capacity [24]:

$$KT=0{,}36\left(VxLp\right) \quad (1)$$

KT is Maximum theoretical field capacity (ha/hr), *V* is Motion in fast forward (m/sec), Lp is working width: *Lp* (m), and a Conversion factor of 0.36 between m2/second and ha/hour.

The competing land area and total time can be estimated to determine the value of effective working capacity, alternatively, it can be determined using the following equation [25,26]:

$$KE=\frac{A}{t} \quad (2)$$

KE is effective field capacity (ha/hour), *A* is Land area (ha), and *t* is tool working time (hours).

Tool Efficiency

The operating capacity of the tool can be compared to the theoretical capacity, or the following equation can be used to determine its efficiency value [27]:

$$E=\frac{KE}{KT}x100\,\% \quad (3)$$

*E i*s tool efficiency (%), *KE* is effective field capacity (ha/hour), and *KT* is theoretical field capacity (ha/hour).

Weeding Efficiency

The total weight of weeds and the weight of weeds are used to calculate the weeding success rate. The following equation [28] can be used to calculate the %age of weeding that was successful:

$$Gh=\left(\frac{W_1-W_2}{W_1}\right)x100\,\% \quad (4)$$

Gh is weeding efficiency (%), *W1* is the number of weeds between rows before weeding, and *W2* is the number of weeds between rows after weeding.

Crop Damage Rate

By comparing the amount of damage to plants and the primary crop, or by applying the following equation [29]:

$$PKT=1-\frac{q}{p}x100\,\% \quad (5)$$

PKT is crop damage rate (%), *q* is the number of main plants after weeding, and *p* is the number of main plants before weeding.

3. Result and Discussion

Tool Effectiveness

Table 3 displays the findings of the tool efficiency calculation performed on each claw of the power weeder machine.

Table 3. Presents the results of the efficiency calculations for the tools.

Description	Type Cultivator	
	Horizontal	Vertical
Value KT (ha/hour)	0.72597	0.72597
Value KE (ha/hour)	0.00627	0.00526
Efisiensi	86.04%	72.42%

Based on Table 3, the theoretical field capacity (*KT*), influenced by the machine's width and speed, is 0.72597 ha/hour for rice fields utilizing the two types of cultivator claws [30]. The effective field capacity (*KE*), which represents the actual average area covered by the machine during field operations, was 0.00526 ha/hour for the vertical cultivator claw and 0.00625 ha/hour for the horizontal cultivator claw . This variation can be attributed to factors such as the operator's skill in maneuvering the machine, transitioning between lines, and initiating work activities [12].

In the experimental tests, the vertical cultivator claw achieved an average work rate of 0.114 ha/hour, while the horizontal cultivator claw had a work rate of 0.096 ha/hour. This discrepancy is influenced by the design of the cultivator claws and soil conditions, which can affect overall performance [31] . The work efficiency (E) of the horizontal claw cultivator in paddy fields was 86.04%, compared to 72.42% for the vertical claw cultivator. This indicates that the horizontal claw cultivator is more effective for weeding rice plants, as evidenced by its higher efficiency percentage [13].

Welding Productivity

Table 4 displays the findings of the comparison of weeding productivity on each claw of the power weeder machine.

Table 4. Compares the productivity of claw cultivators with power weeders.

Description	Type Cultivator	
	Horizontal	Vertical
Initial Weed Amount	797	745
Amount of Uprooted	695	37
Amount of Cut Weeds	47	669
Final Weed Amount	55	39
Deprive percentage	87.34%	4.91%
Cut percentage	6.69%	89.92%
Weeding Efficiency	93.10%	94.77%

According to Table 3, the horizontal type of cultivator's claws had a removal rate of 87.34% and the vertical type had a removal rate of 4.91%. The cultivator's claws of the vertical type chopped weeds with an efficiency of 89.92%, and the cultivator's claws of the horizontal type cut weeds with an efficiency of 6.69%. The horizontal type cultivator claws' weeding effectiveness is 93.10%, whereas the vertical type cultivator claws' weeding efficiency is 94.77 %. The type of weed, the period of weeding, and the design of each cultivator's claw all have an impact on the variation in % the age value of each claw. This is supported by earlier studies carried out by [12]. Additionally, many elements that influence mechanical weeding effectiveness rely on design parameters, work speed, and ground disturbance [32]. plant and weed species, plant height and rice field depth [33].

Crop Damage Rate

Table 4 presents the results of the calculation of plant damage for each type of cultivator claw used in the power weeder.

Table 4. Shows the comparison of the degree of damage a power weeder machine cultivator caused to a claw plant.

Description	Type Cultivator	
	Horizontal	Vertical
Number of Plants Before Weeding	545	558
Number of Plants After Weeding	468	536
Crop Damage Rate	14.13%	5.73%

According to Table 4, the horizontal cultivator's claws caused the most amount of plant damage 14.13% while the vertical cultivator's claws caused the least 5.73%. This is because it depends on many variables, such as the person doing the weeding, the spacing between plants, and the design of the cultivator's claws [13].

The degree of damage done to the rice plants and the effectiveness of weeding are the two factors that determine whether a weeding machine is good or not [34].

4. Conclusion

The study concludes that while the horizontal claw cultivator demonstrates higher work efficiency at 86.04% compared to the vertical claw's 72.42%, the vertical claw excels in weeding efficiency with a rate of 94.77% versus 93.10% for the horizontal type. However, the horizontal cultivator claws result in 14.13% damage to rice plants, significantly higher than the 5.73% damage caused by the vertical claws. Based on these findings, the vertical type claw cultivator is recommended for its superior weeding efficiency and lower plant damage.

Acknowledgements

I would like to express my gratitude to the Yogyakarta National Institute of Technology's Research Institute for Community Service and Innovation (LPPMI) and the Director of Research, Technology and Community Service (DRTPM) of the Higher Education Ministry of Education and Culture for their support of this study. and every other party that we are unable to name individually.

References

[1] Portal PPID Kementerian Pertanian RI, "Portal PPID Kementerian Pertanian RI," Portal PPID Kementerian Pertanian RI, 2020. [Online]. Available: https://ppid.pertanian.go.id/index.php/news/view/1036/portal. [Accessed: Dec. 31, 2023].

[2] D. P. and P. J. Tengah, "Produksi Tanaman Pangan Provinsi Jawa Tengah," eData - Dinas Pertanian dan Perkebunan Jawa Tengah, 2016. [Online]. Available: https://edata.distanbun.jatengprov.go.id/data/detail_cari_atap_tp_produksi. [Accessed: Dec. 31, 2023].

[3] A. Syaifudin and F. A. Nofa, "Types of Rice Weeds (Oryza Sativa L) in Agricultural Land in Terban Village, Warungasem District, Batang Regency, Central Java," Biol. Samudra, vol. 2, no. 2, pp. 128-136, 2020, doi: 10.33059/jbs.v2i1.2959.

[4] R. K. T., S. V. Jogdand, and V. M. Victor, "Field Performance Evaluation of Power Weeder for Paddy Crop," Curr. Agric. Res. J., vol. 6, no. 3, pp. 441-448, 2018, doi: 10.12944/carj.6.3.24.

[5] D. S. Thorat, P. K. Sahoo, D. De, and M. A. Iquebal, "Prototype: A ridge profile mechanical power weeder," AMA, Agric. Mech. Asia, Africa Lat. Am., vol. 48, no. 1, pp. 81-86, 2017.

[6] L. Zhou, Z. Liu, and T. Zhou, "Qualitative Analysis of the Effect of Weeds Removal in Paddy Ecosystems in Fallow Season," Discret. Dyn. Nat. Soc., vol. 2020, pp. 17-19, 2020, doi: 10.1155/2020/8716314.

[7] N. Shimada and S. Sugiura, "Indirect effects of weeds on rice plants via shared heteropteran herbivores," J. Appl. Entomol., vol. 145, no. 1-2, pp. 117-124, 2021, doi: 10.1111/jen.12824.

[8] X. Wang et al., "Temporal variation of SOC storage and crop yield and its relationship - A fourteen year field trial about tillage practices in a double paddy cropping system, China," Sci. Total Environ., vol. 759, p. 143494, 2021, doi: 10.1016/j.scitotenv.2020.143494.

[9] B. S. Chauhan, "Grand Challenges in Weed Management," Front. Agron., vol. 1, no. January, pp. 1-4, 2020, doi: 10.3389/fagro.2019.00003.

[10] A. B. Prasetiyo and K. A. Sekarjati, "Finite Element Simulation of Power Weeder Machine Frame," Indones. J. Comput. Eng. Des., vol. 4, no. 2, pp. 26-34, 2022, doi: 10.35806/ijoced.v4i2.291.

[11] A. B. Prasetiyo et al., "Finite Element Analysis (FEA) of blade weed design using Ansys workbench," Sinergi, vol. 26, no. 3, p. 371, 2022, doi: 10.22441/sinergi.2022.3.012.

[12] A. S. Islam, M. Islam, M. S. Islam, A. L. Rahman, and M. Rahman, "Performance Evaluation of BRRI Power Weeder for Low Land Rice (Oryza sativ L.) Cultivation," Agric., vol. 15, no. 1, pp. 40-48, 2017, doi: 10.3329/agric.v15i1.33427.

[13] S. Pandey, A. K. Verma, A. Sirmour, I. Gandhi, and K. Vishwavidyalaya, "Ergonomical studies on single row power weeder for rice crop," J. Crop Weed, vol. 15, no. 1, pp. 145-150, 2019. [Online]. Available: https://www.cropandweed.com/archives/2019/vol15issue1/15-1-22.pdf

[14] S. Khandai, A. Tripathi, V. Kumar, and A. K. Kerketta, "Ergonomic Evaluation and Comparison of Existing and Modified Power Weeder," Int. J. Curr. Microbiol. Appl. Sci., vol. 7, no. 12, pp. 2476-2481, 2018, doi: 10.20546/ijcmas.2018.712.281.

[15] V. Imaniasita, T. Liana, and D. S. Pamungkas, "Identifikasi Keragaman dan Dominansi Gulma pada Lahan Pertanaman Kedelai," vol. 4, no. 1, pp. 11-16, 2020, doi: 10.20961/agrotechresj.v4i1.36449.

[16] P. Diwan, R. K. Naik, S. Sonwani, S. Sinha, and Y. K. Kosariya, "Developing situation of mechanical weeding in rice," J. Pharmacogn. Phytochem., vol. 8, no. 6, pp. 438-441, 2019.

[17] H. Tang et al., "Analysis of the Mechanism and Performance Optimization of Burying Weeding with a Self-Propelled Inter Row Weeder for Paddy Field Environments," Appl. Sci., vol. 11, no. 21, p. 9798, 2021, doi: 10.3390/app11219798.

[18] Sirmour and Verma, "Design and development of single row power weeder for rice," J. Crop Weed, vol. 14, no. 1, pp. 163-169, 2018.

[19] J. P. Jamalludin, S. Husain, L. Nunik, and M. R. Muhammad, *Alat Dan Mesin Pertanian*, vol. 3. Makasar: UPT Badan Penerbit Universitas Negeri Makasar, 2019.

[20] E. Hasman, "Rancang Bangun Prototipe Mesin Penyiang Mekanis Pada Lahan Dengan System of Rice Intensification," J. Appl. Agric. Sci. Technol., vol. 3, no. 1, pp. 166-177, 2019.
[21] D. Rahmawati, F. Suharjono, and A. Bahariawan, "Alat Penyiang Gulma Sistem Landak Bermotor," J-Dinamika J. Pengabdi. Masy., vol. 1, no. 1, pp. 43-47, 2016, doi: 10.25047/j-dinamika.v1i1.133.
[22] S. Widiyawati, "Perbandingan Tingkat Keberhasilan Penyiangan Tanaman Padi Berdasaran Hasil Modifikasi Power Weeder Tipe Mc1R," J. Ind. Eng. Manag., vol. 2, no. 1, p. 36, 2017, doi: 10.33536/jiem.v2i1.104.
[23] S. Umar et al., "Pengujian Mesin Tanam Padi Sistim Jajar Legowo (Jarwo Transplanter) Di Lahan Rawa Pasang Surut [Assesment Of Jarwo Transplanter On Tidal Swamp Land]," J. Tek. Pertan. Lampung, vol. 6, no. 1, pp. 63-72, 2017.
[24] S. S. Telaumbanua et al., "Performance Comparison of the Implementations of Single Row Power Weeder (Single Engine) and Multi-Row Power Weeder (Twin-Engine) in Rice Fields," IOP Conf. Ser. Earth Environ. Sci., vol. 1038, no. 1, p. 012061, 2021, doi: 10.1088/1755-1315/1038/1/012061.
[25] D. Hunt, *Farm Power and Machinery Management, Cost Determination*, 10th ed. United States of America: Iowa State University Press, 1995.
[26] S. K. Meena et al., "Development and Performance Evaluation of Solar Operated Power Weeder," Int. Res. J. Eng. Technol., vol. 6, no. 7, pp. 1-5, 2019.
[27] B. R. Kiran, C. M. Krishna, and R. J. Prakash, "Performance and Evaluation of Power Weeder, Wheel Hoe, Star Weeder under Dryland Conditions," Int. J. Curr. Microbiol. Appl. Sci., vol. 7, no. 12, pp. 1669-1675, 2018, doi: 10.20546/ijcmas.2018.712.194.
[28] N. K. S. Kumar and A. P. Mohankumar, "Performance Evaluation of a Power Operated Wetland Weeders for Paddy," Int. J. Curr. Microbiol. Appl. Sci., vol. 8, no. 04, pp. 2266-2272, 2019, doi: 10.20546/ijcmas.2019.804.265.
[29] Keshavalu, B. Patil, V. Raghavendra, and S. Khan, "Performance Evaluation of Wet Land Power Weeder for Paddy," Asian J. Agric. Extension, Econ. Sociol., vol. 18, no. 3, pp. 1-8, 2017, doi: 10.9734/ajaees/2017/34910.
[30] E. L. B. Robert Allen Kepner and R. Bainer, *Principles of Farm Machinery*, 3rd ed. United States of America: Avi Publishing Company, 1973.
[31] I. Dewi, B. F. Langai, and B. U. Supriyanto, "Kapasitas Kerja dan Efisiensi Hand Traktor untuk Pengolahan Tanah di Lahan Rawa Pasang Surut Tipe C dan Lahan Irigasi Setengah Teknis di Kalimantan Selatan," Semin. Nas. Lahan Suboptimal, pp. 978-979, 2020. [Online]. Available: http://www.conference.unsri.ac.id/index.php/lahansuboptimal/article/view/1909.
[32] Y. Zhang and X. Chen, "Soil Disturbance and Cutting Forces of Four Different Sweeps for Mechanical Weeding," Soil Tillage Res., vol. 168, pp. 167-175, 2017, doi: 10.1016/j.still.2017.01.002.
[33] Y. Gursoy and C. Chen, "Evaluation of Inter Row Sweeps With Different Working Widths," Appl. Eng. Agric., vol. 33, no. 3, pp. 307-312, 2017, doi: 10.13031/aea.11947.
[34] Witaningsih, "Perbandingan Kinerja Alat Penyiang Gulma Padi Tipe Semi Mekanis dan Mekanis," Universitas Lampung, 2022.