Berkala **PENELITIAN HAYATI**

ISSN: 08526834 | E-ISSN:2337-389X
Volume 29| No. 2| August|2023

Original Article

Rabbit Urine-based Liquid Organic Fertilizer (RULOF) Alters Growth Parameters and Improves the Yield of Three Pak Choi Varieties (*Brassica rapa* Sub. Chinensis)

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Abstract

This research aims to analyze the effect of Rabbit Urine-based Liquid Organic Fertilizer (RULOF), varieties, and interactions with both. The research was conducted at the Green House of the Faculty of Agriculture, University of Jember, in November-December 2022. A factorial Completely Randomized Design (CRD) was used, which consisted of 2 factors with three replications. Factor 1 = RULOF, with four levels: P0 (0 ml/litre), P1 (100 ml/litre), P2 (200 ml/litre), and P3 (300 ml/litre). Factor 2 = Varieties: V1 (Green), V2 (Nauli F1), and V3 (Emone 26). All parameters are significant with the influence of RULOF. Varieties affect all parameters except root length. The interaction of RULOF and variety significantly affect all parameters except the wet weight. The 200 ml/liter RULOF (P2) and Nauli F1 (V2) treatment showed the highest average value of all variables.

Keywords: Pak Choi, RULOF, Varieties
Received: March 4, 2023 Revised: May 19, 2023 Accepted: May 24, 2023

Introduction

Rabbit urine contains very high macronutrients, and its liquid fertilizer product has a significant biological impact on cocoa (*Theobroma cacao* L) (Rosniawaty et al., 2015), melon (*Cucumis melo* L.) (Sunadra et al., 2015), as well as various mustard families (Kurnianta et al., 2021; Guntara et al., 2021; Cholisoh et al., 2018; Kristanto & Aziz, 2019; Kristanto and Aziz, 2019; Hartini et al., 2019). The content of various macronutrient elements in rabbit urine: Nitrogen=1.05-2.72%, Phospor=0.01-1.1%, and K=0.5-0.85% (Rosniawaty et al., 2015; Mutai 2020). Pak Choi (*Brassica rapa* subsp. Chinensis) is an essential horticultural commodity with an average consumption of 2.49 kg/capita/year in Indonesia (Indonesian Food Consumption Database, 2020). But on the contrary, its availability in 2018 was only 2.32 kg/per capita/year. The demand therefore, is fulfilled by the imported Pak Choi (Secretariat General of Agriculture, 2020).

Fulfilment of nutrition is closely related to using good quality varieties with high productivity. Management and the environmental condition, also impact productivity (Pribadi et al, 2014). This study used three Pak Choi varieties, considered the best in Indonesia: Green, Nauli F1 and Emone 26. These varieties have the potential to give the best results with proper management (Oktaviana et al, 2016). This research is projected to answer questions and urgencies related to the reasons for Pak Choi's lack of productivity and also be able to answer recommendations for RULOF composition, which are interacted with the selection of the best superior varieties. This research aims to analyze the effect of RULOF, varieties, and interactions with both.

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Table 1. Summary of ANOVA results. Keys : *=significance, **= very significant, ns= not significant

	F- score		
Parameters	RULOF (P)	Pak Choi Varieties (V)	Interaction (PxV)
Height (cm)	15.74**	4.31*	0.42 ns
Leaves	54.24**	24.97**	2.06 ns
Leave area	15.07**	5.30*	0.94 ns
Wet Weight	65.95**	18.19**	2.80*
Dry Weight (gr)	114.12**	28.71**	2.26 ns
Root Length	8.26**	0.65 ns	0.34 ns
Root Volume	9.70**	4.80*	1.14 ns

Study location

The research was conducted at the Green House of the Faculty of Agriculture, University of Jember, in November-December 2022. A factorial Completely Randomized Design (CRD) was used, which consisted of 2 factors with three replications (see table 1 for CRD design).

Factor 1 = RULOF, with four levels: P0 (0 ml/litre), P1 (100 ml/litre), P2 (200 ml/litre), and P3 (300 ml/litre). Factor 2 = Pak Choi Varieties: V1 (Green), V2 (Nauli F1), and V3 (Emone 26) (see figure 1 for morphology comparison). The character of each variety is shown from the product content (Table 2). A RULOF content test was carried out as a pre-study in the laboratory (Table 3).

http://dx.doi.org/10.23869/bphjbr.29.2.20234
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Figure 1. Morphology of the three varieties. Images were taken at random on the best treatment (size scale not available). Keys=A:V1 (Green); B:V2 (Nauli F1); C:V3 (Emone 26).

Data collection and analysis

Compost media is prepared in polybags (size=30x30 cm). Four kg of topsoil and manure (1:1) were put into each polybag. Seeds from three Pakcoy varieties were used: Green, Nauli F1, and Emone 26. Each individual had four healthy leaves transplanted at 14 days old. Weeding was held starting from 7 Day After Planting (DAP). Watering was held in the morning or evening with a volume of 0.2 L per individual. Pests and diseases are controlled physically or with plant-based pesticides. RULOF (trademark Angoon Farm©) was sprayed on Abaxial leaves every 7th, 14th, 21st, and 28th Day After Sowing (DAS). Plant height and the number of leaves were observed manually every week using a ruler and the bare hand. Wet weight, dry weight, leaf area, and root volume were measured after harvest (35 DAP). Weight was measured with an electric balance. The plants were dried for dry weight until they reached a constant weight in an oven. Leaf area was measured using millimeter block paper. Plant height and root length were measured manually with a ruler. Analysis of Variance was used for data analysis, and Duncan's follow-up test (Multiple Range Test) was performed at a 95% confidence level.

Table 2. The character of each variety on product content.

Parameters	Varieties		
	Green	**Nauli F1**	**Emone 26**
Harvest age	25-30 DAS	25-27 DAS	25-30 DAS
Height	25-27 cm	25-28 cm	21-28 cm
Leaves	Semi-round	Oval	Round
Leaves dimension	P: ± 17 cm; L: L: ± 17 cm	P: 17-20 cm; L: 13-16 cm	P: 17-19 cm; L: 13-15 cm
Wet Weight	± 200 gram	150-220 gram	200-250 gram
Flavour	not bitter	not bitter	not bitter
Information	It can be planted in the highlands and lowlands. Adapted to an altitude of 90-1200 meters above sea level	It can be planted in the highlands and lowlands. Adapted to an altitude of 900-1200 meters above sea level	It can be planted in the highlands and lowlands. Adapted to an altitude of 1100-1250 meters above sea level
Proposer	PT. Winon Intercontinental	PT. East West Seed Indonesia	PT. Primasid Andalan Utama
Researcher	Denichii Takii (Takii Seed and Co.Ltd)	Gung Won Hee (PT. East West Seed`Thailand), Tukiman, Misidi, Abdul Kohar (PT. East West Seed`Indonesia)	Matius Raharjo, Asep Nana, Saman Supardi, Agus Kamal Jaelani

Source: Decree of the Minister of Agriculture 390/Kpts/SR.120/1/2009

Table 3. RULOF analysis results

Variables	Score	Criteria*	Standard*
Nitrogen	0.04	Very low	<2
P_2O_5	0.018	Very low	<2
K_2O	0.007	Very low	<2
pH	4.8	Compatible	4-8

Keys = *Minimum Technical Requirements for Organic Fertilizers and Soil Repairers following the Decree of the Minister of Agriculture No. 28/Permentan/SR.130/B/2009.

Results

The ANOVA results show that all parameters are significant with the influence of RULOF. Varieties affect all parameters except root length. However, the interaction is insignificant for all parameters except the wet weight (see table 1).

The increase in plant height in all RULOF treatments (P0, P1, P2, and P3) gave a level of significance in the increase at the age of 7-35 HST (see figure 2). Generally, a concentration of 200 ml/liter (P2) had the highest average value for plant height (h=22.76 cm), followed by treatments of P1, P3, and P0 at the lowest(h=18.35 cm). Nauli F1 (V2) had the highest average for plant height (h=21.40 cm), and V1 is the lowest (h=19.76 cm).

The 200 ml/liter RULOF treatment (P2) showed the highest average value of leaf growth (n = 11.64),

followed by treatments P3, P1, and P0 at the lowest values. The Nauli F1 (V2) variety showed the highest number of leaves (n = 11.12), followed by V3 and V1 treatments.

Based on the analysis of variance, there was no interaction between RULOF and varieties on leaf area variables. The single factor RULOF has a very significant effect on leaf area variables. The highest average leaf area was in treatment P2 (200 ml/liter) at 106.92 cm^2, while the lowest average was in treatment P0 (control) at 71.00 cm^2. The single factor of the variety has a significant effect on the leaf area variable. The best average leaf area was in treatment V2 (Nauli F1 variety) at 99.87 cm^2, while the lowest average was in treatment V1 (green variety) at 85.64 cm^2.

The analysis of variance showed a significant interaction between the RULOF treatment and the variety of varieties on the plant fresh weight variable. RULOF and varieties have a very significant effect on plant wet weight variables (see table 1). RULOF has a very significant effect on dry weight variables (see table 1). The best average dry weight was in treatment P2 (200 ml/liter) of 2.32 gr, while the lowest average was in treatment P0 (control) of 1.07 gr (see figure 3). Varieties have a very significant effect on plant dry weight. The best average dry weight was V2 (Nauli F1 variety) at 2.05 gr, while the lowest average was V1 (green variety) at 1.56 gr (see figure 3).

RULOF has a very significant effect on root length (see table 1). The best average root length was in treatment P2 (200 ml/liter) at 31.11 cm, while the lowest average was in treatment P0 (control) at 21.02 cm. Varieties have no significant effect on root length variables. The best average root length was in treatment V2 (Nauli F1 variety) at 28.48 cm, while the lowest average was in treatment V1 (green variety) at 26.34 cm (see figure 3).

RULOF has a very significant effect on root volume variables (see table 1). The best average root volume was in treatment P2 (200 ml/liter) at 1.19 ml, while the lowest average was in treatment P0 (control) at 0.19 ml. Varieties significantly affect root volume. The best average root volume was V2 (Nauli F1 variety) of 1.15 ml, while the lowest average was V1 (green variety) treatment of 1.00 ml (see figure 3).

Discussion

The lack of production for various main horticultural commodities, such as Pak Choi, is a major disaster, especially since Indonesia is a producer and, simultaneously, a potential consumer (Indonesian Food Consumption Database, 2020, Secretariat General of Agriculture, 2020). RULOF is a potential solution that combines the abundance of rabbit urine waste and the threat of decreased production of Pak Choi due to the lack of input of essential nutrients that are 'green' and sustainable. The interaction of RULOF and varieties gave significantly different results only on the variable fresh weight of plants with the best treatment combination of 200 ml/liter RULOF concentration and the nauli F1 (P2V2) variety, with the best average fresh weight value of 48.40 gr. RULOF concentration of 200 ml/liter (P2) can increase the vegetative growth of plants such as stems, leaves, and roots. The accuracy of fertilizer application to plants according to nutritional needs can increase optimum plant growth because the nutrients provided are balanced, and the supporting factors that support growth are in optimal conditions (Bustami et al., 2012). RULOF fertilization interacted very significantly with varieties of red spinach on plant height variables aged 14, 21, 28, and 35 DAS, wet weight, and dry weight with the best treatment combination U2V3 (Gumelar et al., 2022).

Treatment with a RULOF concentration of 300 ml/liter (P3) gave lower results for all observed variables than treatment P2. This result follows Hairuddin and Edial's research (2019), where fertilization with too high a concentration of plant needs causes a decrease in yield because fertilizer becomes toxic and inhibits plant growth, so the effectiveness of fertilizer is reduced (Uchida, 2000). Excessive fertilizer supplementation causes agricultural, ecological, and environmental pollution and prevents the increase in yield and quality of vegetable crops (Shang & Shen, 2018). These were thought to be a factor causing the low yield when the RULOF concentration was increased to 300 ml/liter (P3). RULOF has an effect as a source of nutrient availability for Pak Choi, interacting with the various varieties used so that the photosynthetic process that occurs runs optimally and can enhance plant growth and development. RULOF contains the nutrient nitrogen, which supports the growth of roots, stems, leaves, and chlorophyll, which is needed in photosynthesis (Purbasari et al., 2021). Photosynthates are translocated to growing points (Mutryarny and Lidar, 2018). Photosynthate is broken down into energy through the respiration process used by plant cells in cell division and enlargement activities so that plant organs become larger and longer, which is visually shown, one of which is the increase in plant height (Ezward and Haitami, 2022).

RULOF contains the elements N, P, and K quite high, even compared to other Liquid Organic Fertilizer (Rosniawaty et al., 2015; Mutai 2020). The application of RULOF to plants can provide nutrients to support vegetative growth and plant production, increase nutrient content, and stimulate plant growth and production. Nitrogen (N) in RULOF is the main nutrient for plant growth, which is generally necessary for the formation or growth of vegetative parts of plants such as leaves, stems, and roots, assisting metabolic processes such as photosynthesis (Leghari et al., 2016). Phosphorus (P) plays a role in accelerating root growth from various processes and forming a good root system (Malhothra et al., 2018). Potassium is a constituent of the plant

structure and regulates several biochemical processes, such as protein synthesis, carbohydrate metabolism, and enzyme activation. Several physiological processes depend on K, such as stomatal regulation and photosynthesis (Hasanuzzaman et al., 2018)

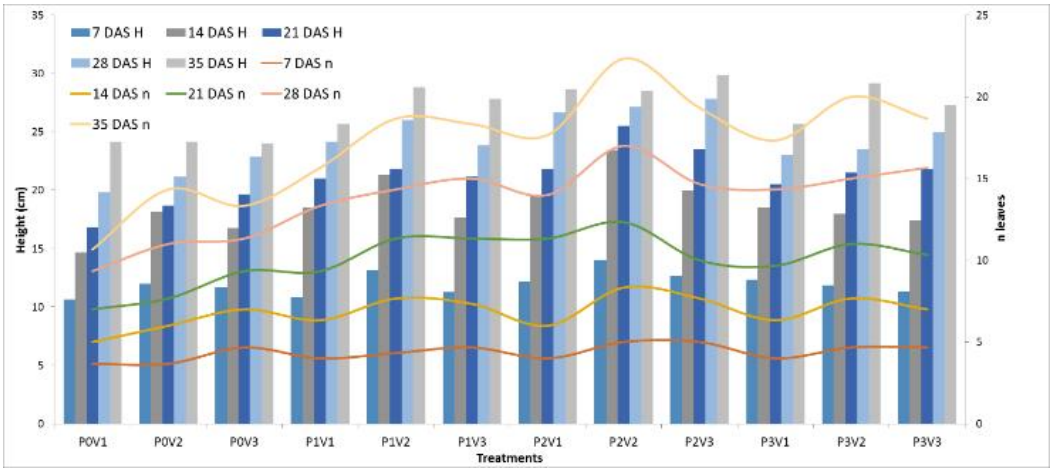

Figure 2. Graph Effect of treatments on plant height (axis 1, Bar chart) and the number of leaves (axis 2, lines). All treatments were observed every week. Keys=DAS: the day after sowing, H: height of plants, n: number of leaves

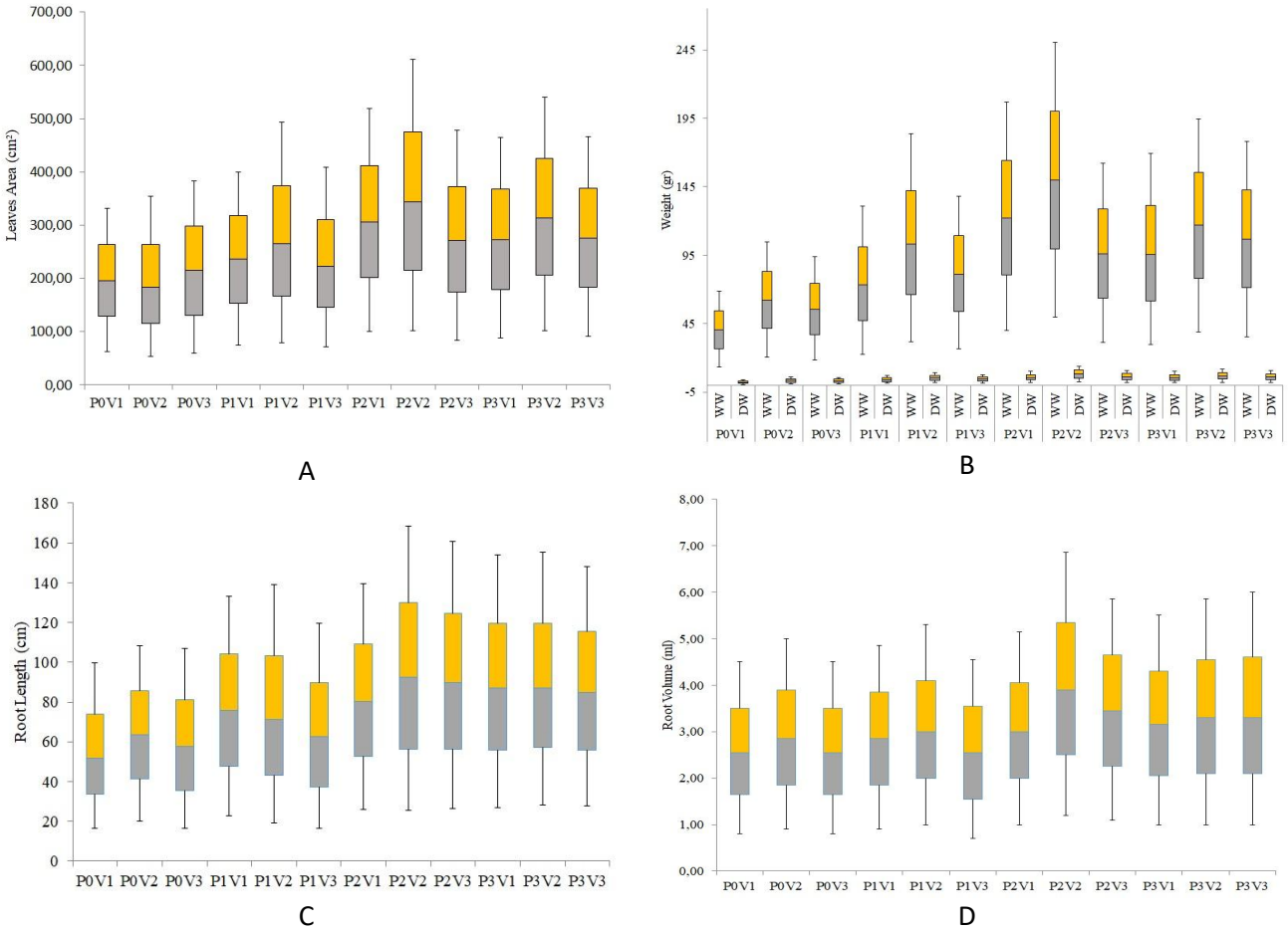

Figure 3. Boxplot graphs of the median and third quartile averages of RULOF performance on various parameters. Keys = A. Leaves area; B. Compile Weight (Keys=WW:Wet Weight, DW:Dry Weight); C. Root Length; D. Root Volume. All parameters are compared in the treatments.

The results of this research show that the three varieties' weight yields are far below each variety's description (see table 5). This new evidence confirms the variation in the biological response of plants to the same variety. This characteristic is thought to be heavily influenced by erratic weather changes during the study, causing the treatment of plants not to grow optimally. This evidence follows the research of Kuswantoro et al (2017), where differences influence the diversity of crop yields in the genotypes of each variety which respond differently to the ability to adapt to specific environmental conditions. There are many factors that affect crop production. these factors are categorized into 3 types. The first category is environmental factors consisting of climatic conditions, soil fertility, topography and water quality. The second category is biological factors consisting of diseases, insects, pests and weeds. The third factor is technological factors consisting of agricultural practices and managerial decisions (Liliane and Charles, 2020).

Farmers are recommended to use Nauli, which is superior with various vegetative and generative parameters. The concentration of 200 ml/liter is the best recommendation, with an increase in weight as the most prominent final parameter. This evidence benefits potential users, such as farmers and the organic farming industry. However, the lack of interaction with varieties illustrates that RULOF allows it to be widely used with superior varieties currently available to farmers. In addition, this fact illustrates broad possibilities for researchers in examining various combinations of environmental influences.

In conclusion, the interaction of RULOF and varieties gave significantly different results only on the variable fresh weight of plants with the best treatment combination of RULOF concentration of 200 ml/liter and nauli F1 (P2V2) variety. RULOF gave highly significant different results for all observed variables, which included plant height, number of leaves, leaf area, plant fresh weight, plant dry weight, root length, and root volume. RULOF concentration of 200 ml/liter (P2) is the best for increasing Pak Choi's growth and yield. Varieties gave significantly different results on height, number of leaves, leaf area, plant fresh weight, plant dry weight, and root volume. The F1 (V2) nauli variety was the best for increasing the growth and yield of Pak Choi.

Acknowledgement

The researcher would like to thank the Plant Protection Study Program for providing permission for the research to be completed.

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