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Research Article

PROVISION OF STIMULANTS MADE OF PEG 6000 AND OLEOCHEMICALS IN INCREASING THE PRODUCTION OF RUBBER PLANTATIONS

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Abstract
Indonesia's rubber plants nationally is still relatively low compared to other natural rubber-producing countries, which is 858 kg/ha/year. The lack of precision of the inefficient exploitation and tapping system implemented by rubber farmers, both community plantations, government and private, is one of the causes of low rubber production in Indonesia. This study aims to determine the influence of the production and physiology of latex in the PB 260 clone community rubber plant after being given a stimulant made of PEG 6000 and oleochemicals. The research was carried out in a community rubber plantation, located in Galang District, Deli Serdang Regency, North Sumatra Province. The altitude of the place is 25 m above sea level with the Ultisol soil type. The research began in July 2022 to November 2022. The plant material used in the field is a 20-year-old PB260 clone rubber plant. Research observations include plant production in the field on smallholder rubber plantations, as well as latex physiological analysis conducted at the Laboratory of the Faculty of Agriculture, Islamic University of North Sumatra and the Sungei Putih Research Institute, Field experiments used a three-replicate factorial group random design with PEG 6000 and Oleochemistry as treatments. The A1 treatment generally had the best effect on all the observational parameters of the study. The combination of PEG 6000 3% and Oleochemistry had an insignificant effect on latex production, rubber dryness, rubber physiology, and rubber histology. However, statistically the combination of P1A1 has a positive effect on rubber plants.

Keywords: Oleochemistry, People's Plantation, PEG 6000, PB 260 Clone, Rubber Plants.

INTRODUCTION

The productivity of Indonesia's rubber plants nationally is still relatively low compared to other natural rubber-producing countries, which is 858 kg/ha/year. India ranks first at 1,986 kg/ha/year, followed by Vietnam at 1,702 kg/ha/year, Thailand at 1,570 kg/ha/year, and Sri Lanka at 1,107 kg/ha/year (Food and Agriculture Organization, 2018). The area of rubber plantations in Indonesia in

2017 reached 3.6 million ha, which is an area of 3.1 million ha or 85% is people's plantations, 8% are large private plantations, and 7% are large state plantations (Directorate General of Plantations, 2018). In 2019 with an export volume of 2,579,800 tons or 21.77% of the world's total rubber exports (Azzahra & Arsi, 2021). The lack of maximum rubber production in Indonesia is due to the fact that most of the rubber plants are managed by smallholder plantations with low productivity, namely 600-650 kg of dry rubber/ha/year (Rohmah, 2015).

The use of stimulants is an opportunity to increase declining rubber production and reduce tapping costs due to higher labor costs (Sinamon et al, 2015; Dessi & Shah, 2023; Fitriani, Triandafillidis & Thao, 2023). The provision of stimulants aims to increase latex production (Atminingsihet al., 2016; Chumburidze et al., 2023; Rahmayani et al., 2023; Setiyani, Baharin, & Jesse, 2023; Yolviansyah et al., 2023). Latex stimulation is generally carried out on mature or mature rubber plants with the aim of increasing latex yield so that it can benefit rubber plantations (Sinamo et al., 2014; Rini et al, 2023; Yusnidar et al., 2023). The application of stimulants to rubber plants can spur metabolism, so that it can extend the latex flow period, and can produce more latex than without the application of stimulants (Suherman, et al., 2020; BoangManalu, Iqbal, & Garcia, 2024; Khoviriza et al., 2024). In large plantations, the stimulant used uses the active ingredient ephecon (2-chloroethylposhonic acid) because of the fact that it is very effective in increasing latex production (Purwaningrum et al, 2016; Herawati, Khairinal, & Idrus, 2023; Sultanuddin et al., 2023).

However, the long-term use of these stimulants can degrade the quality of healthy plants and can trigger physiological stress due to excessive stimulation and incompatibility with the cloning character. If this continues, this can cause the lead groove to dry out so that it will reduce the production of latex (Atminigsih et al., 2016) Therefore, it is necessary to develop stimulant compounds with active ingredients that are more friendly to the physiological conditions of plant health. Rahayuet al (Rahayuet al, 2016) reported that the application of PEG as a stimulant can increase latex production. Rahayuet et al. (Rahayuet al, 2017) also revealed that PEG can increase latex production and increase the bark thickness of 11-year-old PB 260 clone stems. According to the results of Andriyanto and Darojat (2016), it shows that Polyethylene Glycol is proven to increase latex production when compared to ephelon treatment (control).

Salicylic acid has also been reported to be used for the control of plant pathogens. Salicylic acid is a simple phenolic compound that plays an important role in regulating the physiological process and immunization response of plants. Palmitic acid (fatty acid) is known to be one of the basic ingredients that form Acetyl Coenzyme A. Acetyl CoA is an important precursor in primary and secondary metabolism. In secondary metabolism, Acetyl CoA is a precursor to the formation of terpenoid compounds, including polyterpenoids (latex) so that the administration of stimulants made from skin restoration materials containing palmitic acid (fatty acids) can cause latex production to increase (Rahayu, 2017).

The purpose of the study was to determine the influence of the production and physiology of latex in the PB 260 clone rubber plant community after being given a stimulant made of PEG 6000 and oleochemicals.

RESEARCH METHOD

The research was carried out in a community rubber plantation, located in Galang District, Deli Serdang Regency, North Sumatra Province. The altitude of the place is 25 m above sea level with the Ultisol soil type. The research began in July 2022 to November 2022. The plant material used in the field is a 20-year-old PB 260 clone rubber plant, with a planting distance of 2.5 x 5 m. Research observations include plant production in the field on smallholder rubber plantations, as well as latex physiological analysis conducted at the Laboratory of the Faculty of Agriculture, Islamic University of North Sumatra and the Sungei Putih Research Institute.

The field experiment used a three-replicate factorial group randomized design with PEG 6000 and Oleochemistry as treatments. PEG 6000 (P) has 2 treatment levels, namely P0 = No PEG (control), P1 = PEG 6000 3% and Oleochemistry (A) has 4 treatment levels, namely A0 = no fatty acids (control) A1 = (3 grams of salicylic acid + 3 grams of palmitic acid) A2 = (6 grams of salicylic acid + 3 grams of palmitic acid) A3 = (3 grams of salicylic acid + 6 grams of palmitic acid). The variables observed in the field are production, sucrose, P-inorganic and thiol which will be analyzed in the laboratory.

Production Observation (g/p/s)

This observation was observed by measuring the volume of latex produced from each plant, which was then converted to (g/p/s). Production observations are carried out every month which is an average of each observation with a tapping frequency every 3 days (d/3). The Dry Rubber Content (KKK) is measured every 3 days by weighing several drops (± 5 ml) of fresh latex and then in the oven with a temperature of 120oC, for 120 minutes, after which the dry rubber is then weighed again. The value of KKK is dry weight divided by wet weight multiplied by 100%, method of Mc Mullen (1960). KKK = Dry Weight divided by Wet Weight × 100%.

Physiological Observations

Sucrose (mM)

Sucrose observation was carried out twice, before the use of the formula (the beginning of the study) and after the use of the formula (the end of the study). A latex sample was taken as much as 150 µL and then 2.5% TCA was added to the total volume of 500 µL. Then 3 ml of antron and divortex reagents were added, then heated by soaking in boiling water for 15 minutes and then cooled. The next stage is absorption at λ 627 nm (in nanometers), then measured by the anthrone method. Dehydration of sucrose in concentrated sulfuric acid (H2SO4 70%) and heating produce furfural derivatives that react with antrons producing a blue color. Then its absorption was measured at λ 627 nm (in nanometers) using a Beckman DU 650 spectrophotometer (according to the Anthrone Discche method, 1972).

Inorganic Phosphate (Pi) (mM)

Inorganic phosphate observations were carried out 2 times, namely before the formula was applied (at the beginning of the study) and after the formula was applied (at the end of the study). Inorganic Phosphate is measured based on the binding principle by ammonium molybdate then reduced by FeSO4 in an acid reaction so that it becomes blue. The absorption measurement was carried out at λ 750 nm (nanometer) with a Beckman DU 650 spectrophotometer, using the Taussky and Shorr (1953) method.

Thiol (R-SH)

Thiol observation was carried out 2 times, namely before the formula was applied (at the beginning of the study) and after the formula was applied (at the end of the study). A latex sample was taken approximately 1.5 ml, and 2.5% TCA was added so that the volume was 1.5 ml, then added with 10mM 75µL DTNB. Add 1.5 mL of Tris 0.5 M buffer and vortex. Leave at room temperature for 30 minutes. Absorbance is read at λ 421 nm (nanometers) on the Beckman DU 650 spectrophotometer or measured in TCA serum based on its reaction with dithiobisnitrobenzoic acid (DTNB) forming yellow TNB, which absorbs at λ 421 nm (nanometers).) on the Beckman DU 650 spectrophotometer was carried out according to the McMullen (1960) method.

Superoxide Dismutase (SOD) Enzyme

The observation of the Superoxide Dismuntase (SOD) enzyme was carried out 2 times, namely before the application of the formula (at the beginning of the study) and after the application of the formula (at the end of the study). The analysis of SOD compound activity was measured using a modified Beuchamp and Fridovich (1971) method. Previously, the latex was put into a tube and then centrifuged at a speed of 10,000 rpm at a temperature of 40°C for 15 minutes until a latex treatment was obtained. The latex treatment was then added with buffer extract (0.1 g/1.5 ml) then centrifuged again at the same speed, temperature and time. The buffer extract was made by adding 50 mM of potassium phosphate buffer (pH 7.5), 1 mM EDTA, and 1% PVP, then centrifuged at 10,000 rpm at 40 °C for 15 minutes to obtain a homogeneous result. In the reaction buffer, 50 mM potassium phosphate buffer, 13 mM L-mentionine, 75 µM NBT, 0.1 mM EDTA, 100 ml of enzyme extract, 2 µM riboflavin were extracted in a total volume of 1.5 ml. Riboflavin is added where the tube is placed under a 15 W lamp and left for 15 minutes. The reaction is stopped by turning off the lights and placing the tube in a dark place then reading with a spectrophotometer with absorption at 560 nm. One unit of SOD activity enzyme is defined as SOD activity per mg of protein.

RESULTS AND DISCUSSION

Latex Production

The productivity of rubber in the trial was determined from the total amount of latex obtained in accordance with the rubber content on each lead. The observation parameters of plant production are known from the number of grams per tree per tap. The production tendency of stimulant application with control (without stimulant) showed a relatively even and varied response, but the production of rubber with PEG stimulant application was higher than without stimulant.

The results of the variegated fingerprint analysis showed no significant difference in the treatment of stimulant administration with control in the first month to August, showing a significant difference in September – November with P1 (PEG 6000 3%) which produced higher production at 47.26 g/p/s compared to control which only produced 41.43 g/p/s. This is in accordance with the statement (Krishnakumar, et al., 2011) that stimulants can increase latex production by prolonging the flow time due to the blockage of latex vessels being inhibited. (Muhtaria, Supriyatdi et al. 2015) which states that the application of stimulants has a significant influence on the production of dry rubber of rubber seedling plants.

Table 1. Latex Production (g/p/s)

Treatment	Observation Time								
	Beginning	July	August	September		October		November	
PEG Concentration									
P0	24.49	26.47	35.94	36.55	a	40.97	a	41.43	a
P1	26.90	27.45	37.00	41.93	b	46.84	b	47.26	b
Types of Fatty Acids									
A0	24.00	24.86	33.36	36.84		39.80	a	40.26	a
A1	27.78	29.81	38.65	41.57		49.34	b	49.81	c
A2	25.38	25.62	37.06	39.60		43.66	a	44.06	b
A3	25.63	27.54	36.81	38.95		42.83	a	43.25	b
Combination									
P0A0	23.20	23.45	32.45	32.54		35.32		35.69	
P0A1	25.75	29.45	38.45	39.27		47.29		47.91	
P0A2	24.12	27.14	35.67	37.76		42.07		42.52	
P0A3	24.88	25.84	37.18	36.64		39.21		39.58	
P1A0	24.80	26.28	34.28	41.14		44.27		44.84	
P1A1	29.80	30.18	38.84	43.87		51.39		51.71	
P1A2	26.63	24.11	38.44	41.44		45.24		45.59	
P1A3	26.37	29.24	36.45	41.27		46.44		46.92	

Observations show that the treatment of fatty acids has a very real effect in October – November. The highest treatment was the A1 treatment (3 grams of salicylic acid + 3 grams of palmitic acid), resulting in a production of 49.81 g/p/s. Salicylic acid and palmitic acid are oleochemicals that play a role in skin regeneration. In this case, oleochemicals play a role in restoring stress caused by 3% PEG. The application of salicylic acid with an optimal concentration in plants plays an important role in encouraging plant growth and plant metabolism, especially in stressful conditions by increasing plant tolerance to stressful conditions (Singh et al., 2010).

In a study conducted by Murni Sari Rahayu (2017) at a dose of 3% PEG combined with oleochemical solution resulting in the highest latex production among other treatments. This is consistent with this study which combines the application treatment of PEG with oleochemicals to improve latex production. The data in Table 1 show no significant effect on treatment interactions. The highest production yield was in the P1A1 treatment (PEG 6000 3% and 3 grams of salicylic acid + 3 grams of palmitic acid) with a production figure of 51.71 g/p/s. This confirms that the combination of PEG application with oleochemicals can increase production. The application of stimulants causes stress in rubber plants so that plants produce secondary metabolites in the form of latex, then oleochemicals are a counterbalance to the stress that plants get when given PEG stimulants. Oleochemicals play a role in accelerating skin recovery after tapping. If the rubber skin recovers quickly, then the rubber can be tapped again in a shorter time, so production increases.

Dry Rubber Content (KKK) (%)

Dry Rubber Content (KKK) is one of the parameters to observe plant conditions at the time of tapping. In general, the increase in production is inversely proportional to the value of the KKK. The addition of stimulants affects turgor pressure, causing it to rise so that water from within the tissue comes out and causes the KKK to decrease (Sumarmadji, 1999). Stimulants have been proven to reduce KKK when compared to conventional tapping without stimulants (Sumarmadji, 2005).

The observation results showed that there was no significant difference in the treatment of PEG concentration in each observation month. The type of fatty acids has a real effect in September – November. The treatment of A1 (3 grams of salicylic acid + 3 grams of palmitic acid), A2 (6 grams of salicylic acid + 3 grams of palmitic acid), and A3 (3 grams of salicylic acid + 6 grams of palmitic acid) resulted in a lower KKK compared to A0 (control). The combination of the treatment of the two has an unreal effect on the KKK.

Table 2. Dry Rubber Content (KKK) (%)

Treatment	Observation Time								
	Beginning	July	August	September		October		November	
PEG Concentration									
P0	37.13	37.88	37.47	37.18		38.53		39.01	
P1	38.13	38.47	38.15	37.89		39.49		39.98	
Types of Fatty Acids									
A0	38.86	40.51	39.51	41.09	ab	42.69	ab	43.22	ab
A1	35.44	35.82	36.85	35.43	a	37.10	a	37.57	a
A2	38.65	36.89	36.22	36.75	a	37.93	a	38.41	a
A3	37.56	39.47	38.66	36.87	a	38.31	a	38.79	a
Combination									
P0A0	37.81	39.63	37.78	41.63		42.97		43.50	
P0A1	35.02	33.81	38.87	34.56		36.11		36.56	
P0A2	37.88	38.60	35.14	37.01		38.06		38.53	
P0A3	37.79	39.47	38.09	35.50		36.99		37.45	
P1A0	39.90	41.39	41.23	40.54		42.41		42.94	
P1A1	35.87	37.84	34.82	36.31		38.09		38.57	
P1A2	39.43	35.19	37.30	36.49		37.81		38.28	
P1A3	37.33	39.48	39.24	38.23		39.62		40.12	

The lowest KKK was obtained in the P0 treatment (without PEG stimulant) at 39.01% while P1 (with PEG stimulant) showed a higher rate of 39.98%. In the fatty acid treatment, the lowest number was in the A1 treatment (3 grams of salicylic acid + 3 grams of palmitic acid) of 37.57%, which was significantly different from the A0 treatment (control) with a fairly high KKK number (43.22%).

The interaction of the two factors has an unreal effect on the KKK. The lowest outcome was 36.56% in the P0A1 treatment (control and 3 grams of salicylic acid + 3 grams of palmitic acid). The highest result was in the combination of no stimulant or oleochemical (A0P0), which reached 43.50%. Stimulants affect the metabolism of latex cells, one of the changes in their character is the level of dry rubber (Gohet et al., 2010). The application of both treatments has not had a negative effect on the KKK score. The KKK threshold value below 25% is categorized as dangerous (Sumarmadji and Tistama, 2004). Graph 1. showed that the KKK was still high in the A0 (control) treatment, while the treatment with oleochemical application showed a low KKK number.

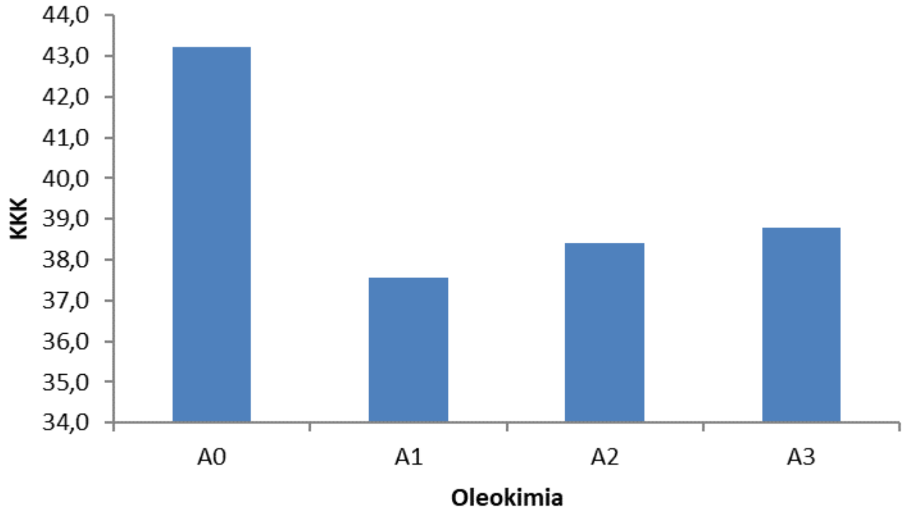

Figure 1. Influence of Oleochemistry on the KKK in November

Physiological Observations

Plant physiological observations are carried out to determine the physiological parameters of plants to the plant exploitation system, plant utilization and to determine the physiological state of plants. Observations are made before and after the application of stimulants and oleochemicals. Some of the parameters observed include inorganic phosphate content, thiol content, sucrose, and enzymes. The results of fingerprint analysis and observation showed that the treatment of PEG stimulant with oleochemistry had a real effect on post-application observation. Based on observation data after application, the highest PEG concentration treatment was obtained in the P1 treatment (PEG 6000 3%) which was 14.33 mM which was significantly different from the P0 (Control) treatment which was 12.88 mM, while the fatty acid treatment was obtained the highest organic phosphate in the A1 treatment (3 g salicylic acid + 3 g palmitic acid) which was 14.81 mM, significantly different from the A0 (Control) treatment, which was 12.49 mM. The interaction of the two factors had an insignificant effect on inorganic phosphate, the highest inorganic phosphate was obtained in the P1A1 treatment (PEG 3% and 3 grams of salicylic acid + 3 grams of palmitic acid) which was 15.41 mM.

The value of inorganic phosphate in all treatments was in the optimal range of 10 – 20 mM. If the inorganic phosphate level is below 10 mM, the plant's metabolism will decrease, if it is above 20 mM, it means that the plant is overexploited or attacked by diseases (Gohet, 1996). According to Lynen (1969) Inorganic phosphate is involved in the process of providing energy in cellular anabolism and in isoprene biosynthesis through the binding of adenosine phosphate and pyrophosphate. Therefore, the results show that the application of PEG in rubber plants has not interfered with the vascular metabolism of latex.

Latex sucrose levels are generally relatively low (<8 mM). All treatments had sucrose levels below 4 mM, resulting in a void of latex constituent materials. The sucrose content is very closely related to the frequency of tapping and the age of rubber plants (Gohet, 1996). Research by Rachmawan and Sumarmadji found that increasing the frequency of tapping decreased sucrose levels in PB 260 clones.

Table 3. Levels of Inorganic Phosphate, Sucrose, Thiol, and Enzymes before and after treatment

Treatment	Inorganic Phosphate			Sucrose		Thiol		Enzymes	
	Before	After		Before	After	Before	After	Before	After
PEG Concentration									
P0	7.24	12.88	a	6.13	2.47	0.39	0.59	0.61	0.74
P1	7.94	14.33	ab	7.94	2.50	0.36	0.76	0.77	0.82
Types of Fatty Acids									
A0	7.55	12.49	a	6.72	2.51	0.34	0.68	0.72	0.73
A1	7.29	14.81	ab	6.76	2.57	0.37	0.71	0.59	0.82
A2	7.05	14.30	ab	7.46	2.50	0.42	0.67	0.71	0.80
A3	8.46	12.81	a	7.20	2.35	0.38	0.63	0.74	0.77
Combination									
P0A0	7.10	11.47		5.82	2.57	0.42	0.61	0.72	0.66
P0A1	6.93	14.21		6.02	2.59	0.39	0.59	0.43	0.82
P0A2	6.84	13.82		6.39	2.48	0.34	0.54	0.61	0.71
P0A3	8.07	12.00		6.28	2.25	0.42	0.59	0.68	0.77
P1A0	7.99	13.50		7.61	2.46	0.26	0.74	0.72	0.81
P1A1	7.65	15.41		7.50	2.56	0.34	0.83	0.74	0.81
P1A2	7.26	14.77		8.53	2.52	0.49	0.80	0.82	0.89
P1A3	8.86	13.62		8.13	2.45	0.35	0.66	0.81	0.77

Thiol levels are an important indicator related to the physiological susceptibility of latex, especially in the occurrence of dry tap grooves (KAS) (Sumarmadji, et al., 2004). The function of thiol is to activate enzymes involved in environmental stressful conditions, and the thiol status indicates the plant's response to exploitation stress. The thiol content is inversely proportional to the intensity of exploitation. The higher the intensity of exploitation, the lower the thiol content (Lynen, 1969).

Enzyme levels showed an increase from before to after PEG application with oleochemicals. The highest enzyme levels were in the combination treatment of P1A2 (PEG 6000 3% and 6 grams of salicylic acid + 3 grams of palmitic acid). Palmitic acid (fatty acid) is known as one of the basic components for the formation of Acetyl Coenzyme A. Acetyl CoA is an important precursor in both primary and secondary metabolism. In secondary metabolism, Acetyl KoA is a precursor to the formation of terpenoid compounds, including: polyterpenoids (latex) so that the administration of stimulants made from skin regeneration containing palmitic acid (fatty acids) can cause the production of latex to increase (Rahayu, 2017).

This study presents a novel approach by integrating PEG 6000 and oleochemicals as stimulants to enhance rubber latex production while maintaining plant health. Unlike conventional stimulants such as ethylene-based compounds, which may lead to physiological stress and decreased rubber quality over time, this study explores the combination of salicylic acid and palmitic acid to counteract stress effects. The research also provides a comparative analysis of different stimulant treatments, offering new insights into their impact on latex yield, dry rubber content, and physiological responses in PB 260 clone rubber trees.

The findings of this study have several important implications. Sustainable Rubber Production, the use of PEG 6000 and oleochemicals as stimulants can serve as an alternative to traditional ethylene-based stimulants, reducing long-term plant stress while maintaining latex productivity. Agricultural Efficiency, the results suggest that optimizing salicylic acid and palmitic acid levels can improve latex flow, allowing rubber farmers to maximize yield with less frequent tapping, reducing labor costs. Environmental Considerations, the study highlights the importance of biodegradable, non-toxic stimulant formulations that minimize negative environmental impacts compared to synthetic chemicals. Economic Benefits for Smallholder Farmers, Since, smallholder plantations dominate Indonesia's rubber industry, this study provides valuable recommendations for cost-effective stimulant usage, helping farmers increase yield without overexploiting their plantations.

Despite its contributions, this study has several limitations, Short-Term Observation, the research was conducted over a five-month period, which may not fully capture long-term effects on rubber tree health, latex quality, and sustainability. Limited Genetic Variation, the study focuses only on

PB 260 clone rubber trees, meaning that findings may not be directly applicable to other rubber clones with different physiological responses. Environmental Factors, the study was conducted at a single location in North Sumatra, limiting its generalizability to regions with different climate, soil composition, and environmental stressors. Lack of Socioeconomic Assessment, the study does not analyze economic feasibility, such as the cost-effectiveness of PEG 6000 and oleochemicals for large-scale adoption in smallholder rubber plantations.

CONCLUSION

The application of PEG 6000 at a 3% concentration positively influenced latex production from September to December compared to untreated plants. Additionally, the A1 treatment, consisting of 3 g of salicylic acid and 3 g of palmitic acid, demonstrated the most significant impact across all observed parameters, including latex production, rubber dryness, physiological responses, and histological characteristics. However, the combination of PEG 6000 (3%) with oleochemical treatment (A1) showed no statistically significant effect on these parameters, although a positive trend was observed in the P1A1 treatment group. These findings suggest that while PEG 6000 alone enhances latex production, its combination with oleochemicals requires further investigation to determine optimal formulations for improving rubber yield and quality. Future research should explore different concentrations and application methods of PEG 6000 and oleochemicals to maximize their synergistic effects. Additionally, long-term studies assessing environmental conditions, soil health, and sustainable latex production practices would provide valuable insights for improving rubber plantation management and productivity.

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AUTHOR CONTRIBUTIONS

Author 1-2 creates articles and creates instruments and is responsible for research, author 3Analyzes research data that has been collected, andinstrument validation.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

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