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Effect of Soil Amendments to Survival Rate of Bidara Laut *(Strychnos lucida* R.Br.*)* in the Mount Tunak Natural Tourism Park, West Nusa Tenggara

(Pengaruh Pemberian Bahan Pembenah Tanah Terhadap Kemampuan Hidup Bidara Laut Strychnos lucida R. Br. *Di Taman Wisata Alam Gunung Tunak Nusa Tenggara Barat)*

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ABSTRACT

Bidara Laut (*Strychnos lucida* R.Br.) has the potential as a medicinal plant in West Nusa Tenggara, but its cultivation encountered many challenges. Mount Tunak, Natural Tourism Park, had similar environmental conditions to the natural habitat of Strychnos lucida and was selected as the location for planting trials. Given the dry climate, high temperature, and soil fertility limitations, the trials applied soil amendments, such as hydrogel, mycorrhizae, mulch, and fertilizer, to enhance the growth. This research aimed to investigate the effects of soil amendments on the survival rate of *Strychnos lucida*. This research used a Randomized Complete Block Design (RCBD) with four treatments and one control. The treatments included applying five grams of hydrogel, five grams of mycorrhizae, 1 m x 1 m of plastic mulch, and a combination of all three. The research used 15 replication blocks, each with an area of 450 m^2 and a spacing of 3 m x 3 m. Each block included ten replication plants (in total 750 plants), and the trial lasted 19 months. The results showed an insignificant growth increase after 19 months of planting in all treatments. There were improvements in survival rate, height growth, and diameter growth by 25%, 85%, and 25%, respectively.

KATA KUNCI

Tanaman Obat, Hydrogel, Mikoriza, Mulsa, Gunung Tunak

INTISARI

Bidara laut (Strychnos lucida R.Br.*) merupakan salah satu tanaman potensial penghasil obat alam di Nusa Tenggara Barat yang sampai saat ini belum dibudidayakan. Taman Wisata Alam (TWA) Gunung Tunak memiliki kondisi lingkungan mendekati habitat alami tumbuhan Strychnos lucida sehingga dipilih sebagai lokasi ujicoba penanaman. Dengan iklim yang kering, panas, permasalahan air dan kesuburan tanah sebagai pembatas, maka dilakukan perlakuan dengan penambahan bahan pembenah tanah berupa hidrogel, mikoriza dan mulsa, pemupukan. Penelitian ini bertujuan untuk mengetahui effek penambahan bahan pembenah tanah terhadap kemampuan hidup Strychnos lucida dengan menggunakan RCBD. Terdapat 4 perlakuan yang diujicobakan yaitu penambahan 5gr hidrogel, 5 gr mikoriza, 1 m x 1 m mulsa plastik, kombinasi ketiganya, dan kontrol. Tanaman diletakkan pada 15 blok ulangan dengan jarak tanam 3 m x 3 m dan luas setiap blok sekitar 450 m2. Setiap perlakuan terdapat 10 tanaman sehingga total berjumlah 750 tanaman. Hasil penelitian menunjukkan terdapat peningkatan pertumbuhan pada umur 19 bulan setelah penanaman pada semua perlakuan yang diujikan meskipun peningkatannya tidak siginifikan. Peningkatan yang terjadi hanya sekitar 25% pada persen hidup, 85% pertumbuhan tinggi, dan 25% pada pertumbuhan diameter.*

Introduction

Medicinal plants provide various medical, cosmetics, and health benefits from their leaves, stems, roots, fruits, and tubers (Siregar et al. 2020). West Nusa Tenggara consists of three main ethnic groups, namely *Sasak* in Lombok (Diantaris et al. 2015), *Samawa* in Sumbawa (Rahayu & Rustiami 2017), and *Mbojo* in Bima (Zulharman et al. 2015), poses local wisdom in utilizing plants for medicinal purposes. Bidara Laut (*Strychnos lucida* R.Br.) has become one of the medicinal plants in West Nusa Tenggara to treat malaria, diabetes, and hypertension (Zuraida et al. 2012a). The industrialization of *S. lucida* as a medicinal plant has increased demand for its raw material. However, its production merely relied on the harvest of natural plants. Therefore, there is a need for cultivation technology to ensure sustainable supply and utilization of *S. lucida*.

Information on suitable cultivation techniques for *Strychnos lucida* was unavailable, and communities did not cultivate widely (Setiawan & Narendra 2012), indicating the need for further research on this plant (Zuraida et al. 2012b). Generative propagation using seeds provides a higher success rate than vegetative propagation. The seed germination rate was 48-59% (Rahayu (2014), while the survival rate at the weaning stage was 93-100% (Rahayu & Wahyuni 2016). Despite the use of rooting hormones to stimulate root growth, vegetative propagation using shoot and stem-cutting techniques still yields a low percentage of rooting (Rahayu & Riendriasari 2016). A cultivation technique that has yet to be known for its success rate is direct planting in the field. Therefore, there is a need for research on direct planting techniques in the field, particularly on land and planting preparations.

Strychnos lucida is a shade tolerance species prevalent in the second stratum of forest canopies (Setiawan 2014a) in warm and dry coastal areas. In Bali, it grows in the western region (Setiawan et al. 2011), while in Lombok, in the southern coastal regions (Krisnawati et al. 2015). In Sumbawa, *S. lucida* is commonly found in the Dompu and Bima regions and Moyo Island (Setiawan et al. 2010). Mount Tunak Natural Tourism Park has warm and dry characteristics with low rainfall, high temperature, and limited groundwater that become the challenge for the initial growth of *S. lucida* planting trials (BKSDANTB 2016). The lowest recorded rainfall was 181 mm/year (Mansur 2020), with daily temperatures averaging above 30°C and 14% humidity (Setyayudi et al. 2019). Mount Tunak, Natural Tourism Park, has lower rainfall and humidity but higher daily temperature than the *S. lucida* natural habitat (Setiawan 2014b). For these reasons, the planting trials applied soil amendments to stimulate initial growth and improve the survival rate of *S. lucida*. The treatments included applying basic fertilization, adding hydrogel to improve soil water retention (Dariah et al. 2015), mycorrhiza to increase nutrient availability (Talanca 2010), and plastic mulch to reduce weed growth and water evaporation. This research aimed to determine the effect of soil amendments on the survival and initial growth of *S. lucida*. The results could contribute to better information on technical cultivation for population restoration. As Hasan (2011) said, Shifting use of *Strychnos lucida* from cultural to industrial has threatened its natural habitat sustainability.

Material and Method

Location and Time

Mount Tunak Natural Tourism Park was under the West Nusa Tenggara Natural Resource Conservation Agency. This park was in the southern part of Lombok Island in Mertak Village, Pujut Sub-district, Central Lombok Regency (Susanty 2018). Its topography consisted of sloping to steep with an inclination of 45-

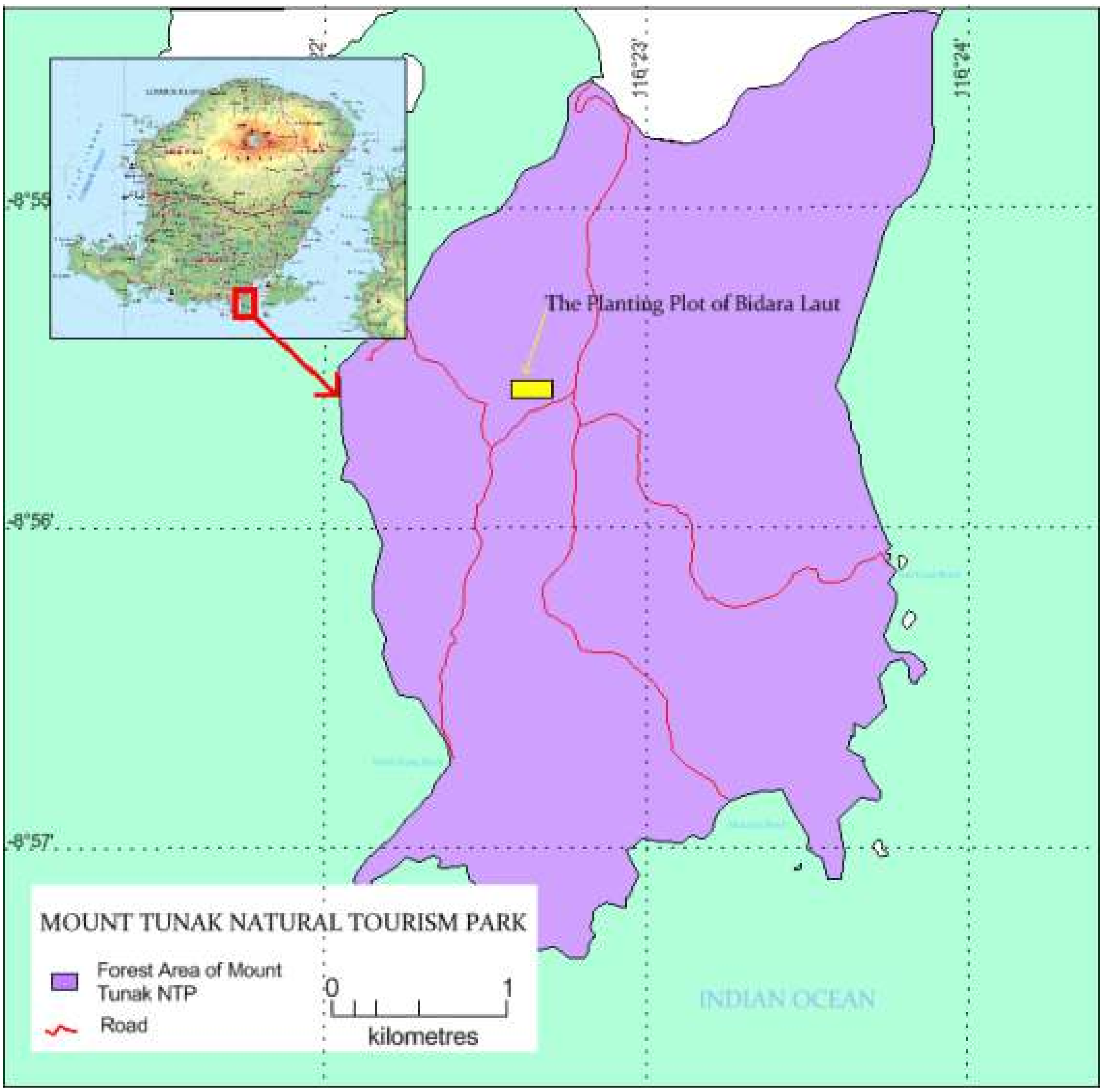

Figure 1. The *Strychnos lucida* planting location in the Mount Tunak Natural Tourism Park

100% from the beach to forest areas with elevations ranging from 0-105 masl. Based on Schmidt and Ferguson's classification, the climate belonged to type E, with an average rainfall of 916 mm/year and 97 rainy days per year. The dominant vegetation was woody plants, homogenous forests, savannas, and shrubs (Afifah 2016).

The location of the *S. lucida* trial plots was in the protection block and on the right side along the path towards the Teluk Ujung beach tourism area (Figure 1). Its dense land cover was mixed forests dominated by woody plants with a 40-60% sunlight intensity. Its topography was flat with an elevation of around 60 masl. The establishment of *S. lucida* planting trial plots was in 2017, and the growth measurements were from January 2018 to June 2019, or approximately 19 months after planting.

Material and Tool

The materials were *S. lucida* seedlings, organic fertilizer, hydrogel crystals, mycorrhiza, plastic mulch, and water. The tools included buckets, scissors, weighing scales, hoes, and measuring equipment, such as a tape meter and a caliper.

Procedure

This research used a Randomized Completely Block Design (RCBD) with four treatments and one control. There were 15 blocks on diverse field conditions with a spacing of 3 m x 3 m, resulting in a total area of 450 m^2. This research used ten replications for each treatment in every block, resulting in 750 *S. lucida* seedlings. Each seedling obtained three kg of manure and soil amendments based on the designed treatments. The treatments included the addition of five grams of hydrogel (P1), ten grams of mycorrhiza (P2), 100 cm x 100 cm mulch (P3), their combination (P4), and a control treatment without any addition (P0).

Analysis

The first measurement occurred one month after planting, while the second was in 2019 or 18 months after planting to observe the initial growth of the *S. lucida* seedlings. The measurement included survival rate, height, and diameter growth. This research used two assumptions in data analysis. The first assumed a normal distribution of the residuals. It used Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) to perform a posthoc test when the ANOVA indicated significant results. The second did not assume a normal distribution of the residuals. It used a non-parametric Kruskal–Wallis test by ranks and the Mann-Whitney U test to compare the treatments.

Result and Discussion

Improved Growth

The ANOVA and Kruskal-Wallis test resulted in nonsignificant differences in the survival rate, height, and diameter average (Table 1). However, the comparison of means in Table 2 indicated higher values of all treatments than the control. The mycorrhiza facilitated the water and nutrients, such as phosphate uptake, to increase the height and diameter growth. The mycorrhiza could expand its hyphae beyond the root system and facilitate the absorption of water and nutrients from more extended areas when the area within the root system lacked water and nutrients (Suryani et al. 2017). This result was consistent with previous research on the effect of mycorrhiza to plant growth. Adding five grams of mycorrhiza yielded the best height growth for acclimatized sandalwood (Herawan & Putri 2018). Laksono and Karyono (2017) also suggested that adding ten grams of mycorrhiza increased the height growth of Indigofera.

The hydrogel addition could improve water availability and facilitate the growth of *S. lucida* in the Mount Tunak Natural Tourism Park, which tended to be warm and dry with rainfall intensity of around 916 mm/year (BKSDANTB 2016). Hydrogel absorbed and stored water up to 40 times the mass and slowly

Table 1. Result of the *S. lucida* growth variance analysis

Variable	sig
Survival rate[1]	0.44
Height[2]	0.47
Diameter[2]	0.62

Description: [1]the result of the ANOVA; [2]the result of the Kruskal Wallis test; Variables significantly different if p-value sig<0,05

Table 2. Comparison analysis of survival rate, height, and diameter

Treatment	Plant growth parameters					
	Survical rate		Height		Diameter	
P0 (control)	25.00	ns	3.77	ns	0.79	ns
P1 (hydrogel)	25.63	ns	5.32	ns	0.81	ns
P2 (mycorrhiza)	32.50	ns	7.32	ns	**1.19**	ns
P3 (plastic mulch)	30.00	ns	6.58	ns	0.97	ns
P4 (hydrogel + mycorrhiza + plastic mulch)	**39.38**	ns	**8.64**	ns	1.08	ns
Average	30.50		6.33		0.97	

Description: - ns: not significant difference at tα 0.05 using the Mann-Whitney U test.

released it into the soil in dry environmental conditions (Neethu et al. 2018). However, growth data showed a nonsignificant difference from the control. The use of hydrogel increased by 3% of survival rate and 41% diameter growth compared to the control. This result did not agree with previous research suggesting that adding hydrogel and manure yielded almost twofold growth of Mimba in Nusa Penida, Bali (Setiawan et al. 2013; Setyayudi et al. 2017).

The mulch application increased the height by 74%, diameter by 22%, and survival rate by 20% compared to the control. The mulch reduced competition for nutrients between *S. lucida* and other natural regeneration in the plots, such as natural seed propagation from surrounding vegetation. Besides, mulch could control and provide optimal environmental conditions for plant growth by regulating soil temperature and moisture content (Raharjo & Kefi 2016). This mechanism resulted in higher growth of *S. lucida* with mulch treatment compared to the control.

This research collected soil samples before and six months after planting to compare the soil properties (Table 3). The measurements indicated that the P, K, and Mg increased while S and Zn decreased. The N, soil organic matter, CEC, Ca, Mn, and Cu nonsignificantly changed. The soil pH increased after the planting. Adding manure and mycorrhiza reduced soil acidity. The manure decomposition could neutralize the H^+ ions and increase the soil pH. Mycorrhiza produced exudates that could bind soil fractions and increase soil pH (Sufardi et al. 2013). Mycorrhiza had more effects on soil nutrients than other amendment treatments because mycorrhiza facilitated the absorption of organic and inorganic soil nutrients to the plants (Johnson et al. 2016).

Mycorrhiza was a phosphate-dissolving fungus that could increase the phosphate availability in the soil by 12.8 times (Herawati et al. 2020). According to Cavagnaro et al. (2015), the presence of mycorrhizal hyphae facilitated the availability of P, N, Cu, and Zn. It prevented soil nutrient loss due to leaching caused by rainfall. Therefore, mycorrhiza could increase plant growth and improve soil chemical properties.

Comparison between Treatments

The survival rate after 18 months of planting was low, with an average of only 30.5% (Figure 2). The survival rate became an essential indicator of the adaptability of the seedlings to their environmental conditions. Figure 2 indicated a significant death rate in all treatments between June 2018 and December 2018, which could relate to the weather conditions (Table 4). The weather data indicated that the region experienced the lowest rainfall from June 2018 to

Table 3. Soil properties before and after planting *S. lucida* in the research location

No	Soil properties	Before planting	After planting	Soil Property level*
1	pH-H2o	5.87	6.7	Neutral
2	N-Total (%)	0.32	0.3	Medium
3	C-organic (%)	1.09	2.0	Medium
4	Texture	Clay loam	Clay loam	
5	CEC (cmol/kg)	30.39	37.3	High
6	P available (ppm)	8.29	66.8	Very high
7	K available (ppm)	11.8	91.7	Very high
8	Ca available (ppm)	224.78	238.5	Very high
9	Mg available (ppm)	1.71	26.9	Very high
10	S available (ppm)	42.06	16.6	Very low
11	Fe available (ppm)	3.17	10.5	Very high
12	Mn available (ppm)	0.93	0.9	Very low
13	Cu available (ppm)	0.08	0.1	Very low
14	Zn available (ppm)	0.61	0.1	Very low

Description: The Soil Laboratory of West Nusa Tenggara Agricultural Technology Research Center analyzed the soil samples;
*measurement of soil property level based on Sulaeman et al. (2009).

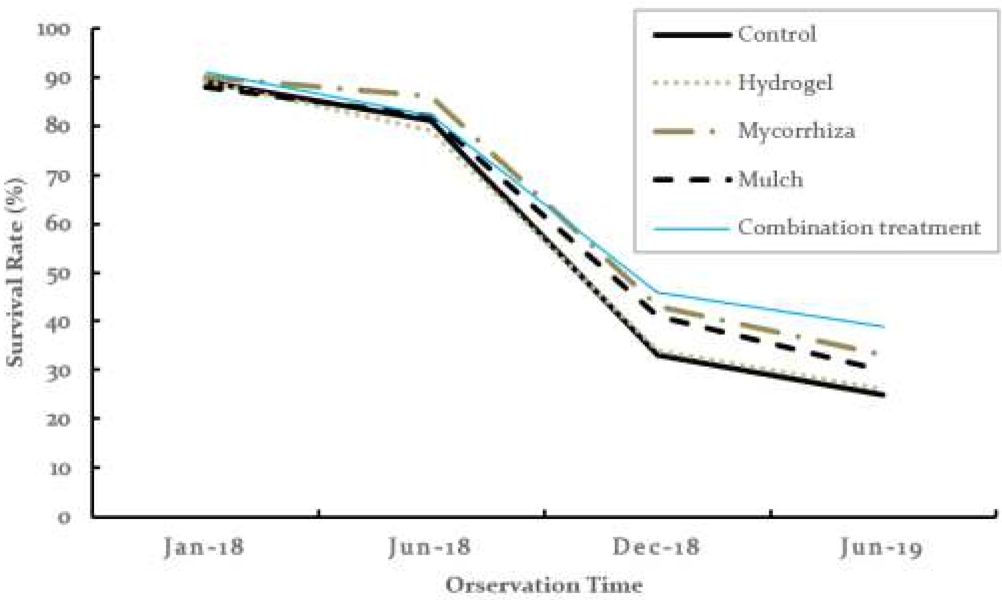

Figure 2. The survival rate of *S. lucida* for 18 months of observation

Table 4. The weather data from the observation station in International Lombok Airport from 2017 to 2019

	Average Temperature (°C)			Rain Fall (mm)			Days with rain			Humidity (%)		
Month	2019	2018	2017	2019	2018	2017	2019	2018	2017	2019	2018	2017
Jan	29	27	32	209	386	226	24	25	20	87	87	87
Feb	28	29	32	112	209	568	16	24	20	86	84	83
Mar	28	32	32	431	326	286	23	16	18	87	81	82
Apr	28	33		210	34		15	3		87	83	79
May	28	28	32	5	1	5	2	2	6	81	81	79
Jun	27	29	27	21	9	22	5	5	8	83	82	79
Jul	27	27	27	3	10	25	3	7	11	81	79	83
Aug	27	26	28	0	9	3	0	9	3	79	78	80
Sep	30	28		0	5		0	5		78	78	80
Oct	27	28	28	0	0	198	0	2	9	76	76	81
Nov	33	29	25	0	255	374	5	15	17	75	83	81
Dec	30	31	28	177	111	386	19	14	25	81	84	86
Total				1168	1355	2093	112	127	137			
Average	28.6	29.0	29.1	97.4	113.0	209.3	9.3	10.6	13.7	81.7	81.3	81.7

Source: Weather bulletin BMKG NTB 2017-2019

December 2018 compared to January 2018 to June 2018 and December 2018 to June 2019. The rainfall significantly correlated with the survival rate of *S. lucida* (Table 5).

In 2018, the region experienced a small rainfall intensity between May and November, with two to nine days of rain causing a significant death rate on the planted *S. lucida*. Rainfall affected the water availability for plant growth. Water became a crucial component in forming the plant body. It also served as the solvent for soil nutrients to allow absorption (Hardjowigeno 1987). Dry soil conditions could reduce the water absorption rate by roots, leading to an imbalance in transpiration rate and causing wilting and death (Jafar et al. 2013).

The hydrogel treatment increased by 3% of survival rate compared to the control, and among the treatments, the hydrogel treatment was ranked the lowest. However, combining the hydrogel with mycorrhizae and mulch increased the survival rate to 40%. This result indicated that water and soil nutrient availability was equally crucial to increase the survival rate of *S. lucida*.

The plastic mulch treatment ensured the supply

Table 5. The Pearson corelation test between survival rate and weather condition

		Survival rate	Rainfall	Humidity	Average Temperature
Survival rate	Pearson CorrelationSig. (2-tailed)N	1	-.997(*)	-.748	-.533
			.047	.462	.642
		3	3	3	3
Rainfall	Pearson CorrelationSig. (2-tailed)N	-.997(*)	1	.795	.470
		.047		.415	.689
		3	3	3	3
Humidity	Pearson CorrelationSig. (2-tailed)N	-.748	.795	1	-.163
		.462	.415		.896
		3	3	3	3
Average Temperature	Pearson CorrelationSig. (2-tailed)N	-.533	.470	-.163	1
		.642	.689	.896	
		3	3	3	3

* significant at the tα0.05 level (2-tailed).

of nutrient stock in the soil without being divided among other plants, resulting in optimal growth (Nurbaiti et al. 2017). The mulch treatment yielded higher survival rates and growth than hydrogel and control. Plastic mulch could reduce weeds (Mokoginta et al. 2017) by blocking sunlight for the underneath seeds, causing etiolation and feeble (Fahrurrozi & Stewart 1994).

However, the mycorrhizae treatment resulted in better growth than the mulch and hydrogel treatments. The mycorrhizae facilitated a larger supply of nutrients, even in the presence of weeds. The ability to spread hyphae also increased the availability of nutrients (Marschner & Dell 1994). The hydrogel treatment had the lowest nutrient stock compared to the other treatments because it facilitated merely as a water supply aid. Based on the average growth and survival rate of *S. lucida* in the research plots, the control yielded the lowest, followed by hydrogel, mulch, mycorrhizae, and the combination treatment.

Conclusion

The *S. lucida* planting trials with RCBD, four treatments, and one control improved the survival rate and growth. The increase included a 25% survival rate, 85% height growth, and 25% diameter growth. However, these increases were statistically nonsignificant.

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