Research Article

The Effects of Elephant Grass Silage Combined with *Indigofera* sp. on the Performance of Bali Cattle

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Abstract | The study aimed to determine the effect of elephant grass silage combined with different levels of *Indigofera* sp. on body weight gain, intake and feed conversion ratio. Twenty-five individually caged Bali cattle were used in this study, allocated to five treatment groups consisting of five animals in each group following a randomized complete design. The treatments were T1: elephant grass silage 100% + *Indigofera* sp. 0%; T2: elephant grass silage 70% + *Indigofera* sp. 30%; T3: elephant grass silage 60% + *Indigofera* sp. 40%; T4: elephant grass silage 50% + *Indigofera sp*. 50%; and T5: elephant grass silage 40% + *Indigofera* sp. 60%. Variables measured were the quality of silage and the performance of Bali cattle fed various dietary treatments. The results showed that the physical characteristics of silage were similar for all treatments. The silage was brown to greenish in colour, had minimum odour from the formation of lactic acid, had solid texture, and was compact. There was no mould growth in the silage, and pH ranged from 3.7 to 4.1. Increasing levels of *Indigofera* sp. added to elephant grass increased the crude protein content of silage, but decreased the content of ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), cellulose, hemicellulose and lignin by up to 40%. Dry matter intake per kg unit of BW was higher ($P < 0.000$) in the T2, T3, and T4 diet than in the T1 or T5 diets. The crude protein intake per kg unit of BW was higher ($P<0.000$) in the T3, T4, T5 diet than T1 and T2. Animals on the T3 diet showed a higher ($P < 0.05$) daily BW gain followed by the animals on the T4 and T5 diets. It can be concluded that the combination of 60% elephant grass and 40% *Indigofera* sp. has the best physical and chemical qualities and is able to increase the daily body weight of Bali cattle.

Keywords | Silage, Elephant grass, *Indigofera sp*, Bali cattle, Performance

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INTRODUCTION

Forages are important for the efficient operation of systems for the processing of livestock. During the dry season, both the quantity and quality of this forage are poor and constitute major restrictions on the production of ruminant livestock. Dynes et al. (2003) state that forage, whether fed as pasture, forage crops, or preserved grass, silage, or haylage, is the most important component in cattle diets. Meanwhile, climate change has the potential to affect the quantity and reliability of output of forage and its quality (Rojas-Downing et al., 2017). Legumes, a high protein source of forage, are used to substitute for grass in cattle diets to fulfil the protein requirements of livestock. Moreover, legumes are one of the alternatives used in intensification systems for ruminant production in pasture, for improvement and diversification of feed, and for reduction of production costs (Sales et al., 2012). Legumes can reduce the greenhouse gas emissions of ruminant production (Lüscher et al., 2014), because they contain saponin (6–15%), tannins (up to 10%), polyphenol oxidase, and protease (Mueller-Harvey, 2006; Kingston-Smith et al., 2010). *Indigofera* sp. is a leguminous tree that has potential as a source of dietary protein and energy, and which has high levels of dry matter and organic matter digestibility (Tarigan et al., 2010).

Several experiments have shown that feeding animals with legume silage increases milk production compared to animals fed only on grass silage (Dewhurst et al., 2003). Rumen nitrogen (N) loss in ruminants fed legumes as their sole diet was higher due to an imbalance in availability between the degradable N present and the fermentable energy supplied by this forage. The breakdown of rumen protein was higher in forage legumes compared to grass (Beever et al., 1986) because of inefficient utilization of N in the rumen and high urinary N excretion (Peyraud, 1993). The water soluble carbohydrates (WSC) contained in the forage must be sufficient to balance crude protein concentration in order to maximize microbial protein synthesis. Legumes usually contain high levels of crude protein and low WSC concentrations; therefore, increasing WSC concentration can improve N-rumen utilization and feed digestibility. Combining grass containing high WSC concentrations with legumes containing high crude protein content is expected to improve digestibility. This study aims to determine the quality of elephant grass silage combined with various levels of *Indigofera* sp. and its effects on the performance of Bali cattle.

MATERIALS AND METHODS

Experimental Animals

This study used 25 Bali cattle aged from 2.5 to 5 years and with bodyweight of 160–170 kg. The research was conducted in Gowa Experimental Field Station, South Sulawesi. The experiment was approved by the Animal Welfare Commission of the Indonesian Agency for Agricultural Research and Development (Balitbangtan/BPTP Sulsel/Rm/03/2020). Cattle were raised using the animal welfare standards of the Indonesian Centre of Agriculture Research and Development, Ministry of Agriculture.

Treatment groups and analyses

Elephant grass and *Indigofera* sp. used in the experiment were cut at 60 days regrowth and obtained from Gowa Experimental Field Station. The ensilage was conducted by mixing fresh elephant grass and *Indigofera* sp. with starters consisted of rice bran and molasses as much as 5% of the total weight of forage. Elephant grass, *Indigofera* sp. and rice bran were mixed thoroughly, put into 60 x 100 cm plastic bags to create anaerobic conditions, and then kept for 21 days. The silage was prepared according to the following treatments: T1 (100% elephant grass + *Indigofera* sp. 0%), T2 (elephant grass 70% + *Indigofera* sp. 30%), T3 (elephant grass 60% + *Indigofera sp*. 40%), T4 (elephant grass 50% + *Indigofera* sp. 50%), and T5 (elephant grass 40% + *Indigofera sp*. 60%). Each treatment was carried out in five replications. The ensiling procedure was performed according to Kondo et al. (2014). The silage was harvested after 21 days to determine physical characteristics of colour, smell, texture, mould presence, and pH. Silage samples were oven-dried at 60°C for 24 hours then ground with a screen size of 1 mm. Samples were analysed in duplicate for their chemical composition of dry matter (DM), organic matter (OM), ash, crude protein (CP), ether extract (EE), crude fibre (CF), and nitrogen-free extract (NFE) by following the AOAC procedure (2005). Samples were also analysed for NDF, acid detergent fibre (ADF), and lignin (Van Soest et al., 1991).

In vivo experiment

Cattle were raised in individual cages and fed twice a day, first at 07.00 with silage and concentrate, and then at 16.00 with silage alone. The concentrate contained 15% crude protein and consisted of 50% rice bran, 15.5% coconut cake, 19% milled corn, 15% fish meal, 0.25% minerals, and 0.25% salt. The concentrate was given at 2 kg/head/day, while drinking water was given *ad libitum*. The feed treatments were carried out for four months, and feed intake was determined by weighing the feed offered and feed remaining every day during the four-month period. The animals were weighed once a month to evaluate body weight gain.

Statistical analysis

Data were analysed using analysis of variance (ANOVA) for the five treatments and five replications. When the ANOVA results for a certain parameter showed a significant difference at $p < 0.05$, the Duncan test was applied to compare the differences among the treatments. Statistical analysis was performed by using SPSS statistics software version 23.

The ANOVA model is:

$Y_{ij} = \mu + \alpha_{ij} + \varepsilon_i$

where:

Y_{ij} = observed variable response

μ = general average

α_{ij} = the effect of the i-th feed on the j-th test

ε_{ij} = effect of the error component

i = 1, 2, 3, 4

j = 1, 2, 3, 4

Table 1: Physical characteristics of elephant grass silage combined with various levels of *Indigofera* sp.

Treatment*	Colour	Odour	Texture	Fungi	pH
T1	the brownish-green,	Typical lactic acid	Whole and compact	No fungi	4.3
T2	the brownish-green,	Typical lactic acid	Whole and compact	No fungi	4.3
T3	the brownish-green,	Typical lactic acid	Whole and compact	No fungi	4
T4	the brownish-green,	Typical lactic acid	Whole and compact	No fungi	4.5
T5	the brownish-green,	Typical lactic acid	Whole and compact	No fungi	4.5

*T1 (100% elephant grass + *Indigofera* sp. 0%); T2 (elephant grass 70% + *Indigofera* sp. 30%); T3 (elephant grass 60% + *Indigofera* sp. 40%); T4 (elephant grass 50% + *Indigofera* sp. 50%); T5 (elephant grass 40% + *Indigofera* sp. 60%)

Table 2: Chemical composition of elephant grass silage combined with various levels of *Indigofera* sp.

Treatments*	Composition (%)							
	DM	CP	Ash	ADF	NDF	Cellulose	Hemicellulose	Lignin
T1	92.98	7.81	14.39	47.89	68.86	34.77	21.28	9.81
T2	91.42	12.26	17.12	47.64	64.21	27.74	16.36	13.29
T3	91.12	18.81	14.66	47.33	55.60	26.69	8.28	14.07
T4	88.70	16.74	14.62	48.50	61.57	29.65	13.08	16.77
T5	88.15	15.48	15.46	48.79	60.48	34.94	13.14	16.64

DM: Dry Matter, CP: Crude Protein, ADF: Acid Detergent Fiber, NDF: Neutral Detergent Fiber.
*T1 (100% elephant grass + *Indigofera* sp. 0%); T2 (elephant grass 70% + *Indigofera* sp. 30%); T3 (elephant grass 60% + *Indigofera* sp. 40%); T4 (elephant grass 50% + *Indigofera* sp. 50%); T5 (elephant grass 40% + *Indigofera* sp. 60%)

Table 3: Effects of Elephant grass silage combined with *Indigofera* sp. on total intake, total organic intake and crude protein intake.

Parameters	Treatment*					SEM	P-value
	T1	T2	T3	T4	T5		
Total dry matter intake (kg/d)	6.18^{ab}	6.16^{ab}	6.43^{c}	6.26^{b}	6.04^{a}	0.053	0.001
Total organic matter intake (kg/d)	5.30^{b}	5.35^{b}	5.48^{c}	5.31^{b}	4.96^{a}	0.022	0.000
Crude protein intake (kg/d)	0.51^{a}	0.75^{b}	1.28^{d}	1.17^{d}	1.06^{c}	0.037	0.000

^{abc}: means in the same line with varying superscript differ significantly (P<0.05).
*T1 (100% elephant grass + *Indigofera* sp. 0%); T2 (elephant grass 70% + *Indigofera* sp. 30%); T3 (elephant grass 60% + *Indigofera sp.* 40%); T4 (elephant grass 50% + *Indigofera* sp. 50%); T5 (elephant grass 40% + *Indigofera* sp. 60%)

RESULTS

In general, the quality of silage produced was acceptable in terms of physical characteristics (Table 1) and chemical components (Table 2). The physical characteristics of silage show that all silage treatments had the same brown to greenish colour, had a distinctive odour of lactic acid, a whole and compact texture, and no mould growth, with the only difference between each treatment being pH value. The highest dry matter content was in T1, at 92.98%, while the lowest dry matter content was in T5, at 81.15%. T3 contained higher crude protein compared to the other silage treatments. The ash content in T2 compared to the other silage treatments. The T2 and T1 treatments had more ash content than T3 at 47.89% and 47.64%, respectively. The lowest ADF content was in T3, at 47.33%. The T4 and T5 treatments had the highest ADF content, at 48.50% and 48.79%, respectively. The lowest cellulose content was in T3, at 27.74%, and the highest was in T5 at 34.94%.

Effects of Elephant grass silage combined with *Indigofera* sp. on total intake, total organic intake and crude protein intake were presented in Table 3. The total DM intake of the cattle fed with the T3 (elephant grass 60% + *Indigofera* sp. 40%) diet was higher (p<0.001) compared to those fed with T5 (elephant grass 40% + *Indigofera* sp. 60%) (Table 3). The total OM intake of the cattle feed with the T5 (elephant grass 40% + *Indigofera* sp. 60%) diet was lower (p<0.000) compared to those fed with T3 (elephant grass 60% + *Indigofera* sp. 40%) diet. The total CP intake of the cattle fed with T3 (elephant grass 60% + *Indigofera sp*. 40%) diet was higher (p<0.000) compared to those fed with the T1 (elephant grass 100% + *Indigofera sp*. 0%) diets. Effects of Elephant grass silage combined with *Indigofera* sp. on digestibility nutrient and nitrogen retention were presented in Table 4. The dry matter and crude protein digestibility of cattle in treatment T3 was significantly higher (p<0.000) compared to treatment T1. The organic

Table 4: Effects of Elephant grass silage combined with *Indigofera* sp. on nutrient digestibility and nitrogen retention.

Parameters	Treatment*					SEM	P -value
	T1	T2	T3	T4	T5		
Dry matter (%)	41.43[a]	44.50[ab]	48.50[c]	46.57[bc]	44.17[ab]	1.011	0.000
Organic matter (%)	21.14[b]	23.61[b]	28.73[c]	20.47[b]	12.31[a]	1.485	0.000
Crude protein (%)	44.13[a]	62.47[b]	81.20[c]	78.25[c]	74.82[c]	2.174	0.000
Nitrogen in feces (g/head/day)	46.48[d]	43.62[c]	38.10[a]	40.98[b]	42.77[bc]	0.803	0.000
Nitrogen in urine (g/head/day)	10.18[a]	12.26[c]	12.62[d]	11.27[b]	10.41[a]	0.105	0.000
Nitrogen digested (g/head/day)	77.38[a]	120.86[b]	149.77[c]	168.21[d]	193.33[e]	1.245	0.000
Nitrogen retention(g/head/day)	39.92[a]	63.90[b]	71.44[c]	75.62[d]	80.28[e]	0.514	0.0000

[abcd]: means in the same line with varying superscript differ significantly (P<0.05); *T1 (100% elephant grass + *Indigofera* sp. 0%); T2 (elephant grass 70% + *Indigofera* sp. 30%); T3 (elephant grass 60% + *Indigofera* sp. 40%); T4 (elephant grass 50% + *Indigofera* sp. 50%); T5 (elephant grass 40% + *Indigofera* sp. 60%)

Table 5: Effects of feeding of Elephant grass silage combined with *Indigofera* sp. on growth performance of Bali cattle.

Parameters	Treatment*					SEM	P -value
	T1	T2	T3	T4	T5		
Initial body weight (kg)	170.1	169.4	170.8	169.8	161	5.758	0,737
Final body weight (kg)	191.6	195.4	204.2	200.6	189.6	4.248	0.130
Average daily gain (kg/h/d)	0.24[a]	0.29[ab]	0.37[b]	0.34[b]	0.31[ab]	0.029	0.045
Feed conversion ratio	27.20[b]	20.18[a]	19.24[a]	19.87[a]	22.97[a]	1.246	0.001

[abc]: means in the same line with varying superscript differ significantly (P<0.05); *T1 (100% elephant grass + *Indigofera* sp. 0%); T2 (elephant grass 70% + *Indigofera* sp. 30%); T3 (elephant grass 60% + *Indigofera* sp. 40%); T4 (elephant grass 50% + *Indigofera* sp. 50%); T5 (elephant grass 40% + *Indigofera* sp. 60%)

matter digestibility of cattle in treatment T3 was significantly higher (p<0.000) compared to treatment T5. The N feces was highest (p<0.000) in cattle fed 100% elephant grass in treatment T1, but the N urine was lowest (p<0.000) in cattle fed treatment T1 compared to other groups. The nitrogen digested and N retention was highest (p<0.000) in cattle fed T5, but was lowest (p<0.000) in cattle fed T1.

Effects of Elephant grass silage combined with *Indigofera* sp. on growth performance were presented in Table 5. There was no difference in the initial and final body weight among the five dietary treatment groups. However, the animals fed with the T3 diet resulted in lower feed conversion ratio (p<0.001) than T1 diets (Table 5).

DISCUSSION

The purpose of silage production is to provide a form of stable feed with dry matter, energy, and other nutrients that are easily digested compared to fresh plants (Kung Jr. et al., 2018). Loss of dry matter and quality that occurs during the ensiling process from the field, to the trial phase, to livestock is unavoidable (Borreani et al., 2018). Based on the characteristics of silage observed, the five silage treatments in the study were suitable for cattle feed, because the pH values ranged from 3.7 to 4.1 and they were not contaminated with mould. The lowest pH was 3.7 in T1, followed by T2 at 3.9. Meanwhile, the pH for both T3 and T4 was 4, and the highest pH was for T5, at 4.1. A good-quality silage has a pH between 3.8 and 4.2 and a smooth texture, brown-greenish colour, smells of lactic acid, has water content of about 60–70% and has a good smell (Ratnakumolo et al., 2006).

Our results illustrate that increasing levels of *Indigofera* sp. addition to elephant grass silage resulted in lower dry matter content. According to McCullough (1977), the potential of elephant grass for silage depends on the concentration of its water content. Loss of dry matter is also influenced by the cutting time and withering of the forage, in which late afternoon cutting can increase WSC (Morin et al., 2012; Brito et al., 2008). In addition, the dry matter content of silage can determine quality, in that the dry matter content of forage can affect the shelf life of silage (Kuncoro et al., 2015). Dry silages can break down quickly when exposed to air because they tend to be more porous in silos than wet silages. These silages do not have sufficient amounts of organic acids (e.g., acetic acid) with antifungal activity to suppress lactate-assimilating yeast growth, a condition which triggers decay in aerobic conditions (Kung Jr et al., 2018).

Protein is one of the most important nutrients and is needed by livestock at various levels of production and various phases of life. This study shows that the crude protein content of silage increased with increasing levels of added *Indigofera sp*. This is presumably because *Indigofera* sp. has high protein content, so mixing it with elephant grass silage will increase the crude protein content of the silage. This is in line with the opinion of Riswandi et al. (2016) that the nutritional quality of grass can be improved by supplementation with legumes. The crude protein content of *Indigofera sp*. leaves varies from 24.2 to 31% (Hassen et al., 2007; Muzzazinah, 2016).

Ash content can be used to determine the minerals contained in a material, which in turn can indicate the success of the demineralization process that has occurred (Kuncoro et al., 2015). The ash content in T2 is the highest 17.12%, respectively, followed by T5, T3, T4 which have 15.46%, 14.66% and 14.62% of ash content, respectively. T1 has the lowest ash content at 14.39%. The high ash content in T2 and T3 treatments indicates that the minerals levels contained were higher than the other treatments.

The ADF concentration refers to the cell wall portions of the forage. The ADF value is important because it will influence the ability of animals to digest the forage. As the ADF increases, the digestibility of the forage usually decreases (Salama and Nawar, 2016). In line with the ADF content, the NDF content in the T3 treatment (with the lowest *Indigofera* sp. level of 40%) was 55.60%, however the NDF content of silage increased with increasing *Indigofera sp*. levels at 50% and 60%. Meanwhile, elephant grass silage without *Indigofera sp*. had the highest NDF content, at 68.86%. Albayrak and Turk (2013) state that forage legumes are known to have lower fibre content than grasses, while grasses also generally contain more NDF. This result indicates that addition of *Indigofera sp*. to elephant grass silage decreased its NDF content. Low NDF values indicates a good-quality silage (Senjaya et al., 2010).

The T3, T2, and T4 treatments had adequate cellulose content, 26.69%, 27.74%, and 29.65%, respectively. The hemicellulose content in T3, at 8.28%, was the lowest compared to other silage treatments, while the highest was T1, at 21.28%, followed by T2, T4, and T5, at 16.36%, 13.08%, and 13.14% respectively. The lignin content in T1, at 9.81%. The highest lignin content was in T4, at 16.77%, then T5, T3 and T2, at 16.64%, 14.07% and 13.29%, respectively. These results illustrate that elephant grass silage combined with *Indigofera sp*. has higher lignin content than silage containing elephant grass alone. Silage with higher *Indigofera sp*. levels contains greater amounts of lignin than silage with lower *Indigofera sp*. levels. Lignin is considered as an anti-nutritional component in forage because it has a negative impact on the nutrient availability of plant fibre (Moore and Jung, 2001). Lignin also inhibits cell wall digestion to a greater extent than the total dry matter digestibility of forage (Jung and Vogel, 1986). In addition, lignin is closely related to cellulose and hemicellulose and can limit the digestion of polysaccharides (Machado et al., 2020).

The utilization of *Indigofera* sp. in ruminant feeding has been evaluated (Tarigan et al., 2018; Ginting et al., 2010). The feed intake and digestibility of the nutrients can be enhanced by the use of different techniques for supplementation and processing (Leng, 1990). The present study was carried out to determine whether Elephant grass silage combined with *Indigofera* sp. can be used efficiently to feed cattle. Dry matter intakes of Elephant grass silage combined with *Indigofera* sp. were significantly different ($p<0.001$) among dietary treatments (Table 3). But, numerically higher intake of Elephant grass silage combined with *Indigofera* sp. and total DM occurred in cattle receiving T3 diets. The high DM, OM and CP intake of T3 diets can be explained by the high CP content (18.81%) and low content of NDF (55.60%). These results indicate that *Indigofera* sp. is good quality protein source in terms of body weight gain. This result is supported by Tarigan et al. (2018) who reported that DM, OM and CP intakes by goat fed on GCP (green concentrate pellets) were greater compared to the control.

The level of crude protein digestibility in the Elephant grass silage combined with *Indigofera* sp. groups were significantly higher ($p<0.000$) compared to the T1 diets. This may relate to the high intake and digestibility of CP in cattle receiving *Indigofera* sp. The N secretion in faeces and urine were significantly lower ($p<0.000$) in Elephant grass silage combined with *Indigofera sp*. groups diets than those of cattle the fed with 0% *Indigofera sp*. Increased fecal N and urine nitrogen could be due to the higher tannin content of Elephant grass silage combined *Indigofera sp*, which reduced the degradation protein in the rumen. In response to the increasing content of tannin in the feed, a decrease in N digestibility and increased secretion of urine and feces (Al-Dobaib, 2009). Tannins can slow down protein degradation in the rumen and can also occur in silage, thereby increasing protein utilization and livestock production efficiency (Huang et al., 2018; Jayanegara et al., 2018). N retention in cattle fed treatment T2 until T5 has increased by 37.53-50.27% compared to T1, indicating the potential of Elephant grass silage combined with *Indigofera* sp. in supporting the productivity of ruminants.

Silage treatment showed the highest increase in daily body weight gain of Bali cows. These results indicate that elephant grass silage with a combination of *Indigofera* sp. at levels of 40% plus concentrate as supplement feed can fulfil the nutritional needs of livestock. The feed has high palatability due to good silage quality. However, increasing levels of *Indigofera* sp. resulted in decreased daily body weight gain in the Bali cows. At the 50% *Indigofera* sp. level, body weight gain dropped to 0.34 kg/head/day and declined further to 0.31 kg/head/day in silage with *Indigofera* sp. level of 60%. At 30% *Indigofera* sp. level body weight gain dropped to 0.29, this value was almost the same as for silage of elephant grass without *Indigofera* sp. (0%), which only increased by 0.24 kg/head/day of body weight. This might be due to an increase in the content of ADF, NDF, cellulose, hemicellulose, and lignin in the silage treatments. In addition, increasing *Indigofera* sp. levels cause more tannin content in silage. *Indigofera* sp. contains anti-nutritional tannins which will become a limiting factor, because most of these substances are toxic (Nurjannah et al., 2019). These tannins can slow down protein degradation in the rumen and can also occur in silage, thereby increasing protein utilization and livestock production efficiency (Huang et al., 2018; Jayanegara et al., 2018). Combination silage at several levels of *Indigofera* sp. offered to Bali cattle increased feed consumption. The highest levels of consumption were recorded in T2, T3, and T4 treatments. This was because the silage had a high level of palatability due to its relatively good quality and nutritional content. Feed that has good palatability will be consumed more readily by livestock (Usman et al., 2013). The palatability of feed is influenced by the smell, taste, texture, and shape of the feed given.

Feed conversion is the amount of feed consumed divided by the bodyweight gain per unit of time. The feed conversion value is more efficient if the amount of feed consumed is less but results in a higher or the same bodyweight gain. Good-quality feed will result in high body weight gain and low feed conversion values. Elephant grass silage combined with several levels of *Indigofera* sp. had significant effect ($P < 0.001$) on feed conversion. Treatment T3 had the lowest conversion value of 19.24, which indicates the treatment was more efficient than the other treatments. Overall, the feed conversion in this study was higher than the feed conversion reported by Tahuk and Dethan (2010), which was 7.55 for fattening Bali cattle fed by local grass and king grass without additional supplements.

CONCLUSION

Increasing levels of *Indigofera* sp. in silage up to 40% resulted in increasing crude protein content, however, the levels of ash, ADF, NDF, cellulose, hemicellulose, and lignin in silage decreased. Silage with a composition of 60% elephant grass and 40% *Indigofera* sp. has the best physical and chemical qualities and is able to increase the daily body weight of Bali cattle compared to other silages.

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CONFLICT OF INTEREST

All authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTION

AN carried out the experiment, performed the statistical analysis and wrote the initial manuscript draft. AS, AE, ABLI and NQ designed and supervised the experiment and revised the manuscript.

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