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Productivity and Nutritive Value of Mutant Benggala Grass (*Panicum maximum* cv Purple Guinea) in the Saline Soil of Coastal Area in Lebak-Banten Province

A. Fanindi*, E. Sutedi, I. Herdiawan, Sajimin, H. Harmini, C. Hidayat, R. Krisnan, & D. Yulistiani
Research Center for Animal Husbandry, National Research and Innovation Agency
Cibinong Science Center, Jalan Raya Jakarta-Bogor, Cibinong, Bogor Regency 16915, West Java Province, Indonesia
*Corresponding author: afanindi@gmail.com/achm054.brin.go.id
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ABSTRACT

The coastal region of Lebak-Banten is an area with a relatively high population of buffalo. The forage requirement has relied on existing forage with low productivity and quality. The study aimed to investigate the physiological, morphological, and nutritional response of mutant benggala grass in the coastal area and to develop salt-tolerant forage crops with high productivity and nutritive value for livestock. The research was conducted in the Binuangeun coastal area, Muara Village, Wanasalam District, Lebak Regency, located at 6°50'34.4"S and 105°53'23.4"E. This study used a completely randomized block design with a factorial arrangement with 5 replications. The first factor consisted of 4 benggala grass mutants: mutant 12, 18, 36, 56, and a control. The second factor was the location or distance of the planting plots from the coastline (FC), consisting of L1: 50 m FC, L2: 75 m FC, L3: 100 m FC, and L4: 500 m FC, representative of low, moderate, and high salinity levels, and no saline. Observations were made during the dry and rainy seasons. The results showed that mutants 12 and 36 had higher fresh forage production during the rainy season, while mutant 36 had the highest forage production at the L1 location (high salinity conditions) during the dry season. Mutant 12 had higher crude protein values at the L2 location (moderate salinity) than the other mutants and locations (salinity levels) during the dry season. Meanwhile, mutant 18 at the L2 location (moderate salinity) had the highest crude protein value during the rainy season. In addition, mutant 12 had a high proline value at the L1 location (high salinity stress) as a plant adaptation response to salinity stress. The study suggests that mutants 12 and 36 have great potential to be developed into new salt-tolerant forage crop cultivars and can be grown in coastal areas of Lebak-Banten.

Keywords: breeding; coastal; forage; mutants; salinity

INTRODUCTION

Banten is one of Indonesia's ruminant development centers, especially buffaloes. For the people of Lebak-Banten, buffaloes are relied upon for their economy and have a certain social value (Fadillah, 2010). Furthermore, Lebak Regency has a buffalo germplasm called "*Kerbau Banten*" (Rusdiana *et al.*, 2019). The buffalo population in Lebak Regency is also the highest among large ruminants, at around 81% (BPS, 2022). The buffalo population is distributed in various regions of the Lebak Regency, including the coastal areas where almost 30% of the buffalo population in the Lebak Regency is located (BPS, 2022). However, the buffalo population in Lebak Regency has been declining yearly due to various factors, such as animal husbandry management, farmer institutionalization, and the availability of high-quality forage (Rusdiana *et al.*, 2019). The cultivation of superior forage crops in coastal areas can address the provision of high-quality forage.

Coastal land is one of the marginal lands with the potential for the development of forage crops. The marginality of coastal land can be seen from its soil texture, water-holding capacity, chemical content, and organic matter (Liang *et al.*, 2021). The main limiting factor for forage crops in coastal land is soil salinity. The saline nature of the soil can be exacerbated by salinization due to climate change. Salinization is the increase of soluble salt in water or soil caused by environmental and human activities (Daliakopoulos *et al.*, 2016). Soil salinity is an abiotic factor that disturbs plant physiological, biochemical, molecular, and photosynthesis processes (Hussain *et al.*, 2019), eventually reducing biomass production (Zörb *et al.*, 2019). Salinity also affects the quality of forage crops by decreasing protein and ash values with increasing salinity levels (Wasim *et al.*, 2021). The quality of forage crops must be considered, as the feed quality largely determines livestock productivity.

Benggala grass (*Panicum maximum*) and elephant grass are forage crops widely used by ruminant farmers in Indonesia. This grass has good potential as animal feed (Bureenok *et al.*, 2016) and has good quality, with crude protein above 10.5%, crude fiber 30.4%, and ash

7% (Ironkwe & Ukanwoko, 2016). It grows well under various suboptimal land conditions, such as acid-dry land (Fanindi *et al.*, 2019) and semi-arid land (Pereira *et al.*, 2021). The adaptability of benggala grass to these suboptimal lands is also expected to extend to saline lands.

No salt-tolerant benggala grass varieties from breeding have been released in Indonesia. Previous studies produced several benggala grass mutants through gamma radiation induction, showing tolerance to acidic and dry lands and high production compared to nonmutant (Fanindi *et al.*, 2019). Gamma radiation was used to accelerate the creation of diversity, in addition to the apomictic reproductive nature and small flowers of benggala grass (Radhakrishna *et al.*, 2018). It is expected that these mutants can be developed into salt-tolerant benggala grass varieties after adaptation tests on coastal lands. This study aimed to determine the physiological, morphological, and nutritive value responses of the benggala grass mutants to saline lands in coastal areas. Salt-tolerant benggala grass varieties are expected to address feed problems in coastal lands and land salinization due to climate change in agricultural areas. Feed availability in coastal areas is also expected to improve livestock development in the region, thus providing additional income for farmers in the area.

MATERIALS AND METHODS

This research was conducted in Binuangeun coastal area, Muara Village, Wanasalam District, Lebak Regency, located at 6°50’34.4”S and 105°53’23.4”E, from January 2020 to December 2020. This research used a completely randomized block design with a 4 x 4 factorial arrangement with 5 replications. The first factor consisted of four mutants of benggala grass (*Panicum maximum* cv Purple Guinea), namely mutant 12, 18, 36, and 56, and a control variety (benggala grass that was not irradiated). Meanwhile, the second factor was the location or distance of the planting plots from the coastline (FC) consisting of: L1= 50 m FC, L2= 75 m FC, L3= 100 m FC, and L4= 500 m FC. The distances were determined on direct soil salinity measurements in the field using a salinity measuring instrument, representative of low, moderate, and high salinity levels, and no saline. The salinity levels, soil texture, pH, organic matter, P_2O_5 and K_2O at the research locations are presented in Table 1. The mutant benggala grass was obtained from a mutant collection at the Livestock Research Institute, which had previously been selected as tolerant mutants in acidic dry land (Fanindi *et al.*, 2022).

The Research Procedure

The seeds of mutant benggala grass were obtained from the pols (cuttings), which were sowed in polybags measuring 10 x 10 cm and containing one pol each. After one month of growth, uniform plants were selected and transplanted into the research plot with a designated salinity level. The research plot consisted of planting beds measuring 4 x 3 m^2. The planting distance between rows and within rows was 0.5 x 0.5 m, resulting in 40 plants per planting bed. Each research plot was repeated 5 times, so there were 25 plantings in each.

Fertilization was not applied in this study, using manure as the basal fertilizer or inorganic fertilizers. Irrigation was only performed at the initial planting stage and after cutting, with no further irrigation conducted, relying solely on rainfall. Weeding was

Table 1. Soil analysis at the research site under various levels of salinity during the dry and rainy seasons

Variables	Dry season				Rainy season			
	L4	L3	L2	L1	L4	L3	L2	L1
Texture								
Sand (%)	37	67	56	50	64	66	64	66
Dust (%)	16	6	4	1	10	1	11	10
Clay (%)	47	27	40	49	26	33	25	24
pH								
H_2O	7.9	8.3	8.4	8.1	8.1	7.9	7.9	7.9
KCl	7.4	7.7	7.7	7.5	7.6	7.6	7.7	7.7
Organic matter								
C-organic (%)	8.72	4.92	5.97	9.50	4.45	6.28	8.74	9.92
N (%)								
C/N ratio								
Extract HCl 25%								
P_2O_5 (mg100 g^{-1})	268	71	64	88	145	110	72	82
K_2O (mg100 g^{-1})	60	51	46	80	43	77	69	74
CEC	32.61	20.60	26.90	34.54	21.97	24.07	26.42	29.26
DHL (dS/m)	0.291	2.83	3.30	7.66	0.224	2.580	3.640	3.390
Salinity (mg/L)	145	1420	1650	3830	112	1288	1818	1696

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). CEC= cation exchange capacity.

carried out when there was significant weed growth but minimal weed growth at the research site.

Variable Observation

The variable observation was conducted after the plants were trimmed at age 3 months. Cutting interval and variable observation were carried out 45 days after planting. Observations were conducted during the rainy and dry seasons to assess the research plant's productivity stability. The rainfall data at the research location are presented in Figure 1. The variables measured were the fresh and dry weights of forage, plant height, number of tillers, leaf length, and width. The nutritional value variables of the grass, consisting of crude protein (CP), ADF, and NDF, ash, Na, Ca, and Cl in forage, were also observed. Observations of proline, chlorophyll a and b, total chlorophyll, carotenoids, and anthocyanin were conducted to examine the physiological response of the plants. Fresh weight was determined by cutting the plant from the ground around 10 cm then weighing it. The dry weight was determined by weighing the sample (500 g) that had been oven-dried at 60 °C for 3 days. Plant height was measured from the ground to the point of plant growth, while the number of tillers was counted by counting the total number of tillers. The length and width of the leaf are measured on the second leaf after the flag leaf or the last leaf. Leaf length was measured from the leaf base to the leaf apex, while leaf width was measured on the widest part of the leaf blade. Crude protein value was calculated using the Kjedhal method (Thiex *et al.,* 2002), Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were calculated using the Van Soest method (Van Soest *et al.,* 1991), ash value was calculated using the Gravimetric method, while Na, Ca, and Cl value in forages were calculated using the AAS method. Proline was calculated using the Bates *et al*. (1973) method, while chlorophyll a, b, total chlorophyll, anthocyanin, and carotenoids were calculated using spectrophotometry. The data obtained from the measured variables were analyzed using ANOVA with SAS 9.4. Subsequently, Duncan's test would be conducted when the differences among treatments were significant.

RESULTS

Production and Morphology of Benggala Grass Mutant

The research sites had sandy-textured soil with a slightly alkaline pH (Table 1). The soil had high to very high carbon value, very low organic N, high P2O5 and K2O, and high cation exchange capacity (CEC) (Table 1) (Sulaeman *et al.,* 2015). The salinity level was low to moderate (Laiskhanov *et al.,* 2022). The salinity level in the control plot (L4) was lower than in plots with low (L3) and high categories (L1). The salinity level during the dry season was higher than during the rainy season. The research plot with a high salinity category (L1) had a value of 3.39 ds/m during the rainy season and 7.66 ds/m during the dry season (Table 1). The laboratory's salinity analysis results were lower than the initial salinity measurements using the salinity measuring device in the field.

The number of tillers, plant height, fresh weight, and dry weight (Table 2) were affected by both the mutant type and location (salinity level) during the dry season ($p<0.01$), and there was an interaction between them. Leaf width was only affected by the location (Table 3). The highest number of tillers during the dry season was obtained from mutant 12 on non-saline plots, although it was not significantly ($p>0.05$) different from the number of tillers at the L1 and L3 plots. The total number of tillers of all mutants was higher than the control plants (Table 2).

The plant height of the control group was not significantly ($p>0.05$) different from that of the mutants across all locations (salinity levels). The shortest plants were observed in mutant L2 under L3 (low salinity). Mutant 36 had the highest fresh weight at the L1 location (high salinity), while mutants 12, 18, and the control group had the highest fresh weight across all locations (salinity levels). Mutant 56 had the highest dry weight at L3 (low) location and under non-saline conditions, followed by mutants 56 and 18 at the L3 location (low salinity). The lowest dry weight was found in mutant 56 at the L1 location (high salinity).

Most of the plant morphology during the rainy season showed no interaction between location (salinity)

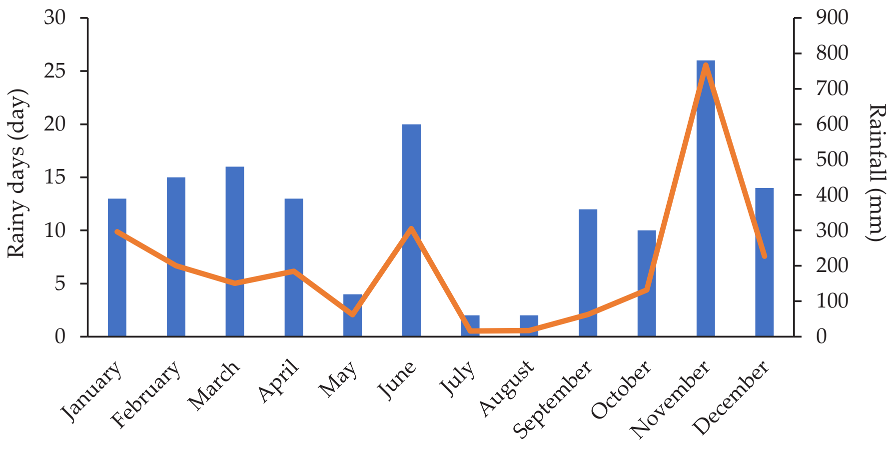

Figure 1. Rainfall (▬, mm) and rainy days (▬, day) at the research site (2021).

Table 2. Height, number of tillers, fresh weight, and dry weight of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the dry season in Lebak-Banten Province

Mutants	Salinity			
	L3	L2	L1	L4
		Tiller		
Mutant 12	40.13±7.75^{abc}	35.86±7.15^{abcd}	35.73±8.03^{abcd}	56.00±8.44^{a}
Mutant 18	43.27±9.02^{ab}	37.40±7.89^{abc}	41.60±5.75^{ab}	35.33±4.98^{abcde}
Mutant 36	43.27±9.02^{ab}	31.87±6.14^{bcdef}	42.20±9.67^{ab}	46.20±5.59^{ab}
Mutant 56	41.07±11.40^{ab}	18.20±5.41^{efd}	14.80±3.10^{ef}	41.93±7.02^{ab}
Control	15.47±7.85^{ef}	14.47±4.89^{ef}	14.07±2.53^{f}	20.00±3.09^{cdef}
		Height		
Mutant 12	114.98±25.83^{b}	149.90±30.80^{ab}	134.67±11.98^{ab}	136.80±26.64^{ab}
Mutant 18	155.33±13.77^{ab}	143.48±29.86^{ab}	159.17±16.52^{ab}	127.67±20.78^{ab}
Mutant 36	141.87±25.42^{ab}	152.65±29.29^{ab}	158.67±36.66^{ab}	126.73±25.16^{ab}
Mutant 56	155.67±29.86^{ab}	129.90±27.78^{ab}	138.80±33.01^{ab}	114.13±28.19^{b}
Control	182.27±6.63^{a}	158.00±23.59^{ab}	181.83±34.75^{a}	154.73±9.10^{ab}
		Fresh weight		
Mutant 12	519.3±51.99^{abc}	448.4±46.04^{abc}	509.40±24.98^{abc}	553.9±73.54^{abc}
Mutant 18	455.2±44.82^{abc}	426.5±53.44^{abc}	553.20±31.60^{abc}	302.8±56.25^{abc}
Mutant 36	546.5±31.26^{abc}	491.3±55.33^{abc}	701.40±24.85^{a}	436.6±54.18^{abc}
Mutant 56	624.4±33.77^{ab}	238.2±24.55^{bc}	150.71±28.24^{c}	452±64.68^{abc}
Control	283.7±29.42^{bc}	271.7±37.11^{abc}	285.13±30.03^{bc}	284.7±45.90^{abc}
		Dry weight		
Mutant 12	103.87±32.22^{bcd}	89.69±24.79^{bcd}	99.84±13.65^{bcd}	110.79±14.71^{bcd}
Mutant 18	127.26±22.18^{abc}	85.29±21.33^{bcd}	110.64±17.22^{bcd}	100.33±8.79^{bcd}
Mutant 36	109.31±32.64^{bcd}	98.26±23.62^{bcd}	140.28±23.47^{ab}	87.32±12.78^{bcd}
Mutant 56	208.13±34.87^{a}	47.63±6.95^{cd}	30.00±6.03^{d}	90.40±18.86^{bcd}
Control	56.75±37.20^{bcd}	54.35±18.61^{bcd}	57.03±10.80^{bcd}	56.93±9.18^{bcd}

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass.
Means in the same variable with different superscripts differ significantly ($p<0.05$).

Table 3. Leaf width and length of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the dry season in Lebak-Banten Province

Treatments	Variables	
	Leaf width (cm)	Leaf length (cm)
Mutant		
Mutant 12	2.93±0.18	55.14±5.59
Mutant 18	3.01±0.29	53.36±7.13
Mutant 36	2.88±0.19	51.61±7.91
Mutant 56	2.92±0.17	51.24±7.40
Control	2.88±0.26	57.85±7.69
Location/salinity		
L4	2.57±0.25^{b}	56.63±6.17
L3	2.67±0.24^{b}	52.60±6.41
L2	3.78±1.05^{a}	53.05±7.26
L1	2.67±0.21b	53.09±8.52

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass. Means in the same column with different superscripts differ significantly ($p<0.05$).

and mutant type (Table 4). Plant height was only affected ($p<0.01$) by the mutant type, with the control plants having the highest plant height (Table 4). Leaf width was not affected ($p>0.05$) by mutant type or location (salinity level). Leaf length was significantly affected by mutant type and location (salinity level) ($p<0.01$), with mutant 56 having the longest leaf length, while the shortest leaf length was observed at the L2 location (moderate salinity levels). The number of tillers was also significantly affected ($p<0.01$) by mutant type and location, with mutants 12 and 36 having the highest number of tillers, while the control plants had the lowest number of tillers. Fresh forage weight was only affected ($p<0.01$) by the mutant type (Table 4). The highest fresh weight was obtained in mutant 12, while the lowest was found in the control mutant. Dry forage weight was affected by the interaction between mutant type and location, where the highest dry weight was obtained in mutant 12 at the L3 location (low salinity conditions). In contrast, the lowest was obtained in the control plants at the L1 location (high salinity conditions) (Figure 2).

Nutrient Value of Mutant Benggala Grass

Nutrient value during the dry season was significantly affected by mutant type and location (salinity levels), and there was an interaction between

Table 4. Height, leaf length and width, tiller number and fresh of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in rainy season in Lebak-Banten Province

Treatments	Variables				
	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Tiller number (tiller)	Fresh weight (g/clump)
Mutant					
Mutant 12	131.03±19.34[b]	2.92±0.23	61.25±3.66[ab]	84.07±26.33[a]	1827.0±181.94[a]
Mutant 18	127.35±14.79[b]	3.40±0.26	63.92±5.55[ab]	56.32±17.53[b]	822.6±158.64[bc]
Mutant 36	131.42±13.38[b]	2.90±0.28	63.75±6.07[ab]	66.62±16.73[ab]	1154.6±119.70[b]
Mutant 56	124.45±14.79[b]	2.86±0.20	64.30±5.73[a]	61.64±26.24[b]	980.2±155.85[bc]
Control	169.05±16.61[a]	2.67±0.29	59.80±6.88[b]	31.32±10.78[c]	694.40±165.45[c]
Location/ Salinity					
L4	134.93±17.62	2.78±0.27	63.60±6.18[a]	70.81±26.33[a]	1058.7±281.49
L3	134.40±11.47	2.90±0.21	64.45±4.95[a]	68.63±11.88[ab]	1068.8±150.64
L2	135.52±19.16	3.19±1.21	58.75±4.85[b]	52.69±28.11[bc]	1174.8±319.70
L1	141.79±13.86	2.93±0.27	63.61±3.37[a]	47.84±20.14[c]	1080.7±26.32

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass. Means in the same column and variable with different superscripts differ significantly (p<0.05).

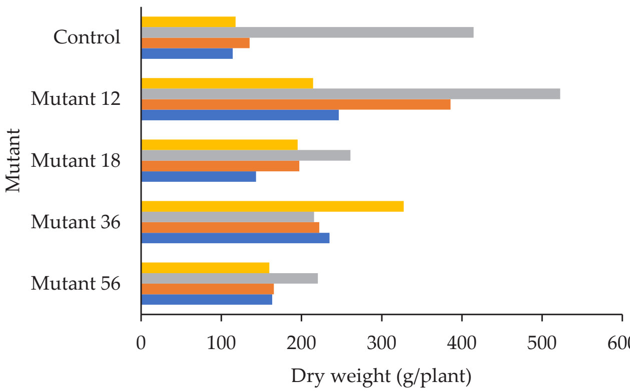

Figure 2. Dry weight (g/plant) of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the rainy season in Lebak-Banten Province. L4 (■)= location 4 (distance of the planting plots is 500 m from the coastline); L3 (■)= location 3 (distance of the planting plots is 100 m from the coastline); L2 (■)= location 2 (distance of the planting plots is 75 m from the coastline); L1 (■)= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass.

them (p<0.01) (Table 5). The highest moisture value was found in mutant 36 at the L2 location (moderate salinity), while the lowest was found in mutant 12 at the L3 location (low salinity conditions) (Table 5). The highest crude protein was obtained in mutant 12 at the L2 location (moderate salinity), while the lowest was found in mutant 18 at the L1 location (high salinity). The highest ash value was observed in mutant 56 at the L3 location (low salinity) and L4 location (no-saline), while the lowest was found in the control at the L2 location (moderate salinity) (Table 5). Control at the L1 location (high salinity) had the highest NDF value, while the lowest was obtained in mutant 36 at the L2 location (moderate salinity). Control at L2 and L1 locations (moderate and high salinity) had the lowest and highest ADF levels, respectively. The measured mineral values in the forages were Ca, Na, and Cl, which can be used as indicators for plants in saline areas. The highest Ca value was obtained in control at the L4 location (non-saline conditions), while the lowest was found in mutant 56 at the L1 (high salinity conditions) (Table 5). The highest and lowest Na values were found in mutant 56 at the L1 and L3 locations (high and low salinity conditions), respectively. The highest Cl value was obtained by mutant 56 at the L1 location (high salinity conditions). At the same time, the lowest was found in control at the L2 and L4 locations (moderate) and under non-stressed saline conditions.

The nutritive values of benggala grass mutant in the rainy season are presented in Table 6. The highest moisture value was found in mutant 12 at the L1 location (high salinity levels), while the lowest was in mutants 36 and 12 at the L2 location (moderate salinity levels). Mutants 12 and 36 at the L2 location (moderate salinity levels) had the highest crude protein values, while the lowest crude protein (CP) was found in mutants 18 and 56 at the L1 location (high salinity conditions). The highest ash value was obtained in mutants 12 and 36 at the L2 location (moderate salinity levels), while the lowest was in mutant 18 at the L1 location (high salinity conditions). NDF and ADF values are indicators in determining forage digestibility. The research results showed that the lowest NDF value was obtained in mutant 12 at the L3 location (low salinity conditions). The highest ADF value was obtained in the control at low salinity, while the lowest was obtained in mutant 18 at the L1 location (high salinity conditions). The highest Ca value was found in mutant 36 under non-stressed salinity conditions, while the lowest was obtained in mutant 36 under L1 location (high salinity conditions). The highest Na value in the forage was found in mutant 36 at the L2 location (moderate salinity), while the lowest was obtained in mutant 18 at

Table 5. Nutrient value of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the dry season in Lebak-Banten Province

Mutants	Salinity			
	L3	L2	L1	L4
		Moisture (%)		
Mutant 12	2.78±0.13^{h}	3.55±0.09^{bcd}	3.21±0.09^{defg}	3.19±0.04^{defg}
Mutant 18	3.17±0.18^{efg}	2.93±0.05^{gh}	3.51±0.32^{bcde}	3.13±0.44^{fg}
Mutant 36	3.26±0.07^{cdefg}	4.41±0.09^{a}	3.76±0.09^{b}	3.71±0.51^{b}
Mutant 56	3.29±0.19^{cdefg}	3.54±0.31^{bcde}	3.27±0.08^{cdefg}	3.62±0.33^{bc}
Control	3.59±0.09^{bc}	3.32±0.05^{cdef}	3.34±0.05^{cdef}	3.10±0.10^{gh}
		Crude protein (%)		
Mutant 12	9.58±0.60^{ab}	9.69±0.57^{a}	8.84±0.77^{cd}	9.31±0.37^{abc}
Mutant 18	7.60±0.38^{fgh}	7.90±0.45^{fgh}	5.19±0.73^{l}	7.53±0.51^{hi}
Mutant 36	8.24±0.12^{ef}	8.78±0.46^{cde}	8.07±0.55^{fgh}	7.33±0.25^{ji}
Mutant 56	8.43±0.14^{def}	7.91±0.12^{fgh}	6.67±0.11^{k}	8.19±0.24^{f}
Control	8.13±0.09^{fg}	8.25±0.13^{ef}	6.86±0.58^{jk}	9.12±0.18^{bc}
		Ash (%)		
Mutant 12	10.19±0.12^{abc}	9.60±0.15^{efg}	10.07±0.15^{abcd}	9.30±0.02^{gh}
Mutant 18	9.87±0.19^{bcde}	9.40±0.16^{fgh}	9.39±0.16^{fgh}	9.83±0.89^{cdef}
Mutant 36	10.28±0.12^{ab}	8.51±0.17^{j}	9.69±0.17^{defg}	9.39±0.43^{fgh}
Mutant 56	10.36±0.15^{a}	9.66±0.32^{defg}	9.71±0.32^{defg}	10.38±0.10^{a}
Control	9.09±0.10^{hi}	8.04±0.18^{k}	8.84±0.18^{ij}	9.60±0.35^{efg}
		NDF (%)		
Mutant 12	71.48±0.54^{defgh}	71.64±1.66^{defg}	72.86±0.89^{cd}	70.50±0.93^{ghi}
Mutant 18	72.21±0.68^{cdef}	70.11±1.13^{hi}	73.61±0.74^{bc}	70.67±1.39^{ghi}
Mutant 36	72.53±1.48^{cde}	69.93±1,71^{i}	73.37±0.81^{bc}	71.26±2.39^{efghi}
Mutant 56	73.53±1.59^{bc}	71.09±0.94^{efghi}	74.37±1.19^{b}	71.37±1.78^{efghi}
Control	73.57±1.46^{bc}	70.84±1.19^{fghi}	76.46±1.42^{a}	71.46±1.81^{defgh}
		ADF (%)		
Mutant 12	46.26±0.48^{def}	45.78±1.12^{efg}	43.73±0.74^{ijk}	45.04±1.17^{gh}
Mutant 18	46.89±0.39^{de}	45.13±1.07^{fgh}	43.83±0.67^{ijk}	45.02±1.15^{gh}
Mutant 36	47.30±0.52^{cd}	43.36±1.17^{jk}	44.26±0.84^{hij}	45.47±0.49^{fg}
Mutant 56	48.08±0.94^{bc}	44.82±0.24^{ghi}	48.27±0.74^{bc}	45.65±1.68^{fg}
Control	48.93±0.44^{b}	42.73±0.29^{k}	52.70±0.73^{a}	48.34±1.45^{bc}
		Ca (%)		
Mutant 12	0.23±0.03^{hi}	0.33±0.04^{def}	0.37±0.05^{de}	0.49±0.03^{ab}
Mutant 18	0.31±0.02^{efg}	0.29±0.02^{fgh}	0.33±0.01^{def}	0.45±0.03^{bc}
Mutant 36	0.26±0.02^{ghi}	0.28±0.05^{fghi}	0.28±0.05^{fghi}	0.48±0.07^{ab}
Mutant 56	0.39±0.07^{cd}	0.33±0.01^{def}	0.15±0.02^{j}	0.51±0.08^{ab}
Control	0.34±0.03^{def}	0.38±0.03^{d}	0.22±0.03^{i}	0.54±0.05^{a}
		Na (%)		
Mutant 12	0.60±0.02^{gh}	0.80±0.10^{cd}	0.55±0.06^{hi}	0.65±0.08^{fg}
Mutant 18	0.50±0.04^{i}	0.70±0.10^{ef}	0.55±0.07^{hi}	0.70±0.03^{ef}
Mutant 36	0.65±0.04^{fg}	0.80±0.02^{cd}	0.85±0.06^{bc}	0.75±0.06^{de}
Mutant 56	0.40±0.01^{j}	0.55±0.09^{hi}	0.95±0.06^{a}	0.70±0.07^{ef}
Control	0.80±0.01^{cd}	0.70±0.12^{ef}	0.90±0.03^{ab}	0.65±0.11^{fg}
		Cl (%)		
Mutant 12	1.97±0.08^{b}	1.97±0.08^{b}	2.11±0.05^{b}	1.35±0.15^{fg}
Mutant 18	2.01±0.29^{b}	1.90±0.12^{bc}	2.08±0.02^{b}	1.52±0.04^{ef}
Mutant 36	2.11±0.10^{b}	1.94±0.16^{b}	2.08±0.11^{b}	1.56±0.07^{de}
Mutant 56	1.97±0.08^{b}	2.09±0.03^{b}	2.39±0.05^{a}	1.59±0.12^{de}
Control	1.35±0.03^{fg}	1.21±0.08^{g}	1.73±0.14^{cd}	1.21±0.16^{g}

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass. Means in the same variable with different superscripts differ significantly ($p<0.05$).

Table 6. Nutrient value of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the rainy season in Lebak-Banten Province

Mutants	Salinity level			
	L3	L2	L1	L4
		Moisture (%)		
Mutant 12	6.60±0.64[fg]	3.62±0.15[k]	15.19±0.21[a]	5.73±0.28[hi]
Mutant 18	6.95±0.83[f]	4.49±0.20[j]	11.62±0.65[c]	4.97±0.90[j]
Mutant 36	6.62±0.42[fg]	3.97±0.68[k]	10.99±0.64[d]	4.90±0.03[j]
Mutant 56	6.74±0.44[f]	6.54±0.19[fg]	12.34±0.32[b]	5.44±0.21[i]
Control	7.60±0.31[e]	6.13±0.15[gh]	11.26±0.48[cd]	4.48±0.10[j]
		Crude protein (%)		
Mutant 12	8.89±0.70[b]	7.48±0.17[d]	7.32±0.11[de]	8.42±0.18[c]
Mutant 18	6.78±0.27[i]	9.41±0.12[a]	4.68±0.12[k]	5.90±0.30[hi]
Mutant 36	7.08±0.10[e]	5.37±0.17[j]	6.72±0.40[f]	6.18±0.17[gh]
Mutant 56	6.20±0.50[gh]	7.49±0.28[d]	4.45±0.10[k]	6.44±0.21f[g]
Control	5.86±0.10[hi]	8.60±0.28[bc]	6.21±0.18[gh]	6.72±0.27[f]
		Ash (%)		
Mutant 12	9.72±0.27[cdef]	11.16±0.18[a]	9.7±0.56[cdef]	10.11±0.15[bc]
Mutant 18	9.60±0.12[ef]	10.40±0.12[b]	8.02±0.15[h]	10.09±0.10[bc]
Mutant 36	10.03±0.10[bcd]	11.43±0.39[a]	8.99±0.32[g]	9.57±0.25[f]
Mutant 56	9.63±0.42[def]	10.20±0.18[b]	8.69±0.26[g]	10.01±0.10[bcde]
Control	8.70±0.44[g]	8.88±0.12[g]	8.89±0.32[g]	8.80±0.21[g]
		NDF (%)		
Mutant 12	69.11±0.62[f]	71.09±0.59[c]	70.87±0.22[cd]	74.42±0.79[a]
Mutant 18	69.88±0.17[ef]	71.50±0.60[c]	70.89±0.61[cd]	74.13±0.80[a]
Mutant 36	70.14±0.15[de]	69.83±0.21[ef]	69.55±1.01[ef]	74.62±0.59[a]
Mutant 56	69.99±0.16[def]	69.73±0.48[ef]	70.89±1.13[cd]	74.76±0.44[a]
Control	71.16±0.51[c]	72.89±0.40[b]	71.72±0.88[c]	74.41±0.39[a]
		ADF (%)		
Mutant 12	50.38±0.62[cde]	50.62±0.46[bcde]	48.71±0.39[e]	49.75±0.82[de]
Mutant 18	50.77±0.79[bcde]	50.17±0.28[cde]	46.78±1.90[f]	50.16±1.10[cde]
Mutant 36	52.18±0.31[abc]	49.75±0.78[de]	49.65±0.62[de]	50.45±0.89[cde]
Mutant 56	52.53±0.64[ab]	49.48±0.75[de]	50.28±0.46[cde]	50.70±0.60[bcde]
Control	54.06±0.80[a]	52.55±0.47[ab]	52.55±0.63[ab]	51.44±0.46[bcd]
		Ca		
Mutant 12	0.23±0.02[de]	0.26±0.02[cd]	0.15±0.02[gh]	0.31±0.02[b]
Mutant 18	0.23±0.02[de]	0.20±0.04[ef]	0.11±0.02[hi]	0.32±0.03[b]
Mutant 36	0.23±0.06[de]	0.20±0.02[ef]	0.10±0.01[i]	0.38±0.04[a]
Mutant 56	0.18±0.02[fg]	0.24±0.01[de]	0.18±0.02[fg]	0.31±0.02[b]
Control	0.13±0.02[hi]	0.29±0.01[bc]	0.12±0.01[hi]	0.23±0.02[de]
		Na		
Mutant 12	0.40±0.05[cd]	0.70±0.10[a]	0.50±0.10[bc]	0.60±0.20[ab]
Mutant 18	0.35±0.10[cde]	0.35±0.05[cde]	0.15±0.05[f]	0.45±0.05[bcd]
Mutant 36	0.45±0.05[bcd]	0.75±0.05[a]	0.40±0.10[cd]	0.50±0.10[bc]
Mutant 56	0.40±0.02[cd]	0.50±0.10[bc]	0.30±0.05[def]	0.50±0.10[bc]
Control	0.50±0.10[bc]	0.16±0.08[f]	0.20±0.05[ef]	0.60±0.10[ab]

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass. Means in the same variable with different superscripts differ significantly ($p<0.05$).

the L1 location (high salinity and in the control at the L2 location (moderate salinity). The highest Cl in the forage was found in mutant 36 at the L2 location (moderate salinity), and the lowest was obtained in control under non-stressed saline conditions (L4 location) (Figure 3).

The Value of Proline, Chlorophyll, Anthocyanin, and Carotenoid

The concentrations of proline, chlorophyll, anthocyanin, and carotenoid were observed in forages during the dry season. Observations were made during this season due to the increase in salinity values in the

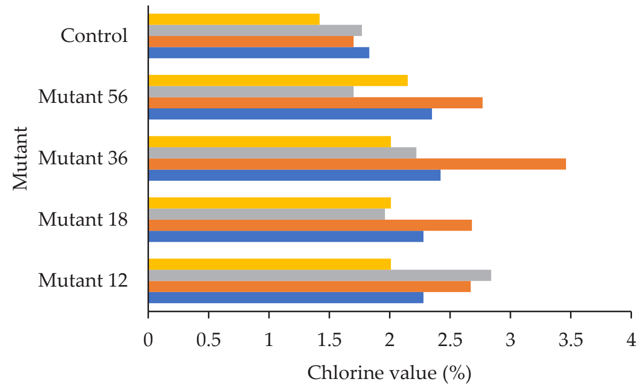

Figure 3. Chlorine (%) value of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the rainy season in Lebak-Banten Province. L4 ( )= location 4 (distance of the planting plots is 500 m from the coastline); L3 ( )= location 3 (distance of the planting plots is 100 m from the coastline); L2 ( )= location 2 (distance of the planting plots is 75 m from the coastline); L1 ( )= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass.

experimental plots (Table 1), which allowed the plant's ability to adapt to salinity with an increase in proline or chlorophyll to be visible. The study results show that there was an interaction between the type of mutant and location (salinity level) ($p<0.01$). The highest proline was obtained from mutant 12 at the L2 location (moderate salinity), while the lowest was found in mutant 56 at the L4 location (non-saline conditions) (Table 7). Mutant 12 had the highest chlorophyll a and b at the L3 location (low salinity), while the control had the highest value at the L2 location (moderate salinity). Mutant 18 under non-saline conditions and mutant 56 under the L1 location (high salinity) had the lowest chlorophyll a, while mutant 18 at the L3 location (low salinity) had the lowest chlorophyll b. The highest anthocyanin was obtained from mutant 12 at the L3 location (low salinity), while the lowest was found in mutant 36 at the L1 location (high salinity). The highest carotene was obtained from mutant 12 at the L3 location (low salinity), while the lowest was found in mutant 36 at the L2 location (moderate salinity).

Table 7. The value of proline, chlorophyll, and anthocyanin of mutant benggala grass (*Panicum maximum* cv Purple Guinea) at different salinity levels in the dry season in Lebak-Banten Province

Mutants	Salinity Level			
	L3	L2	L1	L4
		Proline (%)		
Mutant 12	1.35±0.01^{h}	3.03±0.01^{a}	1.66±0.02^{f}	0.92±0.01^{l}
Mutant 18	0.82±0.03^{m}	1.59±0.01^{g}	1.31±0.02^{i}	0.47±0.01^{o}
Mutant 36	1.73±0.02^{e}	1.13±0.01^{j}	1.93±0.04^{d}	1.12±0.02^{jk}
Mutant 56	1.34±0.03^{h}	1.96±0.01^{d}	1.09±0.01^{k}	0.11±0.02^{p}
Control	2.70±0.01^{b}	1.66±0.02^{f}	2.31±0.02^{c}	0.73±0.01^{n}
		Chlorophyll, a (%)		
Mutant 12	3.71±0.35^{a}	2.60±0.18^{bcd}	2.38±0.20^{cde}	3.03±0.84^{b}
Mutant 18	1.47±0.19^{g}	2.13±0.14^{def}	2.40±0.15^{cde}	1.71±0.24^{fg}
Mutant 36	2.08±0.27^{ef}	1.78±0.13^{fg}	2.67±0.11^{bc}	2.16±0.10^{def}
Mutant 56	2.29±0.28^{cde}	1.97±0.21^{ef}	1.76±0.22^{fg}	2.97±0.11^{b}
Control	3.03±0.15^{b}	3.55±0.12^{a}	2.73±0.16^{cb}	1.94±0.19^{efg}
		Chlorophyll, b (%)		
Mutant 12	1.99±0.10^{a}	1.33±0.14^{cd}	1.27±0.12^{cde}	1.55±0.10^{b}
Mutant 18	0.76±0.20^{j}	1.11±0.07^{efgh}	1.23±0.14^{def}	0.88±0.01^{ij}
Mutant 36	1.08±0.10^{efghi}	0.90±0.14^{hij}	1.43±0.09^{bc}	1.12±0.06^{efg}
Mutant 56	1.23±0.16^{def}	1.01±0.12^{ghi}	0.90±0.18^{ghi}	1.58±0.15^{b}
Control	1.63±0.14^{b}	1.97±0.14^{a}	1.45±0.14^{bc}	1.04±0.08^{fghi}
		Anthocyanin (%)		
Mutant 12	0.19±0.01^{a}	0.08±0.01^{def}	0.07±0.01^{ef}	0.11±0.03^{cd}
Mutant 18	0.06±0.02^{f}	0.07±0.02^{ef}	0.10±0.02^{cde}	0.08±0.02^{def}
Mutant 36	0.08±0.01^{def}	0.07±0.01^{ef}	0.01±0.01^{g}	0.08±0.01^{def}
Mutant 56	0.09±0.02^{def}	0.08±0.02^{def}	0.10±0.02^{cde}	0.10±0.02^{cde}
Control	0.12±0.03^{bc}	0.14±0.02^{b}	0.10±0.03^{cde}	0.10±0.01^{cde}
		Carotene		
Mutant 12	1.15±0.11^{a}	0.76±0.14^{cdef}	0.74±0.05^{cdefg}	0.84±0.11^{bcd}
Mutant 18	0.52±0.09^{ij}	0.65±0.15^{defghi}	0.71±0.07^{defghi}	0.52±0.10^{ij}
Mutant 36	0.61±0.12^{efghij}	0.44±0.12^{j}	0.73±0.04^{cdefgh}	0.61±0.12^{efghi}
Mutant 56	0.66±0.14^{defghi}	0.61±0.14^{efghij}	0.53±0.08^{hij}	0.80±0.12^{cde}
Control	0.92±0.20^{bc}	1.02±0.13^{ab}	0.82±0.03^{cd}	0.57±0.09^{fghij}

Note: L4= location 4 (distance of the planting plots is 500 m from the coastline); L3= location 3 (distance of the planting plots is 100 m from the coastline); L2= location 2 (distance of the planting plots is 75 m from the coastline); L1= location 1 (distance of the planting plots is 50 m from the coastline). Control= benggala grass that was not irradiated; Mutant 12, 18, 36, 56= four mutants of benggala grass. Means in the same column and variable with different superscripts differ significantly ($p<0.05$).

DISCUSSION

The dominant soil texture in the study area is sandy. Soil texture is a physical property of soil that is difficult to change, except by adding organic or inorganic materials (Tahir & Marschner, 2017). The weakness of sandy soil texture is its instability, low water holding capacity, and low nutrient retention, making it vulnerable to nutrient leaching (Shepherd & Bennett, 1998). Soil structure stability is crucial to soil fertility since it significantly affects soil's physical, chemical, and biological properties (Kholaiq *et al.,* 2022). The soil pH values range from 7.9 to 8.1, categorized as slightly alkaline, similar to the pH values in most coastal regions (Kutbay & Surmen, 2022; Kholaiq *et al.,* 2022). Alkaline soil pH in coastal areas is caused by sodium bicarbonate and increased salinity, soil pH plays an important role in the growth and composition of plants in coastal areas (Angiolini *et al.,* 2018). Alkaline soil pH and salinity in coastal areas inhibit plant growth due to osmotic stress, ion toxicity, and nutrient imbalances (Huang *et al.,* 2017). The organic carbon concentration is relatively high, and there is a negative correlation between organic carbon, nitrogen, and carbon/nitrogen ratio with soil pH values (Zhou *et al.,* 2019), as seen from the decreasing trend of organic carbon with increasing soil pH values (Table 1). Alkaline coastal soils typically limit organic carbon accumulation in soil because microbial and soil biological activities become less active with increasing soil pH values (Tripathi *et al.,* 2018). However, the organic carbon in coastal regions varies depending on soil type, soil depth, and land use type (Tesfaye *et al.,* 2016).

The phosphorus (p) value decreases with increasing salinity and soil pH (Table 1). The available p-value in coastal land with alkaline pH is usually very low due to insoluble calcium phosphate minerals forming that inhibit p uptake and plant growth (Elbasiouny *et al.,* 2020). Although p in the soil is influenced by parent material, topography, climate, and soil organisms (Chang *et al.,* 2016), the high cation exchange capacity (CEC) is affected by the alkaline pH and sandy soil texture, leading to high cation value with good exchange capacity. There is a correlation between soil texture and pH concerning the CEC value (Razzaghi *et al.,* 2021). The salinity levels of the experimental land were categorized as low to moderate and exhibited varying levels of electrical conductivity (EC) and salinity concentration (Table 1). Salinity levels were generally influenced by weather conditions, with higher levels recorded during the dry season than the rainy season. This increase in salinity during the dry season was primarily due to evaporation, leading to a higher salt concentration in the soil and seawater. Furthermore, reduced freshwater flow to coastal areas during the dry season contributed to the heightened salt concentration (Medina-Gomez *et al.,* 2014; Akhter *et al.,* 2021).

The number of tillers during the dry season is lower than during the rainy season (Table 2 & Table 4) due to higher salinity levels (Table 1), which cause osmotic stress, inhibit water uptake and transpiration rate, and hinder cell division and expansion, including the number of tillers (Gorham *et al.,* 2010). In addition, salinity reduces tillers in other crops, such as rice (Krishnamurthy *et al.,* 2016). Tiller's number is affected ($p<0.05$) by the interaction between mutant and location (salinity) during the dry season, with the number of tillers in benggala grass correlating with the production of its forage (Fanindi *et al.,* 2019). During the dry season, the highest tillers were found in mutant 12 under non-saline conditions and did not differ from mutants 18 and 36 at the L1 location (high salinity conditions). High tillers number in the L1 location (high salinity conditions) in mutants 36, 12, and 18 were also directly proportional to fresh forage production (Table 2), with mutant 36 having a higher fresh weight than the others, even at high salinity levels. The highest dry weight productivity was found in mutant 56 at the L2 location (moderate salinity) and did not differ from mutant 36 fresh forage dry weight under high salinity conditions (Table 2). Higher productivity in benggala grass mutants compared to the control suggests that there were candidate mutants that were tolerant to salinity. Salt-tolerant forage crops are characterized by their productivity under saline conditions. Masters *et al*. (2007) reported that halophyte plants tolerant to salt experience increased growth at salinity levels of 4-5 ds/m and halve their growth at 40 ds/m. Non-halophyte forage crops that are tolerant to salt, maintain their productivity at salinity levels of 5-10 ds/m and decrease productivity as salinity levels increase.

The number of tillers and fresh weight of forage during the rainy season are affected by mutant type and location (salinity) but not by their interaction (Table 4). Mutant productivity during the rainy season was higher than in the dry season due to the plants' low salinity and sufficient water supply. The highest number of tillers and fresh weight of forage during the rainy season were obtained from mutant 12, followed by mutant 36 (Table 4). The highest dry weights were also obtained from mutant 12 at L3 and L1 locations (low and high salinity); mutants 12 and 36 still had higher dry weights than the control. The high productivity of these two mutants during the rainy season was also shown during the dry season, indicating that mutants were stable at the L1 location (high salinity) and drought stress conditions.

The nutrient value of forage is influenced by salinity and mutant types. Salinity decreased the protein value of benggala grass in both rainy and dry seasons (Table 5 and Table 6). The protein values of mutant benggala grass and control plants also decreased with increasing salinity levels. A decrease in crude protein due to salinity stress has also been reported by Katuwal *et al*. (2020) in *Paspalum* cv Seastar grass. The decrease in protein is caused by many factors, including the accumulation of excessive Na^+ and Cl^-, which causes physiological drought and disrupts photosynthesis, leading to nutrient imbalance (Gupta & Huang, 2014). Although it is difficult to determine concretely how salinity affects a crude protein in grazing plants (Waldron *et al.,* 2020), further testing of crude protein in salt-tolerant plants is necessary because non-protein N is abundant in salt-tolerant plants (Masters *et al.,* 2007). The study results show mutant benggala grass number 12 in the dry season can maintain its protein value at the L1 location (higher salinity levels) (Table 5). The crude protein value of mutant 12 under moderate salinity conditions had the highest crude protein value compared to the other mutants, including control at various locations (salinity levels). The ash value was influenced by salinity and mutant types and their interactions ($p<0.01$). The study shows that the ash value decreased in control with increasing salinity levels. While in mutant benggala grass numbers 12 and 36, the ash increased with the increasing salinity levels. The increase in ash value was the plant's response to salinity, which has a high mineral value in the soil. An increase in ash with increasing salinity in plants has also been reported by Nabati *et al*. (2014) in *Bassia scoparia* and Hedayati *et al*. (2020) in salt-tolerant plants such as *Sorhgum bicolor* and *Bassia indica*.

NDF levels were the highest in control at the L1 location (high salinity), while the lowest was observed in mutant 36 at the L2 location (moderate salinity). Lower NDF values at the L1 location (high salinity levels) were obtained in mutant 12. NDF values are generally inversely related to feed intake and forage energy intake (Waldron *et al.*, 2020), making mutants with non-increasing NDF values at high salinity levels, such as mutants 36 and 12, potentially high-quality forage. In contrast, NDF values decreased with the increasing salinity levels during the rainy season. However, they were categorized as low to moderate. ADF values also decreased with increasing salinity levels during both the dry and rainy seasons. The decrease in NDF and ADF values due to saline stress was also reported by Kumar *et al*. (2018) in the halophytic grass *Dichanthium annualtum* and the halophytic plant *Atriplex gardneri* but did not affect kochia plants (Waldron *et al.*, 2020). The effect of salinity on NDF levels depends largely on the plant species and salinity concentration, as some plant species show decreased or increased NDF levels with increasing salinity levels, while others are not affected.

The Na value in mutant benggala grass in response to salt stress varied among mutants (Table 5). Mutants 36, 56, and the control showed an increased Na value with the increasing salinity level. Meanwhile, mutants 12 and 18 had lower Na at the L1 location (high salinity) than under non-saline conditions. Na value in forage increases with the increasing salinity level, such as in summer savory (*Satureja hortensis*), *Dichanthium* (Kumar *et al.*, 2018), and wheat (Javaid *et al.*, 2019). The positive correlation between Na in forages and salinity was due to the high NaCl in saline soil. Cl value in mutants and the control increased with the increasing soil salinity level, similar to Na value, which increased due to the high NaCl in the soil. Plant salinity leads to excessive accumulation of Na^+ and Cl^+ and usually disturbs ionic homeostasis, poisoning, and photosynthesis. Salt-tolerant plants, such as forage or other crops, will develop efficient mechanisms for antioxidant enzymes, ionic homeostasis, photosynthesis regulation, and hormonal regulation (Amombo *et al.*, 2022).

Forage crops have developed complex mechanisms to cope with salt stress. These mechanisms include genetic and physiological antioxidant systems that remove excess ROS (Amombo *et al.*, 2022), regulate the photosynthesis rate to maintain productivity (Ibrahim *et al.*, 2020; Baiseitova *et al.*, 2018), and osmotic adjustment (Turner, 2018). Proline, an active osmolyte, plays a crucial role in plant mechanisms for salt tolerance (Amombo *et al.*, 2022). Surender *et al*. (2015) found that transgenic sorghum lines with increased pyrroline-5-carboxylate synthetase (P5CSF129A) showed improved photosynthesis rate, chlorophyll, stomatal conductance, and carbon dioxide concentration under salt stress conditions. Mutant 12 had a higher proline concentration at the L2 location (moderate salt conditions) (Table 7), resulting in greater fresh weight production (Table 2). These findings suggest that proline is a crucial organic solute in plant mechanisms for maintaining growth under salt-stress conditions. Mutant 12 also exhibited the highest carotenoid and anthocyanin concentration under low salt levels compared to the other mutants and controls at all salt levels. Studies have shown a positive correlation between antioxidant enzyme activity and relative growth rate, plant height, fresh weight, biomass, and photosynthesis under salt stress conditions (Ibrahim *et al.*, 2020; Yilmaz *et al.*, 2020).

The relationship between salinity tolerance and photosynthesis was observed in the research results, where mutant 12 had higher chlorophyll a and b concentrations than all mutants and all salinity levels. The high chlorophyll in mutant 12 indicates its tolerance to salinity. Baiseitova *et al*. (2018) reported that salt-tolerant plants exhibit higher levels of photosynthetic pigments than sensitive varieties. However, the chlorophyll value of the research plants decreased with increasing salinity levels, especially for chlorophyll b. This decrease may be due to the loss of photosynthetic capacity and the inhibition of ion accumulation towards chlorophyll fraction biosynthesis (Hakim *et al.*, 2014).

The research results on mutant benggala grass under saline conditions in the coastal area of Lebak-Banten Regency show the potential of these mutants to be developed in the region. This potential is evident from these mutants' morphological, physiological, and nutritional responses, which can adapt to saline conditions with high productivity. These mutants are expected to be developed into superior forage crop varieties that are tolerant to coastal areas such as in Lebak-Banten Regency, thus meeting the forage needs of livestock in the region, especially buffaloes. The fulfillment of forage needs is expected to increase the buffalo population and improve the welfare of farmers.

CONCLUSION

Mutants 12 and 36 are potential mutants to be developed in the coastal area of Lebak-Banten and other regions with similar characteristics. The potential of these mutants is supported by research results showing that both mutants have relatively high productivity under saline stress in the rainy and dry seasons. Further research is needed to develop these mutants into superior varieties of salt-tolerant forage crops.

CONFLICT OF INTEREST

There is no conflict of interest in any financial, personal, or other relationship with other people or organizations related to the material discussed in the manuscript.

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