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Effects of cutting growth stages and stay heights on the silage quality of *Pennisetum purpureum* NP cv. TS3 (1)

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Abstract

Napier grass (*Pennisetum purpureum*) cultivated in the tropical and subtropical regions are renowned for its vigorous growth, high nutritive contents and palatability. The aim of the study was to determine the effects of cutting growth stages and stay heights on silage quality of Napier grass cv. TS3 (NP cv.TS3), that was a dwarf plant type of Napier grass and named in 2009. The 3 × 2 factorial design by completely randomized design (CRD) with 3 replications of each treatment was conducted at the Livestock Research Institute, Council of Agriculture, Executive Yuan, Taiwan, R.O.C. Treatments applied were cutting growth stages at the 30, 60 or 90 days and stay heights with 10 and 20 cm. The results showed that crude protein (CP) contents of silage decreased as the cutting growth stages were extended from 30 to 90 days. The contents of neutral detergent fiber (NDF), hemicellulose (HC) and water soluble carbohydrate (WSC) decreased, too. However, the contents of minerals and acid detergent fiber (ADF) increased during ensiling. No significant difference ($P > 0.05$) was found on the pH values of silages among cutting growth stages. The lactic acid content of silage cut at 60 days interval was higher than that of cut at 30 days ($P < 0.05$). There was no significant difference among cutting growth days on the Flieg's scores. The cutting at 60 days and the stay height with 10 cm might be the most optimum for producing high forage yield with high quality for NP cv. TS3.

Key words: Cutting stage, *Pennisetum purpureum*, Silage quality, Stay height.

Introduction

Elephant grass bears the name Napier grass (*Pennisetum purpureum*) to pay tribute to Colonel Napier of Rhodesia currently known in Zimbabwe who carried out remarkable work to notify the Rhodesian agricultural department on the nutritive value of the grass (Singh *et al.*, 2013).

Napier grass grows around the tropical and subtropical regions in the world. It is often used as forage by cut and carry system and grazing (Wijitphan *et al.*, 2009). The plant species and the harvested growth stage were two principal management factors that could have significant impact on the herbage chemical contents, which could affect the silage fermentation characteristics, dry matter recovery and aerobic stability (McEniry *et al.*, 2013). High quality silage was dependent on the quality of the source material used for ensiling which guarantee optimal nutrient concentration (Khalili *et al.*, 2005; Fan *et al.*, 2018; Fan *et al.*, 2019). Silage quality would be affected by harvest stage, while prolonging the primary growth harvest would cause negative consequences on dry matter intake (Kuoppala *et al.*, 2008). Herbage harvested at an early stage tended to be more difficult to ensile for the greater demand of lower pH values by fermentation acids. Extended harvest date inevitably causes a marked increase on dry matter content of the silage. However, it could cause a decrease in the crude protein and NH_3-N contents (Woodard *et al.*, 1991; Perculija *et al.*, 2011; Bijeliæ *et al.*, 2015). Cheng and Chen (1997)

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stated that harvest dates of 60 to 70 days produced adequate dry matter to make better quality silage without any additives. Santos *et al.* (2013) also recommended harvesting the elephant grass at a cutting interval of 50 to 60 days to guarantee adequate moisture content.

Grass with inadequate content of water soluble carbohydrate (WSC) required for fermentation would affect the contents of acetate and butyrate production when on ensiling (Yokota *et al.*, 1992). It was required that WSC content of the source material before ensiling should be at least 30 to 50 g/kg DM for successful ensiling (Weinberg, 2008). High WSC content helped enhance ensiling characteristics (Amer *et al.*, 2012). The optimal harvest period for *Pennisetum* spp. as recommended by several authors might be 6 to 7 weeks for more higher DM and WSC contents (Manyawu *et al.*, 2003). WSC was noted to be higher when the grass was harvested at 6 weeks growth stage (Hoglind *et al.*, 2005). Another principal determinant factor for ensiling quality was low pH value in silage (Yang *et al.*, 2004; Shen *et al.*, 2012; Xie *et al.*, 2012). The level of pH value in silage below 4.2 was considered to be ideal for effective silage preservation (Sebolai *et al.*, 2012; Santos *et al.*, 2013).

The objective of the trial was to determine the effects of cutting growth stages and stay heights left after cutting on silage quality of new Napier grass cultivar cv. TS3, which was selected for high ratio of leaf and stem (Fig. 1). The pH value and Flieg's score (Sebolai *et al.*, 2012) were used to evaluate silage quality.

Fig. 1. The *Pennisetum purpureum* NP cv. TS3 grown at Livestock Research Institute in Tainan city, Taiwan.

Materials and Methods

Field experiment was carried out at the forage crop experimental farm of Livestock Research Institute, Council of Agriculture, Executive Yuan, Tainan, Taiwan, R.O.C. from 2016 to 2018. The experimental field was carried out weed control at first, followed by adding a layer of fresh loamy soil along with organic fertilizer which was uniformly spread over the surface of the soil.

I. Experimental design

The experiment was a 3 × 2 factorial design arranged by complete randomized design (CRD) with 3 replications, given a total of 18 plots. Each plot was an area of 100 × 120 cm^2. The NP cv. TS3, characterized for having prolific tillering capability and quick regrowth, with a potential height reaching to 100 cm, was used for the experiment. The treatments were cutting growth stages at 30, 60 and 90 days and staying at heights with 10 and 20 cm for four cuts in one year (Fig. 2).

II. Preparation of ensiling material

The grass harvested were chopped to a length of approximately 2 cm, 2 kg chopped materials were loaded into polyethylene bags for vacuum sealing, subsequently. The vacuum sealed bags were then laid upright at room temperature for fermentation for 60 days.

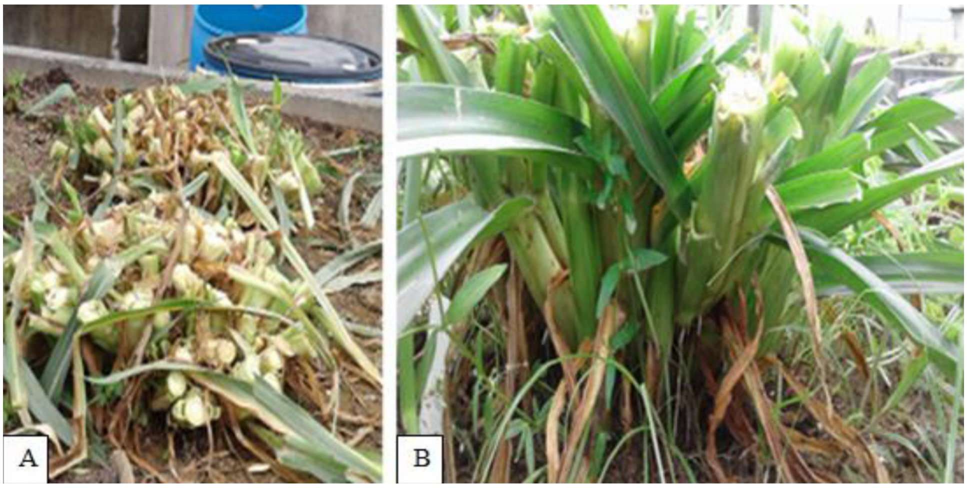

Fig. 2. The NP cv. TS3 harvested stay heights with (A) 10 cm and (B) 20 cm.

III. Silage chemical analysis

After ensiling for 60 days, the bags were opened and weighed. The nutritive compositions of the dry matter of the silage were analyzed, such as crude protein (CP) analytic method by AOAC (1984) and neutral detergent fiber (NDF), acid detergent fiber (ADF), WSC and ash contents by the analytic methods developed by Goering and Van Soest (1970).

IV. pH, lactic acid and Flieg's score

The pH of silage-water was measured by pH meter. The Flieg's scores were evaluated by the contents of volatile fatty acids, including lactic acid, acetic acid, propionic acid and butyric acids, and were determined by the high performance liquid chromatography (HPLC) method by Jones and Kay (1976). Flieg's scores were calculated according to the method designed by McCullough (1979).

V. Statistical analysis

Statistical analysis was conducted using the statistical product and service solution (SPSS 23). The results were expressed as mean ± SE. The data were tested by t-test. The analysis of variance (ANOVA) was through the medium of the Duncan Multiple Comparison Test. Results with $P < 0.05$ were considered statistically significant. All tests were carried out for the most part at least in triplicate.

Results and Discussion

I. Evaluation of crude protein contents after ensiled 60 days

Borreani *et al.* (2008) indicated that the microbiological and nutritional quality in silage were due to factors relating to harvest stage, ensiling technology and the management practices. Results from a comprehensive evaluation of the effect of the cutting growth stages at 30, 60 and 90 days on the CP contents of the silage quality of the NP cv. TS3, it showed a decreasing trend as the harvest dates increased (Table 1). The change in the CP content during ensiling was more pronounced at the cutting interval of 90 days. The CP content of the after ensiling material at cutting intervals of 90 days was near the content stated by Maria *et al.* (2010) for the proper functioning of the rumen, where the minimal content of crude protein required for the good operation of the rumen was 7%. The negative effects of having less than the required amount could affect the ruminal fermentation and consequently the nutrient intake and digestibility. The contents of CP were less changed after ensiling when cut at the 60 days cutting interval growth stage in comparison to those of the 30 and 90 days. The loss was less when cut at stay height 20 cm for the 60 and 90 days cutting growth stages, while that for the 30 days was greater. Fijałkowska *et al.* (2015) explained that the content of crude protein was not so much affected during ensiling in contrast to carbohydrate; in which it was transformed into more highly degradable soluble non-protein compounds. Thus, it could result in lowering the efficiency of the microbial protein synthesis at the level of the rumen. The dry matter content and the pH value of the ensiled materials were noted to be the most important factors to affect proteolysis. Spitaleri *et al.* (1995) observed that the content of crude protein and neutral detergent fiber

Table 1. Chemical contents of grass and silage of NP cv. TS3 harvested at growth stages 30, 60 and 90 days and stay heights with 10 and 20 cm

Material	GS#	SH	CP	NDF	ADF	WSC	HC	P	K	Ca	Mg
	day	cm	%								
Grass	30	10	$16.08^{a*} \pm 0.94$	$51.11^{f} \pm 0.74$	$28.76^{e} \pm 0.51$	$2.40^{c} \pm 0.46$	$22.35^{cd} \pm 0.82$	$1.23^{cd} \pm 0.05$	$5.80^{cd} \pm 0.45$	$0.13^{ef} \pm 0.00$	$0.28^{cd} \pm 0.03$
		20	$14.09^{b} \pm 0.87$	$50.86^{f} \pm 0.58$	$28.68^{e} \pm 0.37$	$4.14^{b} \pm 0.56$	$22.18^{cd} \pm 0.82$	$1.18^{d} \pm 0.03$	$5.28^{d} \pm 0.26$	$0.13^{ef} \pm 0.01$	$0.28^{cde} \pm 0.02$
Silage	30	10	$12.98^{b} \pm 0.63$	47.57g ± 0.77	$33.07^{bcd} \pm 1.54$	$0.74^{c} \pm 0.06$	$14.51^{f} \pm 1.80$	$1.34^{abc} \pm 0.04$	$10.88^{a} \pm 0.09$	$0.26^{a} \pm 0.01$	$0.35^{ab} \pm 0.02$
		20	$12.91^{b} \pm 0.43$	48.01g ± 0.16	$33.40^{bcd} \pm 0.32$	$0.71^{c} \pm 0.07$	$14.61^{f} \pm 0.31$	$1.31^{abc} \pm 0.02$	$10.55^{a} \pm 0.59$	$0.23^{ab} \pm 0.02$	$0.37^{a} \pm 0.00$
Grass	60	10	$10.35^{cd} \pm 0.38$	$55.03^{de} \pm 0.23$	$31.25^{de} \pm 0.34$	$5.86^{a} \pm 0.75$	$23.78^{bc} \pm 0.19$	$1.19^{d} \pm 0.02$	$4.13^{de} \pm 0.29$	$0.11^{ef} \pm 0.01$	$0.23^{e} \pm 0.01$
		20	$10.10^{cd} \pm 0.16$	$57.35^{cd} \pm 0.38$	$31.07^{de} \pm 0.91$	$5.26^{ab} \pm 1.20$	$26.28^{ab} \pm 0.62$	$1.28^{abcd} \pm 0.01$	$3.95^{de} \pm 0.45$	$0.15^{de} \pm 0.03$	$0.28^{cde} \pm 0.01$
Silage	60	10	$10.56^{c} \pm 0.52$	$52.44^{f} \pm 0.56$	$34.89^{bc} \pm 0.88$	$0.78^{c} \pm 0.08$	$17.56^{e} \pm 0.82$	$1.35^{ab} \pm 0.01$	$8.44^{b} \pm 0.32$	$0.20^{bc} \pm 0.02$	$0.33^{abcd} \pm 0.02$
		20	$10.44^{cd} \pm 0.60$	$53.20^{ef} \pm 0.53$	$35.82^{ab} \pm 0.22$	$0.72^{c} \pm 0.06$	$17.39^{e} \pm 0.67$	$1.37^{a} \pm 0.04$	$7.48^{bc} \pm 1.33$	$0.20^{bc} \pm 0.02$	$0.34^{abc} \pm 0.03$
Grass	90	10	$8.03^{e} \pm 0.57$	$58.48^{bc} \pm 0.71$	$31.60^{d} \pm 1.24$	$5.58^{ab} \pm 0.57$	$26.88^{a} \pm 0.56$	$1.20^{d} \pm 0.05$	$3.86^{de} \pm 0.07$	$0.10^{f} \pm 0.00$	$0.24^{e} \pm 0.02$
		20	$8.61^{de} \pm 0.43$	$60.59^{ab} \pm 0.68$	$32.28^{cd} \pm 0.62$	$4.46^{ab} \pm 0.54$	$28.31^{a} \pm 1.31$	$1.26^{bcd} \pm 0.02$	$2.92^{e} \pm 0.36$	$0.13^{ef} \pm 0.01$	$0.30^{bcde} \pm 0.03$
Sialge	90	10	$7.87^{e} \pm 0.54$	$57.41^{cd} \pm 1.05$	$37.84^{a} \pm 0.87$	$0.72^{c} \pm 0.02$	$19.57^{de} \pm 1.20$	$1.29^{abcd} \pm 0.03$	$7.80^{b} \pm 0.39$	$0.19^{cd} \pm 0.01$	$0.31^{abcd} \pm 0.02$
		20	$7.91^{e} \pm 0.51$	$61.10^{a} \pm 0.86$	$38.27^{a} \pm 1.52$	$0.78^{c} \pm 0.03$	$22.83^{c} \pm 0.44$	$1.25^{bcd} \pm 0.03$	$5.82^{cd} \pm 1.33$	$0.18^{cd} \pm 0.01$	$0.37^{a} \pm 0.01$

[#] GS: Growth Stage; SH: Stay Height; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; WSC: Water Soluble Carbohydrates; HC: Hemicellulose; CF: Crude Fiber; P: Phosphorus; K: Potassium; Ca: Calcium; Mg: Magnesium.

[*] Mean ± standard error.

[a, b, c, d, e, f] Means in the same column with different superscripts are significantly different ($P < 0.05$).

were affected to a greater degree by plant maturity than by moisture content on ensiling. This coincided partially with the results from the NP cv. TS3 in the sense that, the more immature grass with higher moisture level had a higher percentage of CP loss compared to the more prolonged growth stages at 60 and 90 days cutting intervals.

II. Evaluation of the contents of fiber and WSC after ensiled 60 days

In relation to the fiber contests were a decreasing trend in both NDF and HC contents while for those of ADF were an increasing trend. As mentioned before, it was noted that both NDF and HC had losses during the ensiling process, however, ADF content increased. Previous research found that the ash content often increased after the ensiling process. Rime *et al.* (1997) attributed this as a result of proportionally larger losses of the other chemical components than that of the ADF. The Table 1 showed that the HC content from 30 to 90 days cutting intervals with stay high of 10 and 20 cm after ensiling loss. However, that of silage NDF content at 90 days with stem height 20 cm increased and both 10 and 20 cm had greater loss on 30 and 60 days silages. For the ADF content, there were significant differences between 10 and 20 cm for the 30 to 90 days cutting interval of silage. Also, Khalili *et al.* (2005) observed that there was lower NDF content in first-cut growth silage in comparison to the regrowth silage. In support, Perculija *et al.* (2011) stated that early harvest gives rise to higher DM and NDF digestibility of the silage. When the forage grew older, their silage had an increase in cell wall carbohydrate, higher ADF content and lower CP content. Alstrup *et al.* (2016) stated that the more lignified stem is associated with greater level of NDF concentration in the silage. These mentioned all coincided with the results obtained during the ensilage process of the NP cv. TS3.

The WSC content of NP cv. TS3 at cutting growth stages 30, 60 and 90 days and the stay heights are 10 and 20 cm. Table 1 showed that except for the treatment of 30 days cutting interval with 10 cm stay height, the WSC contents of silage were lower than those of forage, which meant WSC was consumed at the ensiling process. Interestingly, the 60 days cutting interval with both 10 and 20 cm stay height had the greatest amount of loss in WSC contents, followed by the treatments of 90 days cutting interval. The least WSC content loss was experienced by the cutting interval of 30 days during the ensilage process. It was assumed that due to higher moisture content at the cutting interval of 30 days, the silage material would have acidified at a much shorter duration than the forage of lower moisture content. Forage suitable for ensiling might carry an adequate amount of fermentable substrates in the form of water soluble carbohydrate (Yokota *et al.*, 1992; Kung, 2010; Shen *et al.*, 2012). In support of the mentioned that Yitbarek and Tamir (2014) stated, ensiling was considered a very complex process which was based on many factors including natural microbial phase, harvesting conditions and the sugar content of the forage.

III. Evaluation of the content of mineral after ensiled 60 days

In relation to the alteration of the ash content during the ensilage process, it was noted that there was gain for all of the variables with the exception of phosphorus at the cutting interval of 90 days cut at 20 cm (Table 1). The gain for the ash variables were seen more so on the 10 cm cutting height for the 60 and 90 days cutting interval, whereas for the cutting interval at 30 days it was not as defined. The general trend observed for the cutting interval, was higher gain in potassium during the ensilage process, while calcium was the least that gained. Kuoppala *et al.* (2008) noted that the increase in the ash content is due to an increase in the DM during the ensiling process. According to Weinberg (2008) two of the main components of forage that have effect on the buffering capacity of the forage material were the ash and protein contents, which when high, can result in high buffering capacity.

IV. Evaluation of the pH value after ensiled 60 days

The pH value plays a very pivotal role during the ensilage process, a rapid descent not only helps to inactivate the undesirable microorganism but also facilitates in the protection from degradation of valuable nutrients. The average pH value can fluctuate between 3.8 and 4; this depends on the cutting interval of the forage and the content of water soluble carbohydrates that affect the buffering capacity (Woodard *et al.*, 1991; Santos *et al.*, 2013). A fluctuation trend was observed in the pH values of the NP cv. TS3 at the various cutting growth stages, which did not reach to be significantly different. Close assessment of the pH values revealed that the lowest value was at a cutting interval of 60 days followed by the 90 days (Fig. 3). The result showed in having the one with the highest pH value (Table 2). There was no significant difference between the cutting growth stages and heights in spite of the aforementioned. Woodard and Prine (1991) obtained pH values that fell between the range of 3.8 and 4.4 from the Napier grass silage. It was found that the correlation was connected to the harvest time and the genotype of the forage. The mentioned was consistent with the pH results of the NP cv. TS3, with the exception of the cutting interval at the 30 days cut with 10 cm. Bijelić *et al.* (2015) found that low dry matter content accompanied by high pH value and high butyric acid, in addition to low lactic and acetic acid contents resulted in poor fermentation silage. In addition, Yitbarek and Tamir (2014) stated that clostridia was very sensitive to water availability, therefore, in order to develop and proliferate it requires wet conditions. The mentioned proven contrast to the results obtained at the 30 days cutting interval of the NP cv. TS3 which although had the lower dry matter content among the cutting growth stages tested negative for the presence of butyric acid. One of the problems that high DM can pose according to the above mentioned authors at the hour of ensiling is inadequate compaction of the forage material which can lead to an extended aerobic period, also, oxidative losses and the formation of mold. Also, Liu *et al.* (2016) mentioned that forage of moderate moisture content has better fermentation quality than that of high and low moisture content.

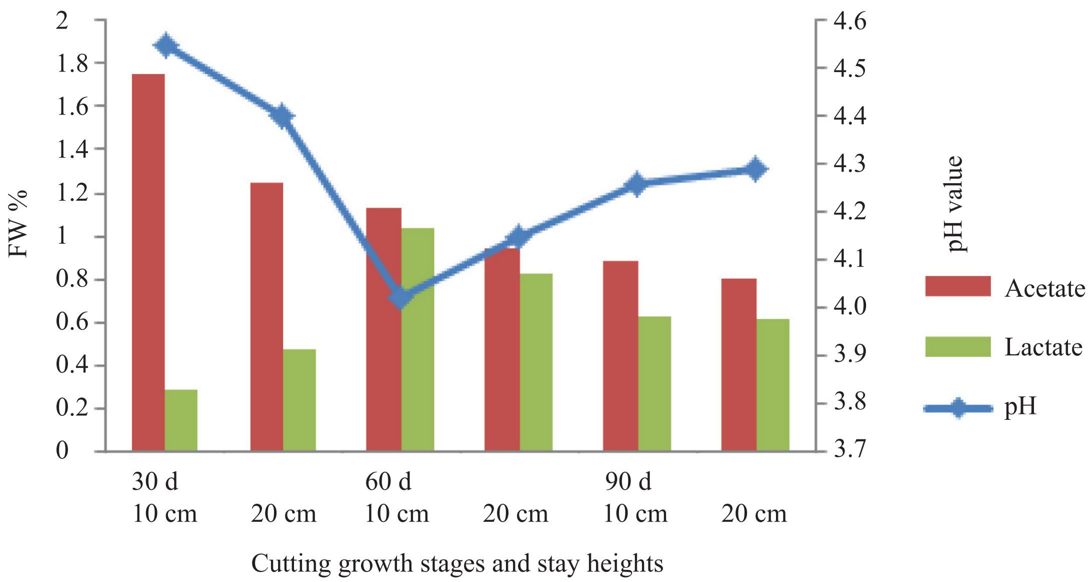

Fig. 3. Evaluation of the contents of volatile fatty acids and pH values of the NP cv. TS3 harvested growth stages 30, 60 and 90 days and stay heights with 10 and 20 cm.

Table 2. The silage quality of NP cv. TS3 harvested at different growth stages and stay heights

GS#	SH	pH	Acetate	Butyrate	Lactate	Flieg's score
day	cm			----------------------------	%	----------------------------
30	10	4.50 ± 0.28	1.75a* ± 0.17	0.00 ± 0.00	0.28 b ± 0.15	51.50 c ± 0.50
	20	4.40 ± 0.27	1.25ab ± 0.36	0.00 ± 0.00	0.47ab ± 0.13	53.92 c ± 1.99
60	10	4.02 ± 0.14	1.13ab ± 0.47	0.00 ± 0.00	1.04 a ± 0.20	67.00 a ± 3.02
	20	4.15 ± 0.13	0.94ab ± 0.10	0.00 ± 0.00	0.82ab ± 0.13	61.25ab ± 2.74
90	10	4.26 ± 0.09	0.88 b ± 0.03	0.00 ± 0.00	0.63ab ± 0.12	58.83 b ± 1.30
	20	4.29 ± 0.28	0.80 b ± 0.05	0.31 ± 0.31	0.61ab ± 0.30	57.25 b ± 1.55

As shown in Table 1.
* Mean ± standard error.
a, b, c Means in the same column with different superscripts are significantly different (P < 0.05).

V. Evaluation of the contents of volatile fatty acids and Flieg's score after ensiled 60 days

In relation to the VFA (volatile fatty acids) of the NP cv. TS3, with respect to acetic acid, there was no significant difference between the cutting growth stages with the exception of the cutting interval at 30 days cut with 10 cm and that of the 90 days harvest cut with 10 and 20 cm (Fig. 3). The trend observed was one that decreased as the cutting interval of the NP cv. TS3 was delayed. The cutting interval that had the higher acetic acid value was at 30 days followed by the

60 days. The cutting height that had the lower acetic acid value fell 10 cm with the exception of the cutting interval at 30 days.

Results obtained on the NP cv. TS3 coincided with the findings of Woodard *et al.* (1991) who stated that immature grass has the tendency to carry a negative correlation with silage quality; this was as a result of high buffering capacity, low conservation and increase in the concentrations of acetate. The immature *Pennisetum* species had higher pH value than that of the mature during ensilaging; in addition, lactic acid and acetic acid were both the principal fermentation components. Also, Yokota *et al.* (1992) mentioned that lactic acid was the principal preservative acid in the silage, which was followed by acetic acid. Muck (1988) mentioned that having a concentration of < 1% butyric acid was deemed favorable. However, it was elucidated that high moisture content of > 79% and pH of > 4.5 created ideal conditions for fermentation. According to the results obtained on the NP cv.TS3, in spite that the silage material from the cutting interval of 30 days had pH value that well exceeded the 4.5 benchmark for clostridium growth and proliferation, the results showed that the 0% butyric acid was an indication of the non-presence of clostridium. The fact that the fermentation of the silage material of the NP cv. TS3 was carried out in polyethylene vacuum sealed mini bags, this could have facilitated a more extensive fermentation. Cherney *et al.* (2004) mentioned that when the effluent cannot escape from the vacuum-packed mini-silos, it can account for higher acids; the effluent production could then lead to a more extensive fermentation. Dry matter recovery was a measure of the effectiveness of the ensiling process (Spitaleri *et al.*, 1995). Bolsen *et al.* (1996) justified the absence of clostridium in forage that carries less than 65% moisture; due to having adequate amount of sugars that helped in reducing the pH to a level that was below 4.6 - 4.8, at which point clostridia growth was inhibited. The cutting interval at 30 days of the NP cv. TS3 having higher moisture content in comparison to the older cutting growth stages at 60 and 90 days, at the cutting interval with 20 cm, recorded relatively high WSC of 4.14%, which contributed to the lower pH value of 4.40 in comparison to the much higher pH value of 4.55 at the cutting interval with 10 cm (Tables 1 and 2).

Lactic acid, the most beneficial in the ensilage process similar to the acetic acid, did not show a well-defined trend throughout the ensilage process, at the different cutting growth stages of the NP cv. TS3. It followed more of a fluctuation path, where the lower value was seen at the cutting interval of 30 days and that of the higher value with the cutting interval of 60 days (Fig. 3). There was no significant difference between cutting growth stages, with the exception between the 30 days interval with the cutting height of 10 cm and that of the 60 days with the cutting height of 10 cm. Good quality silage is achieved when lactic acid is the predominant acid produced, as it is deemed the most efficient fermentation acid and will lower the pH value of the silage the fastest. The more rapid the fermentation process can complete, more nutrients will be retained in the silage (Schroeder, 2004). Also, Oladosu *et al.* (2016) mentioned that rapid descent of the pH value impedes the growth of Clostridia and enterobacteria. The cutting height that carried a slightly higher lactic acid value was that of 10 cm with the exception of the cutting interval of 30 days. Lactic acid is the primary acid produced as a result of lactic acid bacteria degrading water soluble carbohydrate in an anaerobic condition. Continued production of lactic acid which lowers the pH value will eventually stop the growth of all bacteria (Kung, 2010; Muck, 2010; Bijelić *et al.*, 2015). In addition, Ferriera *et al.* (2013) stated that this will result in minimal losses in dry matter and protein and give rise to higher nutritive digestibility values. According to Amer *et al.* (2012) lactic acid concentration was higher in forage of high WSC. This is consistent with results obtained on the NP cv. TS3, except that it was at the cutting interval of 60 days that the lactic content was much higher than that at 90 days. Muck (2010) elucidated that the two key processes required to preserve the forage in the silo was the creation of an anaerobic environment and the fermentation of sugars by lactic acid bacteria to lactic acid and other products. On the contrary, grass with inadequate amount of WSC required for fermentation leads to the production of acetate and butyrate (Yokota and Ohshima, 1991; Yokota *et al.*, 1992).

Flieg's score pivotal in the ensilage process of forage through the rating of its value it can then give an indication on the quality of the forage. The analysis on the Flieg's score of the silage material of NP cv. TS3 showed a similar trend to acetic and lactic acids, it followed more of a fluctuation path with the highest recorded value falling at the cutting interval of 60 days and the lowest at the 90 days interval cut with 20 cm (Fig. 4). That being said, its values between the stay heights with 10 and 20 cm did not show any significant difference.

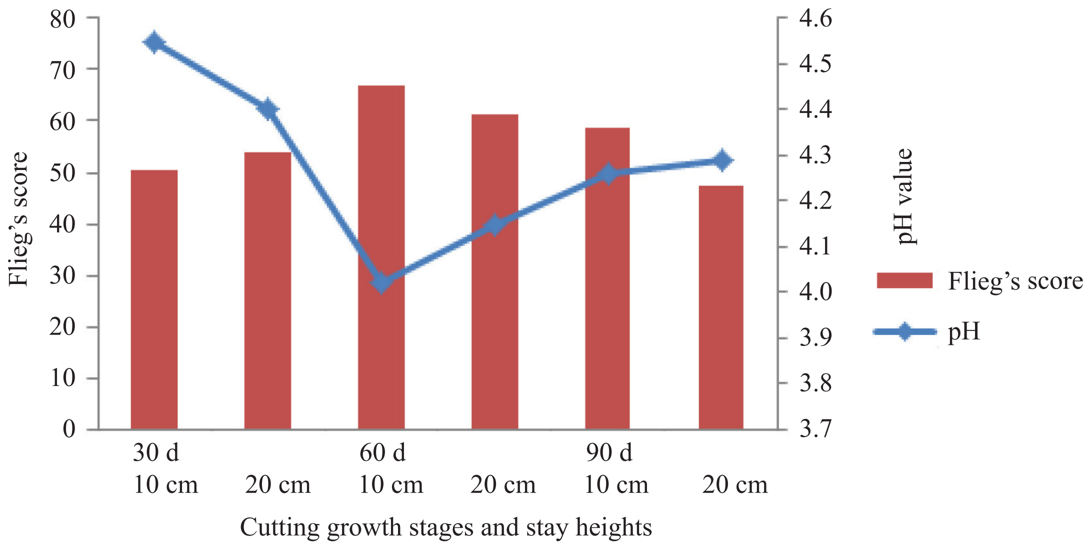

Fig. 4. Evaluation of the pH values and Flieg's scores of the NP cv.TS3 harvested growth stages 30, 60 and 90 days and stay heights with 10 and 20 cm.

Conclusion

There was significant difference on the Flieg's scores among different cutting growth stages and stay heights. The grass cut at 60 days with stay height 10 cm had the highest Flieg's score 67.00 ± 3.02, followed by 90 days with stay heights 10 or 20 cm, then that cut at 30 days with 10 cm stay heights was the lowest Flieg's score 51.50 ± 0.50 (Table 2). The results above might suggest that the cutting growth stages at 60 days with stay height 10 cm was considered the most optimum for producing high forage yield and high silage quality of the NP cv. TS3.

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不同割期及留椿高度對狼尾草台畜草三號青貯品質之影響 (1)

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摘　　要

狼尾草 (*Pennisetum purpureum*) 在熱帶與亞熱帶地區是生長快速、高營養分與適口性佳的重要牧草草種。本試驗目的旨在探究狼尾草台畜草三號植株在不同割期及留椿高度對青貯品質之影響。本試驗於行政院農業委員會畜產試驗所進行，採 3 x 2 複因子完全逢機設計 (completely randomized design, CRD)。處理因子包括割期 30、60、90 天及留椿高度為 10 及 20 公分。試驗結果顯示，當割期由 30 天、60 天延長至 90 天，青貯後之粗蛋白質 (crude protein, CP) 含量隨之降低，中洗纖維 (neutral detergent fiber, NDF)、半纖維素 (hemicellulose, HC) 與水溶性碳水化合物 (water soluble carbohydrate, WSC) 含量亦隨之降低，礦物質和酸洗纖維 (acid detergent fiber, ADF) 則在青貯後含量提高。結果顯示 30、60、90 天割期並不影響青貯後 pH 值 ($P > 0.05$)，青貯後乳酸含量則以 60 天割期最高，而 30 天為最低且達顯著差異 ($P < 0.05$)，青貯品質評分 (Flieg's score) 以割期 60 天留椿高度 10 公分為最高，割期 30 天留椿高度 10 公分為最低。因此，狼尾草台畜草三號建議以生長 60 天的割期及留椿高度 10 公分之新鮮材料做成之青貯料品質最佳。

關鍵詞：割期、狼尾草、青貯品質、留椿高度。

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