TOTAL NON-STRUCTURAL CARBOHYDRATE (TNC) OF THREE CULTIVARS OF NAPIER GRASS *(Pennisetum purpureum)* AT VEGETATIVE AND REPRODUCTIVE PHASE

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ABSTRACT

An experiment was conducted to determine Total Non-structural carbohydrates (TNC) of three cultivars of napier grass (*Pennisetum purpureum*) harvested at vegetative and reproductive phases. The cultivars tested were Taiwan (Gt), King (Gk) and Mott (Gm) and arranged in a 3 x 2 of treatments with four replicates following nested design. The results showed that the highest sugar content ($P<0.01$) was found in Gt cultivar and the lowest was in Gm cultivar. The highest starch content ($P<0.01$) was found in Gk cultivar and the lowest was in Gt cultivar. TNC content of Gt and Gk cultivars were not significantly different, but both were significantly higher ($P<0.01$) compared with the Gm cultivar. It can be concluded, that there were differences in TNC between cultivars, however, the TNC content in Gk cultivar was not different with Gt cultivar, while Gm cultivar have the lowest ($P<0.01$) TNC content. At reproductive phase all cultivars have higher ($P<0.01$) TNC and starch content than at vegetative phase

Keywords: cultivar, napier grass, starch, sugar, TNC

INTRODUCTION

Napier grass (*Pennisetum purpureum* Schum) is a perennial grass, famous throughout the wet tropics because its high production capability. Several cultivars have been developed and were introduced to Indonesia such as cultivars of Africa, Hawaii, Trinidad, Merkeri, King, Taiwan and Mott. Although among cultivars of Taiwan, King and Mott are closely related, there are differences between cultivars morphology, growth rate and response to farming practices that lead to differences in production and non-structural carbohydrate content.

Plants product largely consisted of carbohydrates (Cook and Trlica, 2010). Reserved carbohydrate or total non-structural carbohydrates (TNC) is a product of photosynthesis that is needed for respiration, maintenance and new growth (Briske and Richard, 1994; Olson and Lacey, 1996). Plant non-structural carbohydrate (NSC), comprised of starch and sugars, is a products of carbon assimilation (C) that can be stored and used to meet the future demands for growth and metabolism (Sampson *et al.*, 2001; Legros *et al*., 2009). TNC content in forages has been identified as three most important characteristics that require the attention of forage breeders (Wheeler and Corbett, 1989). The reasons mentioned above caused the main focus of grass breeders to produce grass with a high content of NSC (Humphreys *et al*., 2006).

A relatively new analysis used to evaluate grass forage quality is measurement of TNC (Downing, 2007). Determination of NSC composition and content is required to estimate the resources available for plant growth and to evaluate the energy value of feed (Zhao *et al.*, 2010). TNC stored in various plant tissues varies according to species (Herbert, 1996) and cultivars (Shewmaker *et al.*, 2006). High levels of NSC may be found in very mature forage (Watts, 2008). The content of storage carbohydrates in plants are always changing, the content tends to rise in the morning, reaching a maximum in the afternoon and decrease at night (Longland *et al.*, 1999).

NSC is a source of energy available for rumen microbes (Sophie *et al*., 2010). High sugar content in grass allows more efficient utilization of nitrogen in the rumen, preventing excess from being excreted that will cause environment pollution (Miller *et al*., 2001; Lovett *et al*., 2004). Increased non-structural carbohydrates content are fermented to give some energy to support N conversion into microbial protein (Hutington and Burns, 2007).

The use of the principles and objectives of efficient grazing management is the management practices that to produce plants that persistent, high quality of production, and to maintain sufficient leaf area and the level of NSC to store energy (Smith and Lacefield, 2009). Implementation of these strategies has the potential to maintain the stability of grassland ecosystem and enable sustainable livestock production (Manske, 1999).

Studies on the determination of NSC, such as total sugar and starch in vegetative and reproductive growth in different cultivars of napier grass is still very limited. Therefore, the research to determine TNC of three cultivars of napier grass at vegetative and reproductive phase have to be done.

The objectives of the studies were to determine TNC of three cultivars of napier grass at vegetative and reproductive phases

MATERIALS AND METHODS

Plant Culture

The materials used were three cultivar of napier grass planted on 192 pots (18 x 35 cm with diameter 22 cm), filled with regosol soils and were planted with three different napiergrass cultivars, in which each cultivar required 64 vegetative planting materials.

This study consisted of three factors of cultivars G) and two factors of growth (P). Cultivar factor of consisted of Taiwan cultivar (Gt), King cultivar (Gk) and Mott cultivar (Gm). Meanwhile growth factor consisted of vegetative phase (P1) and reproductive phase (P2). Growth phase (P) nested within cultivar factor (G). Each treatment consisted of four replicates, therefore 192 pots were required. The pots then were divided according to the cultivar into 3 groups, and each groups were divided into 8 plots, each plot containing of 8 pots.

Pots were placed randomly following nested design (Steel and Torrie, 1980) in the pattern of randomization. The distance between each cultivar plots was 60 cm, and between plots P1 and P2 was 30 cm.

Vegetative planting materials (cuttings) napier grass cultivars (Gt, Gk and Gm) were planted in the pots using 3 cutting per pot . Thinning were done after 7 days of growth leaving one the best plant in each pot. Urea fertilizer (46% N), phosphorus (18% P2O5) and KCl (50% K_2O) were given at days-3 after thinning at the rate of 100 kg urea/ha and 50 kgTSP/ha and 50 KCl/ha or equivalent to (0.52 g N/pot, 1.33 g P_2O_5/pot and 0.48 g K_2O/pot. Watering and weeding were done if necessary.

Data Collection

Data of production were obtained at 8 week after planting (8WAP) for the treatment of vegetative phase and 13 weeks after planting (13WAP) for treatment reproductive phase. Plants were harvested at 10 cm above the soil surface then were weighed to determine the fresh weight. Chopped fresh samples were then oven dried at 55^{o}C for 3 days. Dried samples then were 1 mm grounded by Wiley mill. These samples were used to determine the dry matter (AOAC, 2005), total sugars by Nelson-Somogi method (Apriyantono *et al*., 1989) and starch content by acid hydrolysis. The TNC or NSC were calculated by Longland and Byrd (2006) with the formula: NSC= TNC = starch (%) + Sugar(%).

Data Analysis

The effects of cultivars and growth phase were determined by analysis of variance (ANOVA) according to Steel and Torrie (1980). The differences between treatment means were determined using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Total Sugar

The results showed that there were differences in sugar content between cultivars of napier grass (Table 1). The highest ($P<0.05$) sugar content was found in Gt cultivar, followed by Gk cultivar ($P<0.05$) and the lowest ($P<0.01$) was in Gm cultuvar. The lowest of sugar content Gm cultivar because it was used as source of energy for tillering (Bartholomew, 1999) and also for respiration and maintenance (Briske and Richard, 1994; Olson and Lacey, 1996). In accordance with

Table 1. Average Total Sugar, Starch and TNC in Cultivars Taiwan, King and Mott at Vegetative and Reproductive Phases

Item		Phase	Total sugar (%)	Starch (%)	TNC (%)
Cultivars					
	Taiwan		5.28^{c}	14.99^{a}	20.27^{c}
	King		4.03^{b}	16.61^{bc}	20.64^{c}
	Mott		2.55^{a}	15.38^{ab}	17.93^{a}
Growth phase					
	Taiwan				
		Vegetative	2.64^{a}	14.65^{a}	17.29^{a}
		Reproductive	7.2^{c}	15.32^{a}	23.24^{c}
	King				
		Vegetative	1.72^{a}	15.89^{a}	17.61^{a}
		Reproductive	6.34^{c}	17.34^{c}	23.68^{c}
	Mott				
		Vegetative	1.75^{a}	14.02^{a}	15.77^{a}
		Reproductive	3.36^{b}	16.73^{c}	20.09^{c}

Superscript (a.b), (b.c) by column cultivars and growth phase significantly different at (P <0.05) and (a.c) were significantly different at (P <0.01)

the findings of Moran (2005) and Kozloski *et al*. (2003), that napier grass cultivars Gm (54 tillers/plot) has puppies over cultivars Gt (26 tillers/plot) and Gk (20 tillers/plot). Tas *et al*. (2006) reported that there were differences in water soluble carbohydrate (WSC) content of four perennial ryegrass cultivars. Wadi *et al.* (2004) found that the total sugar content (TSC) of napier grass, King grass and hybrid napier grass were 11.6%, 13.4% and 16,6%, respectively.

Total sugar at reproductive phase harvested at 13 weeks after planting (13WAP) were significantly higher (P<0.01) compared to the vegetative phase harvested at the 8 weeks (8WAP) for all cultivars tested. The high levels of sugar in the reproductive phase could be caused by decreasing growth rate, so energy used was reduced, but photosynthesis and sugars production still accured resulted in the sugar accumulation. According to Watts (2008) the accumulation of sugars occurs when growth is slowly such that the products of photosynthesis exceed demand for growth.

Starch

The results showed that there were differences in starch content among cultivars of napier grass. The highest (P<0.01) starch content was found in Gk cultivar, followed by Gm cultivar (P>0.05) and the lowest (P<0.01) was in Gt cultivar (Table 1). The high content of starch in Gk cultivar caused photosynthesis exceeds respiration activity. Starch is the main product of tropical grass photosynthesis, and deposited in the chloroplast. Starch reserve in the chloroplast is mobilized and utilized by plant in the darkness and at times of limited photosynthesis (Foyer, 1984). Wadi *et al.* (2004) found that the starch content of napier grass, King grass and hybrid napier grass were 3.12%, 3.58% and 5.67%, respectively.

Starch content in the reproductive phase at 13WAP were significantly higher (P<0.01) than that at 8WAP but not for Gt cultivar. The increased in starch content at in the reproductive phase can be attributed to the exceeding photosynthesis compared to the demand of energy because decreased of new shoots formation so that the result of photosynthesis partly only used for respiration. Maturity is the main factor affected TSC content of forage, but environmental conditions may override stage of growth, producing very mature forage with high NSC concentration (Watts, 2008). That phenomenon showed that the starch content increases with increasing maturity of the plant. According to Chatterton *et al.* (2006), the starch content in vegetative tissues (up to 10% DM) generally increased with increasing maturity.

Total Non-Structural Carbohydrates (TNC)

TNC in the tropical grass composed of the total sugar and starch. The average TNC of napier grass Gt, Gk and Gm cultivar on vegetative and reproductive phase are presented in Table 1. The results showed that there were differences ($P<0.01$) in TNC content between cultivars of napier grass. The highest ($P<0.01$) TNC was found in Gk cultivar, followed by Gt cultivar ($P>0.5$) and the lowest ($P<0.1$) was in Gt cultivar. Wadi *et al.* (2004) found that the TNC content of napier, King grass and hybrid napier grass were 22.0%, 15.2%, and 22.3%, respectively.

TNC in the reproductive phase harvested at 13WAP were significantly higher ($P<0.01$) than 8WAP for all cultivars tested. The high content of TNC in the reproductive phase was attributed to the increase of total sugar and starch in all cultivars due to increased in maturity. The results of this study is in agreement with the report of Kozloski *et al.* (2005) that NSC content in napier grass cultivars increased with increasing of age. Mott cuts 30, 50, 70 and 90 days yields 108 g/kg DM, 117 g/kg DM, 141 g/kg DM, 144 g/kg DM, respectively. Study conducted by Villanueva-Avalos (2008) found that levels of TNC in WW-B.Dahl grass 0.26 g/plant in the vegetative phase was increased to 2.22 g/plant at reproductive phase.

CONCLUSION

It can be concluded that there were differences in TNC content between cultivars of napier grass, however, the TNC content in Gk cultivar was not different with Gt cultivars, while Mott cultivar have the lowest TNC content. The reproductive phase showed that all cultivars have higher TNC and starch content than at vegetative phase.

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