

Yield and Nutritional Quality Potential of Three Fodder Grasses in the Northern Region of Sri Lanka

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ABSTRACT. Feeding standards of ruminant livestock could be significantly enhanced through the cultivation of improved quality forages which are suitable for different agro-climatic condition of the country. Therefore, a field experiment was carried out to assess the growth parameters, herbage yield and chemical composition of maize (*Zea mays*), sorghum (*Sorghum bicolor* (L.) moench), and hybrid Napier (*Pennisetum purpureum* X *Pennisetum americanum*) in the northern region of Sri Lanka. The experiment was conducted during the period of December 2015 to June 2016 with three treatments consisted of maize (variety Pacific 984), sorghum (variety Sugargraze), and hybrid Napier (variety CO-3), each having three replicates under randomized complete block design. Growth parameters were measured at two week intervals up to the 8th week and the crops were harvested at the 10th week after planting for making silage. Among the species, maize was superior ($p < 0.05$) to others in terms of growth, and resulted the highest ($p < 0.05$) fresh matter yield of 52.27 t/ha/cut, with a dry matter yield of 17.11 t/ha/cut, whereas the lowest ($p < 0.05$) crude fiber and dry matter (DM) yield were obtained from CO-3. In terms of chemical composition, sorghum showed the highest ($p < 0.05$) crude protein (CP) (14.37%) and *in vitro* dry matter digestibility (IVDMD) (66.05%) while the lowest ($p < 0.05$) IVDMD and CP were recorded in CO-3 and maize, respectively on DM basis. In addition, the cost of production of maize and sorghum was less than that of CO-3. The results revealed that maize and sorghum performed better than CO-3 in terms of growth, yield, nutrient composition, and cost effectiveness in the northern region of Sri Lanka.

Keywords: Chemical composition, forage yield, hybrid Napier variety CO-3, maize, sorghum

INTRODUCTION

Livestock production has been growing intensively in Sri Lanka aiming the achievement of the policy goal of production of sufficient animal protein with self-sufficiency in milk production. Development of livestock sector in Sri Lanka is hindered by many constraints, and unavailability of quality feed is a major factor (Houwens *et al.*, 2015). The main feed resources for ruminants in Sri Lanka are natural pasture and crop residues, which are low in quality and quantity for sustainable livestock production (Ibrahim *et al.*, 1999). This results in low productivity of dairy animals of the country (Premaratne and Premalal, 2006). Increased livestock production can be achieved through the cultivation of high-quality

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forages with a high-yielding ability that is adapted to different agro-climatic condition of the country.

Northern Province is located in the dry zone of Sri Lanka which encompasses five administrative districts, namely Jaffna, Kilinochchi, Mullaitivu, Mannar, and Vavuniya. The area of Northern Province is 8, 848.21 km² accounting around 13.22% of the total land area of the island. The livestock industry is becoming an important part of agriculture in the Northern Province of Sri Lanka. The livestock sector is considered as a supplementary source of income for the farming society in the region. Average daily milk production of the Northern Province in 2014 was 65,663 liters (<http://www.np.gov.lk>, Accessed on 08.10.2016). The agro-climatic condition of the northern region is suitable for growing good quality tropical forages.

Many forage crops such as maize (*Zea mize*), sorghum (*Sorghum bicolor* (L.) moench), and hybrid Napier (*Pennisetum perpureum* X *Pennisetum americanum*) variety CO-3 are grown by the farmers in the region. Maize is one of the most suitable crops having wide adaptability under varying agro-climatic conditions. As it has yielded a potential far higher than any other cereal crops, it is sometimes referred as the miracle crop or the ‘Queen of Cereals’. Fodder quality of green maize is far undefined (Chaudhary *et al.*, 2012). Sorghum is grown as an important forage crop in many parts of the world due to its profuse productivity and water use efficiency, especially under drought conditions (Sanchez *et al.*, 2002). Fodder sorghum is stimulated at large-scale dairy farms of Sri Lanka, to bridge the dry season that lasts from October to January (Houwens *et al.*, 2015). CO-3 was developed by the Tamil Nadu Agricultural University in Coimbatore, India and introduced to Sri Lanka in 1999. It is a popular fodder crop among farmers at present. CO-3 is characterized by its profuse tillering ability, high yield potential, high crude protein concentration, quick re-growth capacity, high palatability, free from other adverse factors and resistance to pest and disease attacks (Premaratne and Premalal, 2006).

Along with high yielding potential and climatic adaptability, nutritional quality is also a criterion for the selection of suitable fodder grasses by the farmers in the Northern Province of Sri Lanka. Therefore, a field experiment was conducted to evaluate the growth, yield, and nutritional quality of fodder maize (*Zea mize*) variety Pacific 984, sorghum (*Sorghum bicolor* (L.) moench) variety Sugargraze, and hybrid Napier (*Pennisetum perpureum* X *Pennisetum americanum*) variety CO-3 in the northern region of Sri Lanka.

METHODOLOGY

A field experiment to compare the growth, forage yield, and nutritional quality of three fodder species was conducted from December 2015 to June 2016 at a farmer’s field, located in the Thavasikulam village (8.74158 °N latitude, 80.47671 °E longitudes; 104 meters elevation), 5 km South West of Vavuniya city in Sri Lanka. The soil type in the area is Reddish Brown Earth (Mapa *et al.*, 2010). Fodder sorghum variety Sugargraze, maize variety Pacific 984 and hybrid Napier variety CO-3 were chosen for the study. The experiment was laid out in a randomized complete block design (RCBD) having three replications. The plot size was 5 X 5 m. Three seeds of the maize and sorghum were planted in one spot manually at the spacing of 45 X 30 cm and 65 X 45 cm, respectively. After germination, only two healthy plants were selected for further study from each spot. Stem cuttings of CO-3 having two healthy nodes were planted with 1 X 1 m spacing.

Soil samples were collected randomly from the experimental plots before planting and analyzed for physicochemical properties (pH - 7.2, Electrical Conductivity – 1.1 mS/m, organic matter - 0.88%, total N - 0.11%, soil texture – sandy clay loam) using standard methods (Dharmakeerthi *et al.*, 2007; Reeuwijk, 2002) to determine the application of organic and inorganic fertilizer. Before planting, farmyard manure at the rate of 15 t/ha (Premaratne and Premalal, 2006) was applied and the recommended fertilizer dose of 200: 120: 100 kg Urea: Triple super phosphate: muriate of potash ha⁻¹ was applied as a basal application on the tenth day after planting. Plots were irrigated with an equal amount of water when required. Weeds were slashed after one month of establishment.

During the growing period, for each variety, five plants from each plot were randomly selected to measure the growth. Growth parameters such as the height of the plant from the base where it touches the soil to the vertically held leaf tip, number of leaves, and number of tillers were measured at two weeks interval up to the eighth week of growth. The crops were harvested at the proper stage of maturity level which was around 70 days after planting for making silage. Sub-samples (600 g) of each fodder species were taken, chopped, and dried in an oven at 60 °C until constant weight was obtained. Dried samples were ground to pass a 1 mm sieve and analyzed for proximate composition. Crude protein (CP), crude fiber (CF), ether extract (EE), organic matter (OM) and total ash were determined according to the AOAC (2005) procedure. *In vitro* dry matter digestibility (*IVDMD*) was determined according to Tilley and Terry method (1963) as modified by VanSoest and Robertson (1985).

The collected data were statistically analyzed using Statistical Analysis Software version 9.1.3 (SAS, 2009), and Duncan’s multiple range test (DMRT) was used to compare means.

RESULTS AND DISCUSSION

Growth parameters

The growth parameters such as number of leaves per plant, plant height, and leaf length of maize, sorghum, and CO-3 are shown in Tables 1 to 3. The results indicated that the number of leaves, plant height and leaf length of all fodder species increased with maturity.

Table1. Number of leaves per plant (Mean ± SE) of maize, sorghum and CO-3 at different stage of maturity[†]

Species	Number of leaves			
	Week 2	Week 4	Week 6	Week 8
Maize (Pacific 984)	5.93 ^a ± 0.12	7.73 ^a ± 0.12	9.53 ^a ± 0.26	11.07 ^a ± 0.21
Sorghum (Sugargraze)	5.40 ^a ± 0.19	6.80 ^a ± 0.33	8.27 ^a ± 0.21	8.67 ^a ± 0.25
CO-3	5.27 ^a ± 0.33	24.73 ^b ± 2.03	44.33 ^b ± 3.90	109.67 ^b ± 2.73

[†]Means with different superscripts in columns are significantly different (p<0.05)

Hybrid Napier variety CO-3 at 4th, 6th and 8th week of growth stage produced the highest (p<0.05) number of leaves compared to the other two fodders (Table 1) where, no significant differences were observed between sorghum and maize. This may be due to the profuse tillering capacity of CO-3 (Premaratne and Premalal, 2006) compared to the other two fodders. A field experiment of CO-3 carried out by Mounika *et al.* (2015) in India reported a high number of leaves (156.15) per plant at 13th week with 45 X 45 cm spacing. Since leaves

have higher nutritive values than the stem of the plant, the number of leaves per plant is a very important parameter for calculating the growth and forage yield of fodder species (Ibrahim *et al.*, 2014). Variation in results may be due to the differences in maturity level, plant spacing, and climatic conditions.

Table 2. Plant height (Mean \pm SE) of maize, sorghum and CO-3 at different stage of maturity[†]

Species	Plant height (cm)			
	Week 2	Week 4	Week 6	Week 8
Maize (Pacific 984)	34.83 ^b \pm 1.48	76.53 ^b \pm 2.20	143.47 ^b \pm 3.12	213.33 ^b \pm 2.68
Sorghum (Sugargraze)	34.93 ^b \pm 1.47	76.33 ^b \pm 2.81	149.87 ^b \pm 2.68	231.67 ^c \pm 3.42
CO-3	27.17 ^a \pm 1.78	62.20 ^a \pm 2.06	102.80 ^a \pm 3.32	145.80 ^a \pm 2.64

[†]Means with different superscripts in columns are significantly different ($p < 0.05$)

According to the Table 2, sorghum was the tallest at the 8th week ($p < 0.05$) growth, whereas the lowest plant height was observed in CO-3. Similar plant height of CO-3 (144.19 cm) was recorded by Mounika *et al.* (2015) whereas values reported by Wangchuk *et al.* (2015) for plant height (175 cm) and leaf number (360) grown in Bhutan after one year of establishment varied highly. According to Epasinghe *et al.* (2012), mean plant height for CO-3 (172 cm) was higher compared to maize (199 cm) and sorghum (218 cm) at 9th week of growth when grown in the wet zone of Sri Lanka. The possible explanation for the variable results may be due to the diverse agro-climatic condition between the wet and dry zones of Sri Lanka.

Table 3. Leaf length (Mean \pm SE) of maize, sorghum and CO-3 at different stage of maturity[†]

Species	Leaf length (cm)			
	Week 2	Week 4	Week 6	Week 8
Maize (Pacific 984)	32.33 ^b \pm 1.12	57.27 ^a \pm 4.56	88.47 ^c \pm 1.64	91.27 ^a \pm 1.43
Sorghum (Sugargraze)	26.63 ^a \pm 1.45	56.20 ^a \pm 1.78	79.67 ^b \pm 1.67	86.13 ^a \pm 1.84
CO-3	49.27 ^c \pm 1.81	58.87 ^a \pm 1.97	70.53 ^a \pm 2.18	85.60 ^a \pm 2.07

[†]Means with different superscripts in columns are significantly different ($p < 0.05$)

The mean leaf length of forage species was not different ($p > 0.05$) at 4th and 8th week of growth stage where maize produced the highest leaf length (Table 3). In general, when the leaf length increases, leaf area of the plant will also increase and leads to a higher forage yield, attributing to efficient photosynthesis (Goldsworthy *et al.*, 1974; Awan *et al.*, 2001; Amin, 2011). A similar finding was observed in the present study. Leaf length of CO-3 measured at the 8th week of maturity was similar to that of leaf length (82.26 cm) reported by Mounika *et al.* (2015) at 13th week of growth.

Fresh and dry matter yield of fodder

The forage yield of the three fodder species is given in Table 4. According to the yield obtained at the 10th week, fresh and dry matter yield were the highest ($p < 0.05$) in maize compared to the others. The dry matter yield of maize in the present study is comparable to the findings of Wiersma *et al.* (1993) who reported 15.30 t/ha at half milk line stage of hybrid maize in the North Central Wisconsin. However, Uzun *et al.* (2009) reported 76.48

t/ha fresh matter yield of sorghum after 15th week of planting in Turkey. The fresh matter yield reported for CO-3 in the present study was slightly higher than the values of 29.77 and 27.56 t/ha/cut reported by Chellamuthu *et al.* (2011) and Mounika *et al.* (2015), respectively, when cut at 13th week after planting in India. A study conducted by Epasinghe *et al.* (2012) in the wet zone of Sri Lanka has recorded an average dry matter yield of 3.57, 3.66, 5.23 t/ha/cut for maize (Rambo), CO-3 and Sugargraze, respectively at 9th week of planting. The variation in the yield may be due to the differences in the variety of maize, soil, climatic condition, and maturity level at harvest.

Table 4. Fresh and dry matter yield (Mean \pm SE) of maize, sorghum and CO-3 at 10th week after planting[†]

Species	Fresh matter yield (t/ha)	Dry matter yield (t/ha)
Maize (Pacific 984)	52.27 ^c \pm 1.16	17.11 ^b \pm 0.38
Sorghum (Sugargraze)	40.27 ^b \pm 0.15	6.26 ^a \pm 0.02
CO-3	36.00 ^a \pm 0.23	6.12 ^a \pm 0.03

[†]Means with different superscripts in columns are significantly different (p<0.05)

Although high yield was reported in maize variety, multi harvests could be obtained from the other two fodder species used in the present study. CO-3 could be maintained as a perennial crop up to 2 years under proper management practices together with the correct application of fertilizer, irrigation in drought period (Premaratne and Premalal, 2006), whereas sorghum could be managed properly as a ratoon crop to get up to three harvests. However, the cost of maintenance will be high if the crop is harvested continuously. The cost of production of green forages were 1.75, 2.09, and 5.7 Rs/kg, whereas the expenses for the production of dry fodder were 5.35, 13.44, and 32.66 Rs/kg for maize, sorghum, and CO-3, respectively. According to the results, the production cost of sorghum was twice of that of maize, whereas CO-3 showed five times high production cost compared to maize. This is due to the high production cost and low productivity of CO-3 compared to the other two fodder species.

Chemical composition of fodder species

The highest (p<0.05) values for CP and CF were observed in sorghum whereas, maize reported the lowest (p<0.05) amount of CP at the time of harvesting (Table 5). According to Epasinghe *et al.* (2012), the CP content of Sugargraze in the wet zone of Sri Lanka at the 7th week of growth was 17.12%, whereas a value of 12.2% was reported on 7th week of growth in Indonesia by Moran (2005) indicating the location specific variations in composition.

Table 5. Chemical composition (Mean \pm SE) of maize, sorghum and CO-3 (g/100 g DM)[†]

Parameters	Maize (Pacific 984)	Sorghum (Sugargraze)	CO-3
DM	32.73 ^c \pm 0.01	15.55 ^a \pm 0.02	17.00 ^b \pm 0.01
CP	7.35 ^a \pm 0.09	14.37 ^c \pm 0.01	10.92 ^b \pm 0.17
CF	35.15 ^a \pm 0.60	38.28 ^b \pm 0.14	33.35 ^a \pm 0.57
EE	2.45 ^a \pm 0.01	3.74 ^b \pm 0.05	4.34 ^c \pm 0.05
ASH	10.70 ^a \pm 0.18	11.76 ^b \pm 0.02	16.06 ^c \pm 0.01
OM	78.59 ^c \pm 0.36	76.49 ^b \pm 0.41	67.87 ^a \pm 0.01

[†]Means with different superscripts in rows are significantly different (p<0.05)

Chaudhary *et al.* (2012) reported a value of 7% CP for maize at milky stage in an experiment done in India, whereas a value of 16.33% was reported by Epasinghe *et al.* (2012) at 7th week of growth in the wet zone of Sri Lanka. The low CP content obtained in the present study might be due to the difference in maturity level, and variety. However, the CP content of CO-3 in the present study was in accordance with the findings of Vijayakumar *et al.* (2009) and Wangchuk *et al.* (2015). In contrast, Premaratne and Premalal (2006) reported a CP content of 15 –16% for CO-3 when harvested at the proper stage of maturity in the mid country of Sri Lanka. According to the Table 5, DM content of maize was twice of that of sorghum and CO-3, whereas the EE and ash contents of CO-3 reported the highest ($p<0.05$) value compared to other two species. The CP, CF, EE, and ash content reported by Heuze *et al.* (2015) were 3.0-12.8, 19.1-36.6, 0.7-3.1, and 2.5-11.8%, respectively for maize and 2.5-16.3, 22.6-43.2, 1.1-3.1, and 5.4-13.7%, respectively for sorghum. The values obtained in the present study were in accordance with the report of Heuze *et al.* (2015). Crude fiber and ash content of CO-3 reported by Premaratne and Premalal (2006) and Epasinghe *et al.* (2012) deviate slightly from the present observations. These deviations could attribute to the difference in soil and climatic condition of two zones, namely wet and dry zone of Sri Lanka.

The *IVDMD* values among forages were 60.84, 66.05, and 55.95 %, respectively for maize, sorghum and CO-3. Sorghum showed the highest ($p<0.05$) *IVDMD* while CO-3 recorded the lowest ($p<0.05$) *IVDMD*. The *IVDMD* values observed from the three fodder crops were comparable to the finding of Epasinghe *et al.* (2012). The feeding value of forage is determined primarily by the intake and digestibility. Digestibility is variable among various fodder sources and is an inverse function of lignifications (Ouda *et al.*, 2005).

CONCLUSIONS

Maize, variety Pacific 984 produced the highest fresh and dry matter yield compared to sorghum, variety Sugargraze and hybrid Napier, variety CO-3 within the 10th week of growth. Sugargraze was superior to Pacific 984 and CO-3 in terms of crude protein and *in vitro* dry matter digestibility. Based on the results obtained from the nutritional quality, forage yield, and cost of production, Pacific 984 and Sugargraze performed well compared to CO-3 in the field located in the northern region of Sri Lanka.

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