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Research Article

EVALUATION OF BIOMASS PRODUCTION AND SUGAR CONTENT OF SAMURAI 2 VARIETY OF SORGHUM AT DIFFERENT CUTTING AGES AND UREA FERTILIZER APPLICATIONS

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Abstract

Sorghum bicolor *var* Samurai 2 is a well growing variety in dry land. This study aims to investigate the best total forage biomass production and sugar content in stems as a result of different cutting ages and urea doses at the primary cut and cutting after the first and second ratoon. The study used a factorial randomized block design (3 x 3) with 4 replications. The first factor was different ages, consisting of 80, 85, and 90 days, and the second factor was different doses of urea, consisting of 200, 300, and 400 kg ha^{-1}. The results showed that there was no significant interaction effect on parameters. At the primary harvest, both cutting age and nitrogen level showed no significant effect (p >0.05) on chlorophyl (unit), panicle proportion (%), and total forage biomass production (ton/ha^{-1}). The cutting age of the plant affected (p <0.05) tiller number, the proportion of stem and leaf (%). At the second harvest (ratoon 1), there was a significant effect of the cutting age (p <0.05) on tiller number, proportion of fresh leaf, and total forage biomass production. Furthermore, at the third harvest (ratoon 2), the cutting age showed a significant effect (p <0.05) on tiller number and leaf proportion. It was found at the third harvest (second ratoon) that delaying the cutting age resulted in a significant decrease in total biomass production and an increase in stem brix sugar content (%) compared to the first harvest (primary) and the second harvest (ratoon 1) in sorghum *var* Samurai 2.

Keywords: *biomass, chlorophy, ratoon, sorghum*

INTRODUCTION

Sorghum is an important energy crop utilized for both food and feed. *Sorghum bicolor var* Samurai 2 is a mutant variety developed by the National Nuclear Energy Agency of Indonesia. The agronomy characteristics and biological value of the sorghum have been reported by Malalantang et al., (2019) and Wahyono et al. (2017), who described the possible use of all or part of its biomass as an energy source for feed. This sorghum variety is harvested at 113 days after planting, with 12 leaf blades, panicle length of 33.9 cm, seed color of white lime, sugar content of ± 7.8%, ethanol production potential of ± 666 liters/ha, resistant to pests, and able to grow well in humid to dry soil (Sihono *et al.,* 2014). It is tolerant to temperature, salt, and water shortage (Tack *et al.,* 2017). Sorghum Samurai 2 has several advantages, including a flowering age of ±63 days, plant characteristics can be ratton, total biomass yield potential of ±28.6 tons ha^{-1}, plain white seed color (Dudato *et al.,* 2020). The seeds are used to produce bioethanol and bioenergy (Zegada-Lizarazu & Monti, 2012; Pannacci & Bartolini, 2016), while the stem biomass is used for forage. Sorghum biomass contains non-structural carbohydrates (*sucrose, fructose, glucose and starch*) (Almodares et al., 2011) and structural carbohydrates (*hemicellulose, cellulose and lignin*) which can be easily used as a source of bioenergy (Zegada-Lizarazu & Monti, 2012). Furthermore, the advantage of sorghum in general is the ability to grow new shoots or

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saplings as a crop and can be harvested again, which is called ratoon (Livingston & Coffman, 2003). Sorghum crops can be harvested 2 to 3 times during their life, including primary crops and ratoons as forage sources containing carbohydrates sustainably without increasing production costs (Tsuchihashi & Goto, 2008). High ratoon ability needs to be supported by appropriate fertilizer levels and the right harvest time for each ratoon, as sorghum is a C4 plant that responds to N fertilization (Gardner *et al.,* 1994) and produces sugar effectively (Antonopoulou *et al.,* 2008)

The high growth, production, and nutrition performance of sorghum is strongly supported by fertilizer availability during stocking (Sebetha & Modisapudi, 2019). Nitrogen is an essential component of the formation of structural compounds, genes, and the main metabolism in plant cells, including chlorophyll, amino acids, ATP, and nucleic acids (Marschner, 1995). Providing an N input of 120 kg/ha resulted in optimal growth of stems, leaves, and sugar and ethanol production in sorghum (Mekdad & Elsherif, 2019). Applying urea at a rate of 180 kg/ha increased biomass and seed yield (Uchino et al., 2013). Pholsen & Somsungnoen (2005) reported that there was an increase in most of the growth parameters of sorghum plants with an increase in the application of N and K from 450 to 650 kg/ha-1 and 50 to 100 kg ha^{-1}. Sharma & Kumari (1996) stated that the application of K fertilizer from 25 to 50 kg/ha^{-1} can increase plant height, leaf area index, plant growth rate, total dry matter production, K concentration, and yield of sorghum plant biomass. The application of N fertilizer is very important for providing macronutrients to meet the sorghum' nutritional needs (Zhao *et al.,* 2005). Excessive N level, however results in a reduction in net energy for plants, an increase in CO_2 emission conditions (Lewandowski *et al.,* 1995) as well as an increase in the potential for aquifer pollution (Jaynes et al., 2001; Celik *et al.,* 2017). The application of N fertilizer to sorghum plants varied between 45 - 224 kg/ha^{-1} and 150 - 240 kg/ha^{-1} (Zhao *et al.*, 2005; Maughan *et al.,* 2012). In addition, it is also necessary to understand the proper harvesting age.

Harvesting sorghum at the milk dough stage produces optimal sugar content (Mekdad & Elsherif, 2019), as well as cutting at an age of 70 DAP, which is applied to produce sorghum growth and nutrition (Hussein et al., 2014). Harvesting sorghum at 100 - 130 DAP produced the best production and nutrition in terms of plant height of 189.64 cm, biomass production of 2.31 $tons/ha^{-1}$ in dry matter, and sugar concentration of 10.91% (Barik *et al.,* 2017). It is suspected that there is an interaction effect between N and harvesting age on the development and growth cycles of the flower, milk stage, soft dough, and hard dough stage (Lyons *et al.,* 2019) and biomass production and quality. The interaction of observations of N fertilizer application and harvesting age for sorghum *var* Samurai 2 is still unknown. It is therefore that this study was conducted to investigate the effect of N application and harvesting age on growth, biomass production, and sugar level contained in the stem of sorghum *var* Samurai 2.

MATERIALS AND METHODS

The research was conducted at the Jonggol Animal Science Teaching and Research Unit, IPB-University Indonesia, during the rainy season. Selected sorghum (Samurai 2) seeds used in this study were obtained from the university seed collection center. Thirty-six plots with 9 m^2 were used as experimental plots, where the sorghum crops were grown. Chlorophyll meter was used to measure chlorophyll content. Sugar content was measured by using a refractometer sugar Brix meter (%). Urea containing 45% of nitrogen was used as fertilizer with levels according to the treatments.

Sorghum Planting Procedure

The research phase begins with mechanical land processing. Two weeks after tillage, sorghum var Samurai 2 seeds were sown in a single method using the planting hole method within row spacing of 15 cm and between row spacing of 75 cm. The plot size was 3 m x 3 m. In each hole, 3-5 sorghum seeds were sown with a depth of 1-2 cm, then manure was mixed with rice husk and applied directly on the seeds. Urea fertilizer was applied 14 days after transplanting, urea fertiliser was applied after harvesting each ratoon with treatments namely: 200, 300, 400 kg/ha^{-1}. Harvesting was carried out according to the treatments at 80, 85, and 90 days after sowing. Harvesting for each plant of both primary and ratoon was 10 cm above ground. Fresh biomass production of each plot was recorded. Samples were taken based on the number of rows, and then each part of the plants, consisting of stems, leaves, and panicles, were weighed

Experimental Design and Data Collection

The study was laid out in a factorial randomized block design (3 x 3) with 4 replications. The first factor was harvesting age of 80, 85, and 95 days, and the second factor was urea dose consisting of 200, 300, and 400 kg ha^{-1}. The parameters measured in this study were chlorophyll content, total fresh forage biomass, tiller number, plant parts (panicle, leaf, and stem), and stem sugar content. The chlorophyll content was obtained by using the *Green Leaf Detecto*r. Tiller number was counted from new shoots appearing a week after the primary cut and ratoons. Total fresh forage biomass production (tons/ha^{-1}) was obtained by weighing all of the harvested sorghum biomass (except roots). Sugar content in the stem (% brix) was measured using a *refractometer*. Proportion of leaves, stems, and panicles calculated based on fresh weight (% w/w). The data obtained were analyzed using SPSS 20 software and further tested by Duncan's test when the means were significantly different.

RESULTS AND DISCUSSION

Biomass Production and Biomass Profile of Sorghum *Var* Samurai 2 at First Harvest (Primary)

As depicted in Table 1, the results revealed no significant interaction effect as well as a single factor (p >0.05) of both N level and/or harvesting age on leaf chlorophyll (unit) at first harvest in the primary stage. The values ranged between 42.84 and 47.47 units. This indicates that the application of urea (N) fertilizer up to 400 kg N/ha^{-1} did not influenced leaf chlorophyll because N mobilization used at the age of 80, 85, and 90 days of cutting tends to have passed the flowering phase and the milk phase (*generative*) so that the absorption of N elements tends to decrease compared to the growth of the vegetative phase. There was no significant interaction effect (p >0.05) of both harvesting age and N dose on the number of tillers. The tiller number increased (p <0.05) due to the treatment of harvesting age, with the highest number of tillers at 85 DAP harvesting with a value of 4.54 and the lowest at 90 DAP harvesting with a value of 3.52. This is probably due to at 80 to 85 DAP. Sorghum was at the milking stage moving towards the soft stage, where the utilization of N assimilates is still optimal to form protein and energy in the stems to produce new tillers. The proportion of stems based on fresh weight (%) was significantly higher (p <0.05) at 90 DAP (66.82%) compared to 80 DAP (62.72%). N fertilization did not affect (p>0.05) stem proportion. Furthermore, the interaction of both factors did not affect the proportion of fresh panicles (p >0.05). Harvesting age influenced (p<0.05) fresh leaf proportion, but not urea (N) fertilizer and interaction of both factors when N was added up to 400 kg ha^{-1}.

Delaying harvesting from 80 to 90 DAP resulted in a reduction (p <0.05) of leaf proportion, meanwhile, the stem proportion increased with increasing harvesting time (Table 1), indicating a transition of plant parts from leaf to stem as the plants were getting older. However, since the interaction effect of both N levels and harvesting age did not influence the leaf proportion, the high N level did not compensate to enhance leaf growth at the soft dough stage (90 DAP). There was no interaction effect (p >0.05) between both treatment factors, as well as single factor on total biomass based on the total biomass (tons ha^{-1}). This condition is probably because the age of cutting 80 - 90 DAP is the optimal vegetative phase transition to plant generative, resulting in the utilization of dry matter production substrates not only for the growth of stems and leaves but also for panicle development and seed filling. The yield of total forage biomass in first harvest (primary) ranged from 22.40-27.81 tons ha^{-1} which was higher than the study of Barik *et al.,* (2017) with biomass production in sweet sorghum ranging from 13.75 - 24. 66 tons/ha^{-1} but lower than Sriagtula *et al.,* (2019) in sorghum *var* BMR in the application of urea (N) up to 150 kg/ha^{-1}, resulting in total fresh biomass production of 24.75-35.77 tons ha^{-1}. Furthermore, the assessment of sugar content in stems (% brix) also showed no interaction (p >0.05) between cutting age and different doses of urea (N) as well as when the assessment was based on each treatment factor. This is because the cutting age of 80 - 90 DAP is a transition from the flowering stage to the milk and soft stage so that the non-structural carbohydrates in the stem are translocated to form new shoots which result in a relatively low brix (%) value. The value of the brix sugar content (%) in this study was lower than Sriagtula *et al*., (2019) in sorghum *var* BMR in the administration of urea (N) up to 150 kg ha^{-1} resulting in a brix value of 10.09 - 10.78%.

Biomass Production and Biomass Profile of Sorghum *Var* Samurai 2 at Second Harvest (Ratoon 1)

Second harvest (ratoon 1) was carried out after first harvest (Primery) with the same cutting time and dose of urea (N) used. Biomass production and biomass profile of sorghum *var* Samurai 2 affected by harvesting age and dose of urea (N) fertilizer harvest (ratoon 1) can be seen in Table 2.

Table 2 presents the assessment of various research parameters based on the treatment of days after harvesting (DAH) and administration of urea fertilizer doses (N) on the development and growth of sorghum *var* Samurai 2 at second harvest (ratoon 1). The interaction between treatments did not affect (p >0.05) leaf chlorophyll. The results showed that variations in harvest age and urea (N) fertilizer doses yielded relatively similar chlorophyll values, ranging from 32.91-39.82 units. These similar values were probably due to the supply of N nutrients used by plants evenly at the cutting age of 80 - 90 DAH, so that the translocation of dry matter not only to leaves and stems but also to the seeds and panicles developments.

Furthermore, the number of tillers (stems) was influenced (p <0.05) by the age of the cut, while giving urea (N) fertilizer produced the same value (p >0.05), nor did the interaction between the two factors. A higher number of tillers was observed at the age of 80 DAH because this stage was a transition from the vegetative to the generative phase. During this period, photosynthates are optimally stored in the stems, resulting in an increased number of tillers.

The proportion of fresh stems (%) yielded a different value (p <0.05) when based on the treatment factor of cutting age, with the highest value at 90 DAH of cutting, namely 63.24%, and the lowest in the 80 DAH treatment with a value of 60. 13%, but the value of the proportion of fresh stems did not differ based on the application of urea (N) fertilizer and its interactions. The high production of fresh stems (%) at the cutting age of 90 DAH is probably related to the number of tillers produced. The number of tillers produced was relatively smaller compared to other treatments, resulting in more optimal stem growth. Furthermore, based on the proportion of fresh panicles, it was found that all treatment factors and their interactions were not able to influence (p >0.05) changes in the value of the proportion of fresh panicles. The value of the proportion of fresh panicles ranged from 14.97 to 22.57%. Assessment of the proportion of fresh leaves (p <0.05) was influenced by the age of the cut, while the factor of urea (N) and interaction was not able to increase the proportion of fresh leaves. The highest proportion of fresh leaves was in the 90 DAH treatment, with a value of 21.12%, and the lowest value of 18.71% in the 80 DAH treatment.

There was no significant interaction effect (p >0.05) between harvesting age and N dosage on total forage biomass (ton/ha^{-1}). The increase in total green biomass was found in the 80 DAH treatment (22.73%) and the lowest was in the 90 DAH treatment (18.97%). Total forage biomass is the total plant weight in each plot. The value of forage biomass (%) in the second harvest (ratoon 1) decreased significantly when compared to the first harvest (Primary). There was no significant interaction effect (p > 0.05) both harvesting age and N dose on brix sugar content (%). The average value of sugar content is between 3.99% - 6.14%. The value of brix sugar content (%) at second harvest (ratoon 1) was not different from that of second harvest II (ratoon 1). Sorghum *var* Samurai 2 is agronomically a plant that optimizes its growth in panicle formation and seed filling, which may affect the decrease in the value of brix sugar content in stems. The results of observations of total biomass production and the value of brix in ratoon 1 were lower compared to Harahap *et al.,* (2023) using sorghum *var* Samurai 1 ratoon 1, which resulted in a total biomass production value of 21.81 - 35.96 tons/ha^{-1} and a brix sugar content value of 10.14-12.40%.

Biomass Production and Biomass Profile of Sorghum *Var* Samurai 2 at Third Harvest (Ratoon 2)

Third harvest (Ratoon 2) of shorgum *var* Samurai 2 significantly decreased biomass production and significantly increased stem sugar content compared to first harvest (Primary) and second harvest (ratoon 1). Biomass production, sugar content, and biomass profile of sorghum *var* Samurai 2 affected by harvesting ages and doses of urea (N) fertilizer at third harvest (Ratoon 2) can be seen in Table 3.

There was no significant interaction effect or single factor (p>0.05), both N content and harvesting age on leaf chlorophyll (units), the third harvest (Ratoon 2), with values between 38.30 - 44.85 units. There was no interaction effect (p>0.05) between the two treatment factors and the dose of N, but the harvesting age significantly affected (p<0.05) the number of tillers. The number of puppies obtained was 2.77, 1.78, and 1.84. In addition, there was no significant interaction between each treatment factor (p> 0.05), both harvesting age and N dose on the proportion of fresh stem and panicle (%). The mean fresh stem and panicle proportions were 55.05 - 65.64% and 7.90 - 13.52%, respectively. The treatment of harvesting age had an effect (p<0.05) on the proportion of fresh leaf (%). The highest proportion of fresh leaf was found at 80 DAH cutting (31.89%) and the lowest at 90 DAH cutting (28.45%). Age of harvest and dose of N and their interactions had no effect (p >0.05) on total forage biomass (ton/ha^{-1}). The average value of total forage biomass production ranged from 2.51 - 4.18 tons ha^{-1}. Total forage biomass production obtained at the third harvest (ratoon 2) is very low when compared to biomass production at the first harvest (Primary) and the second harvest (ratoon 1), with an average value of 22.40 - 28.40 tons ha^{-1} and 15.42 - 25.69 tons ha^{-1}, respectively. The drastic decrease in total forage production in ratoon 2 is thought to be due to the reduced ability to produce new tillers, which correlates with the low number of tillers produced. Age of harvest and dose of N and their interaction had no significant effect (p > 0.05) on brix sugar content (%). An interesting thing also happened to the parameter of sugar content, namely an increase in the value of sugar content when compared to the first harvest (Primary) and the second harvest (Ratoon 1). The high value of brix sugar content at the third harvest is thought to occur through the translocation of dry matter production in the panicles, so that the assimilate substrate components are optimally redistributed to the stems. The average value of sugar content in ratoon 2 ranged from 10.82 to 12.20%. The results of the brix sugar content were different from those reported by Efendi *et al.* (2013) on black sorghum, producing a brix value of 5.3%, and Harahap *et al.* (2023) on sorghum *var* Samurai 1, producing a brix value of 12.33 - 14.16%.

Table 1. Effect of harvesting ages and administration of urea fertilizer doses on biomass production, sugar content, and biomass profile of sorghum *Var* Samurai 2 at first harvest (Primary) based on fresh weight

Cutting age	Urea doses			
	200kg/ha	300kg/ha	400kg/ha	Mean ± S.D
		Chlorophyll (Unit)		
80 DAP	47,47±3,49	43,47±0,86	45,98±3,98	45,64±1,68
85 DAP	43,26±0,44	47,22±2,33	46,44±3,21	45,64±1,41
90 DAP	42,84±5,00	45,33±1,74	44,14±2,82	44,11±1,64
Mean ± S.D	44,52±2,32	45,34±0,75	45,52±0,90	
		Tiller number (stems)		
80 DAP	3,85±1,43	4,35±0,96	3,74±0,50	3,98±0,46[ab]
85 DAP	3,50±0,66	5,11±0,92	5,00±0,54	4,54±0,19[a]
90 DAP	3,65±0,93	2,70±1,15	3,40±0,83	3,25±0,16[b]
Mean ± S.D	3,67±0,39	4,05±1,12	4,05±0,18	
		Stem proportion (%)		
80 DAP	63,87±0,34	61,73±3,03	62,55±2,69	62,72±0,59[b]
85 DAP	62,64±1,66	61,64±2,99	66,28±1,97	63,53±0,70[ab]
90 DAP	67,37±2,19	67,43±1,69	65,67±1,11	66,82±0,54[a]
Mean ± S.D	64,43±1,40	63,60±0,76	64,83±0,79	
		Panicle proportion (%)		
80 DAP	10,70-±0,34	10,09±0,60	11,60±0,82	10,80±0,24
85 DAP	15,10±1,66	12,26±0,54	10,75±0,75	12,70±0,14
90 DAP	9,00±0,53	8,79±0,29	9,97±0,26	9,25±0,14
Mean ± S.D	11,60±0,56	10,38±0,16	10,77±0,61	
		Leaf proportion (%)		
80 DAP	25,43±1,18	28,18±1,42	25,85±0,95	26,49±1,19[a]
85 DAP	22,62±0,57	26,10±1,21	22,97±1,15	23,78±0,90[b]
90 DAP	23,63±0,54	23,78±0,64	24,36±0,55	23,92±0,58[b]
Mean ± S.D	23,78±0,36	26,02±0,40	24,39±0,30	
		Biomass production (ton/h^{-1})		
80 DAP	25,52±7,12	22,40±4,16	28,40±7,30	25,44±1,77
85 DAP	25,95±3,40	23,41±2,38	24,68±6,87	24,68±2,35
90 DAP	27,81±5,18	25,74±2,84	24,39±6,38	25,98±1,80
Mean ± S.D	26,43±1,86	23,85±0,92	25,82±0,46	
		Stem sugar content (%)		
80 DAP	4,89±1,91	6,06±1,08	4,16±1,72	5,04±0,44
85 DAP	4,62±1,32	4,80±2,12	4,42±2,11	4,61±0,46
90 DAP	3,53±1,28	3,20±0,83	3,30±1,54	3,34±0,36
Mean ± S.D	4,35±0,36	4,69±0,69	3,96±0,29	

Different superscripts in the same row or column show significant differences ($p<0.05$); DAP = Days after plant

Table 2. Effect of harvesting ages and administration of urea fertilizer doses on biomass production, sugar content, and biomass profile of sorghum *Var* Samurai 2 at second harvest (Ratoon 1) based on fresh weight

Cutting age	Urea doses			
	200kg/ha	300kg/ha	400kg/ha	Mean ± S.D
Chlorophyll (Unit)				
80 DAP	39,82±7,63	38,23±2,61	35,04±4,89	37,70±2,51
85 DAP	36,91±4,25	34,78±3,64	35,06±0,66	35,88±1,92
90 DAP	32,91±4,51	33,83±3,44	38,38±1,67	35,04±1,43
Mean ± S.D	36,55±1,88	35,61±0,55	36,16±3,90	
Tiller number (stems)				
80 DAP	3,00±0,43	3,60±0,49	3,10±0,53	3,23±0,05[a]
85 DAP	2,85±0,44	2,80±0,28	3,10±0,35	2,92±0,08[a]
90 DAP	2,40±2,20	2,40±0,54	2,25±0,19	2,35±1,07[b]
Mean ± S.D	2,75±1,02	2,93±0,14	2,82±0,17	
Stem proportion (%)				
80 DAP	58,56±1,88	62,29±2,94	59,46±3,58	60,13±0,97[b]
85 DAP	65,74±4,31	59,47±1,50	62,21±7,03	62,47±2,76[ab]
90 DAP	63,38±1,41	63,18±4,48	63,15±2,33	63,24±1,50[a]
Mean ± S.D	62,59±1,56	61,65±3,16	61,60±3,65	
Panicle proportion (%)				
80 DAP	22,57±1,33	19,19±1,20	21,69±0,62	21,15±0,21
85 DAP	14,97±0,51	19,91±0,52	16,77±2,28	17,22±1,10
90 DAP	15,31±1,03	15,20±0,91	16,42±0,91	15,64±0,15
Mean ± S.D	17,62±0,54	18,10±0,34	18,29±0,69	
Leaf proportion (%)				
80 DAP	18,77±0,33	18,52±0,53	18,85±1,34	18,71±0,54[b]
85 DAP	19,29±0,76	20,62±0,29	21,03±2,00	20,31±0,89[ab]
90 DAP	21,31±0,78	21,62±0,38	20,43±0,73	21,12±0,20[a]
Mean ± S.D	19,79±0,25	20,25±0,40	20,10±0,64	
Biomass production (ton/h^{-1})				
80 DAP	22,36±6,93	20,14±5,60	25,69±8,43	22,73±1,42[a]
85 DAP	18,33±4,11	20,28±3,64	21,53±12,21	20,05±4,82[ab]
90 DAP	15,42±5,82	17,78±6,40	14,72±3,06	15,97±1,78[b]
Mean ± S.D	18,70±1,42	19,40±1,42	20,65±4,60	
Stem sugar content (%)				
80 DAP	4,07±0,90	6,14±1,77	4,54±2,03	4,92±0,59
85 DAP	4,83±2,26	4,80±1,53	5,72±2,10	5,12±0,39
90 DAP	3,99±2,09	4,73±2,22	4,86±2,09	4,52±0,08
Mean ± S.D	4,30±0,74	5,22±0,35	5,04±0,04	

Different superscripts in the same row or column show significant differences ($p<0.05$); DAH = Days after harvest

Table 3. Effect of harvesting ages and administration of urea fertilizer doses on biomass production, sugar content, and biomass profile of sorghum *Var* Samurai 2 at third harvest (Ratoon2) based on fresh weight.

Cutting age	Urea doses			
	200kg/ha	300kg/ha	400kg/ha	Mean ± S.D
		Chlorophyll (Unit)		
80 DAP	44,85±7,25	38,90±6,07	38,30±9,73	40,68±1,87
85 DAP	40,91±4,68	38,36±3,21	41,58±3,58	40,28±0,77
90 DAP	38,91±2,52	35,89±5,65	37,43±2,84	37,41±1,72
Mean ± S.D	41,55±2,37	37,72±1,55	39,10±3,79	
		Tiller number (stems)		
80 DAP	1,49±0,33	1,50±0,35	2,35±0,70	1,78±0,21[b]
85 DAP	3,13±0,54	2,49±0,33	2,70±0,42	2,77±0,11[a]
90 DAP	1,93±0,50	2,28±1,00	1,30±0,48	1,84±0,30[b]
Mean ± S.D	2,18±0,11	2,09±0,38	2,12±0,15	
		Stem proportion (%)		
80 DAP	58,44±0,81	55,38±3,70	58,47±3,34	57,43±1,27
85 DAP	64,98±2,91	60,39±4,69	60,39±3,53	61,92±0,87
90 DAP	65,64±1,13	62,93±0,44	55,05±3,42	61,21±1,56
Mean ± S.D	63,02±2,91	59,57±0,79	57,97±0,10	
		Panicle proportion (%)		
80 DAP	13,52±1,25	10,42±0,19	8,12±0,42	10,69±0,56
85 DAP	7,90±0,18	8,56±0,19	10,58±0,49	9,01±0,17
90 DAP	10,64±0,29	9,20±0,28	11,19±0,52	10,34±0,14
Mean ± S.D	10,68±0,59	9,39 ±0,05	9,96±0,05	
		Leaf proportion (%)		
80 DAP	28,05±1,13	34,20±0,82	33,41±0,83	31,89±0,10[a]
85 DAP	27,12±1,09	31,60±0,25	29,03±1,00	29,07±0,46[ab]
90 DAP	23,72±0,87	27,87±0,57	33,75±1,80	28,45±0,64[b]
Mean ± S.D	26,30±0,14	31,04±0,29	32,06±0,17	
		Biomass production (ton/h^{-1})		
80 DAP	2,99±1,76	2,51±0,74	3,24±2,68	2,92±0,97
85 DAP	2,99±1,29	4,32±2,11	3,91±3,01	3,74±0,86
90 DAP	3,68±3,52	2,86±1,85	4,18±0,73	3,57±1,40
Mean ± S.D	3,22±1,17	3,23±0,72	3,78±1,23	
		Stem sugar content (%)		
80 DAP	11,72±1,58	12,14±0,64	11,38±1,63	11,74±0,56
85 DAP	12,20±1,85	11,85±0,77	12,65±1,47	12,23±0,55
90 DAP	11,43±2,81	10,82±1,78	11,89±0,89	11,38±0,96
Mean ± S.D	11,78±0,65	11,60±0,63	11,97±0,39	

Different superscripts in the same row or column show significant differences (p<0.05); DAH = Days after harvest

CONCLUSION

Differences in cutting ages of 80, 85, and 90 days at the primary and ratoon harvesting stages resulted in changes in the proportion of fresh plant parts and total forage biomass production but not in the addition of urea (N) doses. Third harvest (Ratoon 2) resulted in a decrease in total biomass production and a significant increase in the sugar content of brix stems (%) compared to first harvest (Primary) and second harvest (Ratoon I) in sorghum *var* Samurai 2.

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