Agronomy characteristics of several types of sorghum from radiation mutations as a ruminant animal feed provide

S S Malalantang1,4, L Abdullah2, P D M H Karti2, I G Permana2 and Nurmahmudi3
1 Ph.D Student of Department of Animal Nutrition and Feed Technology, IPB University, Bogor, Indonesia
2 Department of Animal Nutrition and Feed Technology, IPB University, Bogor, Indonesia
3 Agency for the Assessment and Application of Technology, Indonesia
E-mail: sjenny.sm@gmail.com

Abstract. Sorghum plant has the potential to be the forage of the future because of its endurance to drought. The production and its quality quite high with the ability to be harvested several for one planting. This research was aimed to evaluated the agronomy characteristic of sorghum Samurai 1, Samurai 2, Pahat and BMR Patir 37 as feed in the hard dough phase. The experiment was done by using a completed randomized design (CRD) with 4 types of sorghum and 4 repeated factors. The size of the research field was 2 m x 2 m for each group and was made as many as 16 groups. The distance between each group was 1 m and planting distance for each plant in the group was 25 cm in line. Plants are harvested in the hard dough phase when the seeds cannot be squeezed with fingers. From this research, the results show that based on the agronomic characteristic the potential type for feed production is Samurai 1 which has the production characters such as plant height, stem length, leaf length, leaf width, stem weight, leaf weight, and fresh total biomass that are better than Samurai 2, Pahat, and Patir 37 types.

Keywords: Agronomy, characteristics, feed, ruminants, sorghum.

1. Introduction
The climate fluctuation has the possibility to give a bad effect on to the fodder sustainability in Indonesia. In the dry season, several areas experience drought and it affects the productivity of ruminants, whose life depends on the availability of the greens roughages. With that in mind, it is needed for the evaluation of the ability to produce fodder that can sustain the drought climate. One of the feed plants, which is also a crop, that can endure the drought would be sorghum.

Sorghum is a species that can adapt to a wide environment, cultivated as cereal plants and annual greens in the tropical area, sub-tropical as well as temperate in the world [1]. This type of plant has the ability to adapt to the climate change and drought as well [2]. If there is drought, sorghum leaves are able to reduce the transpiration by quickly rolling itself. Sorghum also is able to adapt to puddle and therefore, it has the potential to be available all year around.

4 To whom any correspondence should be addressed (sjenny.sm@gmail.com)
Sorghum is the fifth main cereal after wheat, rice, corn and barley [3,4]. The type of sorghum in Indonesia is classified into 3 types, which are grain sorghum for the crop, forage sorghum for forage and sweet sorghum as a material for fructose (liquid sugar) or sometimes can be processed further to be bioethanol. Sorghum Samurai 1, Samurai 2, Pahat and BMR Patir 37 are types of sorghum that were acquired as a result of radiation mutation (mutant). Each has different characteristics according to its genetic behavior. The research result [5] of Pahat sorghum showed that the grains production (5 ton ha\(^{-1}\)), plant height (158 cm), tannin (0.012%) and multifunction [5]. The productivity of Samurai 1 grain is higher with 7.5 ton ha\(^{-1}\) and the stem sugar content is around 12-18%, which makes it suitable for bioethanol material. The variety of Samurai 2 has the potential for high productivity, biomass 47 t/ha, while Patir 37 is a specific sorghum for fodder as it has relatively low lignin and tannin content.

Sorghum plants can be used as a substitute for corn on a dry ranch [7]. The advantage of sorghum is in its capacity to hold production and quality even though in its second harvest [8]. Identifying the stem, leaves, and sorghum flower that has different variety become important because of the possibility that gives a different response to the growth of the specific parts of the plant.

Sorghum profile with the best produce agronomically is needed to minimalize the loss of harvest while facing climate change. The stem, leaf, and sed will affect the production of the plant, therefor it can be decided the variety with the highest production. This writing will explain the comparison of the four mutated sorghum type based on the agronomy characteristic such as plant height, stem length, leaf length, leaf width, stem weight, leaf weight, flower weight, and the total biomass production, and therefore the information of the best sorghum agronomically as ruminant feed supply can be obtained.

2. Material and methods
The research was done at the IPB University experiment field. Before the planting, land cultivation was done and then the research field was formed with a size of 2 m x 2 m, as many as 16 fields. The distance between field was 1 m and the distance between plants in a single line was 25 cm, while the distance between each line was 25 cm, and with that, 81 holes were formed for each field. Before the planting, the soil sample was taken to be analyzed. The soil then was given manure as much as 2 ton/Ha, which continued by liming the soil and after the whole process, then the planting could be done. The sorghum seed planting was done by using a pointy stick to make the holes as deep as 2-3 cm [9]. After the seed sprouted and grew normally, then it was selected so there was only one plant per hole. The fertilizing was done 15 days after planting (HST). As for the fertilizer, it was a combination of urea, TSP, KCI with a ratio of 4:3:2 (g:g:g) with a dose of 270 kg ha\(^{-1}\) [10]. The sorghum harvest was done when the plant reached the phase hard dough. Sorghum harvesting was done with height around ±10 cm above the ground, then it was measured for the production parameter.

3. Experimental design
The experiment was done by using the completed randomized design (CRD), with 4 types of sorghum and 4 repeated factors:

- S1 : Sorghum Samurai 1
- S2 : Sorghum Samurai 2
- PH : Sorghum Pahat
- PT : Sorghum BMR Patir 37

With linear model as shown in equation 1:

\[ Y_{ijk} = \mu + \tau_i + \varepsilon_{ij} \]  

\( Y_{ijk} \): Observation i and duplication j  
\( \mu \): mean  
\( \tau_i \): sorghum variety effect i  
\( \varepsilon_{ij} \): error of i-th and repeated factor
All growth measurements data that was obtained then was analyzed with analysis of variance (ANOVA) and if between each treatment showed any real difference on the level of $P<0.05$ it was then continued with Duncan’s multiple ranges [11].

Observation of Agronomy Characteristic:
1. Plant height (cm) was measured from the base of the stem at the surface of the soil to the tip of the panicle just before harvest.
2. Stem length (cm) was measured from the base of the stem to the panicle of harvest.
3. Leaf length (cm) was measured from the leaf base up to its edge by the fifth leaf in time of harvest.
4. Leaf width (cm) was measured from left to right of the widest part of the leaf on the fifth leaf by the time of harvest.
5. Fresh stem production (ton ha$^{-1}$) was calculated based on the weight of the fresh stem by the time of harvest, multiplied with the production of fresh stem (ton) and area of the harvest field (ha).
6. Fresh leaf production (ton ha$^{-1}$) was calculated based on the weight of the fresh leaf by the time of harvest, multiplied by the production of fresh leaf (ton) and area of harvest field (ha).
7. Production of fresh panicle (t ha$^{-1}$) was calculated based on the fresh panicle weight of the crop at harvest times the production of fresh panicle (t ha$^{-1}$) and the area of harvest.

Fresh biomass (t ha$^{-1}$) was calculated based on the fresh weight of plants at harvest times the production of biomass (t ha$^{-1}$) and the area of harvest.

4. Result and discussion

4.1. Plant height, stem length and panicle length

The result of the research of the average plant height, stem length and panicle length on the sorghum plant Samurai 1, Samurai 2, Pahat, and BMR Patir 37 can be seen in table 1. The plant height is around 128.76 cm to 197.08 cm. The variant analysis result shows that the type of sorghum gives a significant difference ($P<0.05$) to its plant height. Duncan’s multiple ranges shows that the Samurai 1 variety produced taller plant height (197.08 cm) compared to Samurai 2 (182.98 cm), BMR Patir 37 (165.92 cm), and Pahat (128.76 cm).

Table 1. The research result of the average plant height, stem length and panicle length.

| Variables         | Sorghum type       |
|-------------------|--------------------|
|                   | Samurai 1 | Samurai 2 | Pahat | BMR Patir 37 |
| Plant height (cm) | 197.08$^a$ ±0.58 | 182.98$^b$ ±0.67 | 128.76$^c$ ±0.76 | 165.92$^d$ ±0.88 |
| Stem length (cm)  | 165.10$^a$ ±0.64 | 157.01$^b$ ±0.52 | 104.99$^c$ ±0.50 | 140.84$^d$ ±0.62 |
| Panicle length (cm)| 31.98$^a$ ±0.41 | 28.43$^b$ ±0.47 | 23.77$^c$ ±0.72 | 25.09$^d$ ±0.44 |

Notes: Superscripts $^abcd$ on the same line showed a significant difference ($P<0.05$)

The observation result on the plant stem length in table 1. on average, the stem length is between 104.99 cm to 165.10 cm. The variant analysis result shows that the type of sorghum made a real difference ($P<0.05$) to the stem length. Duncan’s multiple ranges showed that Samurai 1 variety produced longer stem length (165.10 cm) compared with Samurai 2 (157.01 cm), BMR Patir 37 (140.84 cm), and Pahat (104.99 cm).

The result that was obtained on the panicle length can be observed in table 1. The panicle length averagely was between 23.77 cm to 31.98 cm. The variant analysis result showed that the sorghum type does make a difference ($P<0.05$) towards the panicle length. Duncan’s multiple ranges showed that the Samurai 1 type produced a panicle length longer (31.98 cm) compared with Samurai 2 (28.43 cm), BMR Patir 37 (25.09 cm), and Pahat (23.77).

The characteristic difference between the four Sorghum are caused by their respective genetic behavior. The average plant height and stem length of Samurai 1 sorghum is bigger than Samurai 2, Pahat and BMR Patir 37. Samurai 1 sorghum is specialized to be harvested of its stem for sugar raw
material or processed for the production of ethanol (sweet sorghum), therefore it has superior plant height and stem. Plant height, stem length and flower length that was collected from the research result are lower from the reported result by [13,14,15,16,17,18]. This difference was caused by the climate, planting distance, soil pH and different soil fertility.

4.2. Width and length of the leaf
The average length and width of the leaves based on the result of the research can be seen in table 2. The length of the leaf on average was between 75.32cm to 81.00 cm. The analysis result showed that sorghum type influenced a real difference (P<0.05) for the length and width of the leaf.

Table 2. The research result of the average length and width leaf on the sorghum plant.

| Variables             | Sorghum type         |
|-----------------------|-----------------------|
|                       | Samurai 1 | Samurai 2 | Pahat | BMR Patir 37 |
| Leaf length (cm)       | 81.00±0.56 | 79.03±0.62 | 75.32±0.79 | 77.30±0.84 |
| Leaf width (cm)        | 9.75±0.24   | 8.60±0.37  | 6.61±0.23  | 7.51±0.24  |

Notes: Superscript a,b,c,d on the same line showed a significant difference (P<0.05)

4.3. Weight of stems, leaves, panicles and biomass production
The average weight of stems, leaves, panicles, and fresh total biomass production can be seen in table 3.

Table 3. The research result towards the average -weight of stem, leaf, panicle, and fresh –biomass.

| Variable                     | Sorghum type         |
|------------------------------|-----------------------|
|                              | Samurai 1 | Samurai 2 | Pahat | BMR Patir 37 |
| Stem weight (t ha⁻¹)         | 34.94±0.19 | 30.82±0.15 | 21.24±0.10 | 24.51±0.08 |
| Leaf weight (t ha⁻¹)         | 13.14±0.23 | 8.70±0.10  | 5.57±0.07  | 6.28±0.25  |
| Panicle weight (t ha⁻¹)      | 7.64±0.17  | 6.53±0.12  | 5.06±0.15  | 5.49±0.05  |
| Total production (t ha⁻¹)    | 55.73±0.34 | 46.05±0.21 | 31.87±0.25 | 36.29±0.24 |

Notes: Superscript a,b,c,d on the same line showed a significant difference (P<0.05).

The average weight of the stem of the plant was around 21.24 ton ha⁻¹ to 34.39 ton ha⁻¹ (table 3.). Based on the variant’s analysis, it can be seen that the varieties give different real influence (P<0.05) to the stem weight. Duncan’s multiple ranges showed that the Samurai 1 variety produced heavier stem weight (34.94 ton ha⁻¹) compared with the Samurai 2 (30.82 ton ha⁻¹), BMR Patir 37 (24.51 ton ha⁻¹), and Pahat (21.24 ton ha⁻¹).

The leaf weight that is written in table 3 showed that the average leaf weight was around 5.57 ton ha⁻¹ up to 13.14 ton ha⁻¹. The result of the variant analysis showed that the sorghum type made a significant difference (P<0.05) toward the leaf weight. Duncan’s multiple ranges showed that Samurai 1 variety produced heavier leaf weight (13.14 ton ha⁻¹) compared to Samurai 2 (8.70 ton ha⁻¹), BMR Patir 37 (6.28 ton ha⁻¹), and Pahat (5.57 ton ha⁻¹).

The weight of the panicle can be seen in table 3. The average weight for it was between 5.06 ton ha⁻¹ and 7.64 ton ha⁻¹. The Analysis result showed that the sorghum type influenced quite a lot (P<0.05) toward the panicle weight. Duncan’s multiple ranges showed that Samurai 1 sorghum produced more panicle weight (7.64 ton ha⁻¹) compared to Samurai 2 (6.53 ton ha⁻¹), BMR Patir 37 (5.49 ton ha⁻¹) and BMR Patir 37 (5.06 ton ha⁻¹).

The production of stem, leaf, and panicle dictates the total of the plant biomass production. The enhancement of the biomass production is caused by the high production of stem, leaf, and flower. This research result is lower than what was reported by Sriangtula et al. [18], Puteri et al. [20] and
Oktanti [21]. This difference was caused by the climate, planting distance, soil pH and different soil fertility.

5. Result and discussion

Agronomically, the type of sorghum that is potentially to be developed as the supply for ruminant feed, would be Samurai 1 sorghum, as it has more of the production characteristic such as plant height, stem length, stem weight, leave length and leave width that is more qualified than those of Samurai 2, BMR Patir 37 and Pahat.

6. References

[1] Department of health Australian Government 2017 The Biology of Sorghum bicolor (L) Moench subs bicolor (Sorghum) (Wisconsin: Department of health)

[2] Meliala M G, Trikoesoemaningtyas and Sopandie D 2017 Keragaan dan kemampuan meratun lima genotipe Sorgum J. Agronomi Indonesia 45 2154-161

[3] Chamarrthi S K, Sharma H C, Vijay P M and Narasu M L 2011 Leaf surface chemistry of sorghum seedlings influencing expression of resistance sorghum shoot fly Atherigona soccata J. Plant Biochem. Biotechnol 20 2211–216. https://doi.org/10.1007/s13562-011-0048-3

[4] Hilley J, Truong S, Olson S, Morishige D and Mullet J 2016 Identification of DwI, A regulator of Sorghum Stem Internode Lenght J. PLoS ONE 11 31-16 https://doi.org/10.1371

[5] Wahyono T, Astuti D A, Wiryawan K G and Sugoro I 2014 Pengujuan ransum kerbau berbahan baku sorghum sebagai sumber serat secara in vitro dan in sacco J. Ilmiah Aplikasi Isotop dan Radiasi 10 2113-126.

[6] Srigatula R, Karti P D M H, Abdullah L, Supryanto and Astuti D A 2016 Dynamics of fiber fraction in generative stage of M10-BMR Sorghum Mutant Lines International J. of Science; Basic and Applied Research (IJSBAR) 25 258-68.

[7] Getachew, Makkar H P S and Beeker 2000 Effect of polyethylene glycol on in vitro degradability of nitrogen and microbial protein synthesis from tanninrich browse and herbaccoccus legumes, Br. J. Nutr. 84 73-83

[8] Mahfouz H, Mohamed A M, Megawer E A and Mahmoud A S 2015 Response of growth parameters, forage quality and yield of dual purpose sorghum to re-growth and different levels of FYM and N fertilizers in reclaimed soil Int J. Curr. Microbiol. APP. Sci. 4 11762-782

[9] Prasad P V V and Staggenborg S 2010 Growth and Production of Sorghum and Millets (Manhattan: Department of Agronomy, Kansas State University).

[10] Supriyanto 2010 Pengembangan sorgum di lahan kering untuk memenuhi kebutuhan pangan, pakan, energi dan industri Makalah Simposium Nasional 2010: Menuju Purworejo Dinamis dan Kreatif http://dppm.uii.ac.id

[11] Steel R G D and Torrie J H 1993 Prinsip dan Prosedur Statistika (Pendekatan Biometrik) Penerjemahan: B Sumantri (Jakarta, ID: Gramedia Pustaka Utama).

[12] Oktanti N 2018 Uji daya hasil sorgum (sorgum bicolor (L) Moench) generasi F5 hasil seleksi dengan metode pedigree [skripsi] (Bogor, ID: Institut Pertanian Bogor).

[13] Miron J, Zuckerman E, Sadeh D, Adin G, Nikbachat M, Yosef E, Ben-Ghedali D, Carmi A, Kipnis T and Solomon R 2005 Yield, composition and in vitro digestibility of new forage sorghum varieties and their ensilage characteristics Anim. Feed Sci. Tech., 120 17–32.

[14] Carmi A, Aharon Y, Edelstein M, Umiel N, Hagiladi A, Yosef E, Nikbacha M, Zenou A and Miron J 2006 Effects of irrigation and plant density on yield, composition and in vitro digestibility of a new forage sorghum variety, tal, at two maturity stages Animal Feed Science and Technology 131 120–132.

[15] Beck P A, Hutchison S, Gunter S A, Losi T C, Stewart C B, Capps P K and Phillips J M 2007 Chemical composition and in situ dry matter and fiber disappearance of sorghum × Sudangrass hybrids J. Anim. Sci. 85 545–555.
[16] Atis I, Konuskan O, Duru M, Gozubenli H and Yilmaz S. 2012. Effect of harvesting time on yield, position and forage quality of some forage sorghum cultivars. Int. J. Agric. Biol, 14, 879–886.

[17] Subagio H and Aqil M 2015 Perakitan dan Pengembangan Varietas Unggul Sorgum untuk Pangan, Pakan, dan Bioenergi e-Jurnal litbang.pertanian.go.id/index.php/lppan/article. 9, 139-50.

[18] Sriagtula R, Karti P D M H, Abdullah L, Supryanto and Astuti D A 2016 Growth biomass and nutrient production of brown midrib sorghum mutant lines at different harvest time Pakistan J. of Nutrition 15, 16524-531.

[19] Telleng M M, Wiryawan K G, Karti P D M H, Permana I G and Abdullah L 2016 Forage Production and nutrient composition of different sorghum varieties cultivated with Indigofera in intercropping system Media Peternakan 39, 3203-209 DOI: 10.5398/medpet.2016.39.1.53

[20] Puteri R E, Karti P D M H, Abdullah L and Supryanto 2016 Productivity and nutrient quality of some sorghum mutant lines at different cutting ages Media Peternakan 38, 2132-137 DOI: 10.5398/medpet.2015.38.2.132

[21] Oktanti N 2018 Uji Daya Hasil Sorgum (Sorghum bicolor (L) Moench) Geenerasi F5 Hasil Seleksi dengan Metode Pedigree [Bachelor Thesis] (Bogor, ID: Institut Pertanian Bogor)