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Productivity, Nutrient Composition, and Hydrocyanic Acid Concentration of Super-2 Forage Sorghum at Different NPK Levels and Planting Spaces

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ABSTRACT

Low digestibility and toxicity of hydrocyanic acid (HCN) in sorghum forage are disadvantage for ruminant. Appropriate fertilizer application and planting strategy can improve sorghum yield and quality. A field experiment was aimed to investigate the productivity, nutrients content, and HCN concentration of Super-2 forage sorghum (*Sorghum bicolor* (L) *Moench*) at different planting spaces and levels of NPK fertilizer. The seeds were planted according to 3×3 factorial design in which the first factor was planting space (J1= 90×20 cm, J2= 75×25 cm, and J3= 60×30 cm) and the second factor was three levels of NPK fertilizer (P1= 0 kg/ha; P2= 100 kg/ha; and P3= 200 kg/ha, respectively). Crude protein (CP), crude fiber (CF), and HCN concentration were affected by the interaction of NPK levels × planting spaces ($p<0.05$). The CP and HCN content increased as NPK levels increased at all planting space patterns while CF content decreased. NPK fertilizer application significantly increased yield production (DM, OM, and CP productions), whereas planting space treatment did not show any improvement except for CF that significantly lower on 60×30 cm planting space. Sorghum receiving 200 kg/ha of NPK at 60×30 cm planting space produced the highest CP and the lowest CF content, resulting in the highest OM and CP biomass production. In conclusion, NPK fertilizer significantly improved productivity and nutrients composition and in the same way, also increased HCN concentration of sorghum Super-2 varieties.

Keywords: hydrocyanic acid; fertilizer level; planting space; biomass sorghum production

INTRODUCTION

In most regions of Indonesia, limited quality and quantity of forage remain to be a common problem that limits the productivity of ruminants. Feed crops are generally planted on marginal land with low soil nutrient contents resulting in a low productivity. Therefore, introducing new species and varieties of fodder and pasture is important to the area where they are scared. Sorghum has been introduced and cultivated in Indonesia particularly in the marginal and dry areas. Compared to the other forages, sorghum is more promising in term of dry matter production, drought tolerance, and better regrowth performance after grazing or cutting (Shakeri *et al*., 2017). However, low digestibility and toxicity of HCN in the young plant are the main disadvantages (Singh *et al*., 2008).

Planting space is closely related to yield density that affects crop production per unit of land area. Grain sorghum is commonly cultivated in a space of 75-100 x 25 cm (Fromme *et al*., 2012). Sharifi *et al*. (2009) explain that higher space density promotes competition among plants in absorbing nutrients. Furthermore, fertilize the soil with compound fertilizer (nitrogen, phosphorus, and potassium), particularly nitrogen is vital for plant growth because it promotes shoot elongation, tillering regeneration, leaf to stem ratio, succulency, and palatability of fodder crop (Choudhary & Phrabu, 2016). Several works observed improvement of sorghum biomass and protein content by increasing nitrogen application but it also lowered forage quality because of increasing hydrocyanic acid (HCN) and nitrate contents, the toxic compounds when consumed by animals (Sher *et al*., 2012; Cameron *et al*., 2013). Generally, forage sorghum is needed to be fertilized with 20 kg of N, 40 kg of P, and 30 kg of K, but it depends on soil characteristics (Buah *et al*., 2012). It is observed when HCN is readily absorbed into the bloodstream of grazing ruminants, it causes cellular asphyxiation leading to an illness of cattle even at a dose as little as 0.5 g (Karthika & Kalpana, 2017).

Hydrocyanic acid concentration is heritable and subjected to modification through selection and breeding, as well as by climate, the stage of maturity, the stunting of plant, the type of soil and fertilizer. Compound fertilizer (NPK) application is considered to be essential for growth and regrowth during growing season. NPK fertilizer contains more than one nutrients, the primary macronutrient content is NPK (16:16:16) which is 16% Nitrogen element (N), 16% Phosphorus element (P) and 16% Potassium element (K), and the other secondary macronutrients (Li *et al*., 2010). However, a higher level of fertilizer application may increase prussic acid contents that ultimately poison to animals (Karthika & Kalpana, 2017). The farmers are generally not familiar with the optimum growth stage of forage sorghum that should be fed to the livestock. They apply either over or underdose of nitrogen fertilizer to get the higher forage yield of sorghum and harvest at any growth stage without having the knowledge of HCN poisoning and its relation with these practices (Karthika & Kalpana, 2017).

There are very few studies testing the effect of plant spacing and dosage of NPK fertilizer on sorghum biomass production as ruminant feed. Therefore, it needs to be further investigated. This study aimed to evaluate the growth performance in the form of plant height and productivity of dry matter (DM), organic matter (OM), crude protein (CP) and HCN concentrations in Super-2 varieties of sorghum as animal feed at different planting spaces and doses of NPK fertilizer.

MATERIALS AND METHODS

Study Site Condition

A field study was carried out within 6 months from January to June 2017 at the pasture research land of Agrotechnology Innovation Center, Universitas Gadjah Mada. The soil characteristics and chemical composition were presented in Table 1. The study area was situated at -7°79′N latitude, 110°46′E longitude and 120 m above mean sea level, received annual rainfall at 2.157 mm and the average temperature was 23-29°C.

Experimental Design and Treatments

The study was arranged for 3×3 factorial design in a completely randomized block design whereas the first factor was planting space and the second factor was levels of NPK fertilizer with three replications, resulting in 27 experimental units. Sorghum seed (*Sorghum bicolor* (L) *Moench*, Super-2 varieties) from the cereal plant research center, Maros, South Sulawesi, was cultivated in 27 plots with 3×4 m for each in three different spaces (J1= 90×20 cm, J2= 75×25 cm, and J3= 60×30 cm, respectively). For the second factor, the NPK fertilizer was applied in which group P1 didn't receive fertilizer (0 kg/ha), group P2 received 100 kg/ha, and group P3 received 200 kg/ha, respectively of compound fertilizer with a ratio of N, P, and K at 16:16:16, respectively.

Briefly, the soil was homogenized using manual tractor and received 5 ton/ha manure as organic fertilizer obtained from beef cattle farm in the same area that contained 18% of organic matter. Thereafter, three seeds of sorghum were planted in each hole and NPK fertilizer was applied 14 days later at sorghum ratoon. The NPK fertilizer was applied 5-10 cm underground. Watering was conducted by weekly technical irrigation system as well as weeding schedule. Defoliation was conducted 60 d after planting. Further, after regrowth phase 1 was completed in 60 d, the plants were defoliated for the 2-phase. Plant height was measured individually starting from the ground to the highest point of the plants in each plot.

Forage Biomass Determination and Laboratory Analysis

Collected samples from all parts of the plant were cut 3-5 cm in length and packed in the dark bag then immediately dried at 55°C for 72 h. Further, the samples were milled through a 1-mm screen for proximate and HCN concentration analysis. The chemical composition of samples were analyzed according to AOAC (2005) for DM (method 973.18), OM (method 942.05), CF (method 963.09) and CP (method 984.13), while ether extract (EE) was measured using method by Kamal (1997). Crude protein was determined by analyze N concentration using the Kjeldahl method then CP was calculated by multiplying the N content by 6.25 (CP= N × 6.25). Total DM, OM, and CP production were calculated by biomass production= biomass (DM, OM, CP) × chemical composition (DM, OM, CP) (%) of fresh production of forage.

Hydrocyanic acid analysis was conducted at the Laboratory of Food and Agriculture Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada according to Bradbury *et al*. (1999). Briefly, each sample was ground up with a mortar and weighted at 100 mg. A buffer solution at pH 6 was placed in a flat bottom plastic bottle then added by 1 mL of distilled water and 100 mg of sample and the bottle was closed with a screw-capped lid. Blank was made similarly with no leaves or sample. All of the bottles were stand up for 24 h at the room temperature (25°C). The plastic stripe from the picrate paper was removed carefully. The picrate papers both blank and sample were immersed in 5 mL of water for shaking for about 30 minutes. After that, the picrate papers were removed from both bottles after 30 minutes. The absorbance of the picrate solution was measured through spectrophotometer at 510 nm and

Table 1. Soil inceptisol characteristics of the field experiment

Soil variables	Value (%)
Fraction percentage	
Sand content	71.23
Dust content	18.85
Clayey content	9.92
Chemical characteristics	
pH value	6.6
Organic matter content	2.38
N total	<0.1
P total	0.05
K total	0.7
C	1.38
C/N ratio	15
Fulvic acid	0.11
Humic acid	0.07
Humin	2.21

cyanide concentration (ppm) was calculated by multiplying the absorbance value with 396.

Statistical Analysis

The collected data were subjected to two-way Analysis of Variance following the completely randomized block design in 3×3 factorial arrangement. The planting space and levels of NPK fertilizer were applied as fixed factors while replication is a random factor. The differences between treatment means were subjected to Duncan's Multiple Range Test when p<0.05. SPSS version 16.0 was employed to analyze the data.

RESULTS

Nutrients Composition of Sorghum Super-2

Analysis of variance indicated that there were no interaction effects from planting space × levels of NPK fertilizer (p<0.05) on nutrient compositions (DM, OM, CP, and CF). Treatments also did not affect DM and OM composition of the sorghum (p>0.05). For CP and CF content, increasing NPK levels would increase CP and decrease CF content of the sorghum (p<0.05). The average ranges of sorghum contents were 50.7-59.8 g/kg DM for CP and 350.4-359.6 g/kg DM for CF, respectively (Table 2). On average, the CP content increased by 17.9% compared with control treatment when a 200 kg/ha of NPK was applied. Furthermore, the CF content showed a reverse trend with 2.56% decreased when 200 kg/ha NPK fertilizer was applied. Also, planting space significantly affected CP and CF content of the sorghum (p<0.05). The J1 treatment produced higher average CP content than other planting spaces treatment while it also resulted in a higher average CF content.

Productivity of Sorghum Super-2 Varieties

Biomass productivities of forage sorghum were evaluated by measuring the height of plant, DM, OM, and CP biomass production from the second ratoon.

The height of sorghum. The interaction effect between NPK levels and planting spaces was not detected for plant height of sorghum Super-2 in this experiment (p>0.05). The average plant heights from the research were 309.33 cm for J1, 295.00 cm for J2, and 305.67 cm for J3, respectively, as is shown in Table 3. There was no significant different observed in the height of plant as influenced by different planting spaces. However, a significant increase was observed with the increasing levels of NPK fertilizer. The averages of plant height from P1, P2, P3 NPK levels were 275.17, 304.44, and 330.39 cm, respectively. The highest plant was found in the plant that received 200 kg/ha of NPK fertilizer, in which there was an increase of 16.71% compared to the group without NPK fertilizer.

Dry matter production. The NPK fertilizer significantly increased DM production of the sorghum (p<0.05) while the DM production was not influenced by the planting space. Average DM production from Super-2 sorghum varieties was 1.83 tons/ha for P1, 3.07 tons/ha for P2, and 3.54 tons/ha for P3, respectively. The highest production of sorghum Super-2 varieties was obtained at 200 kg/ha NPK dose that resulted in 3.72 tons/ha of DM while control group which did not receive NPK fertilizer showed the lowest DM production of 1.59 tons/ha. There was no significant interaction effect of the level of NPK rate and planting space on dry matter production in this study.

Table 2. Average of dry matter, organic matter, crude protein, and crude fiber contents of sorghum super-2 varieties treated with different planting spaces and levels of NPK fertilizer

Variables	Levels of NPK (kg/ha)	Planting space (cm)			Average
		J1	J2	J3	
Dry matter (g/kg)	P1	233.4±6.4	243.4±6.4	252.4±9.1	243.1±5.4
	P2	254.4±3.2	229.5±4.8	253.7±4.5	245.9±5.9
	P3	247.3±4.4	232.9±7.2	231.6±3.3	237.2±6.8
	Average	245.0±7.8	235.3±3.9	245.9±7.1	
Organic matter (g/kg DM)	P1	932.8±8.2	935.0±1.3	932.5±3.3	933.4±4.6
	P2	941.0±2.8	933.4±4.2	938.7±3.5	937.7±4.6
	P3	932.8±3.0	937.2±4.5	939.7±5.0	936.6±4.8
	Average	935.5±6.1	935.2±3.5	936.9±4.8	
Crude protein (g/kg DM)	P1	53.1±1.2	47.1±1.4	51.8±1.0	50.7±1.5^{y}
	P2	54.6±1.7	49.7±1.4	54.9±1.6	53.0±1.6^{y}
	P3	62.7±1.5	57.8±1.9	58.9±1.3	59.8±1.8^{x}
	Average	56.8±1.3^{p}	51.5±1.7^{q}	55.2±1.6^{pq}	
Crude fiber (g/kg DM)	P1	360.6±1.7	360.5±0.2	357.7±0.6	359.6±1.7^{x}
	P2	357.3±0.6	351.3±0.4	351.6±0.4	353.4±1.9^{y}
	P3	352.4±0.2	348.6±1.3	350.3±0.6	350.4±1.8^{z}
	Average	356.7±1.7^{p}	353.4±1.4^{q}	353.2±1.4^{q}	

Note: ^{p,q} Means in the same row with different superscripts differ significantly (p<0.05); ^{x,y,z} Means in the same column with different superscripts differ significantly (p<0.05); J1= planting space at 90×20 cm; J2= planting space at 75×25 cm; and J3= planting space at 60×30 cm; P1= NPK fertilizer level at 0 kg/ha; P2= NPK fertilizer level at 100 kg/ha; and P3= NPK fertilizer level at 200 kg/ha.

Table 3. Average of plant height, dry matter production, organic matter production, and crude protein production of sorghum super-2 treated with different planting spaces and levels of NPK fertilizer

Variables	Levels of NPK (kg/ha)	Planting space (cm)			Average
		J1	J2	J3	
Plant height (cm)	P1	285.50±2.12	242.00±2.83	298.00±2.83	275.17±2.84[z]
	P2	306.67±2.82	305.00±1.41	301.67±0.71	304.44±2.28[y]
	P3	335.83±2.83	338.00±0.71	317.33±2.12	330.39±2.29[x]
	Average	309.33±2.64	295.00±2.61	305.67±2.80	
Dry matter production (tons/ha)	P1	1.59±0.08	1.89±0.04	1.99±0.05	1.83±0.09[y]
	P2	2.95±0.06	2.99±0.09	3.25±0.04	3.07±0.03[x]
	P3	3.44±0.08	3.72±0.09	3.45±0.07	3.54±0.07[x]
	Average	2.66±0.09	2.87±0.10	2.90±0.05	
Organic matter production (tons/ha)	P1	1.48±0.02	1.76±0.08	1.88±0.05	1.71±0.07[y]
	P2	2.76±0.04	2.82±0.06	3.05±0.02	2.87±0.08[x]
	P3	3.20±0.04	3.48±0.08	3.23±0.07	3.30±0.06[x]
	Average	2.48±0.04	2.69±0.09	2.72±0.08	
Crude protein production (tons/ha)	P1	0.083±0.002	0.087±0.004	0.100±0.001	0.090±0.005[z]
	P2	0.163±0.007	0.153±0.007	0.180±0.006	0.166±0.006[y]
	P3	0.217±0.005	0.217±0.009	0.207±0.008	0.213±0.008[x]
	Average	0.154±0.003	0.152±0.007	0.162±0.006	

Note: [x,y,z] Means in the same column with different superscripts differ significantly (p<0.05); J1= planting space at 90×20 cm; J2= planting space at 75×25 cm; and J3= planting space at 60×30 cm; P1= NPK fertilizer level at 0 kg/ha; P2= NPK fertilizer level at 100 kg/ha; and P3= NPK fertilizer level at 200 kg/ha.

Organic matter production. The planting space factor did not affect the organic matter (OM) production of sorghum Super-2 varieties. The result was in line with plant height and DM production of the forage sorghum. NPK application significantly improved sorghum OM production (p<0.05) (Table 3). The OM of sorghum receiving 100 kg/ha and 200 kg/ha of NPK increased by 40.42% and 48.18%, respectively, compared with plant without NPK fertilizer. The average OM production from each NPK levels of P1, P2, and P3 were 1.71 tons/ha, 2.87 tons/ha, and 3.30 tons/ha, respectively. For OM production, the interaction effect from the treatments did not significant (p>0.05).

Crude protein production. Crude protein (CP) production represents the amount of CP as biomass produced by sorghum that can be utilized by ruminants (Table 3). The CP production was not affected by different planting spaces as this result is in line with plant height, DM, and OM production yields. Increasing levels of NPK application significantly increased CP production (p<0.05). There was no effect of NPK levels × planting spaces on CP production (p>0.05).

Hydrocyanic Acids Concentration of Sorghum Super-2 Varieties

The concentration of hydrocyanic acid (HCN) of Super-2 forage sorghum was presented in Table 4. The HCN concentrations were affected by NPK levels and planting space shown by a significant interaction between the factors (p<0.05; Table 4). Treatment of J3 and P1 resulted in the lowest HCN concentration (145.78 ppm) in comparison with other treatments (p<0.05). Meanwhile, J2 and P3 treatments produced the highest concentration of HCN (243.67 ppm) than other treatments (p<0.05).

Table 4. Hydrocyanic acid (HCN) concentration (ppm) of sorghum super-2 varieties treated with different levels of NPK fertilizer and planting spaces

Levels of NPK (kg/ha)	Planting space (cm)		
	J1	J2	J3
P1	198.28±9.23[bc]	168.24±2.62[cd]	145.78±6.28[d]
P2	182.84±5.17[bc]	198.65±4.59[bc]	190.91±9.05[bc]
P3	177.18±5.35[bc]	234.67±7.58[a]	186.72±5.00[b]

Note: Means with different superscripts differ significantly (p<0.05); J1= planting space at 90×20 cm; J2= planting space at 75×25 cm; and J3= planting space at 60×30 cm; P1= NPK fertilizer level at 0 kg/ha; P2= NPK fertilizer level at 100 kg/ha; and P3= NPK fertilizer level at 200 kg/ha.

DISCUSSION

Nutrient Composition

The application of NPK fertilizer into different planting spaces of sorghum super-2 was expected to fill soil nutrients under marginal land with a desired enable space and nutrients to be used more effectively by the plant. The higher the CP content with the lower CF content of sorghum super-2 fertilized with the increasing levels of NPK fertilizer possibly due to the more available N that could improve soil nutrition that eventually improved forage sorghum quality. It has been suggested that CP content is primarily improved by the higher N applications (Hoffman *et al.*, 2014). The CP content of the sorghum in the current research ranged on 47.1-62.7 g/kg DM that was lower when compared with the result of Khan *et al*. (2007) reporting the average CP content of 94.2 g/kg DM in the second cutting stage. The lower result was primarily related to the time of measurement; in the present study, the CP content was quantified on the second regrowth of the plant. Rahman *et al*. (2001) stated that the nutritive value of forage reduced after regrowth phase. Nutritive values of sorghum are also vary among varieties (Ardiansyah *et al*., 2016; Sriagtula *et al*., 2017). The CP content of sorghum can be two-times higher in the first growth. For instance, Puteri *et al*. (2015) reported the range of CP content of 108.9-136.2 g/kg DM in some sorghum mutant lines quantified in the first cutting stage.

Katterings *et al.* (2005) explain that forage yield and quality characteristics are generally determined by the harvesting stage, genotype, management practice, and cutting times. Increasing number of cuttings reduces the biomass production and chemical composition of the forage. Rahman *et al.* (2001) suggested that the quality of sorghum reduced up to 40% when cutting by multiple times that attributable to the loss of vigour in plants and the reductions of the number of tillers. It was also reported that CP content reduced from 11.6% to 5.8% due to harvesting after regrowth or grazing.

Nitrogen fertilizer plays vital roles in improving the sorghum production, particularly in the beginning phase of growing because the starter fertilizer can promote early growth that enables plants to capture more radiation and other soil nutrients overall during the growing season (Subedi & Ma, 2009). Hence, an increase in CP content and CP biomass yield resulted from NPK application may subsequently be responsible for the benefits of N fertilizer on protein yield.

Furthermore, fiber fraction of plants such as NDF (hemicelluloses, cellulose, and lignin) and ADF (cellulose and lignin) are considered to be the important indicators of forage quality when it functions as ruminant animal feed (Assefa & Ledin, 2001). Higher quality sorghum characterized by a lower CF content in this study was in opposition with several previous studies. Chaturvedi (2005) and Liman *et. al*. (2018) found that under nitrogen treatment, sweet sorghum had higher concentration of NDF and ADF. Similarly, it was also reported by Wang *et al*. (2015) and Zhang *et al*. (2016) that N fertilizer had limited effect on forage quality. It could also be associated with the other factors such as varieties, soil characteristics, cutting period, and environmental condition. Lower CF content as an effect of increasing NPK levels in this study can be further investigated to study the possible way to improve forage quality.

Biomass Production

The amount of dry matter production obtained in this study was presented in the Table 3. It showed that DPM ranged on 1.59-3.45 tons/ha, while Sriagtula *et al.* (2016) reported the average DMP of 7.04-7.76 tons/ha from variety of lines in the first cutting stage. The average results were lower because the present DMP was obtained only from the second ratoon while other studies were almost from the first growth of plant. The lower DMP eventually influenced the lower OM, CP and CF productions compared with the results reported by Sriagtula *et al*. (2016).

The increase of plant height in this study can be explained as a response to the improved availability of nitrogen in the soil. Hao *et al*. (2014) reported that increasing levels of nitrogen into the cultivated plant promoted the photosynthesis process. Nitrogen plays an urgent role in plant growth because the plant leaves are an important component in the photosynthesis. The higher height of plant is mainly caused by the increasing concentrations of NPK fertilizing doses. The higher N, P and K availabilities will increase the accumulation of photosynthate in the upper part of the plant. This is consistent with the argument of Kumar *et al.* (2013) suggesting that photosynthesis is influenced primarily by the availability of nitrogen. Sawargaonkar *et al.* (2013) demonstrated an increase in forage yield by 56% with application of nitrogen fertilizer of 90 kg/ha relative to group without N fertilizer while Buah *et al*. (2012) obtained an increase of 40%-69% by N application between 40-120 kg/ha.

Higher OM production is an expression of the higher growth rate of the plant. Nitrogen and the other fertilizer elements such as P and K are important to maintain the tiller density and reproductive development. Those elements are critical in enhancing soil nutrient in supporting the improvement of sorghum biomass production. Ali *et al*. (2014) reported that initial trials with NPK in compound form showed the most promising effects on plant biomass production compared with individual (N, P, K) and combined (NP, PK, NK) effects of fertilizer treatments. Lee *et al*. (2017) suggested that determining optimal agronomic management could be a useful tool for improving forage biomass yields.

Production of OM of Sorghum Super-2 was not affected by the interaction between plant spacing and NPK fertilizer level. The OM plant production is a net production of plants. The amount of plant ash varies depending on the plant species and the intensity of sunlight that hits it. Nutrients absorbed by plants from the soil are mineral constituent parts of the plant. A number of authors reported that soil fertility was improved by application of NPK fertilizer. Nitrogen fertilizer promotes sucrose content, protein percent and growth rate in sweet sorghum (Kumar *et al.,* 2013). As reflected from this study, it indicates that the increase total tiller number resulted from the increasing levels of NPK application ultimately increases the biomass yields in term of organic matter.

The highest increased in CP production from 0.09 tons/ha to 0.213 tons/ha was observed when 200 kg/ha NPK fertilizer was applied. That increase can be related to the role of NPK fertilizer in influencing N content in the soil and plant. The more available N, the more N sources can be formed in the plant (Arundale *et al*., 2014). Production of CP biomass is also influenced by the DM production. In fodder crops such as sorghum, sudan grass, and pearl millet, improvement of crude protein, ether extract, and digestible dry matter yields were reported upon N application (Mohan *et al*., 2015). Ayub *et al*. (2002) reported that quality parameter of forage sorghum, such as CP, EE, and ash content, increased with the increased level of N fertilization. However, neutral and acid detergent contents decreased with the increase in N levels.

Hydrocyanic Acid Content

In regard with concentration of HCN in the forage sorghum, Purnomohadi (2016) reported that sweet sorghum varieties fertilized by 200 kg/ha of urea had range of HCN from 209-258 ppm whereas normal range of HCN content only around 102-234 ppm. The increasing phenomena of HCN content can be related to the role of N fertilizer. Among many factors, unevenness of nitrogen and phosphorus contents in the soil causes the increase in HCN concentration. Similarly, the higher level of nitrogen application increased HCN concentration of forage sorghum that eventually poisoning animals (Sher *et al*., 2013).

Sher *et al*. (2012) report that the maximum safe limit recommended for cyanide acid concentration in plants is 300-500 ppm. Treatment of planting space significantly influenced ($p<0.05$) cyanide acid concentration. Glucosianogenic levels can be decreased with increasing plant density, and vice versa (Sher *et al*., 2012). However, the present finding showed there was no significant different on HCN concentration indicating that the ranges of current planting space did not change metabolism. The results showed that the addition of NPK fertilizer and planting space showed a significant interaction effect on hydrocyanic acid content.

CONCLUSION

Application of NPK fertilizer significantly improved productivity and nutrients composition and in the same way also increased HCN concentration of sorghum Super-2 varieties. Planting space did not affect productivity, HCN concentration, and major nutrients composition of sorghum super-2 varieties except for the crude fiber that was significantly lower on 60×30 cm planting space. Sorghum receiving 200 kg/ha of NPK at 60×30 cm planting space produced the highest CP and the lowest CF content, resulting in the highest OM and CP biomass production.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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