Annals of Agri-Bio Research **28** (1): 85-89, 2023 **Impact Score : 0.28 (Scopus)**

Yield, Seed Protein Content and Percentage Stem Sugar in Ratoon Sorghum Varieties with Liquid Organic Fertilizer

EKA NURMALA SARI, SUPRIYONO* AND PUJI HARSONO

Department of Agronomy, Graduate School, Faculty of Agriculture, Universitas Sebelas Maret (UNS), Jl. Ir. Sutami 36A, Kentingan, Surakarta, 57126, Central Java, Indonesia
**(e-mail: supriyono_uns@yahoo.com; Mobile: +628 13929 83443)*

(Received: May 20, 2022; Accepted: June 28, 2022)

ABSTRACT

Sorghum belongs to multipurpose cereal with high protein content and can potentially be an alternative food. This plant could be cultivated using ratoon system. The advantages of ratoon system are shorter harvesting time, less need for water and lower production cost. The application of liquid organic fertilizer (LOF) functions to supply nutrition to the plant to get optimum yield. The objective of research was to get sorghum variety in the first ratoon with LOF dose providing high yield, seed protein content and percentage stem sugar. The result showed that there was an interaction between treatments or factors, indicating the highest panicle weight per plant and seed weight per plant in Numbu variety with LOF dose of 6 l/ha. Highest seed protein content was obtained in Suri 3 variety with LOF dose of 9 l/ha, and highest stem sap sugar content in Kawali variety with LOF dose of 6 l/ha.

Key words: Nutrition, alternative food, cereal, multipurpose plant

INTRODUCTION

Food diversification is an alternative method to improve food resilience. Sorghum, a multipurpose cereal plant producing seeds occupying the fifth position as the plant, is grown globally (Mundia *et al.*, 2019). Sorghum had similar nutrition content to other cereal plants: 60-80% carbohydrate (Mukkun *et al.*, 2021), 1.24-3.07 g/100 g fat (Leandro *et al.*, 2017), and 9.03-12.73% protein (Mukkun *et al.*, 2021). High protein content of sorghum can be the source of plant protein. The advantages of sorghum compared with other food plants are more adaptive to marginal land, resistant to climate change (Hossain *et al.*, 2022) and needing minimum irrigation (2.5-36 mm/day; Araya *et al.*, 2018). All parts of sorghum could be utilized as food, cattle feed, forage and bioethanol sources; thus, it belongs to the plant with economic value and can be of income source to farmers.

Sorghum can also be cultivated as ratoon crop. Ratoon is shoot growing from the stem of first plant that has been cut for harvesting of seed and then cultivated (Ardiyanti *et al.*, 2019). It is supported with stronger rooting system, wider and deeper to find nutrition. Other advantages of ratoon system among others are: faster harvesting time, food production in any season and suppressing production cost. It is in line with Syuryawati *et al.* (2021) study finding that ratoon system had 57% higher production cost with 2-fold higher profit than the first crop for seed.

To achieve higher yield, adequate nutrition supply is needed. Liquid organic fertilizer (LOF) contains complete nutrition including macro and micro nutrient with growth regulator (Shaik *et al.*, 2022). LOF use is more environment-friendly and supports the effort of developing sustainable farming program. The objective of research was to examine the interaction between various sorghum varieties in the first ratoon and LOF dose, yield, seed protein content and percentage stem sugar.

MATERIALS AND METHODS

The experiment was conducted in February-December 2021 in Cabean Village, Bendosari Sub District, Sukoharjo Regency, Central Java, Indonesia. Protein analysis was carried out in Food Chemical Laboratory, Faculty of Agriculture, Universitas Sebelas Maret

Surakarta. The research used a factorial randomized complete block design (RCBD). The first factor was sorghum variety consisting of Numbu, Kawali and Suri 3. The second factor was LOF dose consisting of four levels: 0, 3, 6 and 9 l/ha. The data were analyzed using analysis of variance (ANOVA) at 5%, followed with Duncan multiple range test at 5% level. Ratoon was made after the first crop was harvested by cutting the part of first joint on sorghum stem about 10 cm above soil surface. Then, two shoots growing from the stem base were selected. The samples were selected using random sampling technique, obtaining three sample plants out of 36 trial compartments, with a total of 108 sample plants. The nutrient content of LOF used included, among others: N 4.15% (10.375 ml), P_2O_5 4.45% (11.125 ml), K_2O 5.66% (14.15 ml), C organic 9.69% (24.9 ml), Fe 505.5 ppm (0.5 ml/l), Mn 1931.1 ppm (1.93 ml/l) , Cu 1179.8 ppm (1.18 ml/l) , Zn 1986.1 ppm (1.98 ml/l) and B 806.6 ppm (8.6 ml/l) at pH 5.61. In addition, this LOF contained humic acid, fulvic acid and growth regulator (giberelin, cytokinin and auxin). The application of LOF was conducted by spraying it using electric knapsack sprayer. The recommended LOF dose was 20-60 cc with 10-30 l water solvent for 100 m^2. This recommended dose was extra to the determination of treatment dose.

Panicle and seed weight per plant (g) were obtained at harvest using analytical balance. The stem's sap sugar level (% brix) was observed by Atago hand refractometer at 105 days after cutting. Protein content was analyzed using micro-Kjedahl method, by weighing 1 g of sorghum seed flour and pouring it into Kjeldhal 100 ml-tube, then adding 7 g of K_2SO_4 and 0.8 g $CuSO_4$ and 12 ml thick H_2SO_4 solution. All materials were heated in destruction tube. It was diluted with aquaduct to get 100 ml solution. The next process was distillation process by adding 50 ml of 40% NaOH and some boiling stones into Kjeldahl tube containing sample. The distillation yield was put into Erlenmeyer containing 30 ml 1% H_3BO_3 with mixed indicator. Distillate was titrated using standard 0.1 M HCL until its colour changed into bright purple. The formula used in determining % protein of sorghum seed was:

$$\text{Percentage N level} = \frac{(ts - tb) \times \text{N HCL} \times 14.008 \times 100\%}{\text{mg sample}}$$

Protein level = % N x 6.25, where, ts: titration volume of sample and tb: titration volume of blank.

RESULTS AND DISCUSSION

Panicle weight was affected by stove weights of panicle and seed growing on the panicle. The panicle weight was the result of dry material accumulation in 50% blossoming phase affected by nutrition, water and temperature during flower initiation that could affect the harvested yield (Zhou *et al.*, 2022). There was an interaction between sorghum varieties in the first ratoon and LOF dose, and panicle weight per plant (Table 1). The highest panicle weight per plant, 67.06 g, was found in Numbu variety at LOF dose of 6 l/ha. The panicle weight per plant was not significantly different at various LOF doses in Kawali and Suri 3 varieties. It indicated that Numbu variety had better response than Kawali and Suri 3 in the term of panicle weight per plant. Sorghum yield was affected by morphological characteristics of respective varieties including varying panicle length, panicle type, seed shape and seed number (Saputro *et al.*, 2021). Morphologically, the panicle of Numbu variety was wide in the middle and had more compact panicle and medium density. The panicle character was very important in determining seed yield, and in identifying and classifying the variety (Rini *et al.*, 2020).

Table 1. The effect of LOF dose on panicle weight per plant (g) in various sorghum varieties in the first ratoon

Sorghum variety	Liquid organic fertilizer dose (l/ha)				
	0	3	6	9	Mean
Numbu	32.56a	27.88a	67.06c	63.1bc	47.65
Kawali	34.16a	33.41a	50.01abc	37.45ab	38.75
Suri 3	40.37abc	56.19abc	43.4abc	37.14ab	44.28
Mean	36	39	53	46	

Different letters indicate the significance at 5% level.

Seed weight was identical with potential yield of a plant variety. The seed weight, according to Jabereldar *et al.* (2017), reflected the correlation between the quantity of nutrition absorbed by the plant and the photosynthesis yield during seed fulfilling process. There was an interaction between sorghum varieties in the first ratoon and LOF dose, and seed weight per plant (Table 2). The highest seed weight per plant (50.55 g) was found in Numbu variety at LOF dose of 6 l/ha. Kawali and Suri 3 varieties did not show significantly different seed weight per plant at varying LOC doses. Various sorghum varieties planted on the same site would show different growth responses and yields. Harsono and Setyowati (2020) study found that Numbu variety had longer string than Kawali does, indicating that string length correlated to seed yield. Each of variety had different seed-producing abilities. Seed formation was affected by environmental factors such as nutrient availability. Ajeigbe *et al.* (2018) stated that the optimum fertilizer application contributed importantly to sorghum yield and quality. The optimum fertilizer quantity was correlated to the maximum production efficiency.

Table 2. The effect of LOF dose on seed weight per plant (g) in various sorghum varieties in the first ratoon

Sorghum variety	Liquid organic fertilizer dose (l/ha)				
	0	3	6	9	Mean
Numbu	18.04a	18.03a	50.55c	44.75bc	32.84
Kawali	24.48ab	36.2abc	38.5abc	24.96ab	31.03
Suri 3	21.98a	39.3abc	30.41abc	28.4ab	30.02
Mean	21.5	31.17	39.82	37.7	

Different letters indicate the significance at 5% level.

Protein was macromolecule functioning to compose body tissues and to maintain the organ health. Protein content of sorghum, according to Mukkun *et al.* (2021), ranged between 9.03 and 12.73%, indicating that sorghum served as protein source to fulfill the food need. There was an interaction between sorghum varieties in the first ratoon and LOF dose, and protein content of seed (Table 3). The highest protein content of seed (9.29%) was found in Suri 3 variety at LOF dose of 9 l/ha.

Table 3. The effect of LOF dose on protein content of sorghum seed (%) in various sorghum varieties in the first ratoon

Sorghum variety	Liquid organic fertilizer dose (l/ha)				
	0	3	6	9	Mean
Numbu	8.57cd	7.43b	8.5cd	6.39a	7.71
Kawali	9.26d	9.14d	8.66cd	7.95bc	8.75
Suri 3	7.99bc	8.89cd	8.37bcd	9.29d	8.64
Mean	8.60	8.48	8.51	7.87	

Different letters indicate the significance at 5% level.

Numbu and Kawali varieties showed lower protein content of seed with the increased LOF dose. Meanwhile, Suri 3 was more responsive to LOF dose administration as indicated with the increased protein content of seed along with the increased LOF dose. Varying protein content and composition of each plant were affected by genotype, water supply, temperature, soil fertility and environment condition during the plant growth (Frankowski *et al.*, 2022). Nitrogen content of fertilizer contributed to amino acid formation in the plant, thereby yielding high protein content. It was because nitrogen functioned to compose amino acid and protein in the plant. The protein contained in sorghum seed was rich of glutamic acid, non-polar amino acid (proline, leucine and alanine) and lysine (Moraes *et al.*, 2012). The high protein content of sorghum seed made it the potential sources of food and alternative cattle feed. This potential could be a solution to the food crisis.

Sap was a fluid contained in the plant stem containing sugar and other (non-sugar) substances such as water, fiber, organic and non-organic substances. Sorghum contained brix sugar between 12 and 20% (Shukla *et al.*, 2017). The sugar content of sorghum stem sap could be utilized as basic material of sugar and bioethanol production. There was an interaction between sorghum varieties in the first ratoon and LOF dose, and the sugar content of stem sap (Table 4). The highest sugar content stem sap (13.13% brix) was found in Kawali variety at LOF dose of 6 l/ha, indicating the significant difference in varying LOF doses. Numbu variety showed the insignificantly different sugar content of stem sap in varying LOF doses. Suri 3 variety showed lower sugar content of stem sap along with the increased LOF dose. The response of respective sorghum varieties to LOF dose application showed different yield of stem sap sugar content, with Kawali showing better response than Numbu and Suri 3.

Table 4. The effect of LOF on the content of the stem sap sugar (% Brix) of various sorghum varieties in the first ratoon at day 105 after cutting

Sorghum variety	Liquid organic fertilizer dose (l/ha)				
	0	3	6	9	Mean
Numbu	10.2bcd	9.53b	10.13bcd	11.20de	10.265
Kawali	10.73cd	10.80cd	13.13f	6.00a	10.165
Suri 3	11.93e	10.00bc	6.80a	9.93bc	9.665
Mean	10.95	10.11	10.02	10.34	

Different letters indicate the significance at 5% level.

LOF is rich of nutrition, one of which is nitrogen. Nitrogen absorption and utilization strongly correlates to sugar availability. Low nitrogen supply could change the distribution of assimilation among various organs in the plant. Sawargaonkar and Wani (2016) study found that nitrogen application greatly affected the increase in the amount of sap and sugar content in sorghum, this was also correlated with increasing the potential yield of ethanol. The treatment with N nutrition administration provided higher stem yield, sugar content and ethanol production than the control. The result of Adinurani *et al.* (2020) found that Kawali variety belonged to sweet sorghum type yielding highest quantity of sap, compared with other varieties. The treatment with liquid organic fertilizer application was a strategy to improve plant production and to reduce negative effect of synthetic fertilizer use.

CONCLUSION

Each of sorghum varieties responded differently to the application of LOF dose. Highest panicle and seed weight per plant were found in Numbu variety at LOF dose of 6 l/ha. Highest seed protein content was found in Suri 3 at LOF dose of 9 l/ha. Highest sugar content of stem sap was found in Kawali at dose of 6 l/ ha.

REFERENCES

Adinurani, P. G., Rahayu, S., Budi, L. S. and Setyobudi, R. H. (2020). Adaptation and phenotype varieties of sweet sorghum [*Sorghum bicolor* (L.) Moench] at different altitude. *Int. J. Adv. Sci. Engin. Infor. Tech.* **10**: 2429-2434.

Ajeigbe, H. A., Akinseye, F. M., Ayuba, K. and Jonah, J. (2018). Productivity and water use efficiency of sorghum [*Sorghum bicolor* (L.) Moench] grown under different nitrogen applications in Sudan Savanna Zone, Nigeria. *Int. J. Agron.* **2018**: 1-11.

Araya, A., Kisekka, I., Gowda, P. H. and Prasad, P. V. V. (2018). Grain sorghum production functions under different irrigation capacities. *Agric. Water Man.* **203**: 261-271.

Ardiyanti, S., Sopandie, D., Wirnas, D. and Trikoesoemaningtyas (2019). Ratoon productivity of sorghum breeding lines [*Sorghum bicolor* (L.) Moench]. *I. Sen. REM* **399** : 01-09.

Frankowski, J., Przybylska-Balcerek, A. and Stuper-Szablewska, K. (2022). Concentration of pro-health compound of sorghum grain-based foods. *Foods* **11**: 01-14.

Harsono, P. and Setyowati, N. (2020). Response and allelochemicals content of two sorghum varieties to manure. *The 5th Int. Sem. on Agribusiness* **518**: 1-7.

Hossain, M. S., Islam, M. N., Rahman, M. M., Mostofa, M. G. and Khan, M. A. R. (2022). Sorghum: A prospective crop for climatic vulnerability, food and nutritional security. *J. Agric. Food Res.* **8** : 1-9.

Jabereldar, A., El-Naim, A., Abdalla, A. and Dagash, Y. (2017). Effect of water stress on yield and water use efficiency of sorghum [*Sorghum bicolor* (L.) Moench] in semi-arid environment. *I. J. Agric. For.* **7** : 1-6.

Leandro, de M. C., Silva, P. S., Duarte, M. H. S. and Maria, P. S. H. (2017). Sorghum (*Sorghum bicolor* L.): Nutrients, bioactive compounds and potential impact on human health. *Crit. Rev. Food Sci. Nutr.* **57**: 372-390.

Moraes, É. A., Queiroz, V. A. V., Shaffert, R. E., Costa, N. M. B., Nelson, J. D., Ribeiro, S. M. H. R. and Martino, H. S. D. (2012). *In* *vivo* protein quality of new sorghum genotypes for human consumption. *Food Chem.* **134**: 1549-1555.

Mukkun, L., Lalel, H. J. D. and Kleden, Y. L. (2021). The physical and chemical characteristics of several accessions of sorghum cultivated on drylands in east Nusa Tenggara, Indonesia. *Biodiversitas* **22**: 2520-2531.

Mundia, C. W., Secchi, S., Akamani, K. and Wang, G. (2019). A regional comparison of factors affecting global sorghum production: The case of North America, Asia and Africa's Sahel. *Sustainability* **11**: 01-18.

Rini, E. P., Rachman, F., Wirnas, D., Trikoesoemaningtyas and Sopandie, D. (2020). Morphological characterization of sorghum lines with aluminium stress and phosphorus deficiency tolerance. *ICFST* **484**: 01-9.

Saputro, A., Samanhudi, Harsono, P. and Supriyono (2021). The growth and yield of several sorghum varieties in the first ratoon. *2nd ICFS* **911**: 1-9.

Sawargaonkar, G. L. and Wani, S. (2016). Nitrogen response of sweet sorghum genotypes during rainy season. *Curr. Sci.* **110**: 1699-1703.

Shaik, A., Singh, H., Singh, S., Montague, T. and Sanchez, J. (2022). Liquid organic fertilizer effects on growth and biomass of lettuce grown in a soilless production system. *Hoet. Sci.* **57**: 447-452.

Shukla, S., Felderhoff, T. J., Saballos, A. and Vermerris, W. (2017). The relationship between plant height and sugar accumulation in the stems of sweet sorghum (*Sorghum bicolor* (L.) Moench). *Field Crops Res.* **203**: 181-191.

Syuryawati, Faesal and Aqil, M. (2021). Sorghum plants with ratoon cultivation increase production and income. *2nd ICFST* **911**: 1-11.

Zhou, W., Long, W., Wang, H., Long, P., Xu, Y. and Fu, Z. (2022). Matter production characteristics and nitrogen use efficiency under different nitrogen application patterns in Chinese double-cropping rice systems. *Agron.* **12**: 01-18.