Journal of the Korean Society of Grassland and Forage Science 41(3): 205~209, 2021
https://doi.org/10.5333/KGFS.2021.41.3.205
ISSN 2287-5824 (Print)
ISSN 2287-5832 (Online)

Research Article

Effect of Seeding Density and Seeding Methods on the Dry Matter Yield of Barnyard Millet

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ABSTRACT

Barnyard millet (*Echinochloa esculenta*) can be processed through soiling, hay, and silage, depending on the weather conditions during harvesting. However, research on barnyard millet is insufficient, and standards for cultivar, seeding density, and fertilizers have not been established. This study was conducted to examine the effects of seeding density and seeding methods on dry matter yields. For this, we used the early-maturing (Shirohie millet) variety of the barnyard millet. The experimental design included different seeding density (10 kg/ha, 15 kg/ha, 20 kg/ha (standard seeding density), 25 kg/ha and 30 kg/ha), and different methods of seeding (drill seeding and broadcast seeding). The seeding date was May 13, 2021, and the harvest date was July 13, 2021. Harvesting was carried out when the heading reached 40 %. Lodging occurred at 5, 9 and 7 at 20, 25 and 30 kg/ha densities in the broadcast seeding, but not in the drill seeding. With decreasing density of seeding, tillage number showed an increasing trend in both drill seeding and broadcast seeding ($p>0.05$). The plant heights were comparable in both drill seeding and broadcast seeding ($p>0.05$). The heading stage of barnyard millet was checked July 7 for drill seeding, and, on July 8 for broadcast seeding. It took 62 days, i.e., till July 13 for the heading to reach 40 % of the output. The dry matter yield of barnyard millet was significantly higher at the seeding density of 30 kg/ha, for both the methods of seeding ($p<0.05$). There was no difference in the chemical composition of grain, based on the seeding method and seeding density. However, as the seeding density increased, the CP, NDF, ADF, and TDN contents increased in both drill seeding and broadcast seeding. We found that, the dry matter content was the highest at the seeding density of 30 kg/ha for both the methods of seeding, but this was only 1.3 times higher than that of 10 kg/ha. Considering the seed price and labor force involved in seeding, it is advisable to have a seeding density of 15-20 kg/ha.

(Key words: Barnyard millet, Seeding density, Seeding method)

Ⅰ. INTRODUCTION

Annually 328 thousand tons of forage corn and Sudanese grass are produced as domestic summer forage crops under 28,000 ha area (MAFRA, 2021) by the livestock farms. However, growing forage corn is difficult, as suitable seeding machine and harvesters are not available. As Sudanese grass is not preferred by the livestock over the forage corn, its cultivation is limited. On the other hand, barnyard millet is better suited as a summer forage crop, as sowing and harvesting are easier than forage corn. In addition, it is more resistant to moisture spoilage than forage corn and is more palatable to livestock than Sudan grass. Barnyard millet can be prepared and used for green feed, hay, and silage, and depending on the weather conditions at harvest time, it can be used in different forms. Recently, as an alternate crop to rice, barnyard millet is attracting attention because it is unaffected by moisture (Jung, et al., 2014). Domestic research is focused on finding the suitability of barnyard millet as a forage crop to grow on the reclaimed land under high salinity conditions (Shin et al., 2004; Shin, et al., 2006; Hwang et al., 2017a; Hwang et al., 2017b). In addition, a study on the seeding period of barnyard millet (Lee et al., 2013) and one on the suitability of different seeding densities and amount of fertilizers on its yield (Cho et al., 2001; Lee et al., 1980) have been reported. Seeding density of Jeju millet, a late-maturing variety, was found to be the highest at 35 kg/ha (Cho et al., 2001) and 40 kg/ha (Hwang et al., 2017 b), and its requirement of nitrogenous fertilizer was 200 and 250 kg/ha, respectively. Application of fertilizers was reported to increase the dry matter yield by 43 % and 45 % (Hwang et al., 2017b). However, research on barnyard millet is scanty, and no standards have been established for the variety, seeding criteria, and speculation.

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Therefore, this study was conducted to examine the effect of the density and method of seeding on the dry matter yield of barnyard millet.

Ⅱ. MATERIALS AND METHODS

1. Experiment design

These studies were conducted in the experimental field of the Department of Animal Resources Development at the National Institute of Animal Science, located in Cheonan, Chungcheongnam-do, in 2021 to understand the effects of the density and method of seeding on the yield of barnyard millet using the early-maturing variety (Shirohie millet).

For the experiment, the seeding densities of 10 kg/ha, 15 kg/ha, 20 kg/ha (normally used density), 25 kg/ha, and 30 kg/ha, were used, with both drill seeding and broadcast seeding methods. For each experiment, an area of 2 × 2 m (4㎡) was used with three repetitions, arranged in randomized block design. The seeding width of 30 cm was used for the drill seeding. The seeding date was May 13, 2021, and the harvest date was July 13, 2021. The harvesting period was set to be when the heading reached 40 %. A mix of nitrogen (N)-phosphorus (P_2O_5)-potassium (K_2O) at 80-200-70 kg/ha was used as fertilizer.

2. Investigation Items

The study criteria included tiller number (n), lodging resistance (1-9), plant height (cm), dry matter yield (kg/ha), and the chemical composition (dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF). The tillage number was measured 30 days after seeding, and the lodging resistance was during the growth period of the barnyard millet. Air temperature (°C) was noted by HOBO onset (H21-USB), and the information on the amount of precipitation (mm) was provided by the Cheonan weather station.

Dry matter (DM) was analyzed according to the AOAC (1990) to calculate the forage value of barnyard millet. The collected samples were dried in a hot air dryer at 65 °C for 72 h, pulverized with a 0.7 mm mesh mill, and stored in plastic sample containers. The crude protein content was measured using an elemental analyzer (Vario Max CUBE, Elementar, Germany) according to the Dumas' method (AAAS, 1884), and using the total nitrogen content, the crude protein content (% CP=% N × 6.25) was calculated. Using an Ankom fiber analyzer (ANKOM Technology Corp., Fairport, NY, USA), NDF and ADF contents were determined according to the method described by Goering and Van Soest (1970). The TDN content (%) was calculated as 88.9-(0.79×ADF(%)) (Jung et al., 2014). For statistical analysis, LSD analysis was carried out using SPSS 18.0 (IBM Corp Chicago).

Ⅲ. RESULTS AND DISCUSSIONS

1. Lodging resistance and Tiller number

Lodging happened in the broadcast seeding method at 5, 9, and 7 at 20, 25, and 30 kg/ha (Table 1), but did not occur in the drill seeding. As the seeding is uneven in the broadcasting method compared to the drill seeding, with lodging. In

Table 1. Characteristics of barnyard millet due to seeding density and seeding methods

	Lodging resistance (1~9)		Tiller number (No. per plant)	
	Drill seeding	Broadcast seeding	Drill seeding	Broadcast seeding
10 kg	-	-	1.78±0.22[a]	2.67±0.29[a]
15 kg	-	-	1.67±0.17[a]	2.56±0.34[a]
20 kg	-	5	1.56±0.53[a]	2.33±0.17[a]
25 kg	-	9	1.33±0.50[a]	2.56±0.29[a]
30 kg	-	7	1.11±0.33[a]	2.44±0.24[a]

*lodging resistance: 1= strong, 9= weak
*means±standard error.

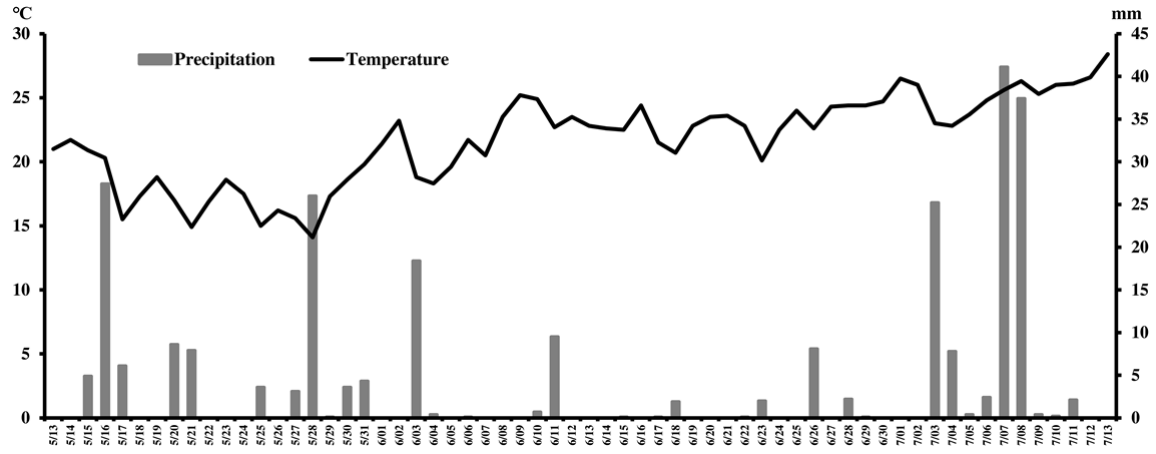


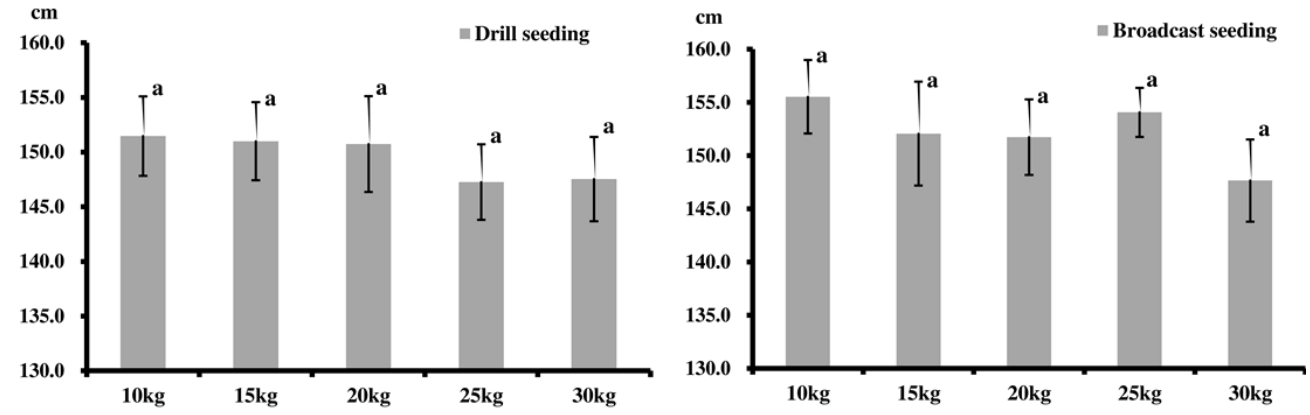
Fig. 1. Average temperature and daily precipitation during the experimental period in Cheonan area.

addition, on July 3, on the day of lodging, heavy rain and strong wind warnings were issued in the Chungnam region, and the amount of precipitation was 25.2 mm (Fig. 1).

As the seeding amount decreased, the tillage number tended to be higher for both drill seeding and broadcast seeding ($p>0.05$). Number of tillers was 1.5 times higher in broadcast seeding with wide inter-plant space, than in drill seeding. This was because of longer growth than due to inter-individual light consolidation, and as the seeding density in soft veins increased, the number of tillers decreased from 2.9 to 2.1 (Han and Kim, 1992).

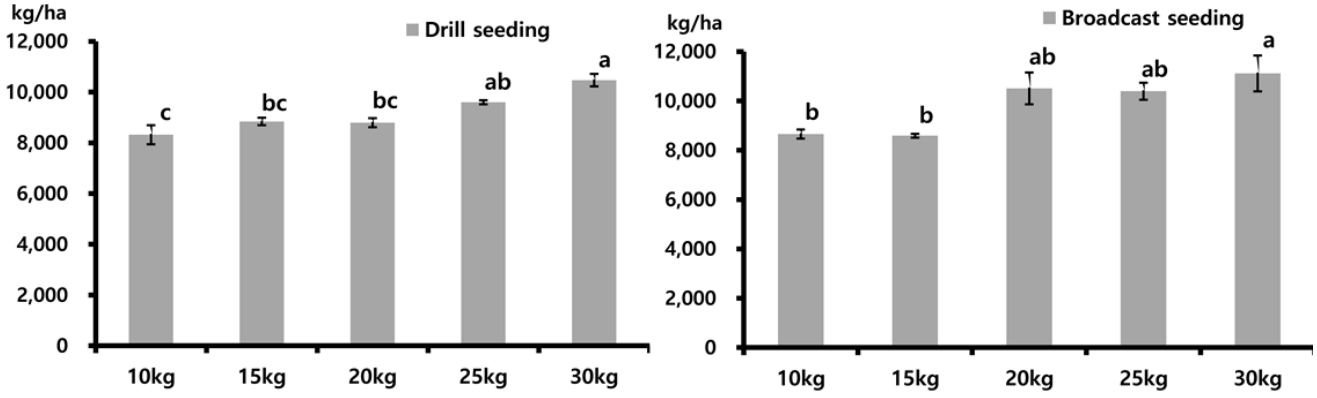
2. Growth status of barnyard millet

There was no significant difference in the plant height of barnyard millet in both drill seeding and broadcast seeding ($p>0.05$, Fig. 1). Plant length was the largest at 151.5 and 155.5 cm at 10 kg/ha but, 147.5 and 147.7 cm were the smallest at 30 kg/ha. However, Cho et al. (2001) reported that as the seeding density of Jeju barnyard millet was increased from 15 kg/ha to 35 kg/ha, the plant height increased, probably due to competition among individuals. These differences may be because of the longer growth period of the Jeju barnyard millet, which is late-maturing, while the Shirohie millet used in this experiment is an early-maturing variety. Cho et al. (2003) reported that the increase in the seedling density from 6 kg/ha to 12 kg/ha resulted in a significant enhancement of average plant height from 128 cm to 148 cm in Jeju Italian millet, but it decreased at higher seed densities of 15 kg/ha and 18 kg/ha. This suggested that the individual plant height increases due to competition up to a certain seeding density, but this is inhibited when competition between individuals becomes more severe. Heading stage of the crop was checked on July 7 for the drill seeding batch and on July 8 for broadcast seeding batch. The heading reached 40 % of the total output on July 13, i.e., in 62 days after sowing. Lee et al. (2013) reported similar results regarding the time required for heading of Shirohie millet, which was 64 days and 75 days. The dry matter yield of barnyard millet was significantly higher at the seeding density of 30 kg/ha for both drill seeding and broadcast seeding ($p<0.05$, Fig. 2). For drill seeding, the dry matter yield was 8,320.8 kg/ha and 10,470.9 kg/ha for the seeding density of 10 kg/h and 30 kg/ha respectively, showing a difference of 2,150.2 kg/ha. The broadcast seeding showed a difference of 2,462.2 kg/ha in the dry matter yield between the seeding densities of 10 kg/h and 30 kg/ha (8,655.6 kg/ha and 11,117.8 kg/ha, respectively). Lee (1980) showed a dry matter yield of 8.3 MT/ha at 20 kg/ha of sowing, similar to 10 kg/ha in this study. In addition, Lee et al. (2013) had a dry matter yield of 12.3 MT/ha with 20 kg/ha of seeding, which is higher than 30 kg/ha in this study. However, according to Cho et al. (2001), the dry matter yields were 7.5, 8.7, 9.7, and 10.2 MT/ha at seeding densities of 15, 20, 25, and 30 kg/ha, respectively, similar to this study. Table 2 shows the chemical composition at the time of drill seeding and broadcast seeding. Method and density of seeding did not change the chemical composition of barnyard millet. However, as the seeding density increased, CP, NDF, ADF, and TDN content also increased for both drill seeding and broadcast seeding. This may be because, the plant height remained shorter with increasing seeding density. Although the



[a,b,c] Means in the column with different superscripts are significantly different($p<0.05$).

Fig. 2. Height of barnyard millet under different seeding density and seeding methods.



[a,b,c] Means in the column with different superscripts are significantly different($p<0.05$).

Fig. 3. Dry matter yield of barnyard millet under different densities and methods of seeding.

Table 2. Chemical composition of barnyard millet according to different densities and methods of seeding

Seeding method	Seeding density	DM (%)	CP	NDF	ADF	TDN[1)]
			% of DM			
Drill seeding	10 kg	17.7	5.9	66.0	38.9	58.2
	15 kg	16.7	7.3	66.4	38.9	58.2
	20 kg	16.9	6.1	64.9	38.2	58.8
	25 kg	17.5	7.3	65.5	38.7	58.3
	30 kg	16.8	6.8	64.3	37.5	59.2
Broadcast seeding	10 kg	16.5	7.4	66.2	39.6	57.6
	15 kg	15.6	7.1	65.0	38.6	58.4
	20 kg	16.9	6.8	66.3	38.7	58.3
	25 kg	15.2	7.8	64.9	38.3	58.6
	30 kg	16.7	6.3	64.0	38.3	58.7

[1)] TDN(%) = 88.9-(0.79×ADF)

results of Lee et al. (2013) regarding NDF, ADF, and TDN contents were similar, the CP content was lower. The above results suggest that, the dry matter of barnyard millet was high at when the seeding density was 30 kg/ha for both drill seeding and broadcast seeding, and was 1.3 times higher than that of the 10 kg/ha density. Considering the seed price and labor force needed for seeding, it is advisable to have a seeding volume of 15-20 kg/ha. In particular, in broadcast seeding,

lodging occurs from 20 kg/ha or more, which increases the labor force necessary for cultivation management.

Ⅳ. CONCLUSIONS

This study was conducted to examine the effect of seeding density and seeding method on the dry matter yield, to establish the seeding standard of barnyard millet. The highest yield of dry matter was at the seeding density of 30 kg/ha for both drill seeding and broadcast seeding. However, the dry matter yield was only 1.3 times higher than that for 10 kg/ha, while the seeding density was three times higher. Also, in broadcast seeding, lodging occurred significantly at 20 kg/ha and higher density. Considering the seed price and labor force needed for the cultivation of barnyard millet, it is advisable to maintain the seeding density at 15-20 kg/ha.

Ⅴ. ACKNOWLEDGEMENT

This research was supported by the “Damage assessment in forages and development of cultivation technology for their damage reduction according to extreme weather (PJ01499607)” and 2021 the RDA Fellowship Program of National Institute of Animal Science, Rural Development Administration, Republic of Korea.

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(Received : September 7, 2021 | Revised : September 24, 2021 | Accepted : September 24, 2021)