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Preliminary Evaluation of Pearl Millet – A New Crop in Nevada

ABSTRACT

Recent droughts have had enormous effects on Nevada's agriculture, where farmers faced considerable cutbacks in irrigation water supply. As a result, producers have expressed interest in the statewide needs assessment of alternative crops. Therefore, the objective of this study was to evaluate pearl millet, a drought-tolerant and low input-requiring crop, as an alternative crop in Nevada and compare influence of two-row spacings 8 and 30 inches on yield and quality. Results demonstrated that pearl millet could be a viable crop in the nation's driest state and revealed a need for more research to determine best- cultivars and management practices specific to Nevada.

Introduction

Lower precipitation, decreased snowpack, and thus, declining water availability threatens irrigated agricultural sustainability in Nevada and the West. Alfalfa is an economically important crop in Nevada, but its high-water requirement hinders its continued production and thus Nevada's agricultural production and sustainability (Neupane et al., 2018). In addition, recent droughts have had enormous effects on crop production throughout the state, where farmers faced considerable cutbacks in the irrigation water supply. As a result, Nevada producers have expressed immense interest in alternative crops in the recent statewide needs assessment (Walia et al., 2021), which require less water and fit their production system while maintaining agricultural sustainability in Nevada. Therefore, alternative crops that require less water and thrive on low fertility lands in Nevada are an alternative approach to increasing crop production, reducing water use, and diversifying Nevada's cropping portfolio.

Millets have been gaining popularity in recent years due to their high resilience to climate change effects and acceptable productivity and nutritional value (Jukanti et al., 2016). Pearl millet [Pennisetum glaucum (L.)] is one of the world's important crops. This crop can survive in diverse ecological conditions, including water scarcity, low pH, and saline soils, providing excellent growth and productivity in less fertile soils. It is a low-input crop with low nutrient demands, requiring few additional nutrients, which can be met through animal manure application or rotations with a leguminous cover crop (Myers, 2002). It can grow sufficiently with annual precipitation as low as 16–26 inches, thus making it one of the most drought-resistant species. Pearl millet is, therefore, a climate-resilient crop that can increase the income and food security of farming communities in arid and semi-arid regions of the world (Satyavathi et al., 2021).

Pearl millet is an annual, warm-season grass belonging to the Poaceae family. It can grow 4-8 feet tall with about ½-1 inch diameter stems, long and pointed leaf blades, upright tillering (side shoots), and a deep root system. The inflorescence and seeds occur in a spike at the end of the stem or tillers, resembling a cattail head. The seeds are cylindrical with varied colors from white, yellow, purple, and brown.

Pearl millet use as a grain on a commercial basis only began in the early 1990s in the United States (Myers, 2002) and has gained importance as a forage crop resulting from a lack of prussic acid (Stephenson and Posler, 1984). Pearl millet is tolerant to drought and high temperatures characteristic of the summer months, making it a popular forage crop in the southeastern region (McKee, 2021). New high-yielding varieties of pearl millet have been developed for forage and grain crop use. Dwarf and semi-dwarf varieties of pearl millet have been developed to emphasize increasing leaf:stem ratio, digestibility, and rust resistance (Andrews and Kumar, 1992). Pearl millet varieties are grown for various purposes such as a forage crop for livestock grazing, silage, hay, green chop, poultry feed, birdseed, summer annual cover crop to suppress weeds, soil-borne diseases, surface mulch, and add organic matter to the soil, and a variety of gluten-free products for human consumption, including beer (Myers, 2002).

In recent years, several studies have been conducted to evaluate pearl millet varieties as a grain and forage crop in other regions; however, there has been no research conducted to assess pearl millet as an alternative forage crop option in Nevada. No local research data are currently available to assist farmers with decisions on pearl millet use as a new forage crop in Nevada. So, the objective of this study was to evaluate the production potential and influence of row spacing on pearl millet forage yield and quality in Nevada.

Figure 1. Pearl millet planted at University of Nevada, Reno, Fallon Research Center, Fallon.

Materials and Methods

A field experiment was conducted at the University of Nevada, Reno, Fallon Research Center, during the 2019 growing season. The soil type on the site was Sagouspe loamy sand (sandy, mixed, mesic, Oxyaquic Torrifluvents), with 0-1% slopes according to USDA-Natural Resources Conservation Service (NRCS) soil survey. It is considered prime farmland if irrigated. The available water capacity is rated as moderate (approximately 7.3 inches).

Before the experiment initiation, the soil was sampled randomly to a depth of 12 inches across the experimental area and composited before soil test analysis, carried out at a commercial laboratory. The results of the soil analysis are presented in Table 1.

Table 1. Selected soil characteristics before initiation of the experiment.

Parameter	**Value**	**Rating**
pH	7.1	-
Texture classification	Loamy sand	-
Sand (%)	85	-
Silt (%)	6	-
Clay (%)	9	-
OM (%)	1.0	Very low
NO_3-N (lbs/ac)	14	Very low
P (Weak Bray) (lbs/ac)	48	Medium
P (Bicarbonate) (lbs/ac)	20	Medium
K (lbs/ac)	312	Medium
Mg (lbs/ac)	322	Medium
Ca (lbs/ac)	2034	Medium
Na (lbs/ac)	58	Very low
SO_4-S (lbs/ac)	4	Very low
[a]CEC (meq/100g)	6.9	-

[a]CEC= cation exchange capacity

The plot area was plowed, disked, and leveled before planting. Bushy type pearl millet hybrid variety FSG 300 was planted on July 10, 2019, at two different row spacings, 8 and 30 inches, using the Plotseed XL plot seeder (Wintersteiger AG., Ried im Innkreis, Austria) and Almaco 4 row cone plot planter, respectively. However, the rows planted at 30-inch row spacing did not germinate well due to deeper seed placement, so the seed was replanted after five days manually. The seed was planted at a rate of 34-35 seeds/ft^2 and a depth of 1 inch. The plots were arranged in a randomized complete block design with three replications and consisted of 6 total plots. The plot size was 150 ft^2 (15 ft long, 10 ft wide). No fertilizer was applied before or during the growing season. Weeds were controlled manually by cultivation. All experimental plots received the same amount of irrigation water throughout the experiment. Supplemental irrigation was provided once per week using a sprinkler irrigation system and was terminated two-week before harvesting. Weather parameters (cumulative precipitation and average temperature) during the growing period are presented in Table 2.

Table 2. Monthly accumulated precipitation and mean air temperature during the growing season (2019) at Fallon and 30-year average (1981-2010).

Month	**Mean air temperature (°F)**		**Cumulative precipitation (inch)**	
	2019	**30-year Avg.**	**2019**	**30-year Avg.**
July	73	75	0.01	0.08
August	-*	72	-	0.16
September	70	64	0.00	0.29
Total	-	-	0.01	0.53

*Data not available. Weather data were collected from the US climate data (https://www.usclimatedata.com/climate/fallon/nevada/united-states/usnv0028/2019/7)

Above-ground biomass of pearl millet was harvested once at a stubble height of 2 inches with a forage harvester (RCI 36A, John Deere 1580 Terrain cut tractor) on September 27, 2019. The crop was harvested at the boot stage from the middle of each plot for forage yield and quality analysis. After measuring the fresh weight of the total sample at the field, a subsample of one lb was taken and oven-dried at 150°F until constant weight, and dry matter (DM) of forage was calculated. After dry weighing, subsamples were mailed to a commercial laboratory for forage quality analysis, including crude protein (CP), acid detergent fiber (ADF), and total digestible nutrient (TDN).

Percent nitrogen (N) was determined using the combustion method, and CP was calculated as:

CP= % N x CF, using a correction factor (CF) of 6.25.

ADF content was measured using Refluxing method, an AOAC Official Method 973.18.

TDN was calculated using the formula:

$$\mathrm{TDN} = (\mathrm{NFC} \times 0.98) + (\mathrm{CP} \times 0.87) + (\mathrm{FA} \times 0.97 \times 2.25) + (\mathrm{NDFn} \times \mathrm{NDFD}/100) - 10.$$

Where NFC = non-fibrous carbohydrate, FA = fatty acid, NDFn = nitrogen free NDF and NDFD = in vitro NDF digestibility.

The statistical analysis was performed using analysis of variance (ANOVA) with mean separation at the <0.05 level (SAS Institute, Cary, NC, USA, 2017).

Results and Discussion

The pearl millet forage yield and quality results are presented in Table 3. The row spacing did not affect the forage DM of pearl millet harvested at the boot stage, yielding about 4.9 tons ac^{-1} (Table 3). The results are consistent with Crookston et al. (2020) reported that row spacing (7.5 and 30 inches) had no significant effect on pearl millet forage yield. However, their DM yields were considerably lower (averaging 0.9 tons ha^{-1} over two years) than observed in the present study. Similarly, lower dried forage yields of 2.8 and 4.4 tons ac^{-1} were reported in another study (Machicek et al., 2019). These lower yields in these studies might have resulted from the use of brown midrib (BMR) pearl millet varieties and other management practices, and BMR varieties were found to yield lower than conventional pearl millet varieties (Oskey, 2020).

Table 3. Effect of row spacing on above-ground dry matter and forage quality of pearl millet, Fallon, Nevada.

Attributes	**Row Spacing (inch)**		**P-value**
	8	**30**	
Dry matter yield (tons ac^{-1})	5.1a	4.6a	0.731
Crude protein (%)	7.1a	7.4a	0.688
ADF (%)	46.5a	45.6a	0.730
TDN (%)	53.9b	55.8a	0.04

* Means within a row followed by the same letter(s) are not significantly different ($P < 0.05$).

Similar to DM forage yields, row spacing did not affect CP and ADF contents, averaging 7.2% and 46.1%, respectively (Table 3). However, CP contents were higher in the present study than reported in an earlier study (Machicek et al., 2019) at 90-day harvests of pearl millet, with CP values of 5.1% and 4.3% in 2016 and 2017, respectively. However, CP content was lower than 10.8% when averaged across three different harvest regimes thrice at 30-d intervals, twice at 45-d intervals, and once at 90-d (Machicek et al., 2019). The lower CP contents in the present study could have resulted from a lack of fertilizer application and lower initial soil nutrient levels (Table 1). Earlier studies found that the CP contents of pearl millet increase with increasing nitrogen fertilization rates as the addition of N fertilizer improve plant N uptake, contributing to increased photosynthetic activity and synthesis of higher protein content (Rostamza et al., 2011). Several other studies have also reported that nitrogen application can increase pearl millet production efficiency, N concentration, and forage quality (Singh et al., 2010; Ayub et al., 2009; Maman et al., 2006).

In contrast to CP contents, higher ADF values of averaging 46% (Table 3) were observed in the present study compared to earlier studies that reported ADF values of 38% and 39.3% of BMR pearl millet planted at 7.5-inch row spacing and harvested after 90 days in 2016 and 2017 (Machicek et al., 2019). Similarly, Bhattarai et al. (2020) reported average ADF values of 34.7% and 28.8% in 2018 and 2019, respectively. However, similar ADF values of 42.1% of pearl millet harvested at the boot stage were found by Oskey (2020). Another study reported a range of ADF values of 32.8, 33.0, 34.7, and 36.4% across various irrigation regimes (0, 60, 80, and 100% reduction of available soil water, respectively). They also observed a decrease in TDN values (54.7, 54.5, 53.2, and 51.4%) as water deficit and ADF content increased (Rostamza et al., 2011). Row spacing significantly influenced TDN contents of pearl millet (Table 3), with higher TDN values observed with wider rows (30 inches). Similar TDN values were reported in an earlier study (Mckee, 2021), where conventional pearl millet had TDN contents of 56.3% and 47.3%, and BMR pearl millet had 53.6% and 51.3% during 2017 and 2018, respectively, when planted at 7-inch row spacing. Another study reported TDN content of 59% with a single 90-day harvest over two years (Machicek et al., 2019). This initial finding suggested that pearl millet may have the potential to be productive in the drier environment of Nevada. However, producers interested in testing these new crops must select the cultivars suitable for production in Nevada.

Conclusions

Pearl millet is an untested crop in Nevada. Therefore, research is needed to provide data on production practices specific to Nevada conditions. This preliminary study demonstrated that warm-season pearl millet might be a viable crop in Nevada conditions, especially with frequent droughts, decreasing snowpack, and a shorter growing season. This study also revealed that future research should be designed to confirm these findings and investigate best performing varieties and management practices suited for Nevada production. Significant research gaps, including marketing, must be addressed before any recommendations can be developed specifically for Nevada growing environments. Addressing knowledge gaps via future research studies will help increase the production of alternative crops and will provide more crop options to producers as they seek to meet the forage demands of Nevada's livestock industry.

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