Influence of Seeding Rate on Growth Performance and Yield of Early Maturing Sorghum

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Abstract
Heavy grazing pressure in Tanzanian semi-arid rangelands coupled with climate change and variability has resulted into severe decline in forage production and changes in vegetation composition. To increase forage biomass production in the face of climate change and variability, climate resilient fodder crops such as early maturing sorghum have been recommended in arid and semi-arid regions. However, paucity of information on the best agronomic practices especially the optimal seeding rate and row spacing fostered the need to carry out research on growth performance and yield of early maturing sorghum. The experiment was conducted at Magadu Dairy Farm to assess the influence of seeding rate on growth performance and yield of early maturing sorghum. The experiment adopted the Complete Randomized Design (CRD), where different seeding rate (such as 8kg/ha, 12kg/ha, 16kg/ha, 20kg/ha) were assigned randomly and replicated three times making a total of 12 subplots. The row spaces were also varied in reciprocal order with seeding rate (60cm in 8kg/ha, 50cm in 12kg/ha, 40cm in 16kg/ha and 30cm in 20kg/ha). Parameters measured were; number of plants germinated, circumference of the plant, Dry matter (DM) yield and height of the plants. The data were subjected to One Way Analysis of Variance (ANOVA) using SAS program of 2014 to analyze the effect of seeding rate on growth attributes and yield of

early maturing sorghum. The study established the positive correlation of seeding rate stimulate and number of plant as well as plant heights. On the contrary, seeding rate was found to be inversely proportion to plant thickness and number of leaves per plant. The above ground biomass was found to increase with increasing seeding rate up to 22.20 tonnes per ha and slightly declined at the highest seeding rate. We recommend for further studies on nutritive values and palatability of fodder sorghum varieties to livestock.

***Keywords**: Biomass yield, Plant density, Row Spacing, Growth Attributes, Fodder crop*

Introduction

Increasing effects of climate change and variability coupled to shrinkage of grazing lands due to other land uses has resulted to severe pressure on natural grazing lands. Heavy grazing pressure in Tanzanian semi-arid rangelands coupled with climate change and variability has resulted into severe decline in forage production and changes in vegetation composition (Selemani 2018). To increase forage biomass production, climate resilient fodder crops have been recommended in arid and semi-arid regions (Abduselam *et al.* 2018). Sorghum has become most popular dual purpose fodder crop adapted in wide range of ecological zones with high yield and nutritious forage potential for livestock production (Ayub et al. 2002).

Using appropriate agronomic practices for growing early maturing sorghum could make a large contribution to livestock feedstock and human food in Tanzania. Although, the early maturing sorghum has been recommended as potential fodder species to enhance biomass production in a wide range of ecological zones (Mishra et al. 2015), there is paucity of information on the best agronomic practices especially the optimal seeding rate and row spacing. Understanding of appropriate seeding rate is imperative to optimize dry matter yield. The current study examined the effects of seeding rate on growth performance and dry matter yield of early maturing sorghum. The current findings and recommendations informed different stakeholders, such as farmers, extension officers, researchers and policy makers on the optimal seeding rate for maximum biomass yield from early maturing sorghum.

Materials and Methods

Description the Study Area

The on-station experiment was conducted at Magadu farm, Sokoine University of Agriculture (SUA), located at Morogoro region Tanzania. The area is situated at 37º 39E and 06º 5' S about 5 km from the center of Morogoro Municipal. The average annual temperature in the region is ranging from 18^{oC} to 30^{oC}. The rainfall is bi-modal, ranging from 600-900mm per annum (Selemani 2018). Short rain is normally occurs in November to December while long rain occurs between March and May. The farm is located in the western slope of Uluguru Mountain and the common vegetation is a mixture of grassland and woodland. Soil texture of the study area is dominated by sandy (12% clay, 4% silt, and 84% sandy) with pH of 5.7 (Kizima *et al* 2014). The common livestock managed in the farm are cattle, goats, sheep and few horses.

Research design and sampling procedure

This study used Complete Randomized Design (CRD) whereas seeding rate was considered as a testing factor with four levels. These levels were; 8 kg/ha, 12 kg/ha, 16k g/ha and 20 kg/ha in respective order. These four levels were replicated randomly three times each making a total of 12 sub-plots. The size of each sub-plot was 2 x 2 m. The row spacing in each subplot were varied in reciprocal order of seeding rate levels such as 30 cm (for 20 kg/ha), 40 cm (for 16 kg/ha), 50 cm (for 12 kg/ha) and 60 cm (for 8 kg/ha). All seeds were sown at the same planting depth of 0.5 cm deep. Prior to sowing the seedbeds were prepared before rainy season and sowing was done at the beginning of the rainy season in early March using hand hoe.

Table 1: Experimental layout

8 kg/ha	12 kg/ha	16 kg/ha	20 kg/ha
12 kg/ha	16 kg/ha	20 kg/ha	8 kg/ha
16 kg/ha	20 kg/ha	8 kg/ha	12 kg/ha

Data collection

Data collection started two weeks after sowing and proceeded after every two weeks for three months consecutively. The following parameters were recorded; number of plants germinated, number of tillers, and number of leaves and estimation of above ground biomass. The quadrat of 0.5 x 0.5 m was used as sampling unit and was thrown randomly in each sub-plot. Within the quadrat the number of germinated plants were counted and recorded. Four plants within the quadrat were selected randomly for counting number of tillers and leaves per plant. The heights of four selected plants were also measured using tape measure. At the end of experiment after two months, dry matter was estimated by using destructive method, where all plants with 0.5 x 0.5 m were harvested from each sub-plot and weighed in the field when still fresh. All harvested samples were taken to the laboratory of the Department of Animal, Aquaculture and Range Sciences for estimation of dry matter. In the laboratory samples were force-dried using an oven for 48 hours under the temperature of 105º C.

Data analysis

Data was analyzed using Statistical Analytical System (SAS) programme of 2014. The data was subjected to One Way Analysis of variance (ANOVA) to analyze the effect of seeding rate on growth attributes and yield of early maturing sorghum. Prior to data analysis normality was checked using the Anderson Darling Test of SAS at 5%. The mean values were separated using the Duncan Multiple Range Test as post hoc test. The study used the following model; Responses (No. of plants, No. of tillers, No. of leaves, stem circumference and biomass in kg/ha) = General mean + Seeding Rate + Residual error.

Results and Discussion

The study established a positive correlation between seeding rate and number of plants germinated. The number of plants per unit area increased with increasing seeding rate where the highest mean value was recorded in 20 kg/ha seeding rate and lowest was at 8 kg/ha seeding rate. However, increasing seeding rate found to have negative effects on growth performance of the Early Maturing Sorghum as evidenced by number of leaves and thickness of stems. The mean numbers of leaves recorded per plant were inversely proportion to the seeding rate (Table 2). Nevertheless, the weakest plants with thinner stems were recorded at plots with relatively higher density of plants. The relatively higher number of leaves and thick stems observed in the lower seeding rate could probably be associated with the minimum competition for light and nutrients. Low plant density reduces competition for nutrient, moisture and sun-light, which in turn favor individual plant to quick growth and attain maximum number of leaves.

On the other hand, the current study found that, increasing seeding rate was proportional with increasing plants' heights. These findings were similar to Saheb (1997) who reported that increasing seeding rate resulted into slight increments in the heights of plants. Although height of plants is largely controlled by plant genetic makeup, but to some extent the environmental factors such as light intensity can significantly influence plant growth (Baloch et al. 2010). Densely populated plants normally compete for solar energy which resulted into thin elongated plants.

Table 2: Growth attributes of the Early Maturing Sorghum

Seeding rate	No. of plants/m^2	No. of leaves per plant	Plant height (cm)	Circumference (cm)
8kg/ha	162.65 ± 3.06c	8.15 ± 0.13a	95.22 ± 1.57b	3.82 ± 0.10a
12kg/ha	120.25 ± 3.06c	7.50 ± 0.13b	104.17 ± 1.57a	3.50 ± 0.10b
16kg/ha	210.21 ± 3.06b	7.63 ± 0.13b	105.14 ± 1.57a	3.60 ± 0.10b
20kg/ha	172.08 ± 3.06a	6.88 ± 0.13c	105.27 ± 1.57a	3.03 ± 0.10c

In addition to seeding rate, temporal growth patterns were established among different growths attributes. For example, number of plants were found to decrease with increasing time (Figure 1a), with a sharp decline from week 1 to week 3 which finally stabilized all the way to week 6. Decreasing plant number with time could be attributed to seedling mortality. Hossen et al. (2018) also established similar pattern on rice seedlings mortality which were found to increase with increasing seeding rate. High seedlings mortality few weeks after germination is associated with severe competition particularly the plots received higher seeding rate (Figure 2). On the other hand, number of leaves increased with increasing time up to week 5 and slightly declined at the last week of the experiment. Decreased number of leaves at week 6 implies that, the planted sorghum matured early and some leaves reached their senescence stage.

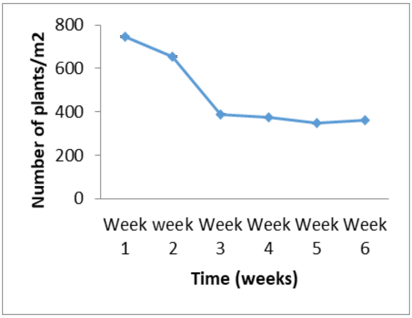


Figure 1 a: Mean number of plants/0.25m2

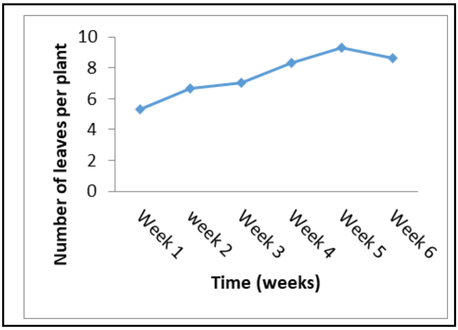


Figure 1b: Mean number of leaves per plant

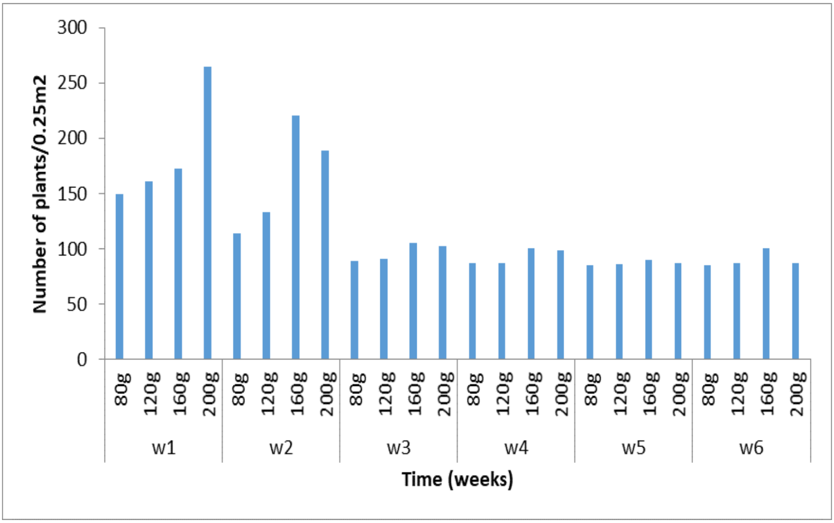
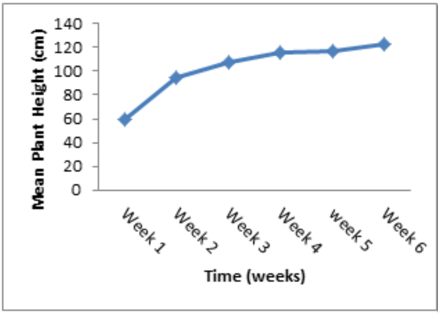


Figure 2: Interaction effects of seeding rate and time (weeks) on plant number

Plant height: diameter growth rate ratio is a function of resource allocation (water and nutrients) within plant cells. The increase in length of the shoot and the root is referred to as primary growth, and is the result of cell division in the shoot apical meristem which was ideal for gramineae family like sorghum. Secondary growth is characterized by an increase in thickness or girth of the plant, and is caused by cell division in the lateral meristem. Under the current study, plants attained their average heights of around 60 cm high in two weeks after germination (Figure 3a). Thereafter, a continuous recording of heights after every two weeks indicates exponential growth pattern where plants heights were noted to increase linearly with time. Interestingly, stem thickness in terms of recorded circumference (Figure 3b) tends to follow similar pattern to those of plant height with time.



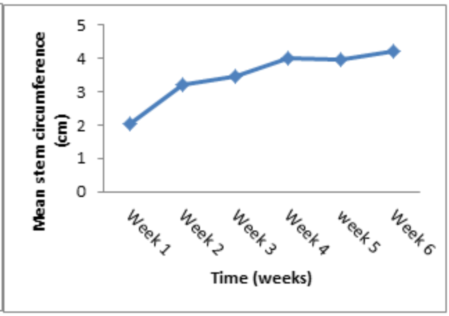


Figure 3a: Mean plant heights **Figure 3b:** Mean plant circumference

Forage productivity is largely determined by growth performance and yield (biomass) . Although the current study failed to establish the linear pattern with regard to seeding rate and above ground biomass, the highest value of biomass was found in the lowest seeding rate (Figure 4). The low biomass in the highest seeding rate could be associated with densely populated plants which resulted into severe competition for water, nutrient resources and light. Snider et al. (2011), concluded that, high seeding rate do not positively affect yield, rather can cause morphological changes such as reduction in tiller number and stem diameter. On the contrary, low seeding rate, allows optimal growth of plants because of little completion for available resources. Sparsely spaced grasses tend to accumulate abundance leaves and tillers which in turn resulted to high biomass production. Lee et al. (2017) established positive correlation between number of tillers and biomass yield for plants with high row spacing which implies that, increasing reproductive tillers in the low seeding rate facilitate more biomass yield. With regard to reproductive tillers, Boe and Casler (2005) reported that biomass produced by high-yielding switch grass cultivars contained predominately reproductive tillers with the maximum number of leaves. On the contrary, Ahmad (1999) reported increasing biomass yield with increasing seeding rate of maize fodder. The disparate between the current study and that of Ahmad (1999) could be associated with difference in nutrients associated with application of Nitrogen fertilizers in previous study and species variation.

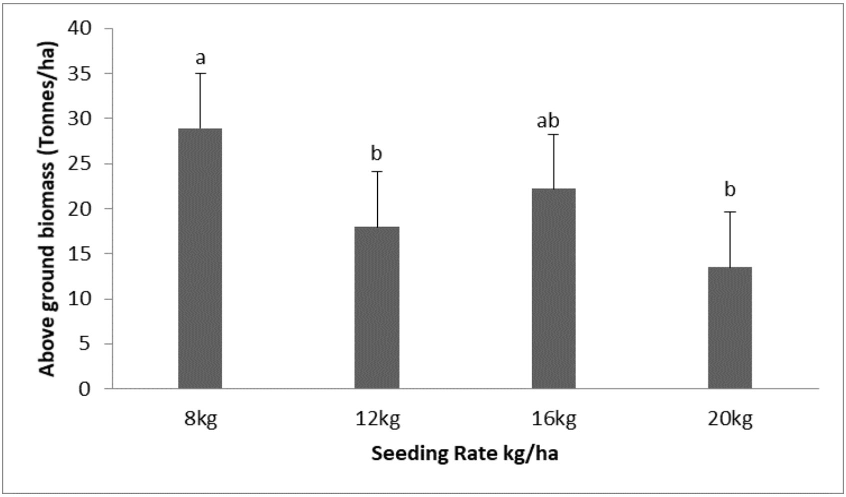


Figure 4: Above ground biomass of Sorghum at different seeding rate

Conclusion

Seeding rate was found to be inversely proportion to plant stem thickness and number of leaves per plant. The high seeding rate was associated to reduction in plant thickness and number of leaves per plants. Interestingly, the above ground biomass was found to decrease with increasing seeding rate up to 22.20 tonnes per ha and slightly declined at the highest seeding rate. The seeding rate of 8 kg/ha is recommended because of its optimal performance in terms of growth and yield. However, we recommend for further studies on nutritive values and palatability of sorghum to livestock.

Acknowledgement
This research would not be accomplished without research permit granted by the Department of Animal, Aquaculture and Range Sciences. Authors appreciated the assistance provided by technical staff at the Department of Animal, Aquaculture and Range Sciences during experimental set up and data collection.

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