Response of Dual-Purpose Sorghum Varieties to Fertiliser and Sowing Dates in Mali's Sudanian Zone

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Abstract

Sorghum is a traditional multipurpose cereal crop that is widely cultivated and consumed by smallholder farmers in Africa's drylands. Low soil fertility, limited fertilizer affordability, and erratic rainfall distribution resulting from climate change and land degradation underline the importance of determining an appropriate sowing time and an effective fertilizer application strategy to reduce risks and increase sorghum productivity. The objective of this research was to determine the impact of planting time (early, medium, and late) and fertilizer types (inorganic, organic, combination, and control) on the performance of two dual-purpose sorghum varieties (Soubatimi and Peke) grown in the Sudanian region of Mali. During the 2019 and 2020 rainy seasons, experiments were carried out at ICRISAT-Mali research station and were laid out in a split-split plot design. Crop biomass, crop yield and yield components at harvest were assessed. Results showed that Soubatimi had the highest average grain yield, followed by Peke, both of which were grown with a combination fertilizer treatment (inorganic+organic). Grain yields in both varieties were unaffected by sowing time. There was a strong correlation between grain yield and grain number per panicle (0.7).This study revealed the importance of fertilizer in the performance of two improved dual-purpose varieties that are important sources of feed for livestock and food for human consumption.

Keywords: Dual purpose sorghum, fertilizer, Mali, Sudanian zone, sowing date

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Introduction

Future warning over the next twenty years was predicted by IPCC (Irfan, 2021) to pass 4°C increase of mean temperature. In the Sahel, increased temperatures may affect the pattern of rainy seasons in diverse ways including: 1) the late onset of cropping season which may necessitate re-sowing, 2) the early cessation of rainfall which necessitates varietal adaptation and the tactical planning of farm operations based on climate information (Abberton et al, 2021). Furthermore, , we find extensive use of arable land for production, a reduction in fallow periods, a limited affordability of fertilizer in the drylands of Africa, all of which contribute to soil degradation. This situation in the region is expected to worsen as the number of people living in West Africa's drylands is projected to rise by 65 to 80 percent by 2030. According to some climate scenarios (Raffaello and Morris, 2016), climate change could result in a 20 percent increase in the region classified as drylands over the same time span, with a cropping pressure steadily increasing as the demand for agricultural products is projected to rise 70–100% by 2050 (Zabel et al 2019).

Improving production by combining different management practices (e.g., fertilizer types and sowing dates) appears to be a key strategy in meeting the expected demand, especially for cereals like sorghum. Sorghum is an important multipurpose traditional cereal crop that is widely grown and consumed by smallholder farmers in the drylands of Africa. According to Obalum *et al.* (2011; cited by Coulibaly et al, 2020), sorghum is the second most important crop after maize in Africa, and the number one crop in West and Central Africa (FAOstat, 2020). In Mali, sorghum ranks fourth among the cereal crops produced after rice, millet and maize (Smale et al 2016). Sorghum is known for being nutrient-use efficient, but its yields can be increased with appropriate fertilizer applications (Ajeigbe et al 2018). Furthermore, due to the uncertainty of rainfall, sorghum was also reported to be very sensitive to sowing time. In this study, we conducted a two years experiment to determine the importance of sowing time (early, medium and late) and fertilizer types (inorganic, organic, the combined and the control) for the performance of two dual-purpose sorghum improved varieties (Soubatimi and Peke) grown in the Sudanian region of Mali.

Methodology

Experiments were conducted under rainfed conditions at ICRISAT-Mali research station at Samanko (12°34’N, 8°04’W, 330 m), over two consecutive years (2019 and 2020). These trials were laid out in a split-split-plot design where fertilizer treatment (3 levels in 2019 and 4 in 2020) was assigned to the main plot, sowing dates to the sub plots (3 sowing dates with 2 weeks interval) and varieties to the sub-sub-plot (Soubatimi and Peke). Cow dung manure was applied to the plots of organic fertilizer in both years (2019, 2020) and as mixed fertilizer with DAP for year 2020 at a rate of 15 kg ha^{-1} around 3 days before sowing. DAP was applied to the plots as inorganic fertilizer in both years and as mixed fertilizer with manure for year 2020 only, at a rate of 100 Kg ha^{-1} at 15 days after sowing (DAS), and urea was added to those same plots at a rate of 50 kg ha^{-1} around 40 DAS for all sowings. At distinct phenological stages, destructive (biomass) and non-destructive (plant height, date of 50% flowering, number of leaves etc.) measurements were made. To assess the effect of factors on measured variables, analysis of variance (ANOVA) was performed using Genstat 19th Edition, and the p values were reported. Correlation analysis was conducted using the PerformanceAnalytics package in R software (R Development Core team, 2011) to determine the components of yield that correlate linearly with yield whether fertilizer was applied or not. Because bird attacks have had a significant impact on grain yield of the first and second sowings, an estimate of grain yield was made using the equation below:

$$Estimated\ grain\ yield = \frac{\text{Harvested dry grain weight}}{(\text{Total number of panicle} - \text{number of missing panicle})}$$

Results and discussions

Effects of fertiliser, sowing dates and Variety

Results indicated that the grain yield data collected in both years showed statistically significant difference ($P<0.001$). Furthermore, the fertilizer types evaluated in this study showed significant effect on grain yield ($P = 0.008$). However, no significant genotypic difference was observed between the two varieties evaluated at 3 sowing dates separated by 15 days interval (data not shown) despite the yield of both varieties was higher when sown late in 2019 while the opposite was true in 2020 (i.e., decrease of grain yield from early to late sowing).

Yield response to fertilizer

According to the findings, the highest mean grain production (2645 kg ha-1) was attained in 2019 for Soubatimi using organic fertilizer (Fig. 1a). Similarly, the Soubatimi grain yield observed under the 0 kg ha-

1 fertilizer condition differed statistically from that observed under the combined fertilizer treatment in 2020. Fertilizer inputs had little effect on Peke's mean grain yield in 2020. (Fig. 1b). However, there was no difference in grain yield between Soubatimi and Peke when the other types of fertilizers were used.

Table 1. Effects of fertilizer and sowing dates on the grain yield of Soubatimi and Peke

	Source of variation	Grain yield	
Years	2019	2283 ± 823	
	2020	1919 ± 918	
Fertilizer	0	1458 ± 758	
	Organic	2310 ± 811	
	Inorganic	2242 ± 825	
	Combined	2503 ± 873	
Sowing dates	Early	2020 ± 848	
	Mid	2010 ± 901	
	Late	2195 ± 938	
Varieties	Soubatimi	2017 ± 927	
	Peke	2133 ± 862	
CV%		41%	
Probability	Year	0.000143	***
	Fertilizer	7.36E-07	***
	Fertilizer x Varieties	0.008	**

=P<0.01;*=P<0.001

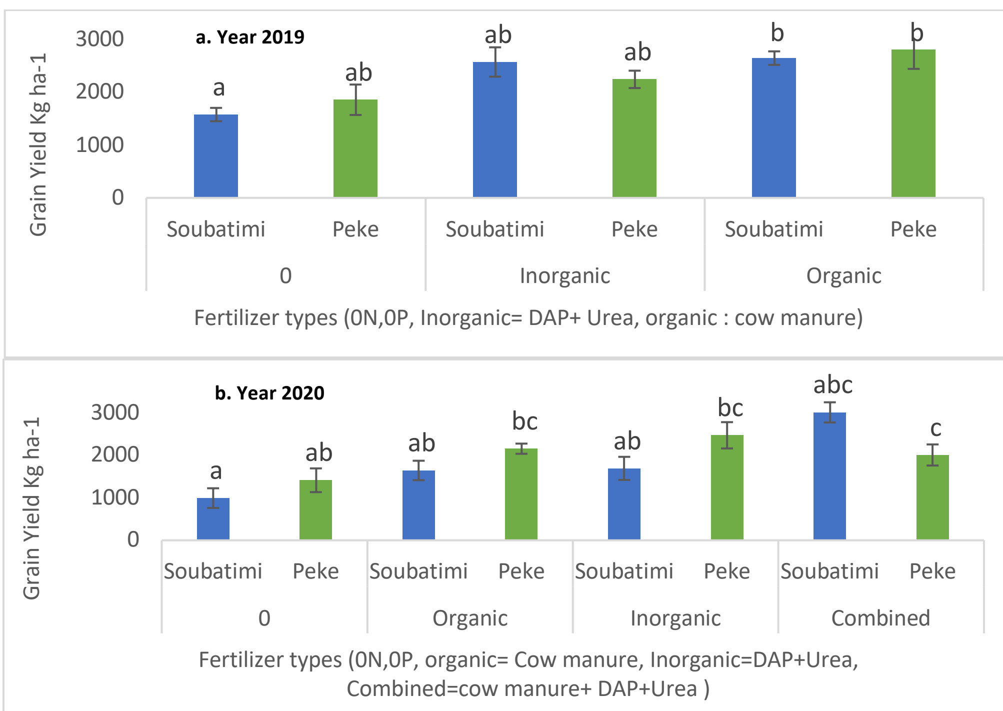

Figure 1. Response of Soubatimi and Peke to the three fertilizer types used in year 2019 (a) and 2020 (b). Differences between means that share a letter are not statistically significant

Grain yield as function of yield components

Correlation analysis was conducted to determine relationship between grain yield and other yield components such as grain number, panicle weight and panicle number harvested. Table 2 shows that higher grain number will result in higher grain yield whether fertilizer is used or not (r=0.8 and r=0.6, respectively for case where fertilizer was not applied and for case where fertilizer was applied). Furthermore, in the situation where fertilizer was not applied, higher correlation was observed between grain yield and number of total panicles harvested, whereas in the case where fertilizer was applied, there was a stronger correlation between grain yield and total panicle weight. Meanwhile the number of total panicles harvested was strongly correlated with the total panicle weight where fertilizer was not applied.

Table 2. Correlation coefficients determine for yield and its components with and without fertilizer

		Grain yield	**Number of total panicles harvested**	**Total panicle weight**	**Grain number**
Without fertilizer	**Grain yield**	1			
	Number of total panicles harvested	0.3	1		
	Total panicle weight	0.2	**0.4***	1	
	Grain number	**0.8***	0.2	0.1	1
With fertilizer	**Grain yield**	1			
	Number of total panicles harvested	0.1	1		
	Total panicle weight	**0.5***	0.2	1	
	Grain number	**0.6***	0.1	0.2	1

*P<0.05

Conclusion and Outlook

This study revealed that fertilizer application can significantly impact sorghum grain yield in Mali. It was also discovered that 14 days intervals between sowing dates may not be enough to detect genetic differences in grain yield of the two dual-purpose sorghum varieties, Soubatimi and Peke, that are relatively less photoperiod sensitive than the landrace guinea types. Future work on this research is to lengthen the days between sowings in order to find the optimal sowing time for these two varieties.

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