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ORIGINAL ARTICLE

Performance of Small Millets under Different Sowing Windows

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ABSTRACT
A field experiment was conducted to evaluate the best sowing window for realizing maximum yield of small millet crops during kharif, 2019 and 2020 at Regional Agricultural Research Station, Tirupati of Acharya N. G. Ranga Agricultural University, Andhra Pradesh. A Factorial randomised block design (FRBD) with three replicates was used to test eighteen treatments. In this experiment, seeds were sown at three different times in June (D_1: First FN in June, D_2: Second FN) and July (D_3: First FN in July) and in Factor B, small millets, as a treatment (C_1 - Foxtail millet, C_2 - Browntop millet, C_3 - Little millet, C_4 - Kodo millet, C_5 - Barnyard millet and C_6 - Proso millet). During 2019 and 2020, all millet crops performed pretty best when sown at II FN of June, however, there was little to no difference in yield between the different sowing windows. The grain production (2128 kg ha^{-1}), gross returns (₹ 63862 ha^{-1}), net returns (₹ 39056 ha^{-1}), and benefit cost ratio (2.58) of foxtail millet were recorded higher than rest of the small millets.
Keywords: *Sowing window, small millets, grain production, net return and benefit cost ratio.*

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INTRODUCTION

Climate change, global warming, food and nutritional security are the most pressing issues confronting the agriculture sector right now and small millets can aid in alleviating these issues to some extent. Millets are C4 plants that are excellent carbon sinks, increasing the possibility to lower CO2 emission, expanding agro-biodiversity, and allowing interaction with other essential crops [2]. Millets are well-known for their climate-resilient traits, which include adaptation to a variety of ecological conditions, reduced irrigation needs, enhanced growth and production under low nutrient input circumstances, less dependence on agrochemicals, and low sensitivity to biotic and abiotic stresses [5]. Millets are often referred as "nutri-cereals" since they are densely packed with energy, minerals, vitamins, antioxidants and dietary fibres and are the staple diet of the millions inhabiting the world's arid and semi-arid tropics. Millets are rich in chemicals that guard against a number of chronic ailments, such as Type II diabetes, cancer, obesity, cardiovascular illnesses and isthmic strokes [4], [3]. These crops have a short lifespan and may adjust in various cropping systems. The United Nations General Assembly has approved a resolution, sponsored by India and backed by more than 70 nations, designating the year 2023 as the "International Year of Millets" in recognition of the significance and to promote these nutritious small grain crops. Small millets are un-researched and under-utilized crops and their production is mainly depends on environmental conditions (e.g. temperature, rainfall, soil fertility etc.) and management practices (e.g. sowing time, sowing method, weed management, water management, nutrient management, harvesting time and method). Non-monetary inputs such as sowing time play a significant role in enhancing crop production among the different management aspects influencing the growth and development of small millet. At present there is no considerable area under cultivation of the small millets in the southern agro-climatic zone. Hence, there is need to find out optimum time of sowing for the small millets as there is increase in demand for the millet's cultivation by the farming community. Hence, a field experiment on

"Performance of small millets under varied sowing windows" was planned with an objective of determining optimum sowing time for small millets in southern zone of Andhra Pradesh.

MATERIAL AND METHODS

A field experiment entitled "Performance of small millets under varied sowing windows" was conductedat the Regional Agricultural Research Station in Tirupati, Acharya N. G. Ranga Agricultural University, during *kharif* 2019 and 2020. Randomized block design (FRBD) with factorial concept was used to test eighteen treatments and replicated thrice. In this experiment, seeds were sown at three different times in June and July (D1: First FN in June, Second FN in June, and First FN in July) and in Factor B - Small Millets (C_1 -Foxtail millet (*Setaria italica*), C_2 - Browntop millet (*Urochloa ramosa*), C_3 - Little millet (*Panicum sumatrense*), C_4 - Kodo millet (*Pasaplaum scrobiculatum*), C_5 - Barnyard millet (*Echinocloa frumentacea*) and C_6 - Proso millet (*Panicum tetragonolobum*). The experimental soil was sandy loam in texture, neutral in reaction (pH 6.7), low in organic carbon (0.35%), low in available nitrogen (207 kg ha^{-1}), medium in available phosphorus (28.3 kg ha^{-1}) and medium in potassium (289 kg ha^{-1}). The crop varieties used for the study, row-to-spacing, plant-to-plant spacing and recommended dosage of fertilizers for the small millets were presented in Table 1. The distribution of rainfall during the crop growth period under different sowing windows was presented in Tables 2 and 3. The gross and net size of the plots was 6.3 m × 4.4 m and 4.5 m × 4.0 m, respectively. Nitrogen fertilizer was applied in two split doses as basal and top dressing at 30 DAS in all the crops. Total quantity of phosphorus and potassic fertilizers were applied as basal at the time of sowing. All of the management techniques for small millets were implemented as per the zonal reports of southern zone of Andhra Pradesh [12]. As described by Panse and Sukhatme (1985) [8], analysis of variance was used to conduct statistical analysis on the grain yield of small millet crops.

RESULTS AND DISCUSSION

Grain Yield

Pooled mean of 2019 and 2020 results indicated that maximum grain yield of small millets was recorded when the sowing was done in II FN of June (1183 kg ha^{-1}), but there is no significant difference between different the sowing windows (Table 4). This might be due to adequate and uniformly distributed rainfall coupled with bright sunshine hours received by the crop from seeding to vegetative phase sown during II FN of June resulted in higher photosynthate production and source to sink translocation. The results support the finding of Nandini and Sridhara (2019) [7], who revealed that foxtail millet sown on II FN of June produced significantly higher grain yield (2049 kg ha^{-1}), straw yield (4261 kg ha^{-1}) and harvest index (0.33) as compared to crop sown on II FN of July and II FN of August. Similar results were envisaged by Andhale *et al*., 2007 [1], Patel *et al*., 2004 [9] and Siddig *et al*., 2013[10]. When the crop was sown at June's I FN, a lower yield was noted. This is because from flowering to reproductive stage, low temperatures and high humidity led to more disease infestation, inflorescence shedding and poor grain setting, which ultimately decreased grain productivity (Singh *et al*., 1975) [11]. With regard to different small millets, foxtail millet (2128 kg ha^{-1}) recorded a significantly higher grain yield which was followed by browntop millet (1250 kg ha^{-1}).The lowest grain yield was recorded with kodo millet (839 kg ha^{-1}).

Economics

Among the sowing windows highest gross returns (₹ 44310 ha^{-1}), highest net returns (₹ 19775 ha^{-1}) and B-C ratio (1.81) was recorded in small millets when sown during II FN of June. The reason might be due to the higher yields and lower cost of cultivation of small millets when sown at II FN of June. Similarly, Mubeena *et al*., 2019[6] recorded significantly higher net returns (₹ 24978 ha^{-1}) and B-C ratio in *kharif* foxtail millet when sown during II FN of June over all other sowing dates. Among six small millets, foxtail millet had recorded highest gross returns (₹ 63862 ha^{-1}), net returns (₹39056 ha^{-1}) and B-C ratio (2.58) which was followed by browntop millet. Foxtail millet had highest yield due to favourable weather coupled with congenial atmosphere and ability to produce more dry matter. The lower gross returns (₹ 29946 ha^{-1}), lowest net returns (₹ 4915 ha^{-1}) and B-C ratio (1.19) were recorded with barnyard millet. Interaction effect of sowing windows and small millets was found to be non-significant.

Table 1: Details of cultivation of small millets

Treatment	Crop	Variety	Spacing (cm^2)	NPK (kg ha^{-1})
C_1	Foxtail millet	SiA-3085	22.5 × 10	50-40-20
C_2	Browntop millet	GPUPBT-6	45.0 × 10	40-20-20
C_3	Little millet	OLM-203	22.5 × 10	50-40-20
C_4	Kodo millet	JK-48	22.5 × 10	40-20-20
C_5	Barnyard millet	Co-2	22.5 × 10	20-20-20
C_6	Proso millet	TNAU-143	22.5 × 10	20-20-20

Table 2: Distribution of rainfall during crop growth period of millets during the different sowing windows (2019)

Crop/Date of Sowing	June I FN, 2019		June II FN, 2019		July I FN, 2019	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
C_1 -Foxtail millet	694	29	461	25	411	27
C_2 -Browntop millet	702	31	461	25	411	27
C_3 -Little millet	626	25	560	31	584	36
C_4 -Kodo millet	698	31	560	31	584	36
C_5 - Barnyard millet	698	31	560	31	584	36
C_6 -Proso millet	698	31	692	44	637	40

Table 3: Distribution of rainfall during crop growth period of millets during the different sowing windows (2020)

Crop/Date of Sowing	June I FN, 2020		June II FN, 2020		July I FN, 2020	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
C_1 -Foxtail millet	754	31	656	27	426	28
C_2 -Browntop millet	765	33	761	33	426	28
C_3 -Little millet	691	27	761	33	596	37
C_4 -Kodo millet	765	33	761	33	596	37
C_5 - Barnyard millet	765	33	761	33	596	37
C_6 -Proso millet	765	33	897	37	657	41

Table 4: Grain yield and economics of small millets as influenced by different sowing windows during *kharif* (Pooled mean of 2019 and 2020)

Treatments	Grain yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit cost ratio (BCR)
Date of sowing				
D_1 - I FN of June	1117	41153	16618	1.68
D_2 - II FN of June	1183	44310	19775	1.81
D_3 - I FN of July	1126	42172	17637	1.72
CD @ 0.05	72			
Small millets				
C_1 -Foxtail millet	2128	63862	39056	2.58
C_2 -Browntop millet	1250	50296	27768	2.24
C_3 -Little millet	912	36482	11451	1.45
C_4 -Kodo millet	839	33545	8514	1.34
C_5 - Barnyard millet	998	29946	4915	1.19
C_6 -Proso millet	889	35575	10544	1.42
CD @ 0.05	342			

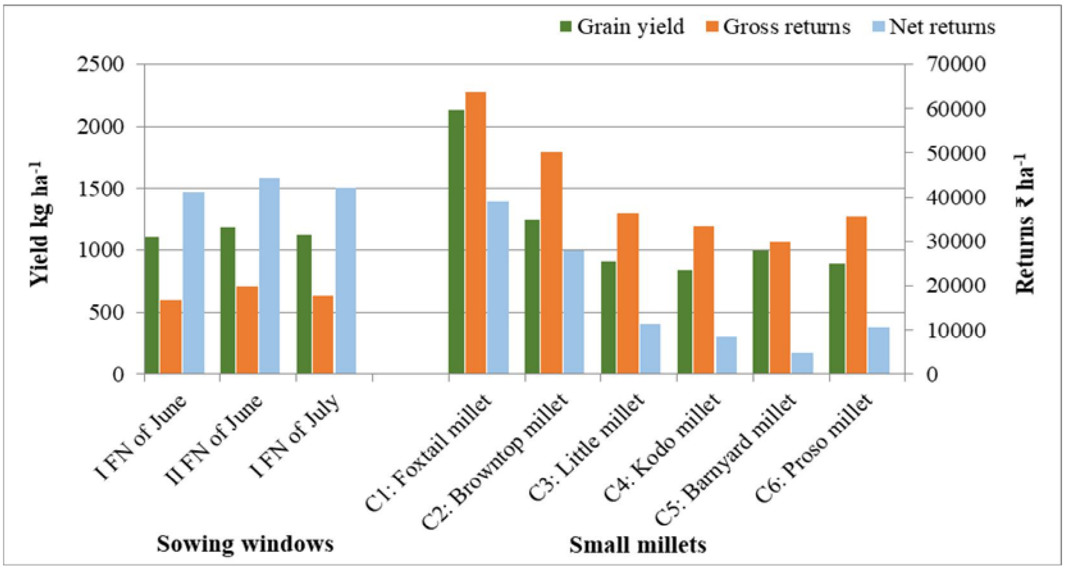

Fig 1. Effect of sowing windows and small millets on yield, net returns and gross returns

CONCLUSION

Optimum sowing window is the most important non-monetary input determining the growth and yield of the crops. From the results of the study, it can be concluded that small millets should be sown in II FN of June in order to achieve a higher yield which is more economically profitable.For higher yields, sowing at the right time is crucial. Foxtail millet cultivation offers farmers the greatest benefits among the six small millets in terms of grain yield, gross returns, net returns and benefit cost ratio.

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