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Influence of sowing windows on the productivity of small millet crops

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Abstract
A field experiment was conducted at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2019 to evaluate the best sowing window for getting maximum yield of small millet crops. Experiment was conducted in split-plot design with millet crops as main plots and sowing windows as sub plot treatments. Results revealed that all the millet crops have performed best at July 1st FN sowing; however, kodo millet at July 1st FN sowing has shown maximum growth attributes, yield attributes and grain yield. Gross income, net income and benefit cost ratio were also found significantly higher for the same treatment as compared to other millets crops at other sowing windows.

Keywords: Sowing window, Kodo millet, little millet, barnyard millet, productivity

Introduction
Small millets are traditional food crops of India since times immemorial and played an important role in food and nutritional security. Due to gradual changes in human food preferences and Government policies, millet cultivation lost its area and confined only to marginal and drought prone lands. Again due to increased conscious towards climate change mitigation strategies, millet cultivation is gaining momentum. Further, small millets can be seen as low cost tactic to eliminate malnutrition in developing countries like India. This would be possible only through improvement in small millet area and production. However, in India small millet area has decreased from 5.29 M.ha in 1951-55 to 0.97 M.ha in 2010-16 (Mal and Padulosi, 2013) [5]. In the similar manner production and productivity of small millets in most of the states were very less than the national averages. Optimum management practices coupled with use of high yielding millet cultivars is the best approach to tackle the problem. Sowing in the optimum sowing window is one such management practices which yields good outcomes without put in any additional monetary inputs. Timely planting of crops generally ensures sufficient time for root development and vegetative growth for optimum harvesting of available soil nutrients and radiant energy (Soler *et al*., 2007) [8]. Due to rapid changes in climatic conditionsover the years, rainfall pattern and also temperatures have significantly altered and hence determination of optimum sowing window become necessary to get higher yields. Due to the limited research information availability on this aspect, this study was proposed.

Materials and Methods
An experiment was conducted during *kharif*, 2019 at Agricultural Research Station, Vizianagaram, Andhra Pradesh, India. The experimental site was deep sandy loam soil with low, high, medium soil available nitrogen, phosphorus and potassium respectively. Soil pH was neutral and organic carbon content was low. Experiment was laid out in split plot design with three replications. Millet crops (C1:Kodo millet; C2:Little millet; C3:Barnyard millet) were assigned to main plots and Sowing windows (S1:July 1st Fortnight(FN); S2: July 2nd FN; S3: August 1st FN; S4: August 2nd FN; S5: September 1st FN; S6: September 2nd FN) were assigned to subplots.
Kodo millet variety JK 41, Little millet variety DHLM 36-3 and Barnyard millet variety VL 207 were used in the experiment. Fertilizer schedule of 40-20-0 kg NPK/ha, 50-40-0 kg NPK/ha, 20-20-20 kg NPK/ha was followed for kodo millet, little millet and barnyard millet respectively. Nitrogen fertilizer was applied in two split doses as basal and top dressing at 30DAS in all the crops. Total quanity of phosphorus and potassic fertilizers were applied as basal at the time of sowing. Observations were recorded from five randomly selected plants at the time of maturity. Data recorded was analysed by using ANOVA to identify the significant components of the treatment means.

Results and Discussions

Performance of millet crops

The growth and yield attributes were significantly varied for three different millet crops. Among the three crops days to 50% flowering and days to maturity were significantly longer for little millet and significantly shorter for barnyard millet. Plant height of barnyard millet was higher, whereas shorter plant height was recorded in kodo millet. However, number of branches per plant and test weight of kodo millet were significantly higher compared to little millet and barnyard millet.

Grain yield was significantly higher in kodo millet which was 261%, 19.5% higher than little millet and barnyard millet respectively. Higher number of productive branches and maximum test weight has contributed to higher grain yield in kodo millet. These results are in agreement with the results reported by Muchow, 1989, who reported highest grain yield in maize compared to sorghum and pearl millet crops. Straw yield of barnyard millet was 150%, 20.5% higher respectively compared to little millet and kodo millet. Maximum plant height might have contributed to higher straw yield in barnyard millet. Harvest index of kodo millet was significantly higher which was 66.2%, 34.5% greater than little millet and barnyard millet respectively. Considering the economics, gross income, net income and benefit cost ratio (BCR) were significantly higher in kodo millet. Though it is not statistically significant, next best crop in terms of net returns and BCR was barnyard millet. Rainfall, Growing degree days (GDD) accumulation were significantly higher for little millet followed by kodo millet and barnyard millet. Longer duration of little millet was the main reason for maximum accumulation of rainfall and GDD. However, high GDD accumulation in little millet could not be converted into economic yield due to lower test weight and low yielding capability in spite of receiving higher rainfall.

Influence of sowing windows

Growth and yield attributes were significantly differed among different sowing windows. Days to 50% flowering and days to maturity were significantly decreased with delay in date of sowing from July 1st FN to September 2nd FN. July 1st FN sowing has taken more time to 50% flowering as well as to maturity. Similarly plant height was also significantly decreased from July 1st FN to September 2nd FN. Plant height recorded in July 1st FN sowing was 14.7%, 34.7%, 49.6%, 66.9%, 88.8% higher than July 2nd FN, August 1st FN, August 2nd FN, September 1stFN,September 2nd FN respectively. Similarly, number of branches per plant and test weight was also significantly higher in July 1st FN sowing compared to later dates of sowing. Khanand Sohail, 2015 reported superior yield attributes with early sowing (June 20th) compared to later dates of sowing (10th July and 30th July) in pearl millet. Grain yield, straw yield and harvest index were significantly decreased with delay in sowing time from July 1st FN to September 2nd FN. Grain yield recorded in July 1st FN sowing was highest and was 19.7%, 119.5%, 193.6%, 302.0%, 412.1% respectively compared to July 2nd FN, August 1st FN, August 2nd FN, September 1st FN, September 2nd FN sowing. Grain yields of fonio millet (*Digitaria exilis* Stapf) decreased by 50% to 87% with delay in sowing from 1st FN of July to mid August (Gueye *et al*., 2015) [2]. Similarly straw yield obtained in July 1st FN sowing was 18.7%, 105.2%, 159.7%, 222.0%, 291.2% respectively compared to July 2nd FN, August 1st FN, August 2nd FN, September 1st FN, September 2nd FN sowing. Maurya *et al*.2016 also reported highest grain yield, straw yield and harvest index with 23rd July sowing compared to 30th July and 6th August sowings in pearl millet. Harvest index and gross income were also followed similar trend of significant reduction from July 1st FN to September 2nd FN. Net income and BCR were significantly higher in July 1st FN sowing. Detroja *et al*.,2018 [1] reported highest net return, BCR and economic efficiency in 10-15 July sowing than that of 25-30 July and 10-15 August sowings. Though it was not statistically on par, next highest net income and BCR were recorded in July 2nd FN sowing. Superior yield attributes and maximum grain yield were the major reasons for higher net income and BCR. From August 2nd FN onwards negative net returns and BCR were recorded. High cost of cultivation and lowest economic yield are the main reasons for negative net returns. All the six sowing windows differed significantly in terms of total rainfall, rainy days and GDD accumulation. July 1st FN sowing has received maximum total rainfall(780.9mm), rainydays(41) and GDD(1507) compared to later dates of sowing, whereas lowest of these parameters were received in September 2nd FN sowing (352.5mm rainfall, 11 rainy days, 1171 GDD respectively) (Fig.2). Radhouane, 2008 reported that optimal pearl millet planting times were between 1549 and 1441 GDD, which accumulated when sowing would be done between first May and early June.A significant decrease in length of the crop growing period with delay in sowing time from July 1st FN to September 2nd FN is the main reason for reduction in accessing more rainfall, rainy days and GDD. As millets are short day plants, forwarding sowing time towards late *kharif* will force the crop to enter into reproductive phase without attaining proper vegetative growth which ultimately effecting the yield attributing characters and yield.

Interaction Effect

Interaction between millet crops and sowing windows was significant for all the growth attributes, yield attributes and yield. All the three crops have performed at its best in the July 1st FN sowing. Among various treatment combinations, kodo millet at July 1st FN sowing was highly productive and profitable. These results corroborates with the results reported by Rurinda *et al*. 2014, who reported significant increase in the yields of all the three crops with early sowing and among the crops maize yielded higher compared to finger millet and sorghum.

Table 1: Effect of date of sowing on growth attributes, yield attributes, yield and economics of small millet crops

Treatments	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches/ plant	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C
Main plots : Millet crops(C)											
C1: Kodo millet	50.3	80.7	78.4	7.8	5.39	1632	5394	22.6	40791.15	15553.15	0.62
C2: Little millet	54.2	85.9	101.9	6.6	2.35	452	2600	13.6	11292.18	-14298.82	-0.56
C3: Barnyard millet	43.4	75.9	137.1	2.3	2.93	1366	6500	16.8	34157.41	8566.41	0.33
S.Em±	0.24	0.34	1.81	0.31	0.03	44.2	114.0	0.26	1104.1	1104.1	0.04
CD (p=0.05)	0.96	1.32	7.13	1.21	0.12	173.4	447.7	1.01	4335.1	4335.1	0.17
Subplots: Sowing dates (S)											
S1: July 1st FN	54.4	86.8	143.9	8.3	4.08	2243	8836	19.6	56069.96	30596.63	1.21
S2: July 1nd FN	52.2	85.0	125.5	6.6	3.94	1874	7441	19.2	46851.85	21378.52	0.84
S3: August 1st FN	50.6	82.7	106.8	6.3	3.68	1022	4307	18.2	25555.56	82.22	0.01
S4: August 1nd FN	48.3	79.1	96.2	5.3	3.47	764	3402	17.5	19092.59	-6380.74	-0.25
S5: September 1st FN	46.1	76.6	86.2	3.9	3.21	558	2744	15.8	13960.91	-11512.43	-0.45
S6:September 2nd FN	44.2	74.9	76.2	2.9	2.96	438	2259	15.4	10950.62	-14522.72	-0.57
S.Em±	0.26	0.24	2.60	0.45	0.03	30.7	82.0	0.19	767.8	767.8	0.03
CD (p=0.05)	0.74	0.71	7.50	1.29	0.08	88.7	236.8	0.54	2217.6	2217.6	0.09
Interaction											
i.Two sub plots at same level of main plots											
S.Em±	0.44	0.42	4.50	0.77	0.05	53.2	142	0.32	1329.9	1329.9	0.05
CD (p=0.05)	0.47	1.22	12.99	2.24	0.13	153.6	172.7	0.93	3840.9	3840.9	0.15
ii.Two main plots at same level of subplots											
S.Em±	1.28	0.51	4.49	0.77	0.05	65.6	410.2	0.39	1641.0	1641.0	0.06
CD (p=0.05)	1.55	1.77	14.11	2.42	0.18	229.1	599.6	1.36	5726.9	5726.9	0.23

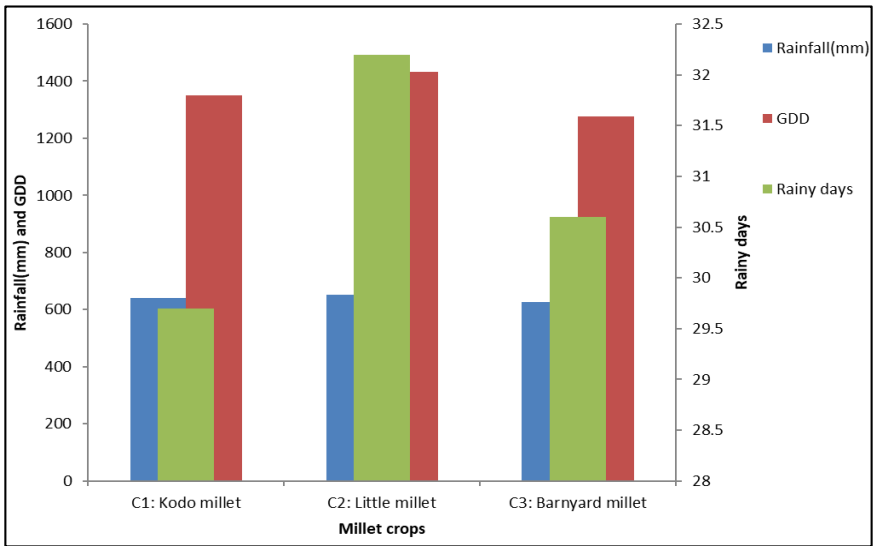

Fig 1: Rainfall (mm), rainy days and growing degree days received by different millet crops

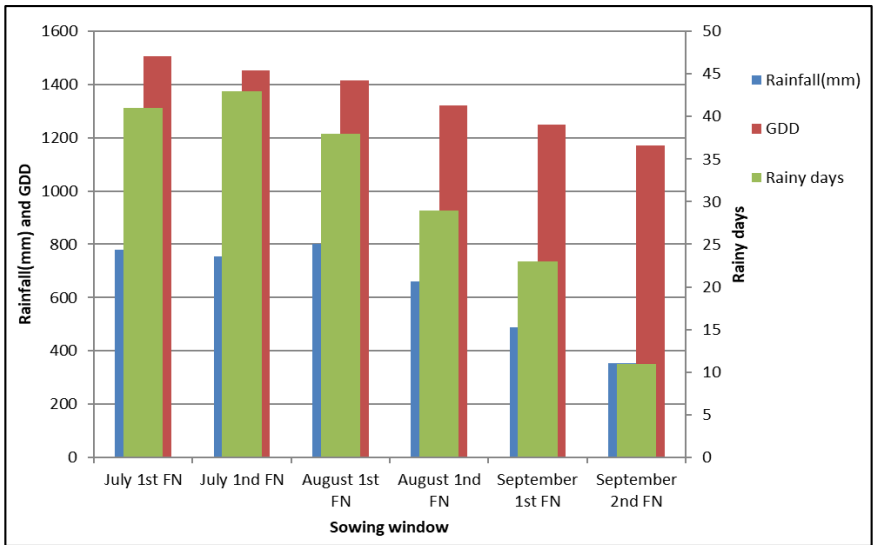

Fig 2: Rainfall (mm), rainy days and growing degree days at different sowing windows

Conclusion

Optimum sowing window is the most important factor determining the growth and yield of the crops. From this study it was concluded that kodo millet at July 1st sowing has given highest grain yield, net income and BCR compared to other dates of sowing and also other crops.

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