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Influence of Sowing Windows and Fertilizer Management Practices on Yield Attributes, Yield, Heart Use Efficiency, Accumulation of Heat Units and Growing Degree Days of Rabi Sorghum Under Rainfed Condition

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A B S T R A C T

Field experiments were conducted at Agricultural Research Station, Kovilpatti between February 2012 to March 2014 to evaluate the influence of sowing windows and fertilizer management practices on growth and yield of rainfed sorghum. The treatment consisted of four date of sowing (D_1: 39 standard week, D_2: 40th standard week, D_3: 41st standard week and D_4: 42nd standard week in main plots and six INM practices (S_1: Control (no manure, fertilizers and Biofertilizers), S_2: 100 % RDF (40: 20: 0 kg NPK /ha) + enriched FYM 750 kg/ha, S_3: 75 % RDF + enriched FYM 750 kg/ha, S_4: 75 % RDF + Biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha, S_5: 50 % RDF + enriched FYM 750 kg/ha and S_6: 50 % RDF + Biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha) in subplots. The results revealed that 39th standard week sown crop registered higher ear head length, ear head girth, grains per ear head, grain yield and stover yield of sorghum but was comparable with 40th standard week and 41st standard week sown crops. These treatments were significantly superior to crop sown during 42nd standard week. Among the INM practices, 75 % RDF + biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha gave higher ear head length, ear head girth, grains per ear head, grain yield and stover yield which was comparable with 100 % RDF (40: 20: 0 kg NPK /ha) + enriched FYM 750 kg/ha. Lower values of yield attributes and yield were obtained with control treatment (No manures, fertilizers and micronutrients application).

Introduction

Grain sorghum (*Sorghum bicolour* L. Moench) is an important cereal crop. It ranks fifth among the world's cereals. It is grown mainly in semi arid areas of the tropics and subtropics. Grain sorghum is a basic human food crop in many developing Africa and Asian countries. It is also used as an animal feed. Among different inputs, distribution of crop seasonal temperature, rainfall and relative humidity would influence rainfed sorghum productivity to a large extent. The extent of effect of these environmental parameters may vary depending on planting time. In rainfed situation, 1st week of October sowing recorded significantly higher grain yield and stover yield compared to rest of the sowing dates (3rd week of October and 1st week of November) (Hulihalli *et al.*, 2016). Extremely high temperature, moisture stress and low humidity during flowering damage

the flowering as well as foliage, desiccation of pollen and interfere with the pollination resulting in poor grain formation. Apart from rainfall, judicial use of manures and fertilizer is essential to attain sustainable crop yield under rainfed conditions. Crop responses to organic and biological nutrient carriers are not as spectacular as fertilizer but the supplementary and complementary use of such sources is known to enhance the utilization efficiency of fertilizers (Yadav, 1998). Keeping these facts in view, a study was undertaken to find out the effect of various dates and fertilizer management practices on yield attributes, yield, heart use efficiency, accumulation of helio thermal units and growing degree days of rabi sorghum under rainfed condition.

Materials and Methods

The field experiment was conducted during Rabi seasons of 2012-13 and 2013-14 at Agricultural Research Station, Kovilpatti. The research station is located at latitude $8^{o}48'$, longitude $77^{o}4'$and altitude 30 m above mean sea level. The soil was clay loam with pH 8.1 with EC 0.11dSm^{-1}. The soils were low in available nitrogen (154 and 162 kg/ha during 2012 and 2013) as well as phosphorus status (8.9 and 9.2 kg/ha during 2012 and 2013) and high in available potassium status (371 and 376 kg/ha during 2012 and 2013). The organic carbon content was also low (0.32 and 0.34 during 2012 and 2013 respectively). The experiment was laid out in split plot design with three replications. The treatment consisted of four date of sowing (D_1: 39 standard week (Sep 24th - 30th), D_2: 40th standard week (1 to 7 'Oct), D_3: 41st standard week (8 to 14 'Oct) and D_4: 42nd standard week (15 to 21' Oct) in main plots and six INM practices (S_1: Control (no manure, fertilizers and Biofertilizers), S_2: 100 % RDF (40: 20: 0 kg NPK /ha) + enriched FYM 750 kg/ha, S_3: 75 % RDF + enriched FYM 750 kg/ha, S_4: 75 % RDF + Biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha, S_5: 50 % RDF + enriched FYM 750 kg/ha and S_6: 50 % RDF + Biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha) in subplots. Sorghum variety K8 was sown as per the treatments at 45 x 15 cm spacing. The crop was grown in a net plot size of 4.5 x 3.6 m. All other recommended agronomic practices were followed to the crop. All the observations were recorded as per the treatments and statistical analysis was made by using suitable computer programme. A base temperature of 10^{o}C was used to compute the thermal units. The data collected from the experiment at different growth stages and at harvest was subjected to statistical analysis as described by Gomez and Gomez (1984). The rainfall received and available soil moisture observed during the cropping period is given in figures 1 and 2.

Results and Discussion

Yield attributes

Panicle length, panicle girth and grains per panicle were found higher under crop sown on first date of sowing (39th SMW) but it was on par with the second (40th SMW) and third (41st SMW) dates sowings during 2012 and 2013 (Table 1). This might be due to delayed on set of north east monsoon during 41st standard meteorological week during both the years. Similar results were observed by (Kalhapure and Shete, 2013). The 100 seed weight of sorghum did not show any significant effect with respect to sowing dates during 2012 and 2013.

With regard to INM practices, 75 % RDF + biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha gave higher yield parameters *viz*., panicle length, panicle girth and grains per panicle which was comparable with 100 % RDF (40: 20: 0 kg NPK /ha) +

enriched FYM 750 kg/ha. It might be due to optimum and regular supply of nutrients to plant from soil during different growth period of the crop by the 75 % RDF + biofertilizer (as seed and soil inoculations) + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha. The results were conformity with the findings of Mudalagiriyappa *et al.*, (2012). Lower yield attributes were obtained with control treatment (No manures, fertilizers and micronutrients application).

Yields

Among different dates of sowing tried, 39th standard week sown crop registered higher grain (722 and 1572 kg/ha) and stover yields (2173 and 4701 kg/ha) during both the years which was comparable with 40th and 41st standard week sown crops. This might be due to better distribution of rainfall and favourable weather condition prevailed during the cropping season with the early date of sowing. Similar results were observed by Mokashi *et al.*, (2008). Sorghum crop sown during 42nd standard meteorological week recorded lower grain and stover yields during both the years. In general, the yield levels of this field experiment were low (503 to 804 kg/ha) due to reduction (33.05 %) and uneven (severe drought from 11.11.2012 to 26.12.2012) distribution of seasonal rainfall during rabi 2012-13.

With respect to INM practices tested, application of 75 % RDF + biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha gave grain yield (804 and 1748 kg/ha) and stover yield (2416 and 5241 kg/ha) which was comparable with 100 % RDF (40: 20: 0 kg NPK /ha) + enriched FYM 750 kg/ha. This might be due to the better availability of macro and micro nutrients during entire growing season because of slow mineralization of nutrients from FYM applied and biofertilizers inoculated. Similar trend of the results were observed by Abdelmuniem and Madhavi (2015). Lower grain as well as strover yields were obtained with control treatment (No manures, fertilizers and micronutrients application).

Table.1 Influence of date of sowing and INM practices on yield parameters and yield of rainfed sorghum

Treatments	Panicle length (cm)		Panicle girth (cm)		Grains / panicle		100 seed weight (g)		Grain yield (kg/ha)		Stover yield (kg/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Date of sowing												
D1	25.76	27.58	12.06	12.08	188	248	2.62	4.28	722	1572	2173	4701
D2	25.64	27.34	11.99	11.99	183	243	2.60	4.26	715	1560	2154	4671
D3	25.45	27.09	11.90	11.87	177	238	2.58	4.26	709	1547	2138	4645
D4	24.46	23.59	11.41	10.01	169	213	2.56	4.25	660	1344	1993	4051
SEd	0.16	0.25	0.08	0.11	2.3	2.7	0.01	0.02	7	15	21	69
CD 5 %	0.33	0.51	0.16	0.22	4.7	5.9	NS	NS	14	31	43	138
INM practices												
S1	18.14	18.53	8.51	8.11	130	167	2.55	4.24	503	1058	1521	3175
S2	28.35	29.71	13.26	12.53	202	264	2.59	4.27	786	1695	2365	5080
S3	25.15	26.08	11.72	11.45	176	232	2.57	4.25	695	1490	2094	4475
S4	29.01	30.68	13.56	13.43	205	278	2.61	4.28	804	1748	2416	5241
S5	24.23	25.05	11.3	10.96	169	222	2.57	4.26	669	1426	2021	4281
S6	27.12	28.36	12.71	12.43	192	250	2.58	4.27	753	1617	2270	4850
SEd	0.34	0.36	0.15	0.16	4.3	4.6	0.01	0.02	9	24	55	81
CD 5 %	0.69	0.74	0.31	0.32	8.7	9.1	NS	NS	19	48	111	163

Table.2 Influence of sowing dates on heat use efficiency (kg/ha/°C day) of rainfed sorghum at different phenophases

Phenophase	Date of sowings							
	39th std. week		40th std. week		41st std. week		42nd std. week	
	2012	2013	2012	2013	2012	2013	2012	2013
Seedling	1.03	1.95	1.02	1.93	1.00	1.91	0.87	1.12
Vegetative	1.56	2.72	1.54	2.68	1.52	2.66	1.38	2.21
Booting	2.00	3.44	1.98	3.41	1.97	3.39	1.85	3.05
Flowering	2.29	3.79	2.27	3.77	2.26	3.74	2.11	3.28
Milking	2.35	4.17	2.33	4.14	2.31	4.11	2.17	3.60
Maturity	2.14	3.82	2.12	3.80	2.10	3.77	1.97	3.30

Fig.1 Rainfall (mm) and available soil moisture (%) during rabi 2012-13

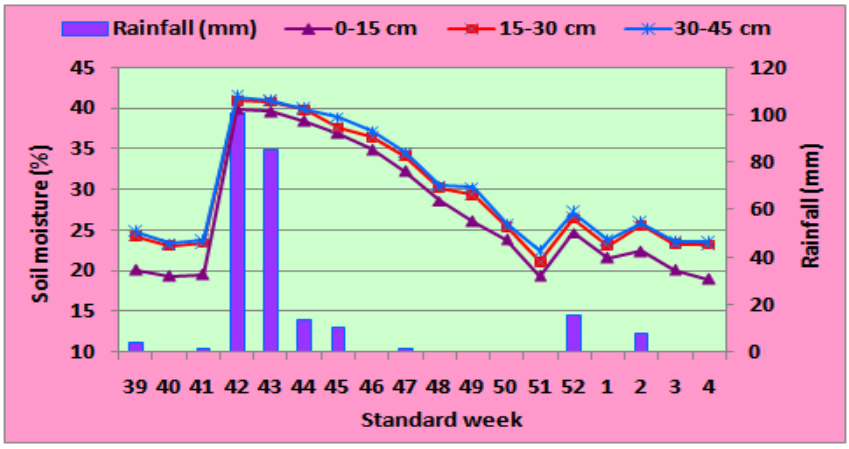


Fig.2 Rainfall (mm) and available soil moisture (%) during rabi 2013-14

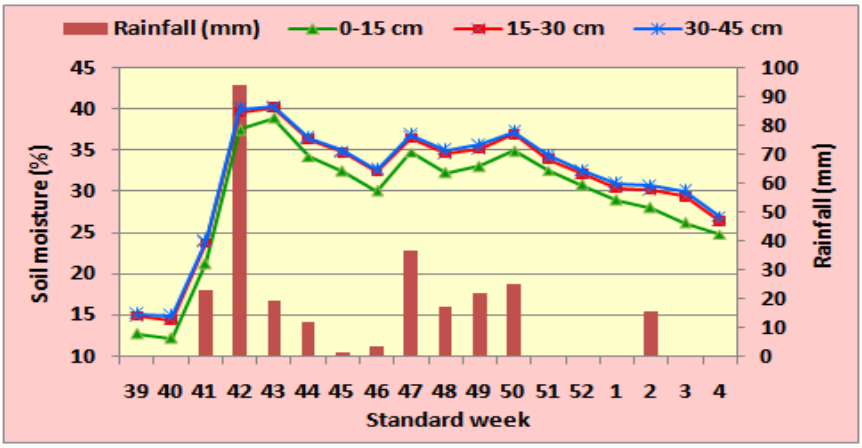


Fig.3 Effect of different sowing dates on heat unit accumulation of rainfed sorghum at different phenophases during 2012

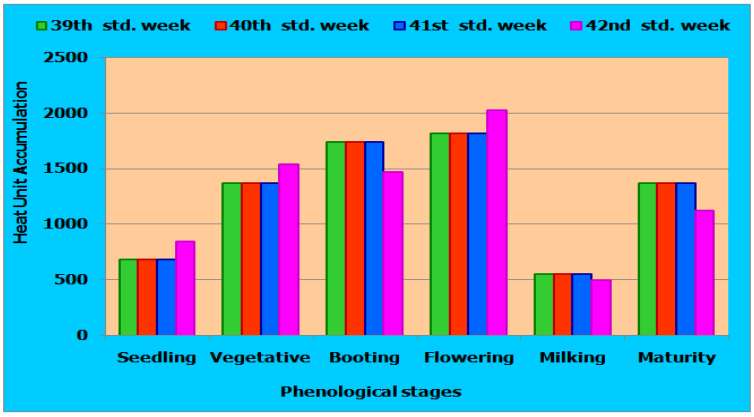


Fig.4 Effect of different sowing dates on heat unit accumulation of rainfed sorghum at different phenophases during 2013

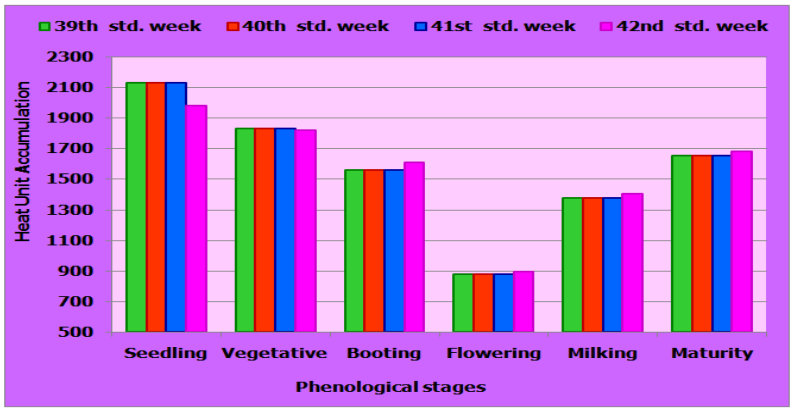


Fig.5 Effect of different sowing dates on growing degree days of rainfed sorghum at different phenophases (2012)

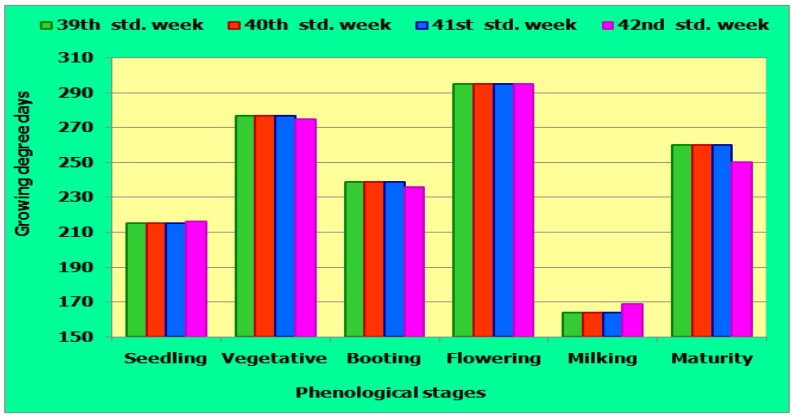
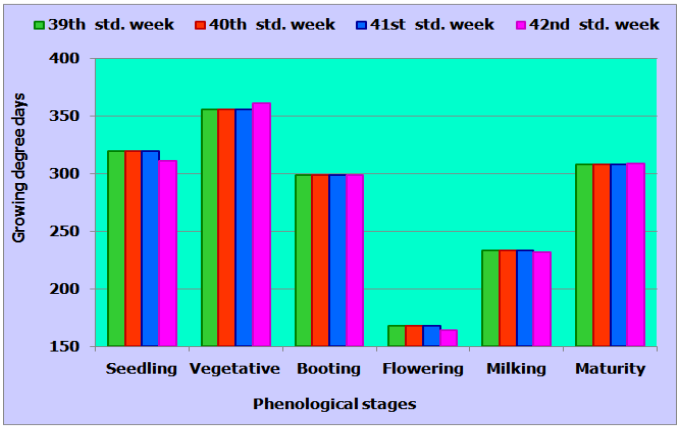


Fig.6 Effect of different sowing dates on growing degree days of rainfed sorghum at different phenophases (2013)



Heat unit accumulation

Crop sown during 39th, 40th and 41st standard weeks recorded higher accumulated heat unit (7536 and 9440). This might be due to late onset of north east monsoon during both the years (Figures 3 and 4). Lowest heat accumulation was observed with very late sown crop (42nd standard week). The thermal unit requirement was increased up to flowering stage and it was decreasing up to milking stage. Thereafter again it increased up to maturity. Similar trend of the results were observed by Waghmare *et al.,* (2010). Higher heat use efficiency was recorded with the crop sown in first fortnight of June and decreased with each delay in sowing. However, at vegetative stage (up to 30 DAS) higher heat units were recorded in June first fortnight sowing (Biradar and Gollagi, 2006).

Growing degree days (GDD)

The 39th, 40th and 41st standard week sown crops recorded higher accumulated growing degree day (AGDD) (Figures 5 and 6). This might be due late onset of monsoon during 41st standard week. Similar result was reported by Mulik *et al.,* (1996). Lower values of AGDD were registered with crop sown during 42nd standard week. GDD values were decreasing from seedling to flowering stage and thereafter it again increased during maturity phase. 39th, 40th and 41st standard week sown crops registered with higher GDD values at all the crop growth phases except during maturity phase while 42nd standard week sown crop recorded higher GDD value at maturity phase.

Heart use efficiency

With regard to heat use efficiency, 39th standard week sown crop recorded higher values at different phenophases of the crop which was comparable with 40th and 41st standard week sown crops during both years (Table 2). Maximum HUE value of 2.35 and 4.17 kg/ha/°C day was noticed during milking stage under 39th standard week. This might be due to more accumulation of dry matter production at milking stage. Similar results have been reported by Agarwal and Upadhyay (2009). Lower HUE values were registered at different crop growth stages with 42nd standard week sown crop in both years.

From the present study it can be concluded that 39th–41st standard weeks sown (September 24th to October 14th) crop applied

with 75 % RDF (40: 20: 0 kg NPK /ha) + biofertilizer + TNAU MN mixture 12.5 kg/ha as enriched FYM 750 kg/ha was found optimum to get higher yield of sorghum under rainfed condition in southern agroclimatic zone of Tamil Nadu.

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