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Effect of irrigation schedule and nitrogen management on growth and productivity of *rabi* sorghum grown under clay soils of South Gujarat

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Abstract
A field experiment entitled "Response of *rabi* sorghum (*Sorghum bicolor* L.) on different levels of irrigation, nitrogen and banana pseudostem sap and its residual effect on summer greengram (*Vigna radiata* L.) under South Gujarat condition" was carried out during *rabi* season of 2016-17 and 2017-18 at college farm of Soil and Water Management Research Farm, Navsari Agricultural University, Navsari. The soil was clayey in texture, rich in organic carbon, medium in available nitrogen, P_2O_5 and K_2O with alkaline in reaction (pH 7.8). Total twelve treatment combinations, consisting of four irrigation schedule based on IW:CPE ratio (I_1=0.4, I_2=0.6 and I_3=0.8) and three nitrogen levels (N_1= 60 kg N ha^{-1}, N_2= 80 kg N ha^{-1} and N_3= 100 kg N ha^{-1}) were tested in a split plot design with four replications. The results indicated that scheduling irrigation at an IW:CPE ratio of 0.8 recorded significantly higher values of almost all the growth characters, yield attributes as well as seed and stover yields of sorghum over 0.6 and 0.8 IW:CPE ratios and remained statistically at par with IW:CPE ratio of 0.8. Days to 50% flowering and maturity were delayed under this IW:CPE ratio. Whereas, higher WUE was obtained when crop was irrigated at 0.4 IW:CPE ratio. Almost all the growth characters, yield attributes, seed and stover yields were found significantly higher when crop has given nitrogen application at 100 kg N ha^{-1} than that over lower dose of nitrogen.

Keywords: Sorghum, irrigation, nitrogen, IW:CPE ratio, moisture

Introduction
Sorghum (*Sorghum bicolor* L.) is a drought resistant crop among the major cereals and the fifth most important cereal in the world after wheat, rice, maize and barley. It is considered as king of millets and staple food and fodder crop of the world's poor and most food-insecure population, located primarily in the arid and semi-arid tropics. Sorghum grain contains 56-73% starch, 11.3% protein and 3.3% fat. Sorghum fodder is considered as an essential feeds for the livestock, which can help in maintaining good health of cattle and contains more than 50% digestible nutrients with 8% protein, 2.5% fat and 45% nitrogen-free extract. Its dietary value is equivalent to corn that way animals enjoy well due to its deliciousness and juicy character (Mehmood *et al*., 2008). It grown on 43.81 million ha area in the world, producing about 65.42 million tonnes grain with an average yield of 1523 kg ha^{-1}. India and USA have largest share of global sorghum area, while the maximum production of sorghum occur in the USA. India presently produces about 5.54 million tonnes of sorghum grain from area of 6.16 million ha and productivity of 884 kg ha^{-1}.
Among the different factors affecting yield, water management and nitrogen play an important role for enhancing yield. Water is the scare natural resource and availability of irrigation water is limited therefore, irrigation water should be utilized most efficiently by scheduling irrigation based on IW:CPE ratio. Application of nitrogen is another key factor affecting yield per unit area results in lower yield and hence optimum plant population produces maximum yield.
Precise information regarding appropriate schedule of irrigation and nitrogen requirements for *rabi* sorghum is very limited. Keeping in view the above considerations, comprehensive research programme planned to study the judicious use of irrigation water which may provide information on not only water use by crop but also when to irrigate and to find out optimum nitrogen requirement for sorghum with the following broad objectives.
For exploiting its maximum yield potentiality and efficient utilization of light, land, water and inputs, optimum plant population is vital factor for *rabi* sorghum. Keeping in view the above considerations, comprehensive research programme was plan to study the judicious use of irrigation water and to determine the suitable dose of nitrogen for *rabi* sorghum with the following broad objectives.

Table 1: Effect of irrigation and nitrogen on days to 50% flowering, days to maturity and length of earhead of sorghum

Tr No.	Treatments	Days to 50% flowering	Days to maturity	length of earhead
	Irrigation: (I)			
I_1	0.4 IW:CPE ratio	44.16	85.91	20.73
I_2	0.6 IW:CPE ratio	46.81	87.41	22.75
I_3	0.8 IW:CPE ratio	53.11	91.98	23.60
	SEm±	0.68	0.76	0.25
	CD (P=0.05)	2.09	2.35	0.76
	CV %	9.77	5.98	7.61
	Nitrogen: (N)			
N_1	60 kg N ha^{-1}	45.77	84.79	21.40
N_2	80 kg N ha^{-1}	48.40	87.70	21.40
N_3	100 kg N ha^{-1}	49.90	92.80	24.28
	SEm±	0.47	0.65	0.19
	CD (P=0.05)	1.33	1.82	0.54
	CV %	6.83	5.08	5.99

Table 2: Effect of irrigation and nitrogen on seed yield, stover yield and field water use efficiency

Tr No.	Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Field water use efficiency (kg ha mm^{-1})
	Irrigation: (I)			
I_1	0.4 IW:CPE ratio	2734	7115	11.39
I_2	0.6 IW:CPE ratio	3317	8328	11.06
I_3	0.8 IW:CPE ratio	3185	8080	8.85
	SEm±	54	123	0.18
	CD (P=0.05)	166	378	0.75
	CV %	12.11	10.85	12.22
	Nitrogen: (N)			
N_1	60 kg N ha^{-1}	2763	7034	9.38
N_2	80 kg N ha^{-1}	3165	7950	10.75
N_3	100 kg N ha^{-1}	3307	8540	11.16
	SEm±	33	107	0.11
	CD (P=0.05)	93	302	0.32
	CV %	7.42	9.50	7.58

Materials and methods

A field experiment was carried out during *rabi* season of 2016-17 and 2017-18 at college farm of Soil and Water Management Research Farm, Navsari Agricultural University, Navsari. The soil was clayey in texture, rich in organic carbon, medium in available nitrogen, P_2O_5 and K_2O with alkaline in reaction (pH 7.8). Total sixteen treatment combinations, consisting of four irrigation schedule based on IW:CPE ratio (I_1=0.4, I_2=0.6 and I_3=0.8) and three row spacing (N_1=60 kg N ha^{-1}, N_2= 80 kg N ha^{-1} and N_3= 100 kg N ha^{-1}) were tested in a split plot design with four replications to ascertain optimum IW:CPE ratio for scheduling irrigation, to find out optimum nitrogen dose, to work out yield, WUE of irrigation and nitrogen dose on yield of *rabi* sorghum.

Results and discussion

Days to 50% flowering

The data pertaining to days to 50% flowering as influenced by different IW:CPE ratio and spacing are summarized in Table 1. Irrigation scheduled at 0.4 IW:CPE ratio (I_1) recorded significantly less number of days (44.16) for 50% flowering whereas, irrigation scheduled at 1.0 IW:CPE ratio (I_3) taken significantly more number of days (53.11) for 50% flowering. lower dose of nitrogen at 60 kg N ha^{-1} (N_1) recorded significantly less number of days (45.77) for 50% flowering whereas, higher dose of nitrogen of 100 kg N ha^{-1} (N_3) taken significantly more number of days (49.90) for 50% flowering. Hugar *et al.* 2010 reported that lower dose of nitrogen application might be increase higher water and nutrient absorbed by plants, thus decrease in days in 50% flowering.

Days to maturity

The data regarding days to maturity on pooled basis as influenced by different IW:CPE ratios and nitrogen dose are presented in Table 1. Irrigating the crop as per 0.4 IW:CPE ratio (I_1) taken significantly less number of days for maturity (85.91) which was on par with IW:CPE ratio of 0.6 (I_2) while, sorghum irrigated at 0.8 IW:CPE ratio (I_3) took significantly more (91.98) number of days to maturity. Whereas, minimum days to maturity were found to be significant due to the lower level (N_1 *i.e.*, 60 kg N ha^{-1}) of irrigation (84.79), Patel *et al.*, 2010.

Length of earhead

The mean data on length of erahead as influenced by different IW:CPE ratio and nitrogen dose are furnished in Table 1. Significantly the highest length of earhead of sorghum plant (23.60 cm) was recorded when *rabi* sorghum was irrigated at 0.8 IW:CPE ratio (I_3). Significantly the lowest earhead length (20.73) was observed under 0.4 IW: CPE ratio (I_1). Application of nitrogen of 100 kg N ha^{-1} (N_3) produced significantly the highest earhead length (24.28). Significantly the lowest length of earhead (21.40) was observed under 60 and 80 kg N ha^{-1} (N_1 and N_2). Patel 2005 reported that optimum availability of moisture at 0.8 IW:CPE ratio without any stress and higher dose of nitrogen increases earhead length per plant.

Seed yield per hectare

A perusal of data on seed yield per hectare as influenced by different IW:CPE ratio and nitrogen dose are furnished in Table 2. The results revealed that significantly higher seed yield of 3317 kg ha^{-1} was produced under IW:CPE ratio 0.6

(I_2) and it was found statistically on same bar with I_3. Significantly minimum seed yield of 2734 kg ha^{-1} was recorded under IW:CPE ratio 0.4 (I_1). Seed yield per hectare differed significantly due to different levels of nitrogen. Application of nitrogen at 100 kg N ha^{-1} (N_3) produced significantly higher seed yield of 3307 kg ha^{-1}. Significantly lower seed yield of 2763 kg ha^{-1} recorded under lower dose of nitrogen *i.e.*, 60 kg N ha^{-1} (N_1). Patel *et al.*, 2010 found that optimum availability of moisture at 0.8 IW:CPE ratio.

Stover yield per hectare

The results regarding stover yield per hectare of sorghum as influenced by different IW:CPE ratio and nitrogen are furnished in Table 2. Irrigation applied at 0.6 IW:CPE ratio (I_2) produced significantly higher stover yield of 8328 kg ha^{-1} followed by irrigating the crop at 0.8 IW:CPE ratio (I_3) which produced stover yield of 8080 kg ha^{-1}. Significantly lower stover yield of 7115 kg ha^{-1} was recorded when sorghum was irrigated at an IW:CPE ratio of 0.4 (I_1). Application of nitrogen at 100 kg ha^{-1} (N_3) gave significantly higher stover yield of 8540 kg ha^{-1}. Significantly lower stover yield of 7034 kg ha^{-1} was recorded under 60 kg N ha^{-1} (N_1). Significantly higher stover yields was found in treatment I_3 (0.8 IW:CPE ratio) because of more photosynthesis and sufficient translocation due to adequate moisture availability.

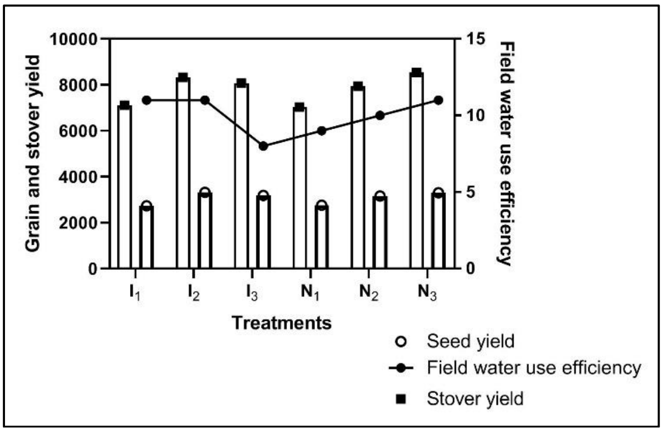

Fig 1: Mean seed, stover yield (kg ha^{-1}) and field water use efficiency (kg ha mm^{-1}) of sorghum as by different treatments.

Field water use efficiency

Data regarding water use efficiency as influenced by different IW:CPE ratio and irrigation are presented in Table 2. Result revealed that as IW:CPE ratio increased from 0.4 to 0.8 the FWUE in decreasing order. Higher FWUE of 11.39 kg ha mm^{-1} was noticed when sorghum was irrigated at 0.4 IW:CPE ratio. FWUE recorded under IW:CPE ratios of 0.6 and 0.8 were 11.06 and 8.85 kg ha mm^{-1}, respectively. The higher FWUE in I_1 than I_2 might be due to slight coincidence of the irrigation schedules with critical stages of crop growth and development. Results revealed remarkable effect of nitrogen on FWUE. The mean values of FWUE recorded with three nitrogen levels *viz*., N_1 (60 kg N ha^{-1}), N_2 (80 kg N ha^{-1}) and N_3 (100 kg N ha^{-1}) were 9.38, 10.75 and 11.16 kg ha mm^{-1}, respectively. These results are in conformation with the results reported by Bhuva and Sharma., 2015.

On the basis of above summarized results, the following conclusions have been drawn:

- Increase in frequency of irrigation significantly delayed days to 50% flowering and maturity whereas, treatment I_1 (0.4 IW:CPE ratio) noticed early flowering and maturity followed by treatment I_2 (0.6 IW:CPE ratio).
- Irrigating the crop at an IW:CPE ratio of 0.8 produced significantly maximum length of earhead.
- Significantly higher seed yield and stover yield per hectare were recorded when sorghum was irrigated with 0.8 IW:CPE ratio (I_3).
- Application of higher quantity of irrigation water reduced the water use efficiency. Sorghum irrigated at an IW:CPE ratio of 0.4 (I_1) increased the FWUE by 28.70% over 0.8 IW:CPE ratio respectively.
- Higher dose of nitrogen exerted their significant influence on days to 50% flowering and maturity.
- Significantly maximum length of earhead was recorded under 100 kg N ha^{-1} (N_3) over lower dose of nitrogen (N_1).
- Higher dose of nitrogen recorded significantly higher seed and stover yield recorded under 100 kg N ha^{-1} (N_3).

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