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White Sorghum Productivity, N-Use Efficiencies In Relation To Irrigations And Nitrogen Levels In Vertisols

T. SWAMI CHAITANYA, P. MUNIRATHNAM AND M. SRINIVASA REDDY
[1]P. G Scholar, Department Agronomy,
[2] Principal Scientist(Agro),RARS,Nandyal
[3] Assistant Professor, Department of Agronomy,
Agricultural College, Mahanandi-518502, Andhra Pradesh, India.

ABSTRACT

Field experiment was conducted at Regional Agricultural Research Station, Nandyal during post rainy season (maghi), 2015-16 to study the response of white sorghum to irrigations and nitrogen levels. Higher number of grains per panicle, grain weight per panicle, grain and stover yield was recorded higher with two irrigations where as 1000 grain weight was non significant with irrigations. All yield parameters and grain yield was higher with the application of 180 kg N ha^{-1} and lower values were obtained with the application of 90 kg N ha^{-1}. With increase in rate of nitrogen application there was an increase in the nitrogen utilization efficiency and greater nitrogen harvest index of sorghum and there was a decrease in nitrogen use efficiency and nitrogen uptake efficiency.

Key words: *Irrigations, Nitrogen levels, Sorghum, Nitrogen use efficiency*

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the world's fifth major crop in terms of production and acreage. It is a staple food crop for millions of the poorest and most food insecure people in the semi-arid tropics of Africa, Asia and Central America. Sorghum is truly a versatile crop that can be grown as a grain, forage or sweet crop. Sorghum is among the most efficient crops in conversion of solar energy and use of water and is known as a high-energy, drought tolerant crop that is environmentally friendly. Due to sorghum's wide uses and adaptation, "**sorghum is one of the really indispensable crops**" required for the survival of humankind. *Rabi* sorghum (post rainy season) has multifaced problems. Irrigation is one of the most important factor that play a important role in sorghum production. As the crop is raised mostly under rainfed condition with the help of stored moisture, the moisture deficiency, especially during later stages of crop growth poses a serious threat to the crop, consequently the yield levels of *rabi* sorghum are very low. In Kurnool district of Andhrapradesh, sowings are generally taken up during post rainy season called *maghi* jowar (middle of September to middle of October). Two situations are prevailing in Kurnool district i.e., in some areas sorghum is completely grown under rainfed conditions whereas in canal ayacut areas, one or two irrigations are being given. Further, under KC canal, it would be very difficult to predict the availability of water for irrigation as the stage of irrigation is very important. Therefore, it is very important to find out how many irrigations can be provided under limited irrigated conditions under KC canal ayacut area for enhancing productivity. Farmers generally go for blanket application of nitrogenous fertilizers without actually knowing the requirement of crop particularly if the crop is irrigated. Irrespective of the situation (whether rainfed or irrigated) farmers indiscriminately use nitrogenous fertilizers for sorghum. Further, newly developed varieties with high yield potential required additional doses of nitrogen fertilizers due to their fertilizer responsive nature. Hence, the present study was conducted to find out the effect of irrigations and varied nitrogen rates on production of sorghum and to determine nitrogen use efficiency during post rainy (*maghi*) season.

MATERIAL AND METHODS

Field experiment was conducted in 2015-16 at RARS, Nandyal to determine the effect of irrigations and graded nitrogen rates on productivity, nitrogen removal and nitrogen use efficiency in sorghum during post rainy season (*maghi*) season. The experimental soil was clay in texture, and it was moderately alkaline in reaction with a pH of 8.6, EC of 0.15 dSm^{-1}, low in organic carbon (0.57 %) and low in available nitrogen (146.2 kg ha^{-1}), medium in available phosphorus (33.2 kg ha^{-1}) and high in potassium (395.6 kg ha^{-1}). Variety NJ-2647 was sown with a spacing of 45 x15 cm. The experiment was laid out in split plot design with three replications and treatment combinations of three irrigation levels and four nitrogen levels making twelve treatments. The three irrigation levels *viz.,* no irrigation (rainfed), one irrigation and two irrigations and four nitrogen levels *viz.,* 90, 120, 150 and 180 kg N ha^{-1}. Recommended dose of phosphorus (40 kg ha^{-1}) and potassium (30 kg ha^{-1}) were applied uniformly to all the treatments. Nitrogen was applied in two equal splits. Half of nitrogen along with full dose of phosphorus and potassium was applied as basal at the time of sowing. The remaining quantity of nitrogen was top dressed at knee-height stage of crop. First irrigation was given at 35 DAS and second irrigation was given at 75 DAS. Grain yield was recorded after harvesting from the net plot and expressed in kg ha^{-1}

Nitrogen use efficiency and components of N use computations

Above ground portion of plants from each plot was randomly sampled at physiological maturity. At each sampling, the leaves were separated from the stems. In addition, heads and the above ground vegetative parts were dried at 60°C in a hot air oven for 72 hr to a constant weight. The oven dry samples were ground using rotor mill and allowed to pass through a 0.5 mm sieve to prepare a sample of 10 g. Nitrogen uptake in grain and straw were calculated by multiplying N content with the respective straw and grain yield ha^{-1}. Total N uptake, by whole biomass was obtained by summing up the N uptake by grain and straw and was expressed as kg ha^{-1}. The straw and grain samples were analyzed for N concentrations from each plot separately using Kjeldahl method as described by was used to calculate N use efficiency according to Moll *et al*. and Ortiz-Monasterio *et al*. The different efficiencies of nitrogen were arrived at employing the following formulae:

Nitrogen Use Efficiency (Kg Kg^{-1}) = Grain yield/N supplied

Nitrogen Utilization Efficiency (Kg Kg^{-1}) = Grain yield/N total in plant

Nitrogen Uptake Efficiency (Kg Kg^{-1}) =N total in plant / N supplied

Nitrogen Harvest index (%) =Grain N content/N total in plant

RESULTS AND DISCUSSION

Yield components and yield

Two irrigations recorded significantly higher number of grains per panicle (1962) than no irrigation (1179), but was comparable with one irrigation (1947). The lowest number of grains per panicle might be due to drought stress that could be related to the decrease of ear length and diameter. Shortage of soil moisture strongly influences the growth and development of reproductive organs and reduces the yield. Similar results were reported by Morad *et al*. (2004). The highest number of grains per ear panicle was recorded with the application of 180 kg N ha^{-1} (1855) but it was comparable with 150 kg N ha^{-1} (1833) and significantly superior to 120 kg N ha^{-1} (1610) and 90 kg N ha^{-1} (1486). Higher number of grain per panicle might be due to increase in the fertility of flowers and increase in leaf area and duration and resulted into increase in supplying assimilates for the sink (Mousavi *et al.,* 2012).

Among irrigation levels, significant variation was observed with regard to grain weight per panicle. Two irrigations recorded significantly higher grain weight per panicle (66.4g) compared to no irrigation (39.8 g) but it was statistically comparable with one irrigation (64.1g). Significant increase in grain weight per panicle was observed with increase in levels of nitrogen from 90 to 150 kg N ha^{-1}. The highest grain weight per panicle (62.7 g) was recorded with the application of 180 kg N ha^{-1} but it was comparable with 150 kg N ha^{-1} (61.2 g). Higher grain weight per panicle might be due to enhancement in number of grains per panicle and thousand grain weight. The results are in conformity with Pushpendra Singh *et al*. (2012) who reported that increase in grain weight per panicle might be due to enhancement in grain number per panicle and weight of individual grain.

Two irrigations produced higher 1000 grain weight (34.3g) which was significantly superior to no irrigation (33.9 g) and one irrigation (34.1g). Water accelerates the process of photosynthesis, ultimately resulting into accumulation of more photosynthates which might have helped in increasing the size and weight of the grains resulting into higher test weight of grains (Kachhadiya *et al*., 2010). Significantly higher values for 1000 grain weight (35.4 g) was recorded at higher nitrogen level i.e. 180 kg N ha^{-1} compared to lower levels of 90 and 120 kg N ha^{-1} while significantly lower test weight was recorded with the application of 90 kg N ha^{-1} (32.3g).

Irrigation levels significantly influenced the grain yield. Application of two irrigations and one irrigation did not bring any significant difference in grain yield, but produced significantly higher grain yields (6101 and

6092 kg ha^{-1}) respectively over no irrigation (2956 kg ha^{-1}). Adequate supply of water under which plant become physiologically more active and also more nutrient availability might have been increased and ultimately resulted in improved growth and development of sinkThe similar observations were recorded by Bhuva and Sharma (2014). Application of two supplemental irrigations during critical crop growth cycles gave manifold increase in the grain yield of *rabi* sorghum (Kadam *et al*., 2009). Similar increase in yield of *rabi* sorghum with three irrigations at critical stages was reported by Wani *et al.* (2003). As explained by Yadav *et al.* (2014), under irrigated condition, yield increase might be due to increased soil moisture content which improved internal water status and growth of plant. Thus, higher rate of water flow from the soil to plant helps in better stomatal conductance and more leaf area which help to sustain better transpiration thereby improving the ear head numbers, ear head size, thousand grain weight and final grain yield in pearl millet.

Significantly, higher grain yield (5486 kg ha^{-1}) was recorded with the application of 180 kg N ha^{-1} but was comparable with150 kg N ha^{-1}(5462 kg ha^{-1}). Application of 90 kg N ha^{-1} produced significantly lower grain yield (4392 kg ha^{-1}). Significant improvement in the grain yield was due to marked improvement in yield attributes like number of grains per panicle, grain weight per panicle, 1000 grain weight and growth parameters like dry matter production and number of green leaves per plant. These results are in corroboration with Dixit *et al.* (2005). The interaction effect of irrigation levels and nitrogen levels on grain yield of sorghum was significant. Significantly higher grain yield (6963 kg ha^{-1}) was produced with two irrigations at 180 kg N ha^{-1} but was on par with two irrigations at 150 kg N ha^{-1} (6947 kg ha^{-1}). On the other hand, lower grain yield (2663 kg ha^{-1}) was produced with no irrigation at 90 kg N ha^{-1} which was on par with no irrigation at 120 kg N ha^{-1} (2943 kg ha^{-1}).

Nitrogen use efficiency and components of nitrogen efficiency of white sorghum

Reduction in NUE with increasing N supply could result from reduction in N uptake efficiency, N utilization efficiency and N retention efficiency. Nitrogen use efficiency is reported to be higher at lower N rates and decrease at higher N rates. This may indicate that plants are unable to absorb N when applied in excess quantities, because their absorption mechanism might have been saturated. Under this condition, there exists the probability that more N will be subject to loss through ammonia gas, leaching or de-nitrification.

Nitrogen Use Efficiency (NUE): Irrespective of irrigations, the NUE was maximum with 90 kg N ha^{-1}, and with every increase in N rate it decreased. Among the irrigations, one irrigation exhibited maximum nitrogen use efficiency (62.6) followed by two irrigations (90.7) and the least was with no irrigation at (58.7) at 90 kg N ha^{-1}.

Nitrogen utilization efficiency (NUTE): It increased with increased N rate up to 150 kg N ha^{-1}, and there after it dwindled at high rate of N application.With respect to irrigations, one irrigation showed maximum nitrogen utilization efficiency (43.2) at 150 kg N ha^{-1}, followed by two irrigations (33.4) and least with no irrigation (21.5).

Nitrogen uptake efficiency (NUPE): It decreased with every increment in the rate of applied N, and the maximum was obtained with 90 kg N ha^{-1}. Among irrigations, two irrigations showed maximum efficiency (1.91) followed by one (1.04) and no irrigation (0.92) with 90 kg N ha^{-1}.

Nitrogen harvest index (NHI): One irrigation possessed higher nutrient harvest index at varied rates of applied N followed closely by two irrigations, while no irrigation had the least nutrient harvest index. This parameter distinctly improved with every increment in N rate from 90 to 180 kg N ha^{-1}.

CONCLUSION: White sorghum can be grown successfully by giving one irrigation with the application of 150 kg N ha^{-1} (as it was comparable with 180 kg N ha^{-1}) for realizing higher yields. In the present study, with increase in the rate of N application there was an increase in the nitrogen utilization efficiency and greater nitrogen harvest index of sorghum .Whereas, concomitantly there was a decrease in nitrogen use efficiency and nitrogen uptake efficiency.

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Table 1: Effect of irrigations and nitrogen levels on yield attributes and yield of white sorghum

Treatments	Number of grains panicle^{-1}	Grain weight panicle^{-1}(g)	1000 grain weight (g)	Grain yield
Irrigations – 3				
I_0:No irrigation	1179	39.8	33.9	2956
I_1 :One irrigation	1947	64.1	34.1	6092
I_2 :Two irrigations	1962	66.4	34.3	6101
SEm ±	49	3.1	0.4	63
CD (P=0.05)	192	12.3	N.S	247
N-levels (kg ha^{-1}) – 4				
N_1:90	1486	50.5	32.3	4392
N_2:120	1610	52.6	33.7	4858
N_3:150	1833	61.2	35.0	5462
N_4:180	1855	62.7	35.4	5486
SEm ±	61	2.6	0.6	77
CD (P=0.05)	182	7.8	1.8	228
Interactions				
I at N				
SEm ±	98	6.3	1.0	127
CD (P=0.05)	N.S	N.S	N.S	425
N at I				
SEm ±	104	6.3	0.9	131
CD (P=0.05)	N.S	N.S	N.S	420

Table 1.a. Interaction effect of irrigations and nitrogen levels on grain yield (kg ha^{-1})

Treatments	**N-levels (kg ha-1)**				
Irrigations	**N_1:90**	**N_1:120**	**N_1:150**	**N_1:180**	**Mean**
I0:Noirrigation	2663	2943	3090	3128	2956
I1 :One irrigation	5637	6013	6350	6367	6092
I2:Two irrigations	4877	5617	6947	6963	6101
Mean	4392	4858	5462	5486	
SEm ±	127				
CD(P=0.05)	425				

Table 2: Nitrogen use efficiency and components of nitrogen efficiency of white sorghum with two irrigations and four levels of nitrogen

Parameter	I_0:NO IRRIGATION	I_1:ONE IRRIGATION	I_2:TWO IRRIGATIONS

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	90 kg N ha-1	120 kg N ha-1	150 kg N ha-1	180 kg N ha-1	90 kg N ha-1	120 kg N ha-1	150 kg N ha-1	180 kg N ha-1	90 kg N ha-1	120 kg N ha-1	150 kg N ha-1	180 kg N ha-1
Nitrogen use efficiency Kg Kg-1	29.5	24.5	20.6	17.3	62.6	50.1	42.3	35.3	54.1	46.8	46.31	38.68
Nitrogen utilization efficiency Kg Kg-1	25.0	26.9	27.3	21.5	39.0	42.0	43.2	38.8	28.2	30.7	33.4	32.5
Nitrogen uptake efficiency Kg Kg-1	0.92	0.91	0.75	0.65	1.40	1.20	0.98	0.91	1.91	1.52	1.38	1.19
Nitrogen harvest index (%)	0.32	0.40	0.41	0.50	0.50	0.52	0.55	0.57	0.39	0.41	0.44	0.46

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