International Journal of Natural Sciences Research
2014 Vol. 2, No. 1, pp. 5-11
ISSN(e): 2311-4746
ISSN(p): 2311-7435

PRODUCTIVITY AND ECONOMICS OF SORGHUM VARIETIES FOR GRAIN AS INFLUENCED BY NITROGEN LEVELS IN SANDY LOAM SOIL

Cleto Namoobe[1] --- R.K. Nanwal[2] --- Pawan Kumar[3]

[1]*Research Scholar, Zambia College of Agriculture, Ministry of Agriculture, Zambia*

[2]*Chief Agronomist*

[3]*Agronomist, Department of Agronomy, CCS HAU, Hisar, India*

ABSTRACT

The experiment was carried out at the Student Farm of CCS HAU, Hisar for two consecutive kharif seasons of 2011 and 2012. The field was laid out in a split plot design following the block randomization system with three replications. Four varieties (HC 541, HC 308, HC 171 and HJ 513) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}) were taken in the main plots and subplots, respectively. Data collected revealed that varieties and nitrogen levels has a significant influence on panicle length, number of grains panicle^{-1}, test weight and grain yield in both the years. Variety HJ 513 gave the maximum panicle length (28.4 and 29.6 cm), highest number of grains panicle^{-1} (1385 and 1402), test weight (17.60 and 24.33g) and grain yield (1949 and 1938 kg ha^{-1}) in both the years. The overall economic optimum nitrogen rate (EONR) was found to be 139.1 kg ha^{-1} for all the varieties. However, each individual variety showed the following EONR: HJ 541 (143.1 kg ha^{-1}), HC 308 (144.4 kg ha^{-1}), HC 171 (139.3 kg ha^{-1}) and HJ 513 (131.5 kg ha^{-1}). The application of 100 kg N ha^{-1} gave the highest net returns and BC ratio. Variety HJ 513 had the highest BC ratio (2.24 and 2.01) in both years.

Keywords: Test weight, Grain yield, Nitrogen, Economic nitrogen rate (EONR), Net returns, Benefit cost ratio.

1. INTRODUCTION

Sorghum ranks fifth in the worldwide production as a grain crop among cereals after wheat, rice, maize and barley [1]. Forage sorghum is the basic feed for livestock and it is especially valuable for feeding animals in most regions of the world [2]. Its fodder contains more than 50% digestible nutrients with 8% protein, 2.5% fat and 45% nitrogen free extract. The grain of sorghum is consumed in some countries by humans. To get high yields of sorghum, the correct amount of nitrogen fertilizer should be applied. On the global scene regarding plant nutrients and their importance, N is considered the most limiting factor for plant growth after water [3]. Grain yield of sorghum is a result of many attributing factors such as panicle length, grains panicle^{-1} and test weight, which work together to enhance yield. It was reported by Almodares, et al. [4] that application of nitrogen increased panicle length. Miko and Manga [5] noticed a non significant influence of nitrogen on panicle length. Application of nitrogen increased the number of grains panicle^{-1} [6]. On the contrary, Soleymani, et al. [7] reported a non significant effect of nitrogen application on number of grains panicle^{-1}. There was an increased test weight with nitrogen application [6]. However, non significant impact was reported by Soleymani, et al. [7] on the same parameter. Guler, et al. [8] observed that the effect of nitrogen levels on grain yield was non significant though the greatest values were obtained with increased nitrogen rates. The application of nitrogen to sorghum improves grain yield with significant linear and quadratic responses [6]. Uchino, et al. [9] also reported a significant increase in grain yield of sorghum up to 90 kg N ha^{-1}.

It is important that optimum N fertilizer dose to crops is established to maximize yields and profits. Increasing the amount of nitrogen will result in loss rather than profits for the producer and fertilizing the plant with nitrogen beyond the optimum amount will lead to considerable loss in yield [10]. Sawyer, et al. [11] observed that economic optimum rates of fertilization are rates that maximize profits for producers.

The objectives of the present study were to find out the effect of nitrogen on sorghum yield attributing characters, productivity and optimum nitrogen dose that would maximize profits.

2. MATERIALS AND METHODS

The research experiment was conducted at the Student Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar during two *kharif* seasons (2011 and 2012). The soil was sandy loam with mean pH 7.40, EC 0.24 (dSm^{-1}), OC 0.40 (%), Available nitrogen 128 (kg ha^{-1}), Available phosphorus 13.0 (kg ha^{-1}) and Available potassium 157.5 (kg ha^{-1}). Experiment was conducted in a split plot design with three replications. The main plots consisted of four sorghum varieties (HJ 541, HC 308, HC 171 and HJ 513), while in the subplots there were four nitrogen fertilizer levels (40, 60, 80 and 100 kg ha^{-1}) with control (0 kg N ha^{-1}). Grain sorghum seeds were sown after presowing irrigation at the spacing of 45 cm x 15 cm. Half nitrogen was applied to each treatment at sowing. The remaining nitrogen fertilizer was applied as top dressing at 35 DAS. Atrazine was applied as a pre-emergence herbicide at the rate of 0.5 kg a.i. ha^{-1} to control weeds. At 15 DAS, thinning was done to obtain the required plant population ha^{-1}. Irrigation of the field was done whenever needed using the channels that were made between plots.

Five plants were picked at random and had their panicles measured with a 30 cm ruler to find their length. Panicle length was averaged as panicle length plant^{-1}. Number of grains panicle^{-1} was obtained by calculating the mean grain number after seeds were counted from five panicles using a seed counting machine. A thousand seed were picked from the counted grains and weighed on a balance to get test weight. The EONR was calculated with the help of the quadratic equation. BC ratio was obtained from the ratio of net returns to cost of cultivation. Recorded data was statistically analysed according to Panse and Sukhatme [12].

3.RESULTS AND DISCUSSION

3.1. Yield Attributes

A perusal of data (Table 1) indicated that varieties and nitrogen levels had a significant effect on the panicle length, number of grain panicle^{-1} and test weight. Variety HJ 513 gave the longest panicles (28.4 and 29.6 cm), highest number of grains panicle^{-1} (1385 and 1402) and maximum test weight (17.6 and 24.33g) among all the varieties tested and HC 171 produced the shortest panicles (19.9 and 21.3 cm), lowest number of grains panicle^{-1} (1243 and 1271) and test weight (13.77 and 20.15g) in both years. It was noticed that as the nitrogen levels increased, panicle length, number of grain panicle^{-1} and test weight also increased significantly. The increase in the panicle length could be due to genetic makeup of varieties as well as the nitrogen applied. The number of grains panicle^{-1} and test weight could have increased due to the nitrogen enrichment as well as the availability of other nutrients to the plants as nitrogen tends to facilitate the uptake of P and K. These results are in line with the findings of [4, 6]. However the results of this study are contrary to [5, 7] who reported that nitrogen application had no significant effect on these parameters.

3.2. Productivity

There was a highly significant effect of varieties on grain yield in both years of the study (Table 1). During both years, cultivar HJ 513 gave the highest grain yield (1949 and 1938 kg ha^{-1}) followed by HJ 541 with 1615 and 1599 kg ha^{-1}, respectively. HC 171 recorded the lowest grain yield (1384 and 1412 kg ha^{-1}). Increasing nitrogen fertilizer levels significantly enhanced grain yield. Application of 100 kg N ha^{-1} recorded the highest grain yield while control resulted in the lowest grain yield. Increased grain yield could be due to an increase in nitrogen uptake and balanced P and K in the soil after N application and also it may be due to enhanced number of grains panicle^{-1} and test weight. These results corroborate with the findings of Buah and Mwinkaara [6] and Uchino, et al. [9].

3.3. Optimum dose of Nitrogen

An examination of data from Table 2 indicated that HC 308 had the highest agronomic optimum nitrogen rate (AONR) (149.6 kg ha^{-1}) and EONR (144.39 kg ha^{-1}) on pooled data basis. Variety HJ 513 showed the lowest AONR (134.8 kg ha^{-1}) and EONR (131.5 kg ha^{-1}). Cursory glance at Fig.1 below revealed that the optimum dose of nitrogen tends to be beyond 100 kg ha^{-1} for all varieties.

4. ECONOMICS

Data (Table 3) revealed that application of 100 kg N ha^{-1} gave the highest net returns among all the nitrogen treatments. Control had the lowest net returns in all the varieties in both years. A further analysis of data showed that the highest BC ratio was obtained with the application of 100 kg N ha^{-1}. Variety HJ 513 had the highest BC ratio (2.24 and 2.01) than other varieties followed by HJ 541 (1.98 and 1.73) in both the years, respectively. The lowest BC ratio (1.41 and 1.45) was observed with HC 171 in both the years, respectively.

The application of nitrogen fertilizer enhanced the yield attributing factors and grain yield. There was a significantly noticeable increase in the yield components and grain yield with increased nitrogen fertilizer level. Application of 100 kg N ha^{-1} gave the highest grain yields. The lowest AONR and EONR were recorded with variety HJ 513 in both years. HJ 513 gave the highest net returns and BC ratio. From the computed data on optimum dose of nitrogen, application beyond 100 kg ha^{-1} to varieties tested can still be economically feasible on the sandy loam soils of Hisar . The mean meteorological data shown in Fig. 2 and 3 depicted that rainfall was better during the second experiment. This must have contributed to the good performance of the sorghum crop.

REFERENCES

[1] J. H. Wong, T. Lau, N. Cai, J. Singh, J. F. Pedersen, W. H. Vensel, W. J. Hurkman, J. D. Wilson, P. Lemaax and B. B. Buchanan, "Digestibility of protein and starch from sorghum (Sorghum bicolor) is linked to biochemical and structural features of grain endosperm," *J. of Cereal Sci.*, vol. 49, pp. 73-82, 2009.

[2] M. Afzal, A. Ahmad and A. H. Ahmad, "Effect of nitrogen on growth and yield of sorghum forage (Sorghum bicolor (L) Moench cv) under three cutting system," *Cercetari Agron. Moldova*, vol. 4, pp. 152, 2012.

[3] V. O. Sadras, "A quantitative top-down view of interactions between stresses: theory and analysis of nitrogen-water co-limitation in mediterranean agro-ecosystems," *Aus. J. of Agric. Res.*, vol. 56, pp. 1151-1157, 2005.

[4] A. Almodares, R. Taheri, M. R. Hadi, and M. Fathi, "The effect of nitrogen and potassium fertilizers on the growth parameters and the yield components of two sweet sorghum cultivars," *Pak. J. Biol. Sci.*, vol. 9, pp. 2350-2353, 2006.

[5] S. Miko and A. A. Manga, "Effect of intra–spacing and nitrogen rates on growth and yield of sorghum (Sorghum bicolor L.)," *Var. ICSV 400. Pat.*, vol. 4, pp. 66-73, 2008.

[6] S. S. J. Buah and S. Mwinkaara, "Response of sorghum to nitrogen fertilizer and plant density in the Guinea Savanna zone," *J. Agron*, vol. 8, pp. 124-130, 2009.

[7] A. Soleymani, M. H. Shahrajabian, and L. Naranjani, "The effect of plant density and nitrogen fertilization on yield, yield components and grain protein of grain sorghum," *J. Food, Agric. and Environ*, vol. 9, pp. 244-246, 2011.

[8] I. G. Guler, S. Yilmaz, H. Y. Emeklier, and G. Akdogan, "Nitrogen and plant density effects on sorghum," *J. Agron*, vol. 7, pp. 220-228, 2008.

[9] H. Uchino, T. Watanabe, K. Ramu, K. L. Sahrawat, S. Marimuthu, S. P. Wani, and O. Ito, "Effects of nitrogen application on sweet sorghum (Sorghum bicolor (L.) Moench) in the semi-arid tropical Zone of India," *Jarq.*, vol. 47, pp. 65-73, 2013.

[10] R. Engel and J. Bergman, "Safflower seed yield and oil content as affected by water and nitrogen," *Fertilizer Facts*, 1997.

[11] J. Sawyer, E. Nafziger, G. Randall, L. Bundy, G. Rehm, and B. Joern. *Concept and rational for regional nitrogen rate guidelines for corn*, Iowa State Univ.Ext.,Ames, 2006.

[12] V. G. Panse and P. V. Sukhatme, *Statistical methods for agricultural workers*, New Delhi: ICAR Publication, 1985.

Table- 1. Effect of varieties and nitrogen levels on panicle length, number of grain panicle^{-1}, test weight and grain yield

Treatments	Panicle length (cm)		Number of grains panicle $^{-1}$		Test weight (g)		Grain yield (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012
Varieties								
HJ 541	22.9	24.1	1323	1313	17.34	21.81	1615	1599
HC 308	21.7	22.8	1304	1301	15.31	21.32	1550	1540
HC 171	19.9	21.3	1217	1210	13.77	20.15	1384	1412
HJ 513	28.4	29.6	1385	1380	17.60	24.33	1949	1938
SEm±	0.46	0.36	22.8	16.9	0.82	0.34	92	71
CD at 5%	1.58	1.23	78.7	58.2	2.84	1.19	320	246
Nitrogen levels (kg ha^{-1})								
0	20.9	22.3	1074	1059	12.43	19.38	1002	1037
40	22.7	23.8	1207	1210	14.83	20.89	1433	1479
60	23.4	24.5	1318	1308	16.66	21.95	1790	1748
80	24.0	25.3	1383	1372	17.24	23.19	1924	1896
100	25.3	26.1	1555	1557	18.87	24.12	1973	1950
SEm±	0.22	0.18	17.3	18.9	0.33	0.29	39	35
CD at 5%	0.62	0.52	49.9	54.6	0.96	0.84	112	101

Table-2. Regression equations, correlation coefficients (R^2) and grain yield (Y) (kg ha^{-1}) from pooled data (2011 and 2012)

Overall and varieties	Regression equation	Correlation coefficient(R^2)	AONR	Yield	EONR	Yield
Overall	$Y= 1003.0 + 15.17x - 0.053x^2$	0.985	143.1	2088.52	139.1	2087.66
HJ 541	$Y= 799.7 + 19.61x - 0.067x^2$	0.949	146.3	2234.59	143.1	2233.90
HC 308	$Y = 1035.0 + 12.27x - 0.041x^2$	0.975	149.6	1953.0	144.4	1951.88
HC 171	$Y = 946.5 + 11.02x - 0.038x^2$	0.970	145.0	1745.45	139.3	1744.22
HJ 513	$Y = 1233.0 + 17.79x - 0.066x^2$	0.975	134.8	2431.80	131.5	2431.10

AONR = **Agronomic optimum nitrogen rate** is the nitrogen rate that will produce maximum grain yield regardless of cost.

EONR = **Economic optimum nitrogen rate** is nitrogen rate that will result in maximum financial return to N. It is usually less than the AONR.

Fig-1. Relationship between N rate and sorghum grain yield (pooled data)

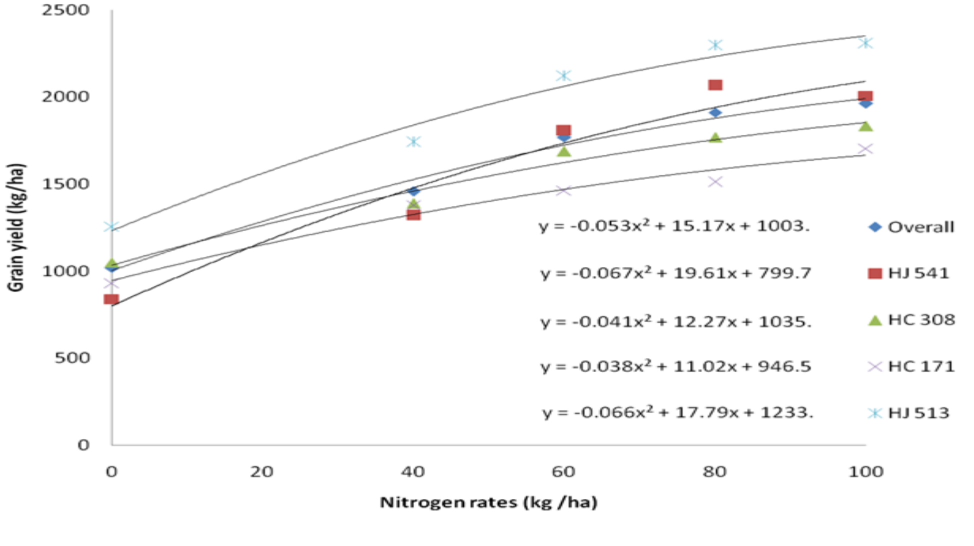

Table-3. Economics of various treatment combinations for sorghum

Treatment combinations	Total cost (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B:C	
	2011	2012	2011	2012	2011	2012	2011	2012
N_1V_1	29830	32064	46851.9	46316.6	17021.9	14252.6	0.57	0.44
N_2V_1	30352	32586	64197.6	65451.4	33845.6	32865.4	1.12	1.01
N_3V_1	30616	32850	83716.5	81940.6	53100.5	49090.6	1.73	1.49
N_4V_1	30874	33108	91419.7	90794.5	60545.7	57686.5	1.96	1.74
N_5V_1	31138	33372	92774.1	90975.9	61636.1	57603.9	1.98	1.73
N_1V_2	29830	32064	46209.9	48181.9	16379.9	16117.9	0.55	0.50
N_2V_2	30352	32586	63543.2	63181.0	33191.2	30595.0	1.09	0.94
N_3V_2	30616	32850	76999.9	76847.2	46383.9	43997.2	1.52	1.34
N_4V_2	30874	33108	79321.4	81550.3	48447.4	48442.3	1.57	1.46
N_5V_2	31138	33372	83913.4	84647.2	52775.4	51275.2	1.69	1.54
N_1V_3	29830	32064	38103.8	41398.1	8273.8	9334.1	0.28	0.29
N_2V_3	30352	32586	56234.6	58943.4	25882.6	26357.4	0.85	0.81
N_3V_3	30616	32850	63098.8	63167.4	32482.8	30317.4	1.06	0.92
N_4V_3	30874	33108	66518.5	64870.8	35644.5	31762.8	1.15	0.96
N_5V_3	31138	33372	74925.9	81803.8	43787.9	48431.8	1.41	1.45
N_1V_4	29830	32064	60234.6	59793.6	30404.6	27729.6	1.02	0.86
N_5V_4	30352	32586	77543.2	79567.7	47191.2	46981.7	1.55	1.44
N_3V_4	30616	32850	92629.6	91143.6	62013.6	58293.6	2.03	1.77
N_4V_4	30874	33108	98805.7	97840.9	67931.7	64732.9	2.20	1.96
N_5v_4	31138	3337	100991	100432.6	69852.9	67060.6	2.24	2.01

<u>**Nitrogen levelsVarieties**</u>

N_1 = Control — V_1 = HJ 541

N_2 = 40 kg N ha^{-1} — V_2 = HC 308

N_3 = 60 kg N ha^{-1} — V_3 = HC 171

N_4 = 80 kg N ha^{-1} — V_4 = HJ 513

N_5 = 100 kg N ha^{-1}

Fig-2. Mean weekly meteorological data during the cropping period of sorghum – 2011

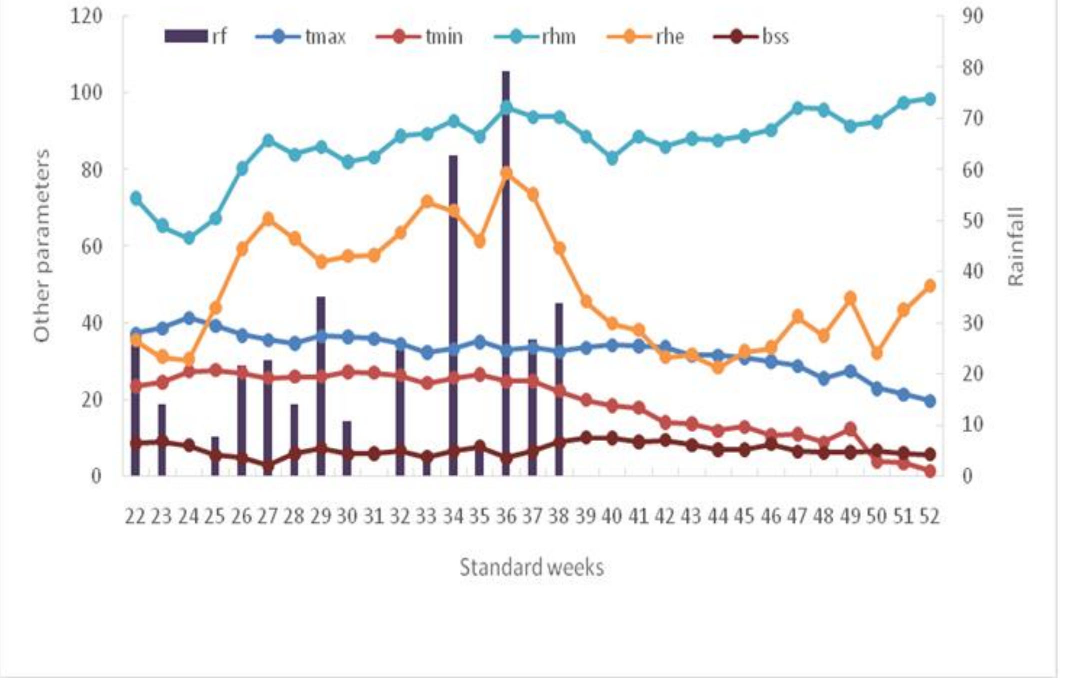

Fig-3. Mean weekly meteorological data during the cropping period of sorghum – 2012