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# NUTRIENT UPTAKE BY GRAIN SORGHUM AS INFLUENCED BY CULTIVARS AND NITROGEN FERTILIZATION IN SANDY LOAM SOIL

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## SUMMARY

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 grain and straw yields were significantly affected by both variety and nitrogen application. HJ 541 gave the highest grain and straw yields (1973 kg ha$^{-1}$ and 18086 kg ha$^{-1}$) with nitrogen application of 100 kg N ha$^{-1}$, respectively. Nitrogen application enhanced N content and uptake in grain, but a non significant effect was recorded in straw by varieties. A non significant response was noticed with N application on P content in grain while P content in straw was significant. Nitrogen levels significantly affected K content in both grain and straw. Total uptake of NPK was enhanced by nitrogen application at all levels while control recorded the lowest total NPK uptake.

**Key words :** Sorghum, fodder, nitrogen, phosphorus, potassium, uptake

Sorghum ranks fifth in the worldwide production as a grain crop among cereals after wheat, rice, maize and barley (Wong *et al*., 2009). Forage sorghum is the basic feed for livestock and it is especially valuable for feeding animals in most regions of the world (Afzal *et al*., 2012). Its fodder contains more than 50% digestible nutrients with 8% protein, 2.5% fat and 45% nitrogen free extract. However, **kharif** sorghum has low nutritive value which may be increased by the application of the correct amounts of optimum fertilizer requirements (Azam *et al*., 2010). Nitrogen, phosphorus and potassium are the essential nutrients needed by plants in large quantities for their growth. On the global scene regarding plant nutrients and their importance, N is considered the most limiting factor for plant growth after water. The application of nitrogen to sorghum improves grain yield with significant linear and quadratic responses (Buah and Mwinkaara, 2009). Uchino *et al*. (2013) also reported significant increase in grain yield of sorghum up to 90 kg N ha$^{-1}$. Rana *et al*. (2000) revealed that P concentration in grain showed an improvement with N fertilizer application. They, further, noticed that N and P fertilizer application resulted in higher K content in grain and straw, besides N and P fertilization resulted in higher K uptake by sorghum plants. Akram *et al*. (2007) reported that N uptake in sorghum was improved with P (80 kgha$^{-1}$) and K (40 kg ha$^{-1}$) application. Rana *et al*. (2000) recorded the highest P uptake with higher application of 100 kg N and 50 kg P ha$^{-1}$. P application in sorghum improves NPK uptake and P apparent recovery (Dongale and Kadrekar, 1992). There was an enhanced P uptake in sorghum with the application of nitrogen (Ashiono *et al*., 2005). K fertilizer application improves sorghum growth and gives higher crop yield (Sharma and Kumari, 1996). K uptake was higher in sorghum after application of 100kg N and 50 kg P/ha (Rana *et al*., 2000). K has a significant role in the translocation of assimilates to sinks by influencing electron transport in the transport chain of crops which increase panicle dry weight (Raja Reddy and Zhao, 2005). Research reports on the NPK uptake in sorghum are scanty; hence the present investigation was carried

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out to study nutrient content and uptake in sorghum as influenced by nitrogen levels.

## 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 N 128 (kg $ha^{-1}$), Available P 13.0 (kg $ha^{-1}$) and Available K 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 pre-sowing 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. Nitrogen, phosphorus and potassium were analysed using colorimetric, vanado molybdophosphoric yellow colour and flame photometer method, respectively (Jackson, 1973). N, P, K contents in grain and straw were multiplied with grain and straw yields to calculate their uptake. Recorded data was statistically analysed according to Panse and Sukhatme (1985).

## RESULTS AND DISCUSSION

### Grain and Straw Yields

There was a highly significant effect of varieties on grain and straw yields of sorghum in both years of the study (Table 1). During both years, the cultivar HJ 513 gave the highest grain (1949 and 1938 kg $ha^{-1}$) and straw yield (17229 and 17248 kg/ha). HC 171 recorded the lowest grain (1384 and 1412 kg/ha ) and straw yield (11407 and 12296 kg/ha). Increasing nitrogen fertilizer levels significantly enhanced grain yield. Application of 100kg N/ha recorded the highest grain and straw yields while control resulted in the lowest grain and straw yields. Increased yields could be due to an increase in nitrogen uptake and balanced P and K in the soil after N application. These results corroborate with the findings of Buah and Mwinkaara (2009), Azam *et al.* (2010).

TABLE 1
Effect of varieties and nitrogen levels on grain and straw yields

| Treatments | Grain Yield (kg/ ha) | | Straw Yield (kg/ ha) | |
|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 |
| **Varieties** | | | | |
| HJ 541 | 1615 | 1599 | 17074 | 16948 |
| HC 308 | 1550 | 1540 | 14679 | 15425 |
| HC 171 | 1384 | 1412 | 11407 | 12296 |
| HJ 513 | 1949 | 1938 | 17228 | 17248 |
| C. D. (P=0.05) | 320 | 246 | 3914 | 2888 |
| **Nitrogen levels (kg/ha)** | | | | |
| 0 | 1002 | 1037 | 11111 | 11131 |
| 40 | 1433 | 1479 | 13981 | 13991 |
| 60 | 1790 | 1748 | 15879 | 16144 |
| 80 | 1924 | 1896 | 16427 | 16783 |
| 100 | 1973 | 1950 | 18086 | 19347 |
| C. D. (P=0.05) | 112 | 101 | 946 | 693 |

### Nitrogen Content and Uptake

Nitrogen levels had a significant effect on N content in grain and straw (Table 2). However, varieties had no effect on N content in straw in both the years of the study. HJ 513 recorded the highest N content (1.99 and 1.83%) in both years, respectively. Nitrogen application significantly increased the N content in grain and application of 100 kg N/ha registered the highest N content in grain. The effect of nitrogen levels on N content in straw was statistically significant. N uptake in grain and straw was significantly influenced by varieties and nitrogen application. Total N uptake increased with an increase in nitrogen level up to 100 kg/ha. HJ 513 had the highest N uptake among the varieties, while HC 171 recorded the lowest N uptake. Fertilizer rate 100 kg N/ha showed the highest N uptake among the fertilizer treatments. These results are in harmony with the findings of Rana *et al.* (2000) and Akram *et al.* (2007).

### Phosphorus Content and Uptake

Varieties had significantly positive impact on P content and P uptake (Table 3) in grain of sorghum in both the years. HJ 513 had the highest P content (0.43

TABLE 2

Effect of varieties and nitrogen levels on N content and its uptake by grain and straw

| Treatments | N content (%) | | | | N uptake (kg/ha) | |
|---|---|---|---|---|---|---|
| | Grain | | Straw | | Total Biomass | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| **Varieties** | | | | | | |
| HJ 541 | 1.65 | 1.58 | 0.59 | 0.62 | 127.93 | 130.25 |
| HC 308 | 1.59 | 1.53 | 0.63 | 0.62 | 117.61 | 120.54 |
| HC 171 | 1.74 | 1.64 | 0.61 | 0.61 | 95.53 | 99.70 |
| HJ 513 | 1.99 | 1.83 | 0.59 | 0.60 | 140.75 | 139.29 |
| S. Em± | 0.03 | 0.03 | 0.01 | 0.01 | 7.45 | 6.11 |
| C. D. (P=0.05) | 011 | 0.12 | NS | NS | 25.71 | 21.10 |
| **Nitrogen levels (kg/ha)** | | | | | | |
| 0 | 1.37 | 1.31 | 0.60 | 0.59 | 81.74 | 80.47 |
| 40 | 1.59 | 1.52 | 0.58 | 0.61 | 104.47 | 109.09 |
| 60 | 1.76 | 1.67 | 0.65 | 0.66 | 134.41 | 135.20 |
| 80 | 1.92 | 1.78 | 0.60 | 0.61 | 134.79 | 134.50 |
| 100 | 2.07 | 1.95 | 0.59 | 0.59 | 146.87 | 152.95 |
| S. Em± | 0.02 | 0.03 | 0.01 | 0.01 | 2.98 | 2.46 |
| C. D. (P=0.05) | 0.07 | 0.08 | 0.04 | 0.04 | 8.59 | 7.10 |

TABLE 3

Effect of varieties and nitrogen levels on P content and its uptake by grain and straw

| Treatments | P content (%) | | | | P uptake (kg/ha) | |
|---|---|---|---|---|---|---|
| | Grain | | Straw | | Total Biomass | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| **Varieties** | | | | | | |
| HJ 541 | 0.35 | 0.33 | 0.16 | 0.16 | 33.42 | 32.51 |
| HC 308 | 0.40 | 0.37 | 0.17 | 0.16 | 30.94 | 30.76 |
| HC 171 | 0.37 | 0.33 | 0.18 | 0.17 | 25.39 | 25.48 |
| HJ 513 | 0.43 | 0.40 | 0.16 | 0.16 | 36.63 | 35.61 |
| S. Em± | 0.01 | 0.01 | 0.002 | 0.002 | 2.30 | 1.69 |
| C. D. (P=0.05) | 0.04 | 0.03 | 0.006 | NS | NS | 5.86 |
| **Nitrogen levels (kg/ha)** | | | | | | |
| 0 | 0.39 | 0.33 | 0.15 | 0.15 | 20.99 | 20.07 |
| 40 | 0.40 | 0.36 | 0.18 | 0.18 | 31.00 | 30.25 |
| 60 | 0.39 | 0.38 | 0.18 | 0.17 | 35.09 | 33.74 |
| 80 | 0.38 | 0.35 | 0.16 | 0.16 | 34.27 | 33.34 |
| 100 | 0.38 | 0.37 | 0.16 | 0.16 | 36.69 | 38.05 |
| S. Em± | 0.02 | 0.02 | 0.002 | 0.002 | 0.86 | 060 |
| C. D. (P=0.05) | NS | NS | 0.006 | 0.006 | 2.48 | 1.74 |

and 0.40%) by grain in both years, whereas, HC 171 recorded the highest P content (0.18 and 0.17%) by straw in both years, respectively. Variety had no significant influence on P content and uptake in straw in both the years except in 2011 when a significant effect was registered with P content in straw and total P uptake in 2012. Nitrogen application did not have any significant influence on P content in grain in both years. However, all nitrogen levels recorded an increase in P content of grain and straw and their uptake in both years except in 2011 and 2012 when 40 and 60 kg N ha$^{-1}$ recorded the highest P content in grain (0.40 and 0.38%), respectively. The findings of Rana *et al*. (2000) and Ashiono *et al*. (2005) are in conformity with these results.

**Potassium Content and Uptake**

Varieties of sorghum significantly influenced K content and uptake in the grain and straw during both the years (Table 4). HC 171 recorded the highest K content (0.31 and 0.29%) in grain in both years, respectively. The highest K content (2.47 and 2.48%) in straw as well as total K uptake (429.54 and 427.43 kg $ha^{-1}$) was scored by HJ 541, in both years, respectively. Nitrogen application significantly affected K content in grain and straw and its uptake in both years. Application of 80 kg N $ha^{-1}$ gave the highest K content (0.30 and 0.29%) in grain in both years, respectively, while the maximum K content (2.27 and 2.24%) in straw was registered by application of 100 kg N $ha^{-1}$. The nitrogen rates 100 kg $ha^{-1}$ gave the highest total K uptake (416.12 and 438.52 kg $ha^{-1}$) in both years. These results agree with what was reported by Rana *et al*. (2000) and Raja Reddy and Zhao (2005).

To sum up, the investigation showed that the application of nitrogen fertilizer influenced NPK content in grain and straw and total NPK uptake. There is higher nitrogen content in grain than straw as most of the nitrogen seems to be translocated to the grains. Increased nitrogen rates increased N content of grain, but not in straw. Nitrogen application gave no significant effect on P content in grain but affected the P content in straw. Similarly, nitrogen application influenced K content and its uptake. From this experiment, application of 100kg N $ha^{-1}$ seems ideal to increase nutrient uptake at the Student Farm, CCS HAU. Variety HJ 513 was superior in its nutrient uptake and thus it was more productive than the other test varieties.

TABLE 4

Effect of varieties and nitrogen levels on K content and its uptake by grain and straw

| Treatments | K content (%) | | | | K uptake (kg/ha) | |
|---|---|---|---|---|---|---|
| | Grain | | Straw | | Total Biomass | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| **Varieties** | | | | | | |
| HJ 541 | 0.26 | 0.24 | 2.47 | 2.48 | 429.54 | 427.43 |
| HC 308 | 0.27 | 0.26 | 2.32 | 2.30 | 345.97 | 360.02 |
| HC 171 | 0.31 | 0.29 | 1.86 | 1.83 | 219.49 | 233.61 |
| HJ 513 | 0.29 | 0.28 | 1.78 | 1.77 | 311.79 | 308.87 |
| S. Em± | 0.002 | 0.004 | 0.045 | 0.043 | 27.71 | 18.14 |
| C. D. (P=0.05) | 0.005 | 0.014 | 0.154 | 0.147 | 95.64 | 62.59 |
| **Nitrogen levels (kg $ha^{-1}$)** | | | | | | |
| 0 | 0.28 | 0.26 | 2.16 | 2.14 | 242.83 | 240.43 |
| 40 | 0.29 | 0.28 | 2.02 | 2.03 | 289.07 | 291.26 |
| 60 | 0.28 | 0.27 | 2.07 | 2.05 | 339.77 | 341.95 |
| 80 | 0.30 | 0.29 | 2.03 | 2.02 | 345.71 | 350.25 |
| 100 | 0.26 | 0.24 | 2.27 | 2.24 | 416.12 | 438.52 |
| S. Em± | 0.001 | 0.003 | 0.046 | 0.043 | 12.25 | 8.71 |
| C. D. (P=0.05) | 0.004 | 0.009 | 0.134 | 0.124 | 35.29 | 25.11 |

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