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# EVALUATION OF PROMISING GRAIN SORGHUM (*Sorghum bicolor* (L.) Moench) STRAINS AT DIFFERENT LEVELS OF FERTILIZER UNDER BAHAWALPUR CONDITIONS

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**Abstract**

Grain sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop grown for human consumption in the world surpassed only by rice, wheat, barley and corn. In Pakistan, it is grown on 0.34 million hectares with annual production of 0.21 million tons with an average yield of 620 kg $ha^{-1}$. Pakistani soils are deficient in N (100%) and P (90%) while deficiencies of K (20%) are crop and soil specific, hence response to N and P is universal. The present study was planned to investigate sorghum yield response to different combinations of nitrogen and phosphorous (NP) as well as potassium (K) to explain fertilizer response and yield variability. This research study was conducted at the experimental area of Regional Agricultural Research Institute (RARI) Bahawalpur during the main cropping season of Kharif-2021 to assess the response of Sorghum under different doses of fertilizer application and find out the best yielding strain amongst RARI-S-22, RARI-S-14 and JAWAR-86 developed at RARI, Bahawalpur. Three Sorghum strains were subjected to different levels of fertilizers under a split plot design arrangement with four treatments and three replications. All N, P & K was applied at sowing time according to treatment plan. A newly developed sorghum strain with a variety, RARI-S-22, RARI-S-14 and JAWAR-86 was grown with three different treatment combinations of nitrogen, phosphorus and potassium applied in the form of urea, diammonium phosphate and potassium sulphate. The results showed that there was a gradual increase in grain yield with the application of fertilizers. The highest yield was obtained in $T_4$ and it was statistically at par with a yield obtained in $T_3$. RARI-S-14 produced higher yields in all the treatments i.e., 987 kg $ha^{-1}$ in $T_1$ (0-0-0), 1510 kg $ha^{-1}$ in $T_2$ (75-45-30 kg $ha^{-1}$), 2138 kg $ha^{-1}$ in $T_3$ (150-90-60 kg $ha^{-1}$) and 2257 kg $ha^{-1}$ in $T_4$ (225-135-90 kg $ha^{-1}$) as compared to others i.e., RARI-S-22 and JAWAR-86. Hence RARI-S-14 proved to be the most yielding strain in this comparative study under the climatic conditions of Bahawalpur.

**Key words:** Sorghum, grain yield, NPK fertilizers, nutrient management

## Introduction

The agriculture production and food systems are facing challenges due to fast-growing population, increasing soil depletion, land degradation, and changing climate. Agricultural production is primarily characterized by low input and output due to smallholder farming. Sorghum (*Sorghum bicolor (*L.) Moench) locally known as Jawar or Chari is an important Kharif season (summer) crop which is grown both for fodder and grains. Sorghum (*Sorghum bicolor* (L.) Moench) is one of the important food crops growing in semi-arid areas under marginal rainfall and soil conditions. The yields variability is also associated with resource availability and nutrient use efficiency (Desta, *et al*., 2022). High degree of variability in crop response to application of nutrients could be associated with variability in soil properties, landscape positions and soil water regimes (Liu *et al*., 2020; Tamene *et al*., 2017). The effectiveness of fertilizer application to respond to a specific soil fertility problem and its positive economic return depends on the identification of production constraints and targeting specific niches (Barłóg, *et al*., 2022). Thus, efforts to increase crop productivity through fertilizer application and to narrow the yield gaps in smallholder farming require stratified fertilizer management in agricultural landscapes (Ichami *et al*., 2020). Sorghum fodder is considered one of the essential feeds for livestock if properly cured as silage with a little supplement of protein, can maintain cattle in good health conditions during the winter with little or no grain supplement. Sorghum fodder contains more than 50% digestible nutrients with 8% protein, 2.5% fat and 45% nitrogen-free extract (NFE). Its nutritional value is equivalent to that of corn that is why animals relish well due to its palatability and succulent nature (Aruna and Visarada, 2019). Pakistani soils are deficient in N (100%) and P (90%) while deficiencies of K (20%) are crop and soil specific, hence response to N and P is universal (Maqsood *et al*., 2016). Several types and varieties of sorghum have been grown for centuries in Sub-continent, China and Africa. In Pakistan sorghum was grown on an area of 0.281 mha in 2007- 08 and 0.263 mha in 2008-09 with long, taller varieties cultivated for fodder and dwarf varieties for grain purposes (Anonymous, 2009).

Mineral fertilizers play a vital role in improving crop yields but the major challenge is to ensure adequate balance between different nutrients and support optimal yield. Current recommendations for producing optimal forage yields of sorghum-sudan grass hybrids suggest application of 50 to 100 kg N $ha^{-1}$, applied in two equal doses at planting and after the first cut (Vander Veen, (2010). Timing and placement of N application should be managed to avoid significant losses while ensuring availability of adequate N when needed by the crop. Sorghum sudan grass is usually managed with low N fertilizer inputs (≤80 kg·$ha^{-1}$) since growth and yield responses to N rates have been reported only up to 80 kg $ha^{-1}$ (Knebl *et al*., 2023).

The optimum P availability is important for improving mineral P concentrations and yields of most crops (Balemi and Negisho, 2012). Soil solution P, following the dissolution of P fertilizers applied to the soils, is either taken up by the plants, precipitated, or adsorbed on the exchange sites in the soil (Penn and Camberato, 2019). Ajeigbe *et al*., 2018) reported an increase in most growth parameters of forage sorghum plants with an increase in N and K rates from 450 to 650 and 50 to 100 kg $ha^{-1}$, respectively (Pholsen, 2003). Depicted that significantly greater K

content in 3 cultivars of forage sorghum with 75 kg $ha^{-1}$ K as compared to that of the plants receiving 25 or 50 kg·$ha^{-1}$ K. Amanullah *et al*., (2016) showed that plant height, leaf area index, leaf area duration, plant growth rate, total dry matter production, K concentration and grain yield increased with K application rate from 25 to 50 kg·$ha^{-1}$. Adequate availability of soil water and minerals is important to support optimal plant growth and production in the arid and semi-arid regions (Golla, B. (2021). Best and wise management of nutrients is a successful strategy to alleviate abiotic stresses (Singhal, *et al.,* 2023), that's why fertilizers are rich source of plant nutrients required for increased crop productivity. The balanced use of fertilizers can help in providing much needed nutrients to the soil, thereby increasing crop yields and reducing damage to the environment. The insufficient and imbalanced use of fertilizers in Pakistan is one of the major causes of crop yield reduction. There are reports in the literature that balanced application of NPK increased sorghum yield up to 122 % in India (Shrotriya, 1998). Higher crop yield means maintaining the supply of organic matter and vegetative cover, thus enhancing moisture retention, nutrient use efficiency and soil productivity (Fageria *et al*., 2005). Kharif fodders have low nutritive value, poor ratooning ability and give poor yield. The quality and quantity of green fodder can be increased by determining its optimum fertilizer requirements. The response of different varieties might be different to fertilizer application under changing soil and environmental conditions. The present research work was undertaken to evaluate the response of newly developed sorghum varieties (RARI-S-14, RARI-S-22 and JAWAR-86) to different combinations of NPK fertilizers for high. The objective of this study was to investigate the interactions between different rates of N, P and K on growth and yield of forage sorghum.

## Materials and Methods

### Experimental site:

An experiment was conducted at Regional Agricultural Research Institute (RARI), Bahawalpur, located in the south of the Punjab Province, Pakistan, during kharif season, 2021 to find out the response of newly developed sorghum variety RARI-S-14, RARI-S-22 and Jawar-86 to different combinations of N, P and K fertilizers. The study site is located at 27.2046°N; 77.4977°E and 214 m above sea level. About 3852.73 hours of sunshine are counted in Bahawalpur throughout the year. It experiences an average annual temperature of 26.1℃ with an annual rainfall of 223 mm. As a nutshell, this region has the climate characteristics of the desert. The soil order in this area is Aridisol. Physical and chemical properties of the soil of the study site are tabulated as:

**Table 1: Physicochemical properties of soil collected from experimental site.**

| Parameters | Value |
|---|---|
| **pH (1:1)** | **8.00** |
| **Organic matter (%)** | **0.56** |
| **EC (1:10) (dS $m^{-1}$)** | **2.90** |
| **P (Olsen's, mg $kg^{-1}$)** | **6.30** |
| **K (mg $kg^{-1}$)** | **118** |
| **Saturation percentage** | **34** |

| Textural class | Loam |
|---|---|

**Treatments and Experimental design**

Three sorghum strains/varieties viz RARI-S-14, RARI-S-22 and Jawar-86 developed at Regional Agricultural Research Institute, Bahawalpur were investigated in this experiment. The fertilizer sources used for N fertilizer (urea containing 46% N), P fertilizer (Diammonium Phosphate containing 46% $P_2O_5$) and K fertilizer (potassium sulfate containing 50% $K_2O$) were applied according to treatment's plan. The experiment was comprised of three treatments along with control ($T_1$); N, P and K($T_2$) application @ 75, 45 and 30 kg $ha^{-1}$; N, P and K application ($T_3$) @ 150, 90 and 60 kg $ha^{-1}$; N, P and K application ($T_4$) @225, 135 and 90 kg $ha^{-1}$; respectively. All treatments were applied in a Split Plot design manner with three replications comprising a total of 36 trial plots. The main plots contained fertilizer combinations whereas, sub plots comprised of varieties. Before sowing, the soil samples were collected from the depth of 0-15 cm and 15 to 30 cm with the help of augur then prepared for pre-sowing analysis, processed and analyzed. After soil analysis, the field land was prepared according to the recommended methods. The seeds were soiled manually with hand-drill at a seed rate of 20 kg $ha^{-1}$ with single row hand drill.

The size of each plot was maintained at of 60 $m^2$, rows spacing was 60 cm. The plants were thinned at the two-leaf stage to achieve a uniform density of 150,000 plants $ha^{-1}$. The fertilizers were applied to each plot as a basal fertilizer to a depth of 15 cm when the seeds were sown. All P, K and ½ N were applied at sowing and the remaining ½ N was applied at first irrigation to avoid Nitrogen losses. Intercultural operations such as thinning, weeding, re-sowing, drainage, irrigation and plant protection measures were taken as and when necessary and kept usual and uniform for all the experimental plots.

**Harvesting**

The crop from each plot was harvested on ripening at about after four months and yield data and other parameters were collected and the components have been expressed in kg $ha^{-1}$ after drying to constant weight.

**Statistical analyses**

The sorghum yield data was subjected to analysis of variance (ANOVA) and the treatment means separated using the least significant difference (LSD) method at 5%.

**Results and Discussion**

**Plant height:**

The collected data depicted that height of sorghum varied significantly with the different levels of NPK (Table 2). At harvest, the tallest plant (310.8 cm) was noted where 225:135:90 NPK kg $ha^{-1}$ was applied which was statistically similar to those in 150:90:60 NPK kg $ha^{-1}$ and 75:45:30 NPK kg $ha^{-1}$ and the shortest (261.8 cm) were recorded from control treatment.

**Panicle Length (cm)**

The collected data depicted that panicle length of sorghum varied significantly with the different levels of NPK (Table 2). At harvest, the maximum panicle length (10.2 cm) was noted where 225:135:90 NPK kg $ha^{-1}$ was applied which was statistically similar to those in 150:90:60

NPK kg $ha^{-1}$ and 75:45:30 NPK kg $ha^{-1}$ and the smallest (7.76 cm) were recorded from control treatment.

**1000-grain weight:**

The data regarding 1000-grain weight were influenced significantly by NPK levels (Table 2). Fertilizer rate of 225:135:90 NPK kg $ha^{-1}$ resulted maximum 1000-grain weight (10.2 g) which was significantly similar to 150:90:60 NPK kg $ha^{-1}$ and 75:45:30 NPK kg $ha^{-1}$ whereas control treatment resulted the minimum 1000-grain weight (8.57 g).

**Table 2: Impact of different levels of fertilizer on productive traits and grain yield of Sorghum strains/varieties.**

| Tr. Plan | Nutrients (kg $ha^{-1}$) | | | Strains / Variety | Plant Height (cm) | Panicle Length (cm) | 1000 grain wt. (g) | Yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | | | | | |
| $T_1$ | 0 | 0 | 0 | RARI-S-14 | 265.1 | 8.0 | 8.70 | 987 |
| | | | | RARI-S-22 | 261.8 | 7.76 | 8.57 | 957 |
| | | | | JAWAR-86 | 264.3 | 8.0 | 8.64 | 972 |
| $T_2$ | 75 | 45 | 30 | RARI-S-14 | 280.4 | 9.1 | 9.20 | 1510 |
| | | | | RARI-S-22 | 278.4 | 9.0 | 8.92 | 1450 |
| | | | | JAWAR-86 | 280.0 | 9.1 | 9.13 | 1465 |
| * $T_3$ | 150 | 90 | 60 | RARI-S-14 | 307.8 | 10.0 | 10.1 | 2138 |
| | | | | RARI-S-22 | 306.6 | 9.91 | 9.86 | 2078 |
| | | | | JAWAR-86 | 307.2 | 9.94 | 10.00 | 2123 |
| $T_4$ | 225 | 135 | 90 | RARI-S-14 | 310.8 | 10.2 | 10.2 | 2257 |
| | | | | RARI-S-22 | 310.2 | 10.1 | 9.89 | 2198 |
| | | | | JAWAR-86 | 310.4 | 10.2 | 9.96 | 2242 |

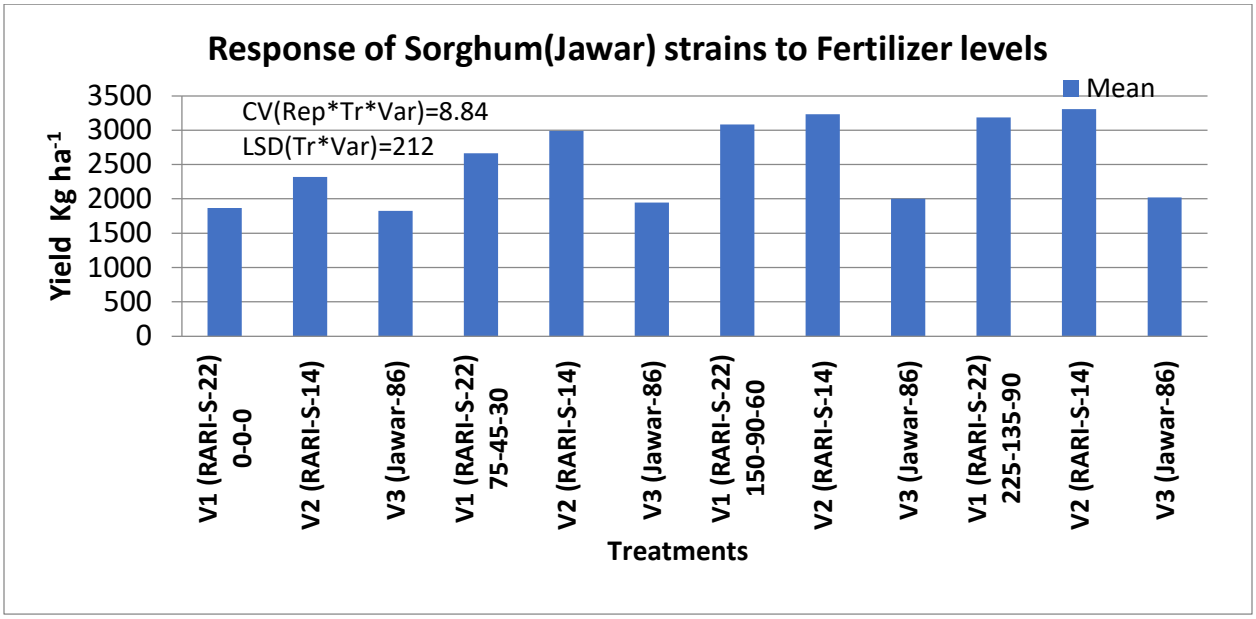
Note: The Data on these parameters were analyzed statistically at 5% level of significance (Steel and Torrie, 1984).

**Grain yield**

Fertilizers are an efficient exogenous source of plant nutrients. In Pakistan, fertilizer use is insufficient and imbalanced. The results showed significant differences in the grain yield of sorghum in all cultivar and variety over Control (Table 1). The application of NPK fertilizers on different lines and variety at the rate of ($T_4$) 225, 135 and 90 NPK kg $ha^{-1}$ resulted in maximum grain yield (2257 kg $ha^{-1}$ 2198 kg $ha^{-1}$ and 2242 kg $ha^{-1}$ respectively) followed by a yield in $T_3$ i.e 2138 kg $ha^{-1}$ 2078 kg $ha^{-1}$ 2123 kg $ha^{-1}$) and these were statistically at par. Significant differences were also observed among different combinations NPK fertilizers application. It was observed that there was gradual increase in yield with N and P application While, $T_2$ and $T_1$ gave yields significantly lower than the yields in $T_3$ and $T_4$. While the minimum grain yield (987kg$ha^{-1}$,

957kgha$^{-1}$ and 972 kgha$^{-1}$) was obtained in control treatment (T1) in all the three lines and variety, respectively (Table 2) similar result also showed by Hussein and Alva (2014). The low yield in the absence of NPK in $T_1$ treatment indicates the positive contribution of these fertilizers to the overall yield of sorghum. So, dose of fertilizer in $T_3$ (150-90-60 kg ha$^{-1}$) is recommended for this strain of sorghum under Bahawalpur climate. Combined use of N, P and K gives better results than a single use of nutrient element. There are reports in literature indicating positive effects of balanced use of N, P and K on crop yield. Medina *et al*., 1984; Azam *et al.,* (2010), Chen*, et al.,* (2021), Khan *et al.,* (2005) reported that use of different combinations of N, P and K fertilizers in different showed best growth and yield of crop. Tanchev (1995) also indicated that N, P and K fertilizers applied in different combinations improved growth and yield of sorghum. Yield data recorded revealed that all the three Strains/variety responded positively to fertilizer doses however, RARI-S-14 produced higher yields in all the treatments i.e., 987 kg ha$^{-1}$ in $T_1$(0-0-0) , 1510 kg ha$^{-1}$ in $T_2$(75-45-30 NPK kg ha$^{-1}$), 2138 kg ha$^{-1}$ in $T_3$ (150-90-60 NPK kg ha$^{-1}$) and 2257 kg ha$^{-1}$ in $T_4$(225-135-90 NPK kg ha$^{-1}$) as compared to others i.e.,RARI-S-22 and Jawar-86. Hence RARI-S-14 is the best in this comparative study under Bahawalpur conditions. The higher yields in new variety could be accredited to positive contribution of a combination of grain yield components like plant height, panicle length and 1000 grain weight which were improved with NPK fertilizer application.

Fig. 1. Impact of different levels of Fertilizer on Sorghum Strains/varieties




## Conclusion

The grain yield of sorghum variety (RARI-S-14, RARI-S-22 and JAWAR-86) increased with the application of NPK fertilizers. The increase in grain yield with fertilizer application may be due to increase in the growth of plant. Yield data recorded revealed that all the three Strains/variety responded positively to fertilizer doses. The maximum grain yield was obtained by the application $T_4$ and it was statistically at par with a yield obtained in $T_3$. RARI-S-14 produced higher yields in all the treatments i.e., 987 kg ha$^{-1}$ in $T_1$ (0-0-0), 1510 kg ha$^{-1}$ in $T_2$ (75-45-30 NPK

kg $ha^{-1}$), 2138 kg $ha^{-1}$ in $T_3$ (150-90-60 NPK kg $ha^{-1}$) and 2257 kg $ha^{-1}$ in $T_4$ (225-135-90 NPK kg $ha^{-1}$) as compared to others i.e., RARI-S-22 and JAWAR-86. Hence RARI-S-14 is the best in this comparative study under Bahawalpur conditions.

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