

## Yield and harvest index of Grain Sorghum as influenced by agronomic management practices in summer rice fallows of Southern Kerala

### ABSTRACT

The study was undertaken at College of Agriculture, Vellayani, during from January 2024 to May 2024 to standardize the tillage, plant population and nutrient management for grain sorghum in summer rice fallows. The experiment was laid out in design RCBD with 2 x 2 x 3 treatments, replicated thrice and the treatments comprised of combinations of two tillage methods ( $t_1$ -zero tillage,  $t_2$ -conventional tillage), two levels of spacing ( $p_1$  – 45 x 15 cm,  $p_2$ - 60 x 15 cm) and three NPK levels ( $n_1$  – 45:25:25 NPK kg ha<sup>-1</sup>,  $n_2$  – 50:25:75 NPK kg ha<sup>-1</sup> and  $n_3$  – 50:25:50 NPK kg ha<sup>-1</sup>). Among yield attributes, sorghum grown under zero tillage with spacing 45 x 15 cm and a nutrient dose of 50:25:50 NPK kg ha<sup>-1</sup> ( $t_1p_1n_3$ ) resulted in higher length of panicle (22.70 cm), number of grains per panicle (1836.67) and grain weight per panicle (35.96 g). Higher grain yield (5.14 t ha<sup>-1</sup>) was obtained in treatment  $t_1p_1n_3$ , which was found on par with  $t_1p_1n_2$  (4.96 t ha<sup>-1</sup>) and higher stover yield (8.10 t ha<sup>-1</sup>) was obtained in treatment  $t_1p_1n_2$  which was found on par with  $t_1p_1n_3$  (7.81 t ha<sup>-1</sup>). Harvest index was higher in the treatment  $t_2p_2n_1$  (0.43) and remained comparable with  $t_1p_1n_3$  (0.40) and  $t_1p_1n_2$  (0.39).

**Key words:** - Sorghum, summer rice fallows, zero tillage, conservation tillage, harvest index

### 1. INTRODUCTION

Sorghum is a versatile crop, renowned for its adaptability to various cropping systems and harsh environmental conditions typical of semi-arid regions. Sorghum can withstand both drought and excessive soil moisture so called the crop camel. The C4 photosynthesis pathway, deep root system and its quick-growing habit allows it to survive on marginal lands, making sorghum a climate-resilient and drought tolerant crop. Paddy fallows basically imply to those lowland kharif sown rice areas, which remain uncropped during rabi season. In South Asia, India accounts for the majority, approximately 79 percent, of the total paddy fallow area, which amounts to around 11.65 million hectares out of the total 15.0 million hectares in the region. Sorghum in paddy fallows is gaining popularity among the farmers and the crop is exclusively cultivated in paddy fallows under zero tillage condition [1].

Sowing of crops under zero-tillage has many economic and environmental benefits over conventional tillage, such as lower labour and fuel needs, reduced soil erosion, reduced run off, increased soil organic C contents, and increased soil biological activity. In rice fallows, after the harvest of kharif transplanted rice, sorghum is sown in second fortnight of December to January under zero-tillage on the residual soil moisture [2].

Changing plant population density is one of the strategies to promote more effective water consumption in the farm. Closer rows and higher plant density result in more efficient use of solar radiation, nutrients and water resources [3]. The yield of grain sorghum can be improved by increasing the plant densities [4].

Sorghum responds well to nutrient application, with higher yields being achieved through a balanced application of NPK. In rice-fallows of Andhra Pradesh the farmers were applying higher dose of fertilizers (150-200 kg N, 75-80 kg P<sub>2</sub>O, and 75 kg K<sub>2</sub>O per ha) [2]. For rainfed sorghum cultivation in Kerala NPK recommendation is 45:25:25 kg/ha [5]. However Karthik (2021) reported the modified fertilizer dose of 50:25:75 kg ha<sup>-1</sup> NPK with N and K in two equal split doses, half of each at basal and at 30 DAS and P as basal dose for cultivating high yielding sorghum varieties as rainfed crop in southern Kerala [6]. Shrotriya (1998) reported that balanced application of NPK resulted in an increase in sorghum yield up to 122 per cent under Indian conditions [7].

The study was undertaken at College of Agriculture, Vellayani, during from January 2024 to May 2024 to standardize the tillage, plant population and nutrient management for grain sorghum in summer rice fallows.

## 2. MATERIALS AND METHODS

### 2.1 Location of study

The experiment was conducted in wetlands of the Instructional farm, College of Agriculture, Velayani, Thiruvananthapuram. The experimental field is located at 8° 25' 47" N latitude and 76° 59' 04" E longitude at an altitude of 24.15 m above the mean sea level. The soil was sandy clay loam with strong acidity, safe electrical conductivity and high organic carbon content. The soil was medium in available nitrogen and high in available phosphorus and low in available potassium. The experiment was conducted during summer season, 2024. The mean maximum temperature ranged between 34.4° C to 32.2° C and mean minimum temperature ranged between 25.8° C to 20.0° C, mean maximum relative humidity ranged between 94.40 per cent to 85.14 per cent, and mean minimum relative humidity ranged between 76.10 per cent to 64.42 per cent. A total rainfall of 343.20 mm was received during the crop growing period.

### 2.2 Treatments:

The experiment was laid out in design RCBD with 2 x 2 x 3 treatments, replicated thrice. The treatments comprised combinations of two tillage methods ( $t_1$ -zero tillage,  $t_2$ -conventional tillage), two levels of spacing ( $p_1$  – 45 x 15 cm,  $p_2$ - 60 x 15 cm) and three levels of NPK ( $n_1$  – 45:25:25 NPK kg ha<sup>-1</sup>,  $n_2$  – 50:25:75 NPK kg ha<sup>-1</sup> and  $n_3$  – 50:25:50 NPK kg ha<sup>-1</sup>). The weeds in the experimental plots were cleared using brush cutter. Bunds were created to divide the experimental area into individual plots. Plots of 4.5 m x 4.5 m were prepared with 30 cm wide bunds on all four sides. Then plots with conventional tillage treatment was ploughed and the clods were crushed, levelled and brought to a fine tith and plots with zero tillage treatment was left as such. The variety used for the study was CO-32. Farmyard manure was applied at the rate of 5 t ha<sup>-1</sup> at the time of land preparation. Nitrogen was applied at the rate of 45 kg ha<sup>-1</sup> and 50 kg ha<sup>-1</sup> as urea to the plots according to the dose and as per the time of application of treatments. Potassium was applied at the rate of 25 kg ha<sup>-1</sup>, 50 kg ha<sup>-1</sup> and 75 kg ha<sup>-1</sup> to the plots according to the dose and as per the time of application of treatments as muriate of potash. The entire quantity of phosphorus at the rate of 25 kg ha<sup>-1</sup> was applied as a basal dose.

### 2.3 Observations

Observations were taken on yield attributes like length of panicle, number of grains per panicle, grain weight per panicle, test weight, grain yield, stover yield and harvest index. Five observational plants were selected and tagged in each plot, and observations were taken from these plants. After the harvest, panicle length was measured from the base of the panicle to its tip and expressed in cm. From the sample plants in each plot, the grains from each panicle were removed and counted, and the mean value was calculated. The grains removed from sample panicles were weighed using an electronic balance. The mean value was calculated and expressed in g per panicle as grain weight per panicle. One thousand fully filled, bold grains were taken and weighed separately from each plot. The mean value was calculated and expressed in grams (g) as test weight. The panicles harvested from each plot were threshed separately, and grains were separated, sun-dried, cleaned, and weighed to calculate the grain yield. The values were recorded and expressed in t ha<sup>-1</sup>. After the harvest was completed, the green stover was cut at ground level from each plot. They were shade dried and then oven dried at 60 ± 5°C until a constant weight was achieved and the weight of the stover was expressed in t ha<sup>-1</sup>. Harvest index (HI) was calculated using the formula suggested by Donald and Hamblin (1976) [8].

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

### 3. Result and Discussion

#### 3.1 Yield attributes

##### 3.1.1 Length of panicle

Sorghum grown under zero tillage with 45 cm x 15 cm spacing and a nutrient dose of 50:25:50 kg NPK ha<sup>-1</sup> (t<sub>1</sub>p<sub>1</sub>n<sub>3</sub>) produced highest length of panicle (22.70 cm) which was on par with all other treatments (t<sub>1</sub>p<sub>2</sub>n<sub>2</sub>-22.57 cm, t<sub>2</sub>p<sub>2</sub>n<sub>3</sub>-22.54 cm, t<sub>1</sub>p<sub>2</sub>n<sub>1</sub>-21.59 cm, t<sub>2</sub>p<sub>1</sub>n<sub>3</sub>-21.37 cm, t<sub>1</sub>p<sub>1</sub>n<sub>2</sub>-21.20 cm, t<sub>1</sub>p<sub>1</sub>n<sub>1</sub>-21.18 cm, t<sub>2</sub>p<sub>1</sub>n<sub>2</sub>-20.49 cm, t<sub>2</sub>p<sub>2</sub>n<sub>1</sub>-20.33 cm, t<sub>1</sub>p<sub>2</sub>n<sub>3</sub>-20.27 cm and t<sub>2</sub>p<sub>1</sub>n<sub>1</sub>-20.26 cm) except t<sub>2</sub>p<sub>2</sub>n<sub>2</sub>(19.26 cm)(Table 1c). The main effects and T x P, T x N and P x N interaction effects could not significantly influence the length of panicle (Table 1a, Table 1b).

##### 3.1.2 Number of grains per panicle

Sorghum grown with zero tillage and 45 cm x 15 cm spacing (t<sub>1</sub>p<sub>1</sub>) produced the highest number of grains per panicle (1585.22) which was on par with t<sub>2</sub>p<sub>2</sub> (1480.44)(Table 1b). Sorghum grown with zero tillage and 50:25:50kgNPKha<sup>-1</sup> nutrient dose produced the highest number of grains per panicle (1577.17) which was on par with treatments t<sub>2</sub>n<sub>1</sub> (1473.33), t<sub>2</sub>n<sub>2</sub> (1451.50) and t<sub>1</sub>n<sub>2</sub> (1426.00) (Table 1b). Sorghum grown with 45 cm x 15 cm spacing and 50:25:50 kg NPK ha<sup>-1</sup> nutrient dose produced highest number of grains per panicle (1685.00) which was on par with p<sub>2</sub>n<sub>1</sub> (1533.33) (Table 1b). Sorghum grown under zero tillage with 45 cm x 15 cm spacing and 50:25:50 kg NPK ha<sup>-1</sup> nutrient dose produced highest number of grains per panicle (1836.67) (Table 1c). The main effects could not significantly influence the number of grains per panicle (Table 1a).

Table 1a. Effect of tillage, spacing and nutrient management on length of panicle, number of grains per panicle, grain weight per panicle and test weight of grain.

Treatments	Length of panicle(cm)	No of grains per panicle	Grain weight per panicle(g)	Test weight(g)
<b>Tillage (T)</b>				
t <sub>1</sub> (Zero tillage)	21.58	1462.78	27.02	25.19
t <sub>2</sub> (Conventional tillage)	20.71	1412.28	22.16	25.32
SEm (±)	0.34	32.30	0.52	0.19
CD (0.05)	NS	NS	1.54	NS
<b>Spacing (P)</b>				
p <sub>1</sub> (45 x 15 cm)	21.20	1464.67	22.48	25.22
p <sub>2</sub> (60 x 15 cm)	21.09	1410.39	26.70	25.29
SEm (±)	0.34	32.30	0.52	0.19
CD (0.05)	NS	NS	1.539	NS
<b>Nutrient management(N)</b>				
n <sub>1</sub> (45:25:25 NPK kg ha <sup>-1</sup> )	20.84	1429.25	21.18	25.28
n <sub>2</sub> (50:25:75 NPK)	20.88	1438.75	26.29	25.26

kg ha <sup>-1</sup> )				
n <sub>3</sub> (50:25:50 NPK kg ha <sup>-1</sup> )	21.72	1444.58	26.30	25.22
SEm (±)	0.42	39.56	0.64	0.23
CD (0.05)	NS	NS	1.884	NS

Table 1b. Interaction effects of tillage, spacing and nutrient management on length of panicle, number of grains per panicle, grain weight per panicle and test weight of grain.

Interactions	Length of panicle(cm)	No of grains per panicle	Grain weight per panicle(g)	Test weight(g)
<b>Tillage (T) x Spacing (P)</b>				
t <sub>1</sub> p <sub>1</sub>	21.69	1585.22	27.73	25.26
t <sub>1</sub> p <sub>2</sub>	21.47	1340.33	26.32	25.11
t <sub>2</sub> p <sub>1</sub>	20.70	1344.11	17.24	25.17
t <sub>2</sub> p <sub>2</sub>	20.71	1480.44	27.08	25.48
SEm (±)	0.48	45.68	0.74	0.26
CD (0.05)	NS	133.968	2.176	NS
<b>Tillage (T) x NPK Levels (N)</b>				
t <sub>1</sub> n <sub>1</sub>	21.38	1385.17	18.29	25.18
t <sub>1</sub> n <sub>2</sub>	21.88	1426.00	31.63	25.28
t <sub>1</sub> n <sub>3</sub>	21.48	1577.17	31.14	25.09
t <sub>2</sub> n <sub>1</sub>	20.29	1473.33	24.07	25.38
t <sub>2</sub> n <sub>2</sub>	19.87	1451.50	20.95	25.23
t <sub>2</sub> n <sub>3</sub>	21.96	1312.00	21.46	25.35
SEm (±)	0.59	55.94	0.91	0.32
CD (0.05)	NS	164.077	2.665	NS
<b>Spacing (P) x NPK Levels (N)</b>				
p <sub>1</sub> n <sub>1</sub>	20.72	1325.17	13.84	25.30
p <sub>1</sub> n <sub>2</sub>	20.84	1383.83	24.50	25.22
p <sub>1</sub> n <sub>3</sub>	22.03	1685.00	29.12	25.13
p <sub>2</sub> n <sub>1</sub>	20.96	1533.33	28.52	25.27
p <sub>2</sub> n <sub>2</sub>	20.91	1493.67	28.09	25.30
p <sub>2</sub> n <sub>3</sub>	21.41	1204.17	23.49	25.31
SEm (±)	0.59	55.94	0.91	0.32
CD (0.05)	NS	164.077	2.665	NS

### 3.1.3 Grain weight per panicle

Results of the main effect shows that sorghum under zero tillage (t<sub>1</sub>) produced the highest grain weight per panicle (27.02 g). Sorghum with 45 cm x 15 cm spacing (p<sub>1</sub>) resulted in highest grain weight per panicle of (26.70 g). Also a nutrient dose of 50:25:50 kg NPK ha<sup>-1</sup> (n<sub>3</sub>) resulted in highest grain weight per panicle (26.30 g) followed by n<sub>2</sub> (50:25:75kgNPKha<sup>-1</sup>) with grain weight per panicle (26.29) which were on par each other (Table 1a).

First order interaction effects shows that sorghum under zero tillage with 45 cm x 15 cm spacing ( $t_1p_1$ ) produced the highest grain weight per panicle (27.73 g) which was on par to all other treatments ( $t_2p_2$ -27.08 g,  $t_1p_2$ -26.32 g) except  $t_2p_1$  (17.24). Sorghum grown under zero tillage with 50:25:75kgNPKha<sup>-1</sup> nutrient dose ( $t_1n_2$ ) produced the highest grain weight per panicle (31.63 g) followed by  $t_1n_3$  (31.14 g) which were on par each other. Sorghum grown with 45 cm x 15 cm spacing and 50:25:50kg NPK ha<sup>-1</sup> nutrient dose ( $p_1n_3$ ) produced highest grain weight per panicle (29.12 g) which was on par with  $p_2n_1$  (28.52 g) and  $p_2n_2$  (28.09 g) (Table 1b).

Sorghum grown under zero tillage with 45 cm x 15 cm spacing and 50:25:50kg NPK ha<sup>-1</sup> ( $t_1p_1n_3$ ) recorded higher grain weight per panicle (35.96 g) which was found on par with  $t_1p_1n_2$  (33.53 g) (Table 1c). The reduced disturbance of soil structure in zero tillage promotes better nutrient retention and availability, which can positively affect grain weight per panicle [9]. Closer spacing may lead to better canopy coverage which enhances light interception and photosynthesis [10]. Research consistently shows that increased nitrogen application improves sorghum yield and grain quality. Higher nitrogen levels (up to 120 kg N/ha) significantly increased grain weight per panicle across various sorghum genotypes [11].

Table 1c. Effect of T X P X N interaction on length of panicle, number of grains per panicle, grain weight per panicle and test weight of grain.

Treatment combinations	Length of panicle(cm)	No of grains per panicle	Grain weight per panicle(g)	Test weight(g)
<b>Tillage (T) X Spacing (P) x NPK Levels (N)</b>				
$t_1p_1n_1$	21.18	1577.00	13.69	25.29
$t_1p_1n_2$	21.20	1601.32	33.53	25.57
$t_1p_1n_3$	22.70	1836.67	35.96	24.93
$t_1p_2n_1$	21.59	1193.33	22.89	25.07
$t_1p_2n_2$	22.57	1510.00	29.73	25.00
$t_1p_2n_3$	20.27	1317.67	28.33	25.25
$t_2p_1n_1$	20.26	1073.33	13.99	25.30
$t_2p_1n_2$	20.49	1425.67	15.46	24.87
$t_2p_1n_3$	21.37	1533.33	22.29	25.33
$t_2p_2n_1$	20.33	1587.78	24.15	25.47
$t_2p_2n_2$	19.26	1477.33	26.44	25.60
$t_2p_2n_3$	22.54	1090.67	20.64	25.37
SEm (±)	0.84	79.12	1.28	0.46
CD (0.05)	2.448	232.04	3.175	NS

### 3.1.4 Test weight

Tillage, spacing, nutrient management could not significantly effect the test weight of sorghum grown in summer rice fallows (Table 1a, 1b and 1c).

### 3.2 Yield

Tillage, spacing and nutrient management significantly effects the grain yield, stover yield and harvest index of sorghum.

Table 2a. Effect of tillage, spacing and nutrient management on grain yield, stover yield and harvest index of sorghum.

Treatments	Grain yield ha <sup>-1</sup> ) (t	Stover yield ha <sup>-1</sup> ) (t	Harvest index
<b>Tillage (T)</b>			
t <sub>1</sub> (Zero tillage)	3.28	6.48	0.33
t <sub>2</sub> (Conventional tillage)	2.42	5.51	0.31
SEm (±)	0.06	0.10	0.007
CD (0.05)	0.172	0.283	0.019
<b>Spacing (P)</b>			
p <sub>1</sub> (45 x 15 cm)	3.08	6.52	0.31
p <sub>2</sub> (60 x 15 cm)	2.62	5.46	0.34
SEm (±)	0.06	0.10	0.007
CD (0.05)	0.172	0.283	NS
<b>Nutrient management (N)</b>			
n <sub>1</sub> (45:25:25 NPK kg ha <sup>-1</sup> )	2.27	5.17	0.32
n <sub>2</sub> (50:25:75 NPK kg ha <sup>-1</sup> )	3.13	7.09	0.30
n <sub>3</sub> (50:25:50 NPK kg ha <sup>-1</sup> )	3.15	5.72	0.36
SEm (±)	0.07	0.12	0.008
CD (0.05)	0.21	0.346	0.023

#### 3.2.1 Grain yield

Sorghum under zero tillage (t<sub>1</sub>) produced the highest grain yield (3.28 t ha<sup>-1</sup>). Sorghum grown with 45 cm x 15 cm spacing (p<sub>1</sub>) resulted in highest grain yield (3.08 t ha<sup>-1</sup>). Also n<sub>3</sub> (50:25:50 kg NPK ha<sup>-1</sup>) resulted in highest grain yield (3.15 t ha<sup>-1</sup>) followed by n<sub>2</sub> (50:25:75kgNPKha<sup>-1</sup>) with grain yield of 3.13 t ha<sup>-1</sup> which were on par each other (Table 2a).

Sorghum grown under zero tillage with 45 cm x 15 cm spacing (t<sub>1</sub>p<sub>1</sub>) produced the highest grain yield (3.96 t ha<sup>-1</sup>). Sorghum grown under zero tillage with 50:25:75kgNPKha<sup>-1</sup> nutrient dose (t<sub>1</sub>n<sub>2</sub>) produced the highest grain yield (4.00 t ha<sup>-1</sup>) followed by t<sub>1</sub>n<sub>3</sub> (3.84 t ha<sup>-1</sup>) which were on par each other. Sorghum grown with 45 cm x 15 cm spacing and 50:25:50 kg NPK ha<sup>-1</sup> nutrient dose (p<sub>1</sub>n<sub>3</sub>) produced highest grain yield (3.99 t ha<sup>-1</sup>) (Table 2b).

Sorghum grown under zero tillage with 45 cm x 15 cm spacing and a nutrient dose of 50:25:50 kg NPK ha<sup>-1</sup> (t<sub>1</sub>p<sub>1</sub>n<sub>3</sub>) resulted in higher grain yield (5.14 t ha<sup>-1</sup>) which was on par with t<sub>1</sub>p<sub>1</sub>n<sub>2</sub> (4.96 t ha<sup>-1</sup>) (Table 2c).

The improvement in yield is attributed to several factors, including better soil moisture retention, timely planting, and reduced soil disturbance. This leads to enhanced yield components as a result of water conservation, better surface residue management, improved soil biological activity, and improved soil structure [12]. Closer spacing improve water use efficiency by reducing evaporation from the soil surface and ensuring more water availability to plants [13] and also closer spacing can suppress weed growth by shading the soil surface, reducing competition for resources and allowing sorghum plants to thrive [14]. Potassium is crucial for promoting optimal plant growth. Activates numerous essential enzymes involved in processes like protein synthesis, sugar transport, N and C metabolism, and photosynthesis thus significantly contributes to improve crop yield [15].

### 3.2.2 Stover yield

Sorghum under zero tillage ( $t_1$ ) produced the highest stover yield ( $6.48 \text{ t ha}^{-1}$ ). Sorghum grown with  $45 \text{ cm} \times 15 \text{ cm}$  spacing ( $p_1$ ) resulted in highest stover yield ( $6.52 \text{ t ha}^{-1}$ ). Also  $n_2$  ( $50:25:75 \text{ kg NPK ha}^{-1}$ ) resulted in highest stover yield ( $7.09 \text{ t ha}^{-1}$ ) followed by  $n_3$  ( $50:25:50 \text{ kg NPK ha}^{-1}$ ) with stover yield of  $5.72 \text{ t ha}^{-1}$  (Table 2a).

Sorghum grown under zero tillage with  $45 \text{ cm} \times 15 \text{ cm}$  spacing ( $t_1p_1$ ) produced the highest stover yield ( $7.27 \text{ t ha}^{-1}$ ). Sorghum grown under zero tillage with  $50:25:75 \text{ kg NPK ha}^{-1}$  nutrient dose ( $t_1n_2$ ) produced the highest stover yield ( $7.99 \text{ t ha}^{-1}$ ) followed by  $t_1n_3$  ( $6.28 \text{ t ha}^{-1}$ ). Sorghum grown with  $45 \text{ cm} \times 15 \text{ cm}$  spacing and  $50:25:75 \text{ kg NPK ha}^{-1}$  nutrient dose ( $p_1n_2$ ) produced highest stover yield ( $7.34 \text{ t ha}^{-1}$ ) which was on par with  $p_1n_3$  ( $6.85 \text{ t ha}^{-1}$ ) (Table 2b).

Sorghum grown under zero tillage with  $45 \text{ cm} \times 15 \text{ cm}$  spacing and a nutrient dose of  $50:25:75 \text{ kg NPK ha}^{-1}$  ( $t_1p_1n_2$ ) resulted in higher stover yield ( $8.10 \text{ t ha}^{-1}$ ) which was on par with treatment  $t_1p_2n_2$  ( $7.88 \text{ t ha}^{-1}$ ) and  $t_1p_1n_3$  ( $7.81 \text{ t ha}^{-1}$ ) (Table 2c).

Table 2b. Interaction effects of tillage, spacing and nutrient management on grain yield, stover yield and harvest index of sorghum.

Interactions	Grain yield( $\text{t ha}^{-1}$ )	Stover yield( $\text{t ha}^{-1}$ )	Harvest index
<b>Tillage (T) x Spacing (P)</b>			
$t_1p_1$	3.96	7.27	0.34
$t_1p_2$	2.60	5.69	0.33
$t_2p_1$	2.20	5.78	0.27
$t_2p_2$	2.65	5.23	0.35
SEm ( $\pm$ )	0.08	0.14	0.009
CD (0.05)	0.243	0.40	0.027
<b>Tillage (T) x NPK Levels (N)</b>			
$t_1n_1$	1.98	5.16	0.28
$t_1n_2$	4.00	7.99	0.33
$t_1n_3$	3.84	6.28	0.39
$t_2n_1$	2.55	5.18	0.35
$t_2n_2$	2.25	6.18	0.27

t <sub>2</sub> n <sub>3</sub>	2.46	5.16	0.32
SEm (±)	0.10	0.17	0.01
CD (0.05)	0.297	0.489	0.03
<b>Spacing (P) x NPK Levels (N)</b>			
p <sub>1</sub> n <sub>1</sub>	1.77	5.38	0.25
p <sub>1</sub> n <sub>2</sub>	3.45	7.34	0.30
p <sub>1</sub> n <sub>3</sub>	3.99	6.85	0.36
p <sub>2</sub> n <sub>1</sub>	2.76	4.96	0.38
p <sub>2</sub> n <sub>2</sub>	2.80	6.84	0.29
p <sub>2</sub> n <sub>3</sub>	2.30	4.58	0.35
SEm (±)	0.10	0.17	0.01
CD(0.05)	0.297	0.489	0.03

Table 2c. Effect of T X P X N interaction on grain yield, stover yield and harvest index of sorghum.

Treatment combination	Grain yield(t ha <sup>-1</sup> )	Stover yield(t ha <sup>-1</sup> )	Harvest index
<b>Tillage(T) X Spacing(P) x NPK Levels(N)</b>			
t <sub>1</sub> p <sub>1</sub> n <sub>1</sub>	1.77	5.90	0.23
t <sub>1</sub> p <sub>1</sub> n <sub>2</sub>	4.96	8.10	0.39
t <sub>1</sub> p <sub>1</sub> n <sub>3</sub>	5.14	7.81	0.40
t <sub>1</sub> p <sub>2</sub> n <sub>1</sub>	2.20	4.43	0.33
t <sub>1</sub> p <sub>2</sub> n <sub>2</sub>	3.05	7.88	0.28
t <sub>1</sub> p <sub>2</sub> n <sub>3</sub>	2.55	4.76	0.38
t <sub>2</sub> p <sub>1</sub> n <sub>1</sub>	1.78	4.87	0.27
t <sub>2</sub> p <sub>1</sub> n <sub>2</sub>	1.95	6.58	0.23
t <sub>2</sub> p <sub>1</sub> n <sub>3</sub>	2.86	5.90	0.33
t <sub>2</sub> p <sub>2</sub> n <sub>1</sub>	3.32	5.49	0.43
t <sub>2</sub> p <sub>2</sub> n <sub>2</sub>	2.56	5.79	0.31
t <sub>2</sub> p <sub>2</sub> n <sub>3</sub>	2.06	4.41	0.32
SEm (±)	0.14	0.24	0.02
CD (0.05)	0.42	0.692	0.05

### 3.2.3 Harvest Index

Harvest index was significantly superior in t<sub>1</sub> (zero tillage) with a value of 0.33. In case of spacing, harvest index was significantly superior in p<sub>2</sub> (60 cm x15 cm spacing) with a value of 0.34. The main effect of nutrient management was found to be significant on harvest index and n<sub>3</sub> (50:25:50 kg NPK ha<sup>-1</sup>) have highest value of 0.36 (Table 2a).

The t<sub>2</sub>p<sub>2</sub> treatment (conventional tillage and 60 cm x 15 cm spacing) shows the highest harvest index (0.35) which was statistically on par with all other treatments except t<sub>2</sub>p<sub>1</sub> (0.27). The treatment t<sub>1</sub>n<sub>3</sub> (zero tillage and 50:25:50kgNPKha<sup>-1</sup>) produced the highest harvest index (0.39). p<sub>2</sub>n<sub>1</sub> treatment (60 cm x 15 cm spacing and 45:25:25 kg NPK ha<sup>-1</sup>) produced highest harvest index (0.38) which was on par with p<sub>1</sub>n<sub>3</sub> (0.36) and p<sub>2</sub>n<sub>3</sub> (0.35).

The treatment  $t_2p_2n_1$  (conventional tillage, 60 cm x 15 cm spacing and 45:25:25 kg NPK  $ha^{-1}$ ) produced highest harvest index (0.43) which was on par with  $t_1p_1n_3$  (0.40),  $t_1p_1n_2$  (0.39) and  $t_1p_2n_3$  (0.38). The highest harvest index observed under conventional tillage and wider spacing may be due to allocation of biomass to grain relative to the total biomass was optimized in this condition. Wider spacing can reduce competition for nutrients and light, potentially leading to more efficient biomass partitioning towards grain production. However, the total biomass (grain + stover) may have been lower compared to the zero-tillage system due to less efficient nutrient use and reduced overall plant density [16].

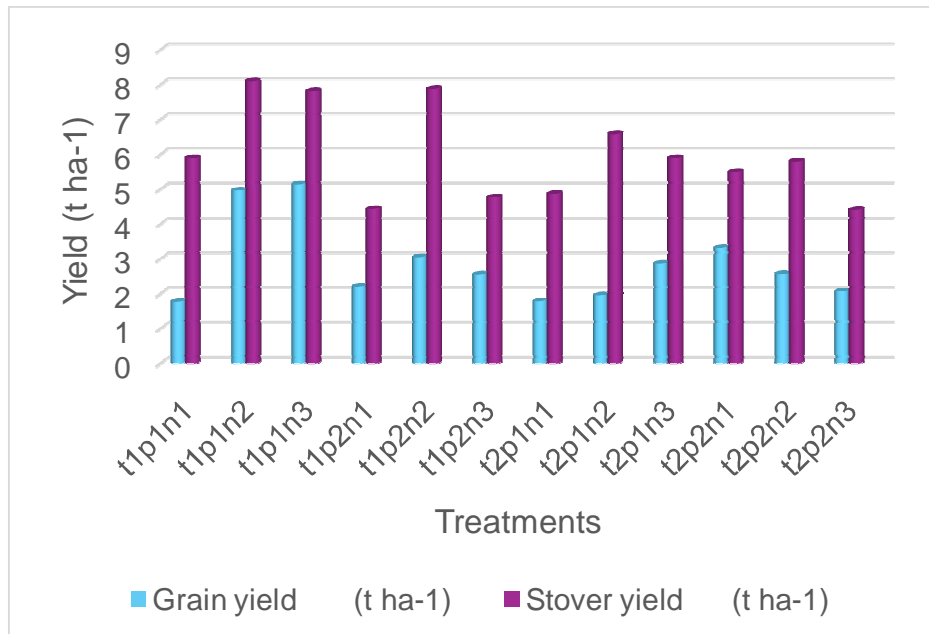


Fig 1. Interaction effects of tillage, spacing and nutrient management on grain yield and stover yield of sorghum ( $t ha^{-1}$ )

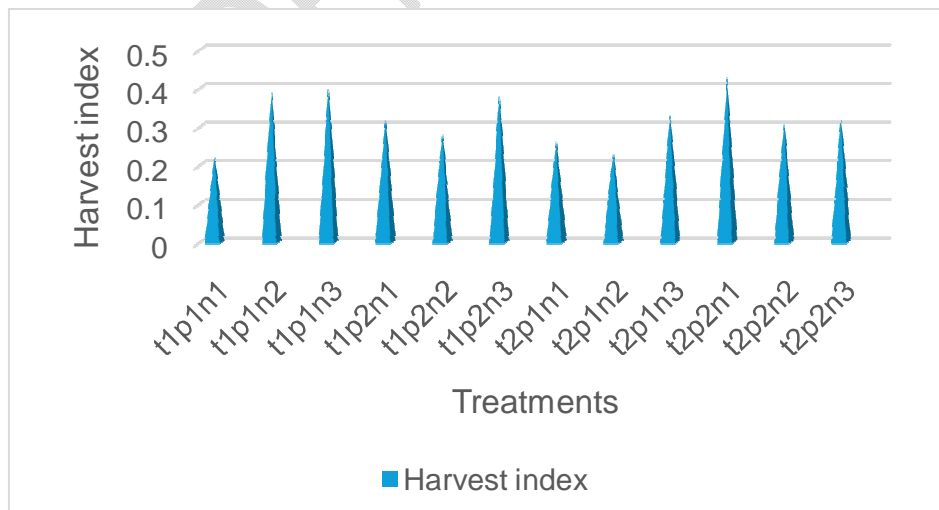


Fig 2. Interaction effects of tillage, spacing and nutrient management on harvest index of sorghum ( $t\ ha^{-1}$ )

#### 4. Conclusion

The results of the study indicated that yield attributes and yield were affected by tillage, spacing and nutrient management. Yield and yield attributes were significantly superior under zero tillage, at a closer spacing of 45 cm x 15 cm and nutrient dose of 50:25:50 kg NPK  $ha^{-1}$  and 50:25:75 kg NPK  $ha^{-1}$ . Considering yield sorghum may be recommended for cultivation in summer rice fallows with zero tillage, spacing of 45 cm x 15 cm and application of 50:25:50 kg NPK  $ha^{-1}$  along with 5  $t\ ha^{-1}$  of FYM.

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