



Effect of Mulching and Tillage Practices on Yield & Yield Attributes of Sorghum

**K. Arun Kumar ^a, Y. S. Satish Kumar ^{a*}, K. Prabhakar ^a,
M. Jayalakshmi ^a, K. Satish Babu ^a,
K. Mohan Vishnuvardhan ^a and ESV Narayana Rao ^b**

^a *Regional Agricultural Research Station, Nandyal, ANGRAU, India.*

^b *Agricultural College, Mahanandi, ANGRAU, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i113312

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/107399>

Original Research Article

Received: 10/08/2023

Accepted: 16/10/2023

Published: 26/10/2023

ABSTRACT

A field experiment was conducted to study the effect of mulching and tillage practices on yield & yield attributes of sorghum at Regional Agricultural Research Station, Andhra Pradesh during 2020-21 & 2021-22 *Kharif* seasons. Mulching, Tillage practices and their interaction showed no significant influence on growth parameters viz., plant height and dry matter production at harvest, days to 50 % population. Whereas, panicle weight, panicle length, grain yield, straw yield and harvest index were significantly higher with zero tillage and with residue mulch. The interaction between tillage and mulch practices was non significant. Maximum gross and net returns were observed with zero tillage with residue mulch practice in grain sorghum. The economic evaluation of mulching and tillage practices in sorghum crop revealed that maximum gross returns (Rs

*Corresponding author: E-mail: yekkaladevikumar@gmail.com;

1,18,659), net returns (Rs 78,579) and B:C ratio (2.96) were obtained with zero tillage practice with mulching practice. The study indicated that tillage and mulching had significant effect on soil fertility and grain yield of sorghum crop.

Keywords: Sorghum; tillage systems; mulching; soil fertility; economics.

1. INTRODUCTION

“World population is growing pressing demand for land, water, food and other resources. Arid and semi-arid regions, where sorghum production practiced, account for about half of the world’s total land area. Sorghum is fifth economically important cereal crop in world after wheat, rice, barley and maize. It is an important feed, food and forage crop. The crop is also used in raw material for the production of alcohol, biofuels, starch, fiber, dextrose syrup and many other products” [1]. “Sorghum is a staple food for millions of people in semiarid regions of the World and supports wheat, rice, maize and other grain crops for food it” [2]. Agricultural production in drylands is limited due to the scarcity of rainfall. Increasing the yield per unit of grain is an effective measure to ensure food security by optimizing agricultural field management practices [3,4].

“Agricultural practices such as mulching, tillage, and their combination are considered as most sustainable agricultural practices in arid and semi-arid regions in retaining soil water in the upper soil layers and reducing the need for irrigation. Compared with traditional soil tillage measures, the implementation of mulching and reduced tillage techniques can significantly reduce soil surface water evaporation, surface runoff, and soil erosion and increase soil water storage. To an extent, it increases crop yield and water use efficiency and guarantees the sustainable development of agriculture. Straw mulching has been widely used for the cultivation of maize (*Zea mays* L.), spring wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), potatoes (*Solanum tuberosum* L.), vegetables and fruit trees” [5].

“To attain this probability, soil erosion will have to be condensed. Mulches are loose coverings or sheet of organic material that is placed on the soil surface. It helps to preserve moisture, repression of weeds, improving soil consistency, insect pest assault and guard roots from severe temperature. Organic mulches improve soil, pleasant soil temperature, hinder weed growth, lessen soil moisture evaporation and improve the

visual qualities of landscapes. A good layer of mulch will help to preserve moisture and suppress weed germination. Mulch enhanced root and increased maize grain yield by increasing plant N-uptake efficiency, falling N discharge losses and improving nutrient preservation over unmulched plots” [6]. Straw mulch is practiced successfully in many advanced countries like America and Australia where it improved many soil aspect as support soil moisture retention ability, prevent wind erosion, control of weeds, nutrient return and soil structure improvement.

2. MATERIALS AND METHODS

The experiment was conducted during the Rabi season of 2020-2021 and 2021-2022 at Regional Agricultural Research Station Nandyal. The center is located at 15.47° N latitude and 78.48° E longitude. The experiment was conducted in an area of 90 m² plot size with 45 cm × 15 cm spacing and fertilizer application of 80-60-40 NPK kg/ha. The total 24 treatments were plotted by using strip plot design consisted of three horizontal practices, T₁ or CT : Conventional tillage (primary, secondary and tertiary tillage as per existing farmers/ researchers practice and sowing by seed cum ferti-drill), T₂ or ZT : Zero tillage (Sowing by seed cum-ferti-drill / cultivator; glyphosate spray to kill existing vegetation after sowing), T₃ or MT : Minimum (Reduced) tillage (Basal fertilizer dose application followed by Disking and sowing by seed drill after running cultivator that incorporates basal fertilizers) and two vertical practices (residue mulch-M1 and without residue mulch-M2). All the six treatments were replicated by 4 times. Strip plot design was statistically analysed by using OPISTAT Software and NTJ 5 variety was selected for the experiment. The parameters like plant height, dry mass production, 100 seed weight, grain yield, straw yield & harvest index were recorded by using standard procedures. Initial soil samples were collected from each plot every year from 0 to 30 cm deep. The samples were subjected for analysis of available N, P, and K. For organic carbon analysis, samples were passed through a 0.2-mm sieve. The organic carbon was measured by wet oxidation [7]; available N by

alkaline– potassium permanganate (KMnO_4) (Subbaiah and Asija 1956); available P by 0.5 M sodium bicarbonate (NaHCO_3) [8]. and available K using neutral normal ammonium acetate method [9].

3. RESULTS AND DISCUSSION

3.1 Growth, Yield Attributes and Yields under Sorghum Crop

Data present in Table 1 shows that plant height, dry mass production and test weight not significantly affected due to highest plant height (317cm) was observed in CTM2 treatment. Lowest drymass production was observed in CTM2 treatment (8278 kg) may be due to lower nitrogen fertilization than recommended dose of fertilization. These results were in accordance with the findings of Prasada Rao et al. [10].

Mulching and Tillage practices and their interaction had significant influence on panicle weight, panicle length, grain yield, straw yield and harvest index. The interaction between tillage and mulch practices was non-significant. Yield attributes and yields of *rabi* sorghum as influenced by tillage and mulch as shown in Table 1. The highest pooled grain yield and straw yield was obtained at zero tillage and lowest pooled grain yield and straw yield at conventional tillage because of zero tillage was attributed to improvement in yield components namely, number of panicle weight and 1000 grain weight. In addition to mulching practices, the highest pooled grain yield and straw yield (3447 kg/ha) (8605 kg/ha) was obtained at zero tillage system compare to other tillage, because of mulching practices reduces the evaporation of water and increases the water holding capacity which results in higher yields. Although, harvest index was not affected by mulch rate, tillage system and their interaction [11] also obtained highest harvest index value on the zero-tillage system. "This was due to mechanical modifications of soil profiles in Conventional Tillage system which could alleviate high subsoil strength, facilitating deeper rooting and, thus, the plant-availability of subsoil resources" [12,13,14]. "Higher soil water availability in Conventional Tillage system compared to Reduced Tillage and No Tillage from sowing to harvest might be responsible for higher leaf area index, better crop growth, and dry matter accumulation and translocation to head at reproductive stage of crop growth producing higher sorghum grain yield" [15]. Deep

tillage has been reported to enhance earthworm activities and increase the abundance of plant growth-promoting rhizobacteria and mycorrhizae in the subsoil. Similar findings were reported by Patil [15], according to him "the grain yield of sorghum was lowest in first year of experiment where minimum tillage operation was carried out as against the conventional tillage". In contradictory to this Agbede and Ojeniyi [16] recorded "higher sorghum yields in zero tillage against the conventional tillage". Similarly, Sen et al. [17] also advocated "the yield advantage of zero tillage against the conventional tillage". On the other hand, results depicted that mulch had affected the grain yield significantly are in line with Agbede and Ojeniyi [16] and Shahid Mehmood et al., [1], that "sorghum grain yield was significantly higher in mulched sorghum than that in non mulched (control)".

Initial and final soil available nitrogen, phosphorous and potassium nutrients were estimated in *rabi* sorghum crop and presented in Table 2. There is no significant difference between any treatment for soil pH, E.C and available potassium. Soil available nitrogen content was significantly high (168 kg ha^{-1}) with Zero tillage with mulching treatment followed by Zero tillage without residue mulching treatment after two years of experimentation. However after two years of experimentation soil available nitrogen content was maintained without depletion. However soil available nitrogen content was significantly decreased due to application of 50% STCR fertilizer dose. Soil available phosphorous content values were significantly differing with mulching and tillage practices. Significantly highest available phosphorus recorded for zero tillage (43.6 kg ha^{-1}) and minimum tillage (40.8 kg ha^{-1}) was statistically similar. Mulching showed significant effect on the soil available phosphorus. Relatively, greater soil available phosphorus was recorded for zero tillage as compared to conventional tillage and minimum tillage. Similar trend was followed in soil available potassium content as in available phosphorous content. But significantly higher values of available potassium were recorded with minimum tillage treatment followed by zero tillage treatment. Relatively, greater soil available potassium was recorded for zero tillage (438 kg ha^{-1}) as compared to conventional tillage and minimum tillage. Maximum increase of as compared to among mulching practices was recorded for poultry manure in all tillage treatments. These results

Table 1. Yield & Yield attributing characters of Sorghum crop as influenced by tillage and mulch (Mean data of 4 replications)

	Plant Height (cm)	Dry Mass production (Kg)	Days to 50% population	Test weight (g)	Grain yield (Kg/ha)	Stover yield (Kg/ha)	Harvest Index
CTM ₁	310	8650	75.75	32.55	3171	8379	27.46
CTM ₂	317	8278	76.00	31.78	2838	8004	26.18
ZTM ₁	312	8835	74.75	35.63	3447	8605	28.61
ZTM ₂	311	8692	76.25	31.30	3267	8353	28.09
MTM ₁	303	8800	75.50	33.88	3365	8568	28.19
MTM ₂	306	8554	75.75	32.18	3205	8333	27.77
SEm±	28	223	7.3	3.04	201	257	
C.D (P=0.05)	NS	685	NS	NS	547	783	
C.V (%)	8.4	10.1	8.7	6.3	12.3	12.7	
Interaction (Mulch x Tillage)							
SEm±	23.67	210.50	7.25	3.12	204	236	
CD (P=0.05)	NS	NS	NS	NS	NS	NS	
Interaction (Tillage x Mulch)							
SEm±	31.44	215.60	8.32	4.32	191	257	
CD (P=0.05)	NS	NS	NS	NS	NS	NS	

Table 2. Influence of Tillage & mulching on soil properties of sorghum crop

Treatment name	pH	E.C (d Sm ⁻¹)	O.C (%)	Available N (Kg/ha)	Available P ₂ O ₅ (Kg/ha)	Available K ₂ O (Kg/ha)	Ca (C mol (p+) kg-1)	Mg (C mol (p+) kg-1)	Sulphur (ppm)
CTM ₁	8.31	0.10	0.30	146	41.2	398	9.0	3.2	13.1
CTM ₂	8.33	0.14	0.30	142	40.2	404	8.8	3.2	12.8
ZTM ₁	8.22	0.08	0.33	168	43.6	422	9.7	4.6	14.1
ZTM ₂	8.30	0.14	0.33	165	42.9	434	9.5	4.3	14.4
MTM ₁	8.28	0.12	0.30	154	39.3	438	9.2	4.5	15.2
MTM ₂	8.30	0.17	0.30	158	40.8	447	9.4	3.9	15.1
S. Em ±	0.45	0.01	0.02	9.04	2.80	24.47	0.51	0.26	0.81
C. D (P=0.05)	NS	NS	0.057	26.23	7.10	NS	NS	0.79	NS
C V (%)	6.8	4.5	8.87	9.32	7.88	12.1	9.82	8.4	7.4
Interaction (Mulch x Tillage)									
SEm±	0.42	0.01	0.01	7.88	2.04	23.61	0.34	0.17	0.74
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Tillage x Mulch)									
SEm±	0.38	0.01	8.32	8.04	2.01	22.83	8.57	0.16	0.71
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial	8.32	0.06	0.33	135	43.05	383	8.2	2.4	12.2

Table 3. Economics of sorghum crop as influenced by tillage and mulch practices

Treatment name	Grain yield (Kg/ha)	Stover yield (Kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit :cost ratio (B:C ratio)
CTM ₁	3171	8379	97411	37623	1.63
CTM ₂	2838	8004	104663	44875	1.75
ZTM ₁	3447	8605	118659	78579	2.96
ZTM ₂	3267	8353	107714	67634	2.69
MTM ₁	3365	8568	104071	62036	2.48
MTM ₂	3205	8333	113451	71416	2.70

are in agreement with Agbede and Ojeniyi [16], Shahid Mehmood et al. [1] and Patil et al. [15] who stated that in zero tillage and mulched plots, available potassium was higher compared to minimum and conventional tillage and unmulched plots. Similar results were noticed in secondary nutrients like calcium, magnesium and sulphur availability during two years of sorghum crop growth in soil.

3.2 Soil Available Nutrient Status

Initial and final soil available nitrogen, phosphorous and potassium nutrients were estimated in rabi sorghum crop and presented in Table 2. There is no significant difference between any treatment for soil pH, E.C and available potassium. Soil available nitrogen content was significantly high (168 kg ha^{-1}) with Zero tillage with mulching treatment followed by Zero tillage without residue mulching treatment after two years of experimentation. However after two years of experimentation soil available nitrogen content was maintained without depletion. However soil available nitrogen content was significantly decreased due to application of 50% STCR fertilizer dose. Soil available phosphorous content values were significantly differing with mulching and tillage practices. Significantly highest available phosphorus recorded for zero tillage (43.6 kg ha^{-1}) and minimum tillage (40.8 kg ha^{-1}) was statistically similar. Mulching showed significant effect on the soil available phosphorus. Relatively, greater soil available phosphorus was recorded for zero tillage as compared to conventional tillage and minimum tillage. Similar trend was followed in soil available potassium content as in available phosphorous content. But significantly higher values of available potassium were recorded with minimum tillage treatment followed by zero tillage treatment. Relatively, greater soil available potassium was recorded for zero tillage (438 kg ha^{-1}) as compared to conventional tillage and minimum tillage. Maximum increase of as compared to among mulching practices was recorded for poultry manure in all tillage treatments. These results are in agreement with Agbede and Ojeniyi (2009), Shahid Mehmood et al. (2014) and Patil et al. (2016) who stated that in zero tillage and mulched plots, available potassium was higher compared to minimum and conventional tillage and unmulched plots. Similar results were noticed in secondary nutrients like calcium, magnesium and sulphur availability during two years of sorghum crop growth in soil.

3.3 Economics

The economic evaluation of mulching and tillage practices in sorghum crop revealed that maximum gross returns (Rs 1,18,659), net returns (Rs 78,579) and B:C ratio (2.96) were obtained with zero tillage and mulching practices. The cost incurred on mulching application and conventional tillage practices reduced the net returns and B: C ratio (1.75) in CTM1 treatment But the treatment CTM2 recorded lowest B: C ratio (1.64). Suitable tillage practices reduces cost of cultivation; increases income, reduces hazardous effects and increases water use efficiency of sorghum that stabilizes and/or improves the food production in the region. Similar economic benefits were reported by Thavaprakash and Malligawad [18] in sunflower and Schlegel et al. [19] in sorghum crop.

4. CONCLUSION

The effect of mulching and tillage practices on sorghum crop was conducted at Regional Agricultural Research Station, Nandyal. It is observed that mulching and tillage practices showed significant effect on soil nutrient content and grain yield of sorghum. It is concluded that high grain and straw yield was obtained at zero tillage practice compare to conventional and minimum tillage practice. The highest harvest index and benefit cost ratio was observed in zero tillage system compared to other treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shahid Mehmood, Shahid Ibni Zamir, Tassadduq Rasool and Waseem Akbar. Effect of Tillage and Mulching on Soil Fertility and Grain Yield of Sorghum. *Scientia Agriculturae*. 2014;4(1):2014:31-36. DOI: 10.15192/PSCP.SA.2014.4.1.3136.
2. Shakoora A. Evaluation of exotic and local cultivars of sorghum for yield, maturity and non-senescence associated characters under rain-fed conditions. *Pakistan Journal of Biology Sciences*. 1999;13:167-174.
3. Gebreyesus Brhane Tesfahunegn. Effect of Tillage and Fertilizer Practices on

- Sorghum Production in Abergelle Area, Northern Ethiopia. 2012;4(2):52-69.
4. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soil. *Current Science*. 1956;25:259-260.14.
 5. Du C, Li L, Effah Z. Effects of straw mulching and reduced tillage on crop production and environment: A review. *Water*. 2022 Jan;14(16):2471.
 6. Aulakh SM, TS Khera, JW Doran, Singh K, Singh B. Yields and nitrogen dynamics in a rice-wheat system using green manure and inorganic fertilizer. *Soil Science Society of American Journal*. 2000;64:1867-1876.
 7. Walkley A, Black CA. Estimation of organic carbon by chromic acid titration method. *Soil Science*. 1934;37:29-38.
 8. Olsen SR, Cole CV, Watnabe FS, Dean LA. Estimation of available phosphorus in soil by extracting with sodium bicarbonate. USDA Circular No. 989, United state department of agriculture, Washington DC, 1954:15.
 9. Jackson ML. *Soil Chemical Analysis*. Prentice Hall of Inco. New York, USA. 498.
 10. Prasada Rao, Subbaiah VG, Chandra Sekhar K. Department of Agronomy, Agricultural College, Bapatla, Acharya N.G Ranga Agricultural University, International Journal of Applied Biology and Pharmaceutical Technology. 2013;4(4):18.
 11. Wang X, Wu H, Dai K. Tillage and crop residue effects on rainfed wheat and maize production in northern China. *Field Crops Research*. 2012;132:106–116.
 12. Patil SL, Mishra PK, Ramesha MN. Tillage and integrated nitrogen management: Does sustain sorghum productivity in Vertisols of Semi-Arid Tropics under varying rainfall situations? *Indian Journal of Soil Conservation*. 2016;44(2): 198–205.
 13. Schneider F, Don A, Hennings I, Schmittmann O and Seidel SJ. The effect of deep tillage on crop yield – What do we really know? *Soil & Tillage Research*. 2017;174:193–204.
 14. Mishra SS Rao, IK Das. Effect of tillage and nutrient management on sorghum (*Sorghum bicolor*) productivity in Alfisols of semi-arid tropical India. *Indian Journal of Agricultural Sciences*. 2019;89(7):1133–9
 15. Patil SL. Winter sorghum (*Sorghum bicolor*) productivity as influenced by tillage practices and nitrogen management in Vertisols of SAT, India. *Soil & Tillage Research*. 2013;126:183–92.
 16. Agbede Taiwo Michael, Ojeniyi SO. Tillage and poultry manure effects on soil fertility and sorghum yield in southwestern Nigeria. *Soil and Tillage Research*. 2009;104:74-81. DOI:10.1016/j.still.2008.12.014
 17. Sen A, Shama N, Singh RK, Pandey M. Effect of different tillage systems on the performance of wheat. Paper for international workshop on herbicide resistance management and zero tillage in rice- wheat cropping system. March 4-6, Department of Agronomy, CCS Haryana Agriculture University, Hisar- 2002;125:004, India.
 18. Thavaprakash N, Malligawad LH. Effect of nitrogen and phosphorus levels and ratios on yield and economics of sunflower. *Research on Crops*. 2002;3:40-43.
 19. Schlegel AJ, Assefa F, Haag LA, Thompson CR, Stone LR. Long-term tillage on yield and water use of grain sorghum and winter wheat. *Agronomy Journal* 2017;110:1–12.

© 2023 Kumar et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://www.sdiarticle5.com/review-history/107399>