Effect of conservation agriculture practices on growth attributes and yield of pigeonpea

ABSTRACT

A two-year field experiment was conducted at Main Agricultural Research Station, Raichur in 2021 and 2022 was laid out in a Split-Split design with four main, two sub and two sub-sub treatments with three replications to evaluate effect of conservation agricultural practices on growth and yield of pigeonpea. The treatments with flat bed, Compartment bund, Ridge and furrow & Broad bed and furrow were takes on main, treatments with mulching and without mulching an sub treatment and FYM and RDF & FYM an sub-sub treatment. Among them ridges and furrow (M_3) method along with mulching FYM and RDF was found to have positive influence of growth parameters *viz*., plant height, number of primary branches and total dry matter production at harvest stage. Adopting the ridge and furrow method can be an effective strategy for optimizing the grain yield (1555 kg ha^{-1} and 1599 kg ha^{-1}) in 2021 and 2022 in pigeonpea crop respectively.

Keywords: Pegionpea, growth and yield attributes, grain yield,

Introduction

Pulses play a vital role in the national economy of India and contribute 27 and 30 per cent of global production and consumption respectively. India is producing 27.3 million metric tonnes of pulses from 31.02 million hectare (Anon., 2022). Considered as smart foods, besides providing green pods as vegetable, dhal and nutritious fodder they offer good scope for crop diversification and intensification. These are endowed with the unique characteristics *viz.,* deep rooting, biological N fixation, huge leaf fall, carbon sequestration, soil amelioration, low water requirement and capacity to withstand harsh climate.

In general, Conservation agriculture means a set of soil management practices that minimize the soil disruption of the soil structure, compaction and natural biodiversity. These practices found to improve the fertility status, variation in total nitrogen content, different fraction of labile carbon pools along with different physical and biological activities of soil which generally contributes the overall quality of the soil. The advantage of CA in terms of better soil quality considers through lower bulk density (BD), increased water holding capacity, higher aggregate stability and better soil structure. On the other hand, CA practices influences soil biological parameters which affect the overall soil quality as it improves the quality, quantity and distribution of organic matter in soil which is a vital factor that largely affect biomass, diversity and activity of soil microorganism as it is the main source of food for soil biota (Reicosky and Saxton, 2007).

Conservation agriculture has proven potential to improving the long-term environmental and financial sustainability of farming. The technology of conservation agriculture provides opportunities to reduce the cost of production save water and nutrients, increase yield. It maintains a soil cover through surface retention of crop residue with no tillage or zero tillage and reduced tillage. Potential benefits of CA include reduction in cost of production, reduced incidence of weeds, saving water and nutrients, increased yields, resource improvement and environmental benefits. Further, it improves physical, chemical and biological qualities of the soil. In pigeonpea, studies on evaluating effect of soil conservation practices are limited and scanty. Hence, assessing effect of soil conservation measures on soil physical, chemical and biological properties, nutrient content and its uptake and yield in sole crop stand of pigeonpea on which present study is aimed occupies its importance.

Considering these above views, the present investigation with the title “Effect of moisture conservation practices on soil properties, growth and yield of pigeonpea (*Cajanus cajan* L.) in black soil” was undertaken with the following objective to study the effect of conservation agriculture practices on growth attributes and yield of pigeonpea.

Material and methods

The field experiment was conducted at Main Agricultural Research Station, Raichur, The experiment was laid out in a Split-Split design with four main, two sub and two sub-sub treatments with three replications. for study *viz.*,

Chart 1. Treatment details.

Treatment Details	Black soil
Main plot: Moisture conservation practices (Interbund management)	
M_1 - Flat bed	-
M_2 - Compartment bund	5.4 m × 7.5 m
M_3 - Ridges and furrow	60 cm furrow
M_4 - Broad bed and furrow	120 cm bed
Subplot:	
S_1 - Crop residue mulching	18-20 t ha^{-1}
S_2 - Without mulching	-
Sub- sub-plot:	
N_1 - RDF N: P_2O_5:K_2O	25:50:0 kg ha^{-1}
N_2 - RDF with FYM	RDF + FYM 6.0 t ha^{-1}

The soils of the experimental site belong to medium deep black soil and clay texture, neutral in soil reaction (7.6) and low in electrical conductivity (0.22 dSm^{-1}). The soil organic carbon content was 4.6 g kg^{-1} and available N (263.42 kg ha^{-1}), available phosphorus (28.68 kg P_2O_5 ha^{-1}) and available potassium (451 kg K_2O ha^{-1}), exchangeable calcium and magnesium (24.82 and 7.86 C mol (p^+) kg), available sulphur (13.30 mg kg^{-1}). The monthly meteorological data for the period of experimentation 2021-2022and 2022-2023were collected at Meteorological Observatory, Main Agricultural Research Station, Raichur**.** Annual mean rainfall received was613 mm and 474 mm during 2021-22 and 2022-23 respectively. However, the distribution of rainfall was erratic (Table 1).

Results and discussion

Plant Height (cm)

At Harvest (cm)

In the years 2021 and 2022, the analysis of plant height at harvest showed that the ridges and furrow (M_3) method consistently had significantly higher values compared to the broad bed and furrow (M_4) and flat-bed (M_1) methods. The values in 2021 were 179.28 cm, 175.05 cm and 168.55 cm for ridges and furrow (M_3), broad bed and furrow (M_4), and flat-bed (M_1) methods, respectively, while in 2022, the values were 183.8 cm, 179.17 cm and 173.02 cm, respectively in descending order. When considering the pooled data from both years, the ridges and furrow (M_3) method consistently recorded significantly higher plant height values of 181.54 cm, 177.11 cm and 170.78 cm for ridges and furrow (M_3), broad bed and furrow (M_4) and flat-bed (M_1) methods, respectively (Table 2). The utilization of the ridge and furrow method in pigeonpea cultivation significantly influenced the plant height at harvest. The raised ridges and sunken furrows created by this method improve soil drainage, aeration and water management, contributing to deeper root development and enhanced plant growth, resulting in taller plants at the time of harvest. Farmers and agricultural practitioners can consider implementing the ridge and furrow method as a cultivation technique to promote taller plants and potentially increase crop productivity in pigeonpea cultivation (Palaniappan *et al.,* 2009).

During the years 2021 and 2022, the analysis of plant height at harvest revealed that the crop residue mulching (S_1) method consistently showed significantly higher values compared to the without mulching (S_2) method. In 2021, the values were 177.89 cm and 171.85 cm for the crop residue mulching (S_1) and without mulching (S_2) methods, respectively, while in 2022, the values were 182.28 cm and 176.26 cm, respectively (Table 2). When considering the pooled data from both years, the crop residue mulching (S_1) method consistently exhibited significantly higher plant height values of 180.09 cm and 174.05 cm for the crop residue mulching (S_1) and without mulching (S_2) methods, respectively (Table 2). The utilization of crop residue mulching method in pigeonpea cultivation significantly influenced the plant height at harvest. The application of crop residues as mulch provides favourable conditions for plant growth, including improved soil moisture conservation, weed control and nutrient availability resulting in taller plants at the time of harvest. Therefore, based on these findings, the crop residue mulching (S_1) method is recommended for achieving better plant height at harvest.

The analysis conducted in 2021 and 2022 on plant height at harvest indicated that there was no significant difference between the fertilizers FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) (Table 2). However, consistently the FYM with RDF (N_2) fertilizer demonstrated higher values compared to the RDF $N:P_2O_5:K_2O$ (N_1) fertilizer. In 2021, the values were 175.67 cm and 174.07 cm for FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) respectively, while in 2022, the values were 180.08 cm and 178.46 cm respectively . When the data from both years was combined, the FYM with RDF (N_2) fertilizer continued to exhibit higher values, with a mean of 177.87 cm compared to 176.27 cm for the RDF $N:P_2O_5:K_2O$ (N_1) fertilizer. The application of FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) did not result in significant differences in plant height at harvest in pigeonpea compared to each other or the control group according to Kumawat *et al*., 2015.

In the pooled data from 2021 and 2022, the analysis of different three-way combinations for plant height at harvest indicated no significant difference among the combinations. However, the combination of ridges and furrow (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) exhibited the highest plant height at harvest, with a value of 186.8. cm This was followed by the combinations of ridges and furrow (M_3), crop residue mulching (S_1) and RDF $N:P_2O_5:K_2O$ (N_1), as well as compartment bund (M_2), crop residue mulching (S_1) and FYM with RDF (N_2) with values of 183.55 cm and 183.05 cm, respectively (Table 2). This trend of higher plant height was consistently observed in both individual years as well. In conclusion, the different three-way combinations evaluated in this study did not show significant differences in plant height at harvest in pigeonpea. However, the combination of ridges and furrow (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) demonstrated the highest plant height, albeit without statistical significance.

Number of Primary Branches

At Harvest

During the years 2021 and 2022, the analysis of the number of primary branches at harvest indicated that the ridges and furrow (M_3) method consistently had significantly higher values compared to the broad bed and furrow (M_4) and flat-bed (M_1) methods (Table 3). In 2021, the values were 20.94, 20.34 and 18.45 for the ridges and furrow (M_3), broad bed and furrow (M_4) and flat-bed (M_1) methods, respectively. Similarly, in 2022, the values were 21.46, 20.9 and 18.87 for the respective methods (Table 3). When the data from both years was pooled, the ridges and furrow (M_3) method consistently recorded significantly higher values of number of primary branches at harvest, with a value of 21.2. This was followed by the broad bed and furrow (M_4) method with a value of 20.62 and the flat-bed (M_1) method with a value of 18.66. The use of the ridge and furrow method significantly influenced the number of primary branches at harvest in pigeonpea. The raised beds and furrows created by this cultivation method create favourable growing conditions that promote root development, water distribution and nutrient availability (Ray *et al*., 2023).

Additionally, the analysis conducted on the number of primary branches at harvest in 2021 and 2022 showed that the crop residue mulching (S_1) method had significantly higher values compared to the without mulching (S_2) method. In 2021, the values were 20.54 and 19.62 for the crop residue mulching (S_1) and without mulching (S_2) methods, respectively (Table 3). Similarly, in 2022, the values were 21.05 and 20.13 for the respective methods. When considering the pooled data from both years, the crop residue mulching (S_1) method consistently exhibited significantly higher values of number of primary branches at harvest, with a value of 20.8 (Table 3). On the other hand, the without mulching (S_2) method had a value of 19.87. Therefore, the crop residue mulching (S_1) method is recommended for achieving a better number of primary branches at harvest. The use of the crop residue mulching method significantly influenced the number of primary branches at harvest in pigeonpea. The presence of crop residues on the soil surface created a favourable environment for root development, improved nutrient availability and aided in weed suppression, all of which contributed to a higher number of primary branches. Employing the crop residue mulching method in pigeonpea cultivation practices can be advantageous in enhancing branching and potentially increasing overall crop productivity which is in accordance with Somasundaram *et al.,* 2018.

Furthermore, the analysis revealed no significant difference between the FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) fertilizers in terms of the number of primary branches at harvest in 2021 and 2022 (Table 3). However, consistently higher values were observed for the FYM with RDF (N_2) fertilizer compared to the RDF N:P_2O_5:K_2O (N_1) fertilizer. In 2021, the values were 20.21 and 19.95 for the FYM with RDF (N_2) and RDF N:P_2O_5:K_2O (N_1) fertilizers, respectively. Similarly, in 2022, the values were 20.73 and 20.46 for the respective fertilizers (Table 3). When the data from both years was combined, the FYM with RDF (N_2) fertilizer still exhibited higher values of 20.47 compared to 20.2 for the RDF N:P_2O_5:K_2O (N_1) fertilizer. It is important to note that the lack of significance does not necessarily mean that fertilizers have no effect on branching.

Regarding the analysis of different three-way combinations for the number of primary branches at harvest in the pooled data of 2021 and 2022, no significant differences were observed. The combination of ridges and furrow (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) had the highest value of number of primary branches at harvest, with a value of 21.86. This was followed by the combination of ridges and furrow (M_3), crop residue mulching (S_1) and RDF N:P_2O_5:K_2O (N_1) with a value of 21.45 and the combination of compartment bund (M_2), crop residue mulching (S_1) and FYM with RDF (N_2) with a value of 21.39 (Table 3). Similar trends were observed when analyzing the individual years. Although no significance was observed with only the factor of concussion and source, it is important to note that these factors could have other benefits, such as improving soil structure and nutrient availability, which may have indirectly influenced the number of primary branches.

Total Dry Matter Production (g plant^{-1})

At Harvest

During the years 2021 and 2022, the analysis of total dry matter production at harvest revealed that the ridges and furrow (M_3) method consistently had significantly higher values compared to the broad bed and furrow (M_4) and flat-bed (M_1) methods (Table 4). In 2021, the values were 256.05 g, 242.87 g and 221.53 g for the ridges and furrow (M_3), broad bed and furrow (M_4) and flat-bed (M_1) methods, respectively. Similarly, in 2022, the values were 262.86 g, 249.03 g and 227.11 g for the respective methods. When the data from both years was pooled, the ridges and furrow (M_3) method consistently recorded significantly higher values of total dry matter production at harvest, with a value of 259.45 g. This was followed by the broad bed and furrow (M_4) method with a value of 245.95 g and the flat-bed (M_1) method with a value of 224.32 g. The use of the ridge and furrow method significantly influenced the total dry matter production at harvest in pigeonpea. The improved water and nutrient management, enhanced root development and reduced weed competition associated with this method contributed to higher biomass accumulation. Employing the ridge and furrow method in pigeonpea cultivation practices can be beneficial in maximizing total dry matter production and potential yield (Pandey *et al.*,2014).

Additionally, the analysis conducted on the total dry matter production at harvest in 2021 and 2022 showed that the crop residue mulching (S_1) method had significantly higher values compared to the without mulching (S_2) method. In 2021, the values were 251.24 g and 232.41 g for the crop residue mulching (S_1) and without mulching (S_2) methods, respectively. Similarly, in 2022, the values were 257.93 g and 238.58 g for the respective methods. When considering the pooled data from both years, the crop residue mulching (S_1) method consistently exhibited significantly higher values of total dry matter production at harvest, with a value of 254.58 g. On the other hand, the without mulching (S_2) method had a value of 235.5 g. Therefore, the crop residue mulching (S_1) method is recommended for achieving better total dry matter production at harvest. The application of crop residue mulching significantly influenced total dry matter production at harvest in pigeonpea. The mulching practice improved soil moisture retention, nutrient availability and weed management, all of which contributed to increased biomass accumulation. Incorporating crop residue mulching into pigeonpea cultivation practices can be a valuable strategy for enhancing total dry matter production and potential yield (Hapemo Ngullie *et al.,* 2022).

The analysis revealed no significant difference between the FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) fertilizers in terms of the total dry matter production at harvest in 2021 and 2022 . However, consistently higher values were observed for the FYM with RDF (N_2) fertilizer compared to the RDF $N:P_2O_5:K_2O$ (N_1) fertilizer. In 2021, the values were 244.35 g and 239.3 g for the FYM with RDF (N_2) and RDF $N:P_2O_5:K_2O$ (N_1) fertilizers, respectively. Similarly, in 2022, the values were 250.66 g and 245.85 g for the respective fertilizers. When the data from both years was combined, the FYM with RDF (N_2) fertilizer still exhibited higher values of 247.51 g compared to 242.57 g for the RDF $N:P_2O_5:K_2O$ (N_1) fertilizer (Table 4). In the context of this study, the lack of significant differences in total dry matter production among the fertilizer treatments suggests that other factors such as soil fertility, environmental conditions and crop management practices may have had a greater influence on biomass accumulation (Verma *et al.,* 2018).

Regarding the analysis of different three-way combinations for the total dry matter production at harvest in the pooled data of 2021 and 2022, no significant differences were observed (Table 4). The combination of ridges and furrow (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) had the highest value of total dry matter production at harvest, with a value of 273.76 g. This was followed by the combination of ridges and furrow (M_3), crop residue mulching (S_1) and RDF $N:P_2O_5:K_2O$ (N_1) with a value of 266.32 g and the combination of compartment bund (M_2), crop residue mulching (S_1) and FYM with RDF (N_2) with a value of 263.42 g . Similar trends were observed when analyzing the individual years while the statistical analysis did not reveal significant differences among the three-way combinations, the combination of ridges and furrow method (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) showed the highest total dry matter production at harvest. This combination holds promise for enhancing the productivity of pigeonpea (Kumawat *et al.,* 2015).

Seed yield (kg ha^{-1})

During the years 2021 and 2022, the analysis of seed yield (kg ha^{-1}) revealed that the ridges and furrow (M_3) method consistently had significantly higher values compared to the broad bed and furrow (M_4) and flat-bed (M_1) methods (Table 5) (Figure 1). The seed yield values were 1555 kg ha^{-1}, 1424 kg ha^{-1}and 1212 kg ha^{-1} for the ridges and furrow (M_3) method in 2021, and 1599 kg ha^{-1}, 1460 kg ha^{-1} and 1238 kg ha^{-1} in 2022, respectively. When considering the pooled data from both years, the ridges and furrow (M_3) method consistently recorded higher seed yield values of 1577 kg ha^{-1}, 1442 kg ha^{-1} and 1225 kg ha^{-1}compared to the broad bed and furrow (M_4) and flat-bed (M_1) methods, respectively. Based on these findings, the ridges and furrow (M_3) method is recommended for achieving better seed yield (kg ha^{-1}). The findings suggest that the ridge and furrow method can be a valuable technique for improving the seed yield of pigeonpea. By creating raised ridges and sunken furrows, the method optimizes water distribution and reduces waterlogging, leading to improved plant growth and higher seed yield.

Similarly, in the years 2021 and 2022, the analysis showed that the crop residue mulching (S_1) method had significantly higher seed yield values compared to the without mulching (S_2) method (Table 5). The seed yield values were 1509 kg ha^{-1}and 1321 kg ha^{-1} in 2021, and 1548 kg ha^{-1} and 1353 kg ha^{-1} in 2022 for the crop residue mulching (S_1) and without mulching (S_2) methods, respectively. The pooled data from both years also consistently showed higher seed yield values of 1528 kg ha^{-1} for the crop residue mulching (S_1) method compared to 1337 kg ha^{-1} for the without mulching (S_2) method (Table 5) (Figure 1). Therefore, the crop residue mulching (S_1) method is recommended for achieving better seed yield (kg ha^{-1}). This demonstrated that the crop residue mulching method positively impacted the seed yield of pigeonpea. Incorporating crop residues as mulch in pigeonpea cultivation can be a sustainable and effective approach to enhance seed yield.

The analysis of seed yield (kg/ha) in 2021 and 2022 did not show any significant difference between the FYM with RDF (N_2) and RDF N: P_2O_5:K_2O (N_1) fertilizers (Table 5) (Figure 1). However, the FYM with RDF (N_2) consistently had higher seed yield values compared to the RDF N:P_2O_5:K_2O (N_1) fertilizer. In 2021, the values were 1440 kg ha^{-1} for FYM with RDF (N_2) and 1391 kg ha^{-1} for RDF N:P_2O_5:K_2O (N_1), while in 2022, the values were 1475 kg ha^{-1} and 1425 kg ha^{-1} , respectively (Table 5). When the data from both years was pooled, the FYM with RDF (N_2) still exhibited higher values of 1457 kg ha^{-1} compared to 1408 kg ha^{-1} for the RDF N:P_2O_5:K_2O (N_1) fertilizer (Table 5) (Figure 1). The non-significant results might indicate that the particular combination of FYM with RDF (N_2) and RDF N:P_2O_5:K_2O (N_1) did not result in noticeable differences in seed yield compared to the control or other treatments.

In the pooled data for 2021 and 2022, the different three-way combinations for seed yield (kg ha^{-1}) did not show any significant difference (Table 5) (Figure 1). The combination of ridges and furrow (M_3), crop residue mulching (S_1) and FYM with RDF (N_2) had the highest seed yield value of 1721 kg ha^{-1}, followed by ridges and furrow (M_3), crop residue mulching (S_1) and RDF N:P_2O_5:K_2O (N_1) with a value of 1646 kg ha^{-1} and compartment bund (M_2), crop residue mulching (S_1) and FYM with RDF (N_2) with a value of 1617 kg ha^{-1} (Table 5) (Figure 1). Similar trends were observed for individual years. It is important to note that the lack of significance does not necessarily imply that these combinations are ineffective or unimportant. Other factors such as environmental conditions, genetic variability and management practices may also contribute to seed yield variation.

Conclusion: The combination of the ridges and furrow method, crop residue mulching and the application of FYM with RDF emerged as the most effective approach, consistently demonstrating superior performance across multiple parameters. By implementing these recommended practices, farmers and agricultural practitioners can optimize pigeonpea crop productivity, improve soil health and ultimately achieve better results.

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Table 1. Initial soil physical and chemical properties of the experimental site

Particulars	Value
I. Physical properties	
Soil texture (Particle size distribution (%))	
Sand (%)	23.75
Silt (%)	22.35
Clay (%)	52.98
Textural class	Clay
Bulk density (Mg m^{-3})	1.35
Particle density (Mg m^{-3})	2.65
Porosity (%)	49.05
Maximum water holding capacity (MWHC) (%)	68.4
Field capacity (%)	45.72
Permanent wilting point	20.4
II. Chemical properties	
Soil pH (1:2.5)	7.72
Electrical conductivity (1:2.5) dSm^{-1}	0.25
Soil Organic Carbon (g kg^{-1})	4.60
Cation Exchange Capacity (Cmol (p^{+}) kg^{-1})	39.24
Exchangeable Sodium Percentage (%)	6.11
Base Saturation (%)	90.69
Available nutrients (kg ha^{-1})	
Nitrogen (N)	263.42
Phosphorus (P_2O_5)	28.68
Potassium (K_2O)	451.00
Sulphur (S)	13.30
Exchangeable calcium (Cmol (p^{+}) kg^{-1})	24.82
Exchangeable magnesium (Cmol (p^{+}) kg^{-1})	7.86
DTPA extractable micronutrients (mg kg^{-1})	
Iron	2.27
Zinc	0.57
Manganese	7.27
Copper	1.58

Table 2. Effect of different soil moisture conservation practices on plant height at harvest

Plant Height (cm)										
M × S × N		2021			2022			Pooled		
		S_1	S_2	Mean (M×N)	S_1	S_2	Mean (M×N)	S_1	S_2	Mean (M×N)
M_1	N_1	169.63	166.61	**168.12**	173.69	170.99	**172.34**	171.66	168.80	**170.23**
	N_2	169.93	168.03	**168.98**	174.57	172.81	**173.69**	172.25	170.42	**171.34**
M_2	N_1	179.61	171.79	**175.70**	183.47	177.25	**180.36**	181.54	174.52	**178.03**
	N_2	180.65	174.37	**177.51**	185.45	178.19	**181.82**	183.05	176.28	**179.67**
M_3	N_1	180.79	175.61	**178.20**	186.31	179.49	**182.90**	183.55	177.55	**180.55**
	N_2	184.90	175.81	**180.36**	188.70	180.69	**184.70**	186.80	178.25	**182.53**
M_4	N_1	177.36	171.12	**174.24**	181.74	174.78	**178.26**	179.55	172.95	**176.25**
	N_2	180.28	171.42	**175.85**	184.30	175.88	**180.09**	182.29	173.65	**177.97**
Mean S		**177.89**	**171.85**		**182.28**	**176.26**		**180.09**	**174.05**	
		M × S		**Mean M**	**M × S**		**Mean M**	**M × S**		**Mean M**
M	M_1	169.78	167.32	**168.55**	174.13	171.90	**173.02**	171.96	169.61	**170.78**
	M_2	180.13	173.08	**176.61**	184.46	177.72	**181.09**	182.30	175.40	**178.85**
	M_3	182.84	175.71	**179.28**	187.51	180.09	**183.80**	185.18	177.90	**181.54**
	M_4	178.82	171.27	**175.05**	183.02	175.33	**179.17**	180.92	173.30	**177.11**
		N × S		**Mean N**	**N × S**		**Mean N**	**N × S**		**Mean N**
N	N_1	176.85	171.29	**174.07**	181.30	175.62	**178.46**	179.08	173.46	**176.27**
	N_2	178.94	172.40	**175.67**	183.26	176.90	**180.08**	181.10	174.65	**177.87**
SOV		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**	
M		1.05	3.63		1.13	3.90		0.83	2.87	
S		1.51	4.92		1.02	3.32		0.80	2.62	
N		1.21	NS		1.42	NS		1.21	NS	
M×S		3.02	NS		2.04	NS		1.61	NS	
M×N		2.42	NS		2.84	NS		2.41	NS	
S×N		1.71	NS		2.01	NS		1.71	NS	
M×S×N		3.43	NS		4.02	NS		3.42	NS	

Table 3. Effect of different soil moisture conservation practices on number of primary branches at harvest

Number of Primary Branches (Harvest)										
M × S × N		**2021**			**2022**			**Pooled**		
		S_1	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**
M_1	**N_1**	18.70	17.85	**18.27**	19.18	18.23	**18.71**	18.94	18.04	**18.49**
	N_2	19.07	18.16	**18.62**	19.53	18.54	**19.03**	19.30	18.35	**18.83**
M_2	**N_1**	20.89	20.10	**20.50**	21.51	20.54	**21.03**	21.20	20.32	**20.76**
	N_2	21.16	20.23	**20.69**	21.62	20.86	**21.24**	21.39	20.54	**20.97**
M_3	**N_1**	21.20	20.41	**20.81**	21.70	21.00	**21.35**	21.45	20.70	**21.08**
	N_2	21.63	20.51	**21.07**	22.09	21.07	**21.58**	21.86	20.79	**21.33**
M_4	**N_1**	20.68	19.77	**20.23**	21.23	20.27	**20.75**	20.95	20.02	**20.49**
	N_2	21.02	19.90	**20.46**	21.57	20.53	**21.05**	21.30	20.22	**20.76**
Mean S		**20.54**	**19.62**		**21.05**	**20.13**		**20.80**	**19.87**	
M × S				**Mean M**	**M × S**		**Mean M**	**M × S**		**Mean M**
M	**M_1**	18.89	18.01	**18.45**	19.35	18.38	**18.87**	19.12	18.20	**18.66**
	M_2	21.03	20.16	**20.59**	21.57	20.70	**21.13**	21.30	20.43	**20.86**
	M_3	21.41	20.46	**20.94**	21.90	21.03	**21.46**	21.66	20.75	**21.20**
	M_4	20.85	19.84	**20.34**	21.40	20.40	**20.90**	21.12	20.12	**20.62**
N × S				**Mean N**	**N × S**		**Mean N**	**N × S**		**Mean N**
N	**N_1**	20.37	19.53	**19.95**	20.91	20.01	**20.46**	20.64	19.77	**20.20**
	N_2	20.72	19.70	**20.21**	21.20	20.25	**20.73**	20.96	19.97	**20.47**
SOV		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**	
M		0.16	0.55		0.15	0.52		0.11	0.39	
S		0.14	0.46		0.12	0.39		0.08	0.26	
N		0.12	NS		0.14	NS		0.10	NS	
M×S		0.28	NS		0.24	NS		0.16	NS	
M×N		0.23	NS		0.29	NS		0.20	NS	
S×N		0.16	NS		0.20	NS		0.14	NS	
M×S×N		0.33	NS		0.40	NS		0.28	NS	

Table 4. Effect of different soil moisture conservation practices on total dry matter production (g plant^{-1}) at harvest

Total Dry Matter Production (Harvest)										
M × S × N		**2021**			**2022**			**Pooled**		
		S_1	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**
M_1	**N_1**	224.84	210.03	**217.43**	230.73	216.02	**223.37**	227.78	213.02	**220.40**
	N_2	227.33	223.92	**225.62**	232.60	229.10	**230.85**	229.96	226.51	**228.24**
M_2	**N_1**	256.29	235.12	**245.70**	263.41	242.10	**252.76**	259.85	238.61	**249.23**
	N_2	259.28	236.74	**248.01**	267.55	243.03	**255.29**	263.42	239.88	**251.65**
M_3	**N_1**	262.82	244.91	**253.87**	269.82	251.43	**260.63**	266.32	248.17	**257.25**
	N_2	270.50	245.98	**258.24**	277.03	253.15	**265.09**	273.76	249.56	**261.66**
M_4	**N_1**	251.38	229.03	**240.21**	258.16	235.13	**246.65**	254.77	232.08	**243.43**
	N_2	257.51	233.57	**245.54**	264.13	238.69	**251.41**	260.82	236.13	**248.47**
Mean S		**251.24**	**232.41**		**257.93**	**238.58**		**254.58**	**235.50**	
M × S				**Mean M**	**M × S**		**Mean M**	**M × S**		**Mean M**
M	**M_1**	226.08	216.98	**221.53**	231.66	222.56	**227.11**	228.87	219.77	**224.32**
	M_2	257.78	235.93	**246.86**	265.48	242.56	**254.02**	261.63	239.25	**250.44**
	M_3	266.66	245.44	**256.05**	273.43	252.29	**262.86**	270.04	248.87	**259.45**
	M_4	254.44	231.30	**242.87**	261.14	236.91	**249.03**	257.79	234.10	**245.95**
N × S				**Mean N**	**N × S**		**Mean N**	**N × S**		**Mean N**
N	**N_1**	248.83	229.77	**239.30**	255.53	236.17	**245.85**	252.18	232.97	**242.57**
	N_2	253.65	235.05	**244.35**	260.33	240.99	**250.66**	256.99	238.02	**247.51**
SOV		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**	
M		3.56	12.33		3.58	12.40		2.84	9.84	
S		2.05	6.69		2.80	9.12		1.21	3.93	
N		2.49	NS		3.00	NS		2.04	NS	
M×S		4.10	NS		5.60	NS		2.41	NS	
M×N		4.98	NS		6.00	NS		4.09	NS	
S×N		3.52	NS		4.24	NS		2.89	NS	
M×S×N		7.05	NS		8.48	NS		5.78	NS	

Table 5. Effect of different soil moisture conservation practices on seed yield per hectare

Seed Yield (kg/ha)										
M × S × N		**2021**			**2022**			**Pooled**		
		S_1	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**	**S_1**	**S_2**	**Mean (M×N)**
M_1	**N_1**	1247.35	1100.75	**1174.05**	1273.33	1124.10	**1198.71**	1260.34	1112.43	**1186.38**
	N_2	1269.05	1234.22	**1251.63**	1295.28	1261.00	**1278.14**	1282.16	1247.61	**1264.89**
M_2	**N_1**	1563.22	1353.15	**1458.19**	1600.04	1384.55	**1492.30**	1581.63	1368.85	**1475.24**
	N_2	1595.23	1367.34	**1481.29**	1639.56	1395.83	**1517.69**	1617.40	1381.58	**1499.49**
M_3	**N_1**	1625.65	1444.98	**1535.32**	1667.34	1484.29	**1575.82**	1646.50	1464.63	**1555.57**
	N_2	1694.70	1458.45	**1576.58**	1747.42	1498.70	**1623.06**	1721.06	1478.58	**1599.82**
M_4	**N_1**	1508.42	1285.96	**1397.19**	1553.00	1320.80	**1436.90**	1530.71	1303.38	**1417.05**
	N_2	1571.54	1330.19	**1450.87**	1611.12	1357.81	**1484.46**	1591.33	1344.00	**1467.66**
Mean S		**1509.39**	**1321.88**		**1548.39**	**1353.38**		**1528.89**	**1337.63**	
M × S				**Mean M**	**M × S**		**Mean M**	**M × S**		**Mean M**
M	**M_1**	1258.20	1167.49	**1212.84**	1284.31	1192.55	**1238.43**	1271.25	1180.02	**1225.64**
	M_2	1579.23	1360.24	**1469.74**	1619.80	1390.19	**1505.00**	1599.52	1375.22	**1487.37**
	M_3	1660.17	1451.71	**1555.94**	1707.38	1491.49	**1599.44**	1683.78	1471.60	**1577.69**
	M_4	1539.98	1308.08	**1424.03**	1582.06	1339.30	**1460.68**	1561.02	1323.69	**1442.36**
N × S				**Mean N**	**N × S**		**Mean N**	**N × S**		**Mean N**
N	**N_1**	1486.16	1296.21	**1391.19**	1523.43	1328.43	**1425.93**	1504.79	1312.32	**1408.56**
	N_2	1532.63	1347.55	**1440.09**	1573.35	1378.33	**1475.84**	1552.99	1362.94	**1457.97**
SOV		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**		**S.Em ±**	**CD at 5 %**	
M		36.53	126.42		34.28	118.63		27.29	94.44	
S		23.25	75.81		12.63	41.20		12.50	40.78	
N		24.10	NS		22.78	NS		16.88	NS	
M×S		46.49	NS		25.26	NS		25.01	NS	
M×N		48.20	NS		45.55	NS		33.75	NS	
S×N		34.08	NS		32.21	NS		23.87	NS	
M×S×N		68.17	NS		64.42	NS		47.73	NS	

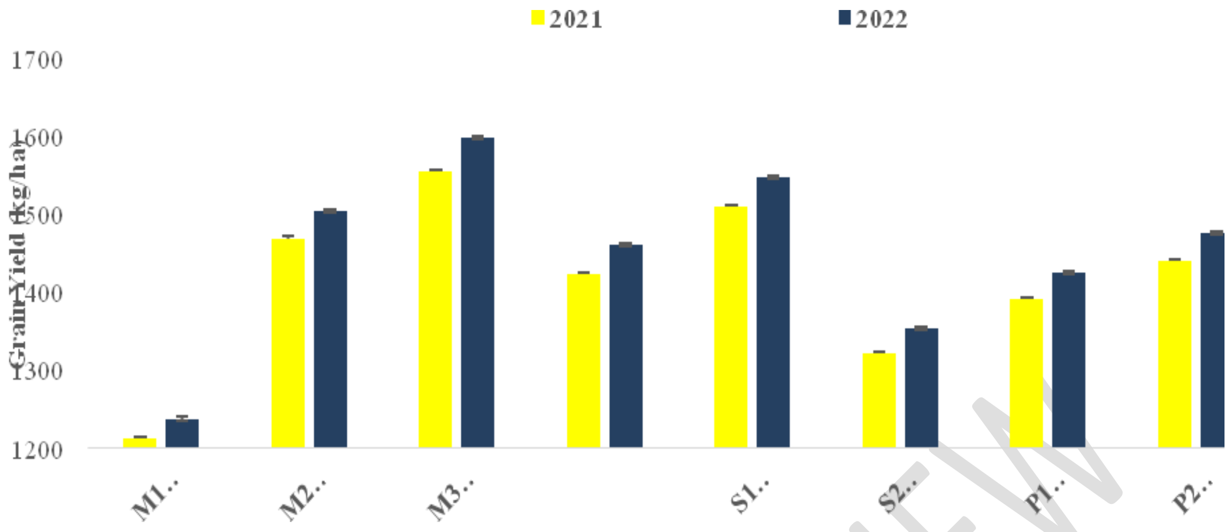

Figure 1. Effect of different soil moisture conservation practices on seed yield per hectare (kg ha^{-1})