INFLUENCE OF DIFFERENT TILLAGE AND NUTRIENT MANAGEMENT PRACTICES ON GROWTH PARAMETERS AND STOVER YIELD OF PEARL MILLET (*PENNISETUM GLAUCUM* (L.) R.BR. EMEND STUNTZ)

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SUMMARY

A field experiment was conducted during *kharif* season of 2021 at Research Farm Area of Bajra Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar to study the influence of different tillage and nutrient management practices on stover yield of pearl millet (*Pennisetum glaucum* (L.) R.Br.). The experiment was laid out in split plot design having three replications with four main plot of tillage practices and four sub plot of nutrient management treatments The tillage practices include CT_1-Conventional tillage (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS), CT_2-Conventional tillage (two harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS), MT_1-Minimum tillage (one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) and MT_2-Minimum tillage (one harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS) whereas, nutrient management had F_1-100% RDF, F_2-75% N through RDF + 2.5 t/ha FYM, F_3-50% N through RDF + 5.0 t/ha FYM and F_4-100% N through FYM treatments. The tillage practice CT_1-Conventional tillage (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) was found significantly superior from other treatments and recorded highest plant population (136.5 000/ha), plant height (185.9 cm), leaf area (1573.6 cm^2), LAI (3.50) at 40 DAS and stover yield (77.25 q/ha) whereas, among nutrient management F_2-75% N through RDF + 2.5 t ha^{-1} FYM had the highest plant population (134.3 000/ha), plant height (186.1 cm), leaf area (1573.5 cm^2), LAI (3.50) at 40 DAS and stover yield (76.44 q/ha).

Key words: Pearl millet, conventional tillage, minimum tillage, FYM and stover yield

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is grown across 27 Asian countries, covering an area of 11.63 million hectares and yielding 15.74 million tonnes in 2020, according to FAO statistics. Originating in West Africa, pearl millet is primarily cultivated in the arid and semi-arid tropics of Asia and Africa. Additionally, it is being tested as a grain and forage crop in the USA, Canada, Mexico, West Asia and North Africa (WANA) and Central Asia. Pearl millet is primarily a rainfed crop in India, dependent on the monsoon season from June to September (Rai *et al.*, 2015). Pearl millet has been shown to outperform sorghum, as it can produce grains with as little as 200 mm of precipitation (Bhuja, 2009). Often referred to as the "poor man's cereal crop" (Alam *et al.*, 2010) due to its production and consumption by the poorest communities in developing countries, pearl millet is rich in antioxidants, bioactive compounds, fiber and essential minerals (Fe, Zn, Ca, Mg, P). Its vitamin content, lipids, and high-quality protein contribute to the balanced nutrition of consumers (Uppal *et al.*, 2015).

Tillage is the initial operation in the cultivation of arable crops, traditionally involving primary (mouldboard plough), secondary (blade harrows) and tertiary (levelling) processes. While good tilth is essential for encouraging root proliferation in heavy soils and improving pearl millet yields (Doty *et al.*, 1975), excessive tillage in light-textured sandy soils can disintegrate clods and expose the soil to erosion. Conversely, reduced tillage may lead to soil compaction in areas with low organic matter, negatively impacting crop performance (Gupta *et al.*, 1983), despite being more economical in terms of time, labor and energy. Pearl millet is a highly efficient nutrient remover from the soil, as evidenced by the fact that each ton of grain produced extracts approximately 31.8–17.4–61.3 kg ha^{-1} of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O), respectively, along with 40–170–20–8 g ha^{-1} of zinc (Zn), iron (Fe), manganese (Mn), and copper (Cu) (Tandon, 2004). The use of manures and to some extent, NP fertilizers helps partially meet the nutrient needs of pearl millet. Manuring through farm yard manure (FYM) is the predominant way of pearl millet crop nutrition in arid and semi-arid rainfed production systems by farmers. Thus, optimum tillage operations, when combined with effective fertilizer management, are crucial not only for enhancing crop productivity but also for maintaining soil health and ensuring long-term sustainability (Maruthi Sankar *et al*., 2006; Nema *et al*., 2008). Keeping the above facts in view, a field study was conducted with different tillage and nutrient management practices to evaluate their effect on plant height and stover yield of the pearl millet crop.

MATERIALS AND METHOD

The experiment was carried out at Research Farm Area of Bajra Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar during 2021 in a split plot design with three replications. The experiment site, located in Haryana's central plains within India's Trans-Gangetic plains agro-climatic zone, has a tropical steppe and semi-arid climate. This climate features extremely hot, dry summers from April to June, transitioning to hot and humid conditions from July to September. The soil of the experimental field was sandy loam in texture, medium in organic carbon, low in available nitrogen, medium in available phosphorus and potassium. After the monsoon rains, the experimental field was ploughed using a tractor-drawn disc harrow. Two rounds of harrowing were carried out for conventional tillage, while only one round was done for minimum tillage. This was followed by cultivating the field to incorporate chipped crop residues and weeds, which helped break up clods and achieve good soil tilth, creating a finely pulverized seedbed ready for sowing during the 29th standard meteorological week. Two conventional tillage treatments with CT_1- two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS, CT_2- two harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS and two minimum tillage with MT_1-one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS, MT_2- one harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS were given under tillage practices. Among nutrient supply, F_1-100% RDF, F_2-75% N through RDF + 2.5 t ha^{-1} FYM, F_3-50% N through RDF + 5.0 t ha^{-1} FYM and F_4-100% N through FYM treatments were applied. The crop was fertilized with the recommended dose of fertilizer *i.e.* 40 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} at the time of sowing and the remaining half dose of the nitrogen was applied 3-4 weeks after sowing and after thinning and gap filling. Additionally, a specific quantity of well-decomposed farmyard manure (FYM) was applied to the designated treatment plots prior to sowing the crop. This manure was thoroughly incorporated into the soil to ensure proper nutrient distribution and to enhance soil fertility. The data recorded on plant population (000 ha^{-1}), plant height (cm), leaf area (cm^2), Leaf area Index (LAI) and stover yield (q ha^{-1}) were subjected to statistical analysis and the mean differences were evaluated by critical difference (C.D.) test at 5% level of significance.

RESULTS AND DISCUSSION

Effect on plant population (000/ha)

The perusal of data in Table 1 depicted that the plant population during *kharif* season of 2021 at 20 days after sowing (DAS) and maturity differed significantly under different tillage practices but did not under nutrient management. However, the plant stand was more at 20 DAS as compared to maturity stage. The maximum plant population (136.5 and 133.9 000/ha) was recorded with tillage practice CT_1 (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) at 20 DAS and harvest and remained significantly superior over all other treatments whereas, the minimum plant population (130.8 and 127.9 000/ha) was recorded with MT_2 (one harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS).

Among nutrient management, F_2 (75% N through RDF + 2.5 t/ha FYM) recorded the maximum plant population of 134.3 and 131.3 000/ha at both the stages as compared to F_1 (100% RDF), F_3 (50% N through RDF + 5.0 t/ha FYM) and F_4 (100% N through FYM).

Effect on plant height (cm)

The significant difference was observed

TABLE 1
Effect of different tillage and nutrient management practices on plant population of pearl millet

Treatment	Plant population (000/ha)	
	20 DAS	At maturity
Tillage practices		
CT_1	136.5	133.9
CT_2	134.7	132.0
MT_1	133.5	130.6
MT_2	130.8	127.9
S. Em±	0.52	0.40
C. D. (P=0.05)	1.85	1.41
Nutrient management		
F_1	133.5	130.7
F_2	134.3	131.3
F_3	133.6	131.1
F_4	134.1	131.2
S. Em±	0.47	0.62
C. D. (P=0.05)	NS	NS

TABLE 2
Effect of different tillage and nutrient management practices on plant height (cm) of pearl millet

Treatment	Plant height (cm)			
	20 DAS	40 DAS	60 DAS	Maturity
Tillage practices				
CT_1	37.5	133.4	175.4	185.9
CT_2	31.1	127.5	171.0	181.5
MT_1	33.4	129.6	172.2	182.7
MT_2	25.6	119.7	164.7	174.8
S. Em±	1.23	1.29	1.49	1.99
C. D. (P=0.05)	4.3	4.6	5.2	7.0
Nutrient management				
F_1	32.3	128.3	171.7	181.9
F_2	36.1	132.4	175.6	186.1
F_3	30.8	125.5	168.8	179.3
F_4	28.5	123.9	167.2	177.5
S. Em±	0.76	0.90	0.90	0.91
C. D. (P=0.05)	2.2	2.6	2.6	2.7

among different treatments of tillage and nutrient management regarding plant height at 20, 40, 60 DAS and maturity (Table 2). The result of the data showed that there was continuous increase in plant height as the plant reached towards maturity stage. The maximum plant height (37.5, 133.4, 175.4 and 185.9 cm) at all the growth stages were recorded with CT_1 (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) and remained at par with MT_1 (one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS). The reason for this might be due to that the tillage operations conducted prior to sowing effectively loosened the soil more than the minimum tillage practice. This improved soil structure likely facilitated better percolation and water storage in the root zone and ultimately increases plant height as suggested by Kovac *et al.* (2005) and Reddy and Reddy (2010). Among nutrient management, F_2 (75% N through RDF + 2.5 t ha^{-1} FYM) produced significantly taller plants (36.1, 132.4, 175.6 and 186.1 cm) in comparison to other treatments whereas, shortest plants (28.5, 123.9, 167.2 and 177.5 cm) were recorded in F_4 (100% N through FYM) at all the growth stages. The combination of organic manures and inorganic fertilizers improved soil aeration which enhanced root proliferation and increased microbial activity. This, in turn, boosted the availability and uptake of essential nutrients for plant growth and development. These results are further supported by the findings of Singh *et al.* (2003). A critical observation of the data revealed the fact that integrated application of both organic and inorganic sources of nutrients were better as compared to sole application of inorganic and organic sources. This might be attributed to better nutrition to crops due to mineralization of FYM and solubilisation of nutrients from the native sources during the process of decomposition (Kumar and Kumar, 2017). This may be ascribed to the manurial capacity of supplying essential major plant nutrients *viz*. N, P, K, Ca, Mg, S; necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn).

The free circulation of oxygen and water in the soil resulting from pulverization (due to tillage) results in increased biological activities in the soil, including that of organism that fix atmospheric nitrogen (Rashidi and Abbassi, 2010). Thus, a biological environment of the soil that is able to turn over soil nitrogen at the rates commensurate with crop requirement and efficient physiological processes inside the plant, so obtained by different tillage practices, ultimately reflected in the increased plant growth. Because, nitrogen is considered as a growth element, thus improved meristematic activities coupled with sufficient availability of photosynthates on account of efficient physiological processes altogether led to increased growth and its attributes. Similar effects of tillage practices on growth of pearl millet crop have also been reported by Usman *et al.* (2014).

Effect on leaf area (cm^2)

The data on leaf area per plant (Table 3) at various growth stages indicates that the leaf area increased most rapidly between 20 and 40 days after sowing (DAS), with a slowdown observed from 60 DAS to maturity. In terms of tillage practices, the treatment CT_1 (two harrow + one cultivator and planking + two inter-culture operations at 15-20 and 30-35 DAS) yielded the highest leaf area at all stages measured: 549 cm² at 20 DAS, 1574 cm² at 40 DAS, 1177 cm² at 60 DAS, and 685 cm² at harvest. In contrast, treatment MT_2 (one harrow + one cultivator and planking + one inter-culture operation at 21-28 DAS) produced lower values: 533 cm², 1553 cm², 1157 cm² and 665 cm², respectively. Notably, CT_1 performance at 40 DAS was statistically comparable to MT_1 (one harrow + one cultivator and planking + two inter-culture operations at 15-20 and 30-35 DAS) but significantly better than CT_2 and MT_2. The highest values of leaf area were recorded at 40 DAS and thereafter a decline in leaf area was recorded up to harvesting. The decline in leaf area at later crop growth stages could be attributed to leaf senescence as crop advanced toward maturity.

TABLE 3
Effect of different tillage and nutrient management practices on leaf area (cm2) of pearl millet

Treatment	Leaf area (cm²)			
	20 DAS	40 DAS	60 DAS	Maturity
Tillage practices				
CT_1	549	1574	1177	685
CT_2	540	1566	1167	677
MT_1	543	1569	1171	679
MT_2	533	1553	1157	665
S. Em±	1.8	1.9	1.5	1.5
C. D. (P=0.05)	6.5	6.6	5.3	5.1
Nutrient management				
F_1	541	1567	1170	679
F_2	548	1573	1175	683
F_3	539	1563	1165	674
F_4	536	1559	1162	671
S. Em±	2.0	1.5	1.5	1.6
C. D. (P=0.05)	6.0	4.3	4.5	4.7

Regarding nutrient application, the treatment F_2 (75% N through RDF + 2.5 t/ha FYM) outperformed other treatments with leaf areas of 548 cm², 1573 cm², 1175 cm² and 683 cm² at the respective growth stages. Conversely, F_4 (100% N through FYM) exhibited the lowest leaf area values: 536 cm², 1559 cm², 1162 cm² and 671 cm². This suggests that both tillage practices and nutrient management significantly influence leaf area development in pearl millet crop.

Effect on leaf area index

Leaf Area Index indicated greenness and photosynthetic efficiency of crop. It followed the same trend as followed by the leaf area The data presented in Table 4 indicated that treatment CT_1 (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) showed significantly better leaf area index than other treatments at all stages of crop growth among different tillage practices. At 20 DAS, CT_1 (1.22) had the maximum LAI. At 40 DAS, the maximum LAI was recorded in treatment CT_1 (3.50) followed by MT_1 (one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) (3.49) whereas, MT_2 (one harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS) recorded the lowest LAI (3.45). LAI at 60 DAS was also recorded highest in treatment CT_1 (2.62) which was notably higher over MT_2 (2.57). The maximum LAI at harvesting was found in treatment CT_1 (1.52) being quite superior over all other treatments.

TABLE 4
Effect of different tillage and nutrient management practices on leaf area index of pearl millet

Treatment	Leaf Area Index			
	20 DAS	40 DAS	60 DAS	Maturity
Tillage practices				
CT_1	1.22	3.50	2.62	1.52
CT_2	1.20	3.48	2.59	1.50
MT_1	1.21	3.49	2.60	1.51
MT_2	1.18	3.45	2.57	1.48
S. Em±	0.004	0.005	0.003	0.003
C. D. (P=0.05)	0.015	0.016	0.011	0.010
Nutrient management				
F1	1.20	3.48	2.60	1.51
F_2	1.22	3.50	2.61	1.52
F_3	1.20	3.47	2.59	1.50
F_4	1.19	3.46	2.58	1.49
S. Em±	0.005	0.003	0.004	0.004
C. D. (P=0.05)	0.014	0.010	0.011	0.011

Among nutrient management practices, LAI was significantly higher in F_2 (75% N through RDF + 2.5 t/ha FYM) treatment (1.22 and 3.50, respectively) at 20 DAS and 40 DAS over other treatments and the similar trend was recorded at 60 DAS whereas, the lower LAI (1.19, 3.46 and 2.58) was recorded in treatment F_4 (100% N through FYM) at 20, 40 and 60 DAS. At the harvest, F_2 exhibited statistically higher value of LAI (1.52) whereas, the lower value was in

TABLE 5
Effect of different tillage and nutrient management practices on stover yield (q/ha) of pearl millet

Treatment		Stover yield (q/ha)
Tillage Practices	Nutrient Supply	
CT_1- Conventional tillage (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS)	F_1–100% RDF	77.56
	F_2–75% N through RDF + 2.5 t/ha FYM	83.52
	F_3–50% N through RDF + 5.0 t/ha FYM	73.40
	F_4–100% N through FYM	74.53
	Mean	77.25
CT_2- Conventional tillage (two harrow + one cultivator and planking + one inter culture operations by kasola at 21-28 DAS)	F_1–100% RDF	73.32
	F_2–75% N through RDF + 2.5 t/ha FYM	74.25
	F_3–50% N through RDF + 5.0 t/ha FYM	70.70
	F_4–100% N through FYM	73.61
	Mean	72.97
MT_1-Minimum tillage (one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS)	F_1–100% RDF	74.72
	F_2–75% N through RDF + 2.5 t/ha FYM	78.49
	F_3–50% N through RDF + 5.0 t/ha FYM	75.45
	F_4–100% N through FYM	75.42
	Mean	76.02
MT_2-Minimum tillage (one harrow + one cultivator and planking + one inter culture operations by kasola 21-28 DAS)	F_1–100% RDF	67.70
	F_2–75% N through RDF + 2.5 t/ha FYM	69.51
	F_3–50% N through RDF + 5.0 t/ha FYM	66.59
	F_4–100% N through FYM	67.96
	Mean	67.94
	S. Em±	1.37
	C. D. (P=0.05)	4.83
Nutrient management	F_1–100% RDF	73.32
	F_2–75% N through RDF + 2.5 t/ha FYM	76.44
	F_3–50% N through RDF + 5.0 t/ha FYM	71.54
	F_4–100% N through FYM	72.88
	S. Em±	1.05
	C. D. (P=0.05)	3.10

F_4 (1.49) (Table 4). The decline in leaf area index as crop advanced toward maturity could be due to senescence of leaves. This could be due to the degree and size of canopy which is a key factor of solar radiation interception, determining photosynthetic activity and net photosynthesis of plant. Similar observations on LAI were reported by Chongre *et al.* (2019) in green gram and Priya and Sathyamoorthi (2019) in foxtail millet.

Effect on stover yield (q/ha)

The stover yield as influenced by tillage and nutrient management practices is presented in Table 2. The data pertaining to stover yield revealed that treatment CT_1 (two harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS) recorded significantly higher value of stover yield (77.25 q/ha) and remained at par with MT_1 (one harrow + one cultivator and planking + two inter culture operations by kasola at 15-20 & 30-35 DAS). Vittal *et al.* (1983) reported that deep tillage improved yield and yield-attributing traits by enhancing soil profile recharge and promoting better rooting depth in Alfisols and thus, increases yield in pearl millet. Among, nutrient management, F_2 (75% N through RDF + 2.5 t ha^{-1} FYM) had the highest stover yield (76.44 q ha^{-1}) and statistical superior over other treatments. F_4 (100% N through FYM) recorded the lowest stover yield (72.88 q/ha). The application of nitrogen along with organic manure can help maintain higher levels of soil organic carbon which enhances total microbial biomass activity and ultimately contributes to higher soil microbial biomass carbon, which resulted in increase in yield and yield attributing characters. These results are in accordance with that of Agarwal and Kumar (1996). The increase in the stover yield by conventional tillage may be due to better root growth, infiltration of water, increase in physico-chemical and biological properties of soil, enhanced growth parameters and plant biomass with efficient and greater partitioning of metabolites towards reproductive structures. These findings are in consonance with those of Javeed *et al.* (2013), Omandi *et al.* (2014) and Kumar *et al.* (2018). Beneficial effects of tillage in terms of mineralisation of nutrients and suppressing weed growth may also have positively impacted on stover yield.

CONCLUSION

On the basis of the data, it can be concluded that conventional tillage practice with two intercultural operations at 15-20 and 30-35 DAS among tillage practices and 75% N through RDF + 2.5 t/ha FYM among nutrient management were effective in ensuring highest plant population, plant height, leaf area per plant, leaf area index and maximum stover yield in pearl millet.

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