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Tillage and Nutrient Management Strategies to Improve the Performances of Little Millet under Irrigated Condition

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ABSTRACT

Background: Millets rank sixth among cereal grains which has a great potential in contributing to food and nutritional security. Little millet (*Panicum sumatrense* L.) a minor millet, quick germinating short duration crop, tolerant to drought, excess moisture and also rich in nutrients. Use of improved varieties under good agronomic management such as tillage practices, crop rotation, cropping system and fertilization by nutrient management through organic manures and foliar supplementation during critical stages helps in improving the soil fertility and maximize the crop productivity. Hence, there is a need to develop the organic nutrient management of minor millets for food production, nutritional security and maintaining the soil fertility as well as productivity. Based on this consideration, a new immersing attempt was made to develop and identify the suitable tillage prac-tices and nutrient management practices on growth and yield of little millet.

Methods: Field experiments were conducted in the research farm of Tamil Nadu Agricultural University, Coimbatore during *summer* and *rabi* season 2022 in order to investigate the growth and yield performances of irrigated little millet under tillage and different nutrient sources. The experiment was laid out in strip plot design with 2 main plot and 7 sub-plot treatments. The main plot consist of tillage practices *viz.,* conventional tillage and farmer's practices whereas sub-plot consist of nutrient management practices includes organic manures along with foliar nutrition.

Result: The results revealed that conventional tillage (Disc plough + Cultivator + Rotovator) with application of enriched vermicompost @ 1 t ha^{-1} followed by foliar spray of 3% *panchagavya* on 30th DAS and 5% of egg amino acid on 45th DAS had greater effect on growth parameters and yield attributes of little millet during *summer* and *rabi* season, 2022.

Key words: Conventional tillage, Foliar spray, Little millet, Organic manures.

Abbreviations: FYM- Farm yard manure; EFYM- Enriched farm yard manure; VC- Vermicompost; EVC- Enriched vermicompost; GM- Goat manure; RDF- Recommended dose of fertilizers; DAS- Days after sowing.

INTRODUCTION

Small millets are "miracle crops" because of its multifaceted use, commonly known as nutri-cereals due to its high contribution on health benefits. Nutri-cereals are mostly grown in the developing nations for both human consumption and animal nourishment. These small grain cereals are found to be domesticated and considered as the "crops of antiquity" because of its inherent tolerant capacity against drought, pest and disease resistance mechanism (Devi *et al*., 2014). India is the world top millet producer with a yearly output of around 12.46 million metric tonnes from an area of 8.87 million hectares. Because of high beneficiary rate, increased awareness over consumer and shifted their main preferences on millet consumption (Prashanthi and Reddy, 2023). Although millets have recently gained more attention for their various food and health benefits and also well adaptation to adverse environmental conditions. But their productivity has remained low and needs to be boosted to enhance their utilization as a food crop (Numan *et al*., 2021).

Little millet (*Panicum sumatrense* L.) is a short-lived crop, fast germination, nutrient rich and resilient to harsh drought and water logging conditions. The states of Karnataka, Madhya Pradesh Andhra Pradesh, Tamil Nadu, Gujarat, Chhattisgarh and Maharashtra where primarily cultivated. It is one among the six small millets grown in most of the regions of scanty and erratic rainfall on poor and marginal soils. Owing to its high nutritional values, the demand for little millet is increasing today particularly from the people suffering from diabetics (Himasree *et al*., 2021). Indiscriminate use of synthetic fertilizers and faulty

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management practices *viz*., nutrient, moisture stress and nutritional quality had greater constraints and threatened the sustainability of millet productivity and soil health condition (Nainwal *et al*., 2018 and Mubeena *et al*., 2019).

Soil tillage is a necessary practice in crop production, has a significant impact on soil properties, crop yield and soil-plant systems through higher nutrient use efficiency. Tilling of soil also had greater impact of microbial activity which influences soil aeration, moisture and temperature (Tripathi *et al*., 2007).

Recently, organic manures usage in crop production was tremendously increasing because of it positive responses led to improve soil fertility, productivity and strengthen the ecological status. Organic farming aims to reduce the use of external inputs and maximization of crop productivity resulted well in enhancing the soil quality by higher soil enzymatic activities (Shukla *et al*., 2011). Increase in demand of non-systematic information on nutrient management in millet cultivation, it is necessary to develop and focus their attention towards the enhancement on millet productivity and quality which creates an enabling environment for millet farmers. In addition to soil fertility status and crop productivity, organic nutrient sources with appropriate tillage practices showed better management method in little millet production. Therefore, the present study was designed to investigate the effect of tillage and different organic nutrient management on the growth and yield of little millet.

MATERIALS AND METHODS

Soil and site description

A field experiment was performed during the *summer* and *rabi* season, 2022 at the experimental farm of Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in nature. The experimental site was located in the western zone of Tamil Nadu at longitude of 76°97′E and latitude of 11°08′N with an elevation of 426 m above MSL.

Experimental setup

The experimental layout was done using strip plot design with three replicates consists of two factors *viz*., main plot (vertical strips) and sub plot (horizontal strips). The treatment details are:

Tillage practices (Vertical strips)

T_1- Conventional tillage (Disc plough + Cultivator + Rotovator).
T_2- Farmer's practice (Cultivator + Rotovator).

Nutrient management practices (Horizontal strips)

N_1- FYM @ 12.5 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS + 3% vermiwash on 45th DAS.
N_2- EFYM @ 1 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS +5% egg amino acid on 45th DAS.
N_3- VC @ 2.5 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS + 3% vermiwash on 45th DAS.
N_4- EVC @ 1 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS+ 5% egg amino acid on 45th DAS.
N_5- GM @ 2.5 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS+ 5% vermiwash on 45th DAS.
N_6- RDF of NPK fertilizers + Foliar spray of water on 30th and 45th DAS.
N_7- Absolute control.

Crop husbandry and cultivation practices

In conventional tillage, the field was ploughed with disc plough to break the hard pan followed by cultivator and rotovator to get fine seed bed and whereas in farmers practice, the field preparation was done with cultivator followed by rotovator. First sowing was done in the month of February, 2022 whereas second sowing was done during September 2022, respectively. The size of each plot was 7 m × 5 m and it was separated by a buffer channel with the distance of 60 cm to reduce the impact of different treatments. Organic and inorganic nutrient sources were applied as per the treatment schedule. Little millet (ATL 1) seeds were sown by line sowing method with inter-row distance of 25 cm and intra row distance of 10 cm respectively. Data on growth parameters and yield attributes of little millet were observed. Data on growth parameters *viz*., plant height, leaf area index, number of tillers, internode tillers, internode length and yield attributes *viz*., number of productive tillers, panicle length, panicle weight of little millet was observed.

Statistical analysis

Statistical analyses of data were carried out for strip plot design. Data were analysed using R Studio as per methods suggested by Gomez and Gomez (1984). Crop data were subjected to the analysis of variance and least significant difference at probability level ≤ 0.05. The non-significant differences were denoted as NS.

RESULTS AND DISCUSSION

Effect of tillage and nutrient management practices on growth parameters

The growth parameters *viz*., plant height, number of tillers, leaf area index, number of tillers per plant, internode tillers and internode length of little millet were significantly influenced by tillage and nutrient management practices.

Plant height

Among tillage system and nutrient management practices, conventional tillage found to be more responsive than the farmer's practice. From the Table 1 and 2, the conventional tillage with enriched vermicompost @ 1t ha^{-1} with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS (T_1N_4) has recorded higher plant height during both the season compared to other treatments. This might be due to the higher availability of nutrients from enriched vermicompost by enhanced activity of soil microorganism could convert organic to inorganic available form of nutrients. In addition to that, higher availability of nitrogen from

Table 1: Effect of tillage and nutrient management on growth parameters and yield attributes of little millet during *summer* season 2022.

Treatments	Plant height (cm)			Leaf area index			Number of tillers/Plant			Number of productive tillers/hill	Panicle length (cm)	Panicle weight (g)
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest		At harvest	
Tillage practices												
T_1	42.1	99.9	106.0	1.20	3.73	2.34	7.48	9.88	10.25	7.91	26.85	2.04
T_2	41.4	94.4	98.3	1.09	2.88	1.94	7.19	8.47	8.97	7.27	26.37	1.93
SEd	2.03	4.35	5.34	0.35	0.24	0.08	0.50	0.65	0.19	0.24	0.48	0.03
LSD (0.05)	NS	9.44	11.58	0.75	0.51	0.18	NS	1.4	0.42	0.53	1.05	0.06
Nutrient management practices												
N_1	42.1	97.4	103.3	1.23	3.62	2.25	7.53	9.61	9.63	7.90	26.70	2.02
N_2	42.8	99.4	105.9	1.26	3.82	2.33	7.77	9.79	9.80	7.95	26.91	2.04
N_3	42.0	96.0	100.9	1.13	3.32	2.07	7.32	9.43	9.60	7.78	26.68	2.00
N_4	43.1	103.1	112.6	1.40	3.94	2.55	7.93	10.52	10.80	8.15	27.30	2.08
N_5	41.6	95.8	98.9	1.06	3.12	2.01	7.24	9.06	9.46	7.53	26.61	1.98
N_6	41.4	94.4	97.2	1.00	2.85	1.97	6.87	8.32	9.28	7.02	26.26	1.93
N_7	39.2	93.9	96.0	0.95	2.45	1.79	6.66	7.52	8.70	6.81	25.79	1.87
SEd	1.44	2.49	3.51	0.01	0.24	0.12	0.39	0.43	0.34	0.29	0.49	0.04
LSD (0.05)	NS	5.41	7.62	0.11	0.53	0.26	NS	0.93	0.74	0.64	1.06	0.09
Interaction effect												
T at N SEd	1.06	1.65	3.87	0.10	0.25	0.12	0.57	0.64	0.29	0.37	0.41	0.05
LSD (0.05)	NS	NS	8.40	NS	NS	NS	NS	1.39	0.63	0.79	0.88	NS
N at T SEd	1.09	1.68	3.90	0.12	0.27	0.14	0.59	0.67	0.31	0.39	0.43	0.07
LSD (0.05)	NS	NS	8.46	NS	NS	NS	NS	1.45	0.67	0.85	0.93	NS

T- Tillage; N- Nutrient management practices; LSD- Least significant difference ($p \leq 0.05$); DAS- Days after sowing; NS- Non significant.

Table 2: Effect of tillage and nutrient management on growth parameters and yield attributes of little millet during *rabi* season 2022.

Treatments	Plant height (cm)			Leaf area index			Number of tillers/Plant			Number of productive tillers/hill	Panicle length (cm)	Panicle weight (g)
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest		At harvest	
Tillage practices												
T_1	41.2	99.3	103.8	1.12	3.41	2.22	7.27	9.21	10.02	7.25	26.46	2.01
T_2	39.3	93.7	96.0	0.99	2.68	1.82	6.66	8.08	8.58	7.07	25.59	1.85
SEd	2.81	4.62	4.56	0.07	0.11	0.11	0.53	0.4	0.41	0.3	1.34	0.13
LSD (0.05)	NS	NS	NS	NS	0.23	0.25	NS	0.87	0.89	NS	NS	NS
Nutrient management practices												
N_1	39.3	94.6	96.2	0.90	2.74	1.87	6.55	8.04	8.94	7.03	25.60	1.92
N_2	41.6	98.1	101.3	1.21	3.48	2.24	7.49	9.23	9.61	7.27	26.54	2.02
N_3	41.4	97.4	101.2	1.09	3.20	2.02	7.36	9.09	9.37	7.21	26.29	1.80
N_4	41.8	100.5	107.8	1.32	3.70	2.48	7.82	9.74	10.55	7.63	26.72	2.06
N_5	40.6	96.4	100.2	1.04	3.06	1.97	6.81	8.93	9.24	7.15	26.12	1.95
N_6	39.9	95.5	98.3	0.98	2.84	1.90	6.71	8.45	9.12	7.11	25.76	1.93
N_7	37.1	92.8	94.0	0.84	2.29	1.67	6.03	7.05	8.28	6.74	25.15	1.84
SEd	1.50	4.39	3.31	0.08	0.19	0.09	0.3	0.49	0.33	0.22	0.96	0.09
LSD (0.05)	NS	NS	7.18	0.17	0.41	0.19	0.66	0.72	0.72	0.47	NS	NS
Interaction effect												
T at N SEd	2.08	6.99	7.00	0.11	0.22	0.13	0.39	0.9	0.86	0.34	1.69	0.14
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N at T SEd	2.11	7.01	7.02	0.12	0.24	0.15	0.41	0.93	0.88	0.37	1.71	0.16
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T- Tillage; N- Nutrient management practices; LSD- Least significant difference ($p \leq 0.05$); DAS- Days after sowing; NS- Non significant.

enriched vermicompost as well as foliar nutrition at critical stages supplies good amount of plant nutrients and essential amino acids from *panchagavya* and egg amino acid leads to increase the plant height at various stages. These was in accordance with Somasundaram *et al*. (2020) and Priyanka *et al*. (2019).

Leaf area index

Higher leaf area index was observed in the conventional tillage with enriched vermicompost @ 1 t ha^{-1} with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS (T_1N_4) might be due to application on essential nutrients and growth promoting substances at critical stages increases leaf number, leaf size which leads to better uptake of nutrients. Maximum LAI at peak flowering stage mainly due to high photosynthetic activity simultaneously increases the chlorophyll production through enriched organic sources in the form of soil and foliar application (Thesiya *et al*., 2019 and Gowda *et al*., 2018). The lowest leaf area index was obtained in the control treatment plot (N_7) under both the tillage system over the seasons. The resultant data analysis was given in the Table 1 and 2.

Number of tillers

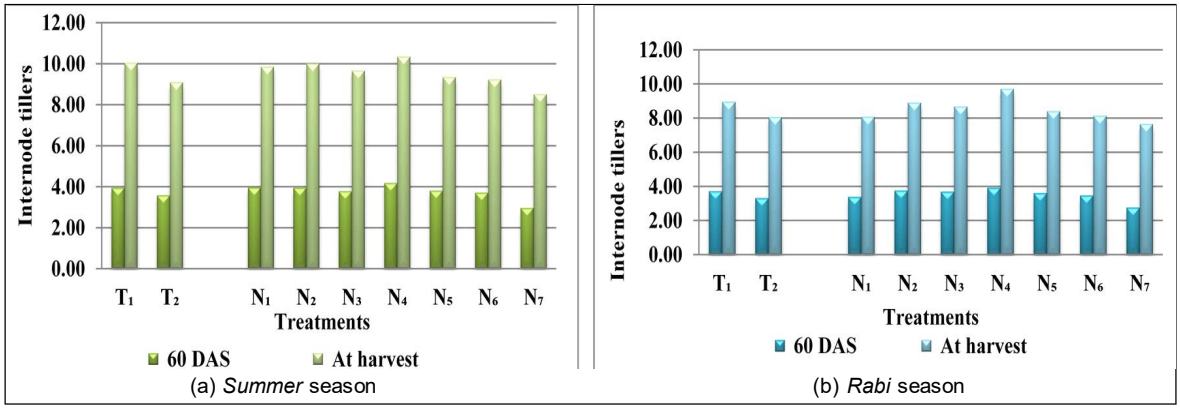
From the experiment, Conventional tillage (Disc plough + Cultivator + Rotovator) significantly influenced the number of tillers per plant at 30 DAS (7.48 and 7.27), 60 DAS (9.88 and 9.21) and at harvest (10.25 and 10.02) during *summer* and *rabi* season, respectively. It also found that, decreased number of tillers per plant was observed with the farmer's practice (Cultivator + Rotovator) during both the season. Among the nutrient management practices, the plot treated with enriched vermicompost @ 1 t ha^{-1} with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS had greater influence on yield attributes during *summer* and *rabi* season *viz*., maximum number of tillers were obtained at 30 DAS (7.93), 60 DAS (10.52) and at harvest (10.80) in the *summer* season and in the *rabi* season, the number of tillers at 30 DAS (7.82), 60 DAS (9.74) and at harvest (10.55), respectively. Adoption of tillage practices and organic manures had positive effect on physical, chemical and biological properties of soil tend to improve the capacity of nutrient uptake due to the presence of soil microbes. Foliar application of *panchagavya* and egg amino acid as foliar spray increases the availability of macro, micronutrients and growth hormones in addition to the presence of huge beneficial microbial population stimulates the crop growth characteristics such as pant height and more number of tillers. These results are in accordance with the findings of Priyanka *et al*. (2019).

Internode tillers and Internode length

Similarly, number of internode tillers and internode length at 60 DAS and at harvest were also significantly increased by combined effect of tillage and nutrient management during both the season (Fig 1 and Fig 2). The maximum number of internode tillers and internode length were obtained with enriched vermicompost @ 1t ha^{-1} with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS under both the tillage practices followed by the enriched farm yard manure @ 1 t ha^{-1} + foliar spray of 3% *panchagavya* on 30th DAS +5% egg amino acid on 45th DAS. This might be due to higher availability of nutrients from the soil as well as foliar nutrition increases the cell growth, cell elongation and development. These results were found to be similar with the findings of Ronanki *et al*. (2018) and Seth *et al*. (2020).

Effect of tillage and nutrient management practices on root length

Effect of tillage and nutrient management practices had significant influences on the root growth and development. From the observation, conventional tillage significantly influenced the root length at 30 DAS (15.77 cm), 60 DAS (21.22 cm) and at harvest (22.29 cm) in the *summer* season whereas with *rabi* season, the root length at 30 DAS (15.41 cm), 60 DAS (20.09 cm) and at harvest (21.46 cm) respectively. Among the nutrient management practices, the maximum root length was obtained in the *summer* season at 30 DAS (15.36 cm), 60 DAS (21.04 cm) and at harvest (21.53 cm) whereas in the *rabi* season, the root length at 30 DAS (15.12 cm), 60 DAS (20.50 cm) and at harvest (20.97 cm) was found, respectively (Fig 3a and 3b). The reason for increased root length under conventional tillage system,



(a) *Summer* season (b) *Rabi* season

Fig 1: Effect of tillage and nutrient management on internode tillers of little millet during *summer* and *rabi* season 2022.

mainly due to the changes in soil physical properties through tillage process enhanced the root growth that influence the root for greater uptake of water and nutrients. Besides, adequate availability of nutrients in soil solution improves root growth through water and nutrient uptake. Higher nutrient uptake leads to profuse more number of roots can markedly results in improve activities of growth and yield attributes in little millet. This is in conformity with earlier findings of Yadav *et al*. (2012) and Louhar *et al.* (2020). The mean minimum root length was found with farmer's tillage practices and in the control treatment (N_7) at during both *summer* and *rabi* season, respectively.

Effect of tillage and nutrient management practices on the yield attributes

Yield attributes such as number of productive tillers per hill, panicle length and panicle weight were significantly influenced mainly due to adoption of nutrient management practices. Conventional tillage plot applied with enriched vermicompost @ 1 t ha^{-1} followed by foliar spray of 3% *panchagavya* on 30th DAS and 5% egg amino acid on 45th DAS (T_1N_4) during both the season resulted more number of productive tillers, maximum panicle length and weight.

From the experiment, it was found that among the two tillage practices, conventional tillage practice (T_1) resulted with increased number of productive tillers hill^{-1} (7.91), panicle length (26.85 cm) and panicle weight (2.04 g) whereas with farmer's practices (T_2), number of productive tillers hill^{-1} (7.27), panicle length (26.37 cm) and panicle weight (1.93 g) were obtained at harvest stages during *summer* season. Similarly, highest yield attributes were obtained higher with conventional tillage than farmer's practices in the *rabi* season. It might be due to improved changes in physical condition of soil which tends to enhance the nutrient uptake and resulted well in better yield attributes.

Among the nutrient management practices, the plot treated with enriched vermicompost @ 1 t ha^{-1} with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS had greater influence on yield attributes during *summer* and *rabi* season *viz*., maximum number of productive tillers (8.15 and 7.63 hill^{-1}), panicle length (27.30 and 26.72 cm) and panicle weight (2.08 and 2.06 g) were obtained, respectively. It was found on par with the treatment enriched farm yard manure @ 1 t ha^{-1} along with foliar spray of 3% *panchagavya* on 30th DAS + 5% egg amino acid on 45th DAS. These might be due superiority of organics might have been induced by increased and prolonged availability of nutrients, resulting in better utilization of applied nutrients from soil through soil microorganism activities. Higher

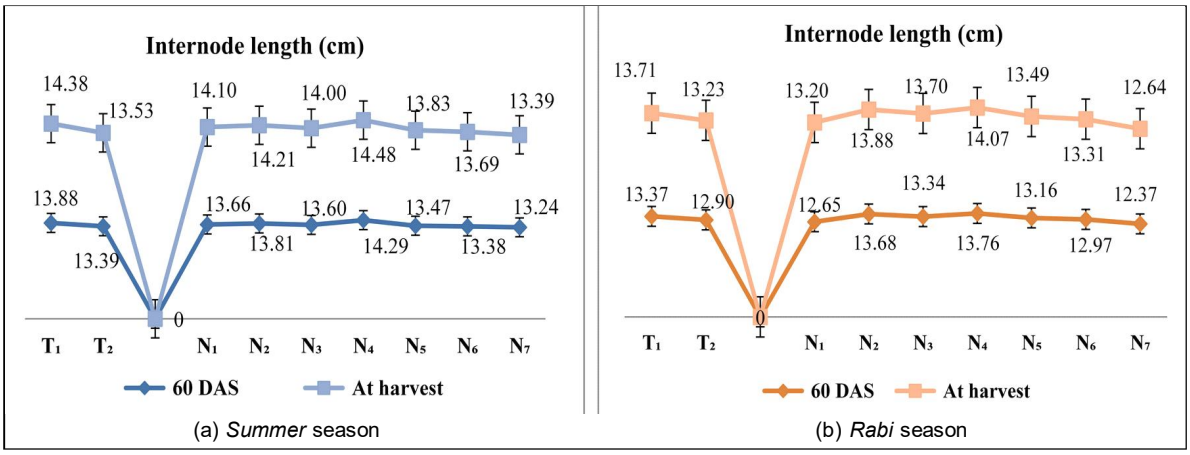


Fig 2: Effect of tillage and nutrient management on internode length of little millet during *summer* and *rabi* season 2022.

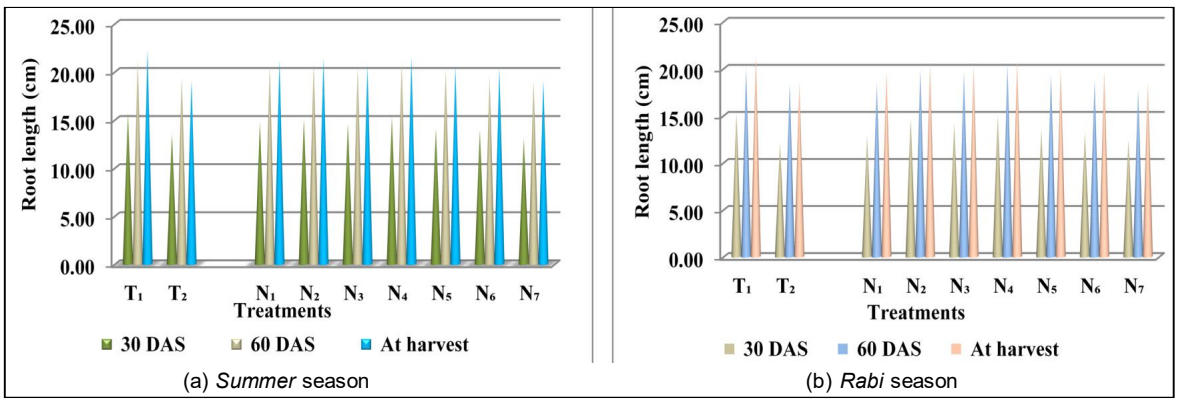


Fig 3: Effect of tillage and nutrient management on root length of little millet during *summer* and *rabi* season 2022.

photosynthetic and enzymatic activity could be the reason for greater nutrient uptake by plants which involves in the enhancement of yield characteristics. Similarly plants absorb more nutrients from the soil and transform it into useful sink. These results were in consonance with earlier findings of Bana *et al*. (2012) and Krupashree *et al*. (2022). The lowest productive tillers were noted in control plot (N_7) under both tillage practices during both summer and *rabi* season. This might be due to non-application of nutrient supplements to plants at critical stages results in reduced tiller production which directly showed the negative impact on yield attributes of little millet. The results of data were given in the Table 1 and 2.

CONCLUSION

From the above study, it could be inferred that conventionally tilled little millet has greater impact on the crop productivity than the farmer's practice. During both *summer* and *rabi* season, conventional tillage system (Disc plough + Cultivator + Rotovator) with application of enriched vermicompost @ 1 t ha^{-1} followed by foliar spray of 3% *panchagavya* on 30th DAS and 5% egg amino acid on 45th DAS showed the better performances of little millet with respect to growth and yield characteristics under irrigated condition. Furthermore, use of enriched organic manures not only enriches crop growth, it also preserves the soil health to produce healthy and quality grain, which is the basis of human health, ultimately determined by the soil fertility.

Conflict of interest

The authors declare that they have no conflict of interest.

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