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Influence of different types of mulching and biofertilizer on growth of finger millet (Variety-VL Mandua 379)

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Abstract
A field experiment was conducted at Himalayan University farm, Jullang, Itanagar, Arunachal Pradesh, during the *kharif* season of 2023 with 8 treatments replicated thrice in randomized block design, to determine the effect of different types of mulching and biofertilizer on growth of finger millet (*Eleusine coracana*.). The available nutrient status showed high nitrogen (N), low phosphorus (P), and medium potassium (K) levels. The experiment included the following treatments T_1-Control, T_2- Karanj leaf mould at + *Azotobacter*, T_3-Karanj leaf mould + *Phosphorus solubilizing bacteria* at, T_4- Neem leaf mould + *Azotobacter*, T_5-Paddy straw + jute bag + *Rhizobium*, T_6-Paddy straw + *Phosphorus solubilizing bacteria*, T_7-Black polythene + *Azotobacter* and T_8-Saw dust + *Rhizobium.*
The highest plant height recorded was 31.27 cm at 30 DAT, 76.87 cm at 60 DAT, 99.20 cm at 90 DAT, and 100.80 cm at harvest, highest number of tillers plant^{-1} recorded was 2.33 at 30 DAT, 2.80 at 60 DAT, 3.67 at 90 DAT, and 4.07 at harvest, highest number of leaves plant^{-1} recorded was 25.27 at 30 DAT, 33.40 at 60 DAT, 38.73 at 90 DAT, and 32.13 at harvest and plant dry weight recordings of 8.23 g at 30 DAT, 27.77 g at 60 DAT, 40.64 g at 90 DAT and 51.06 g at harvest were observed with treatment T_5 - Paddy straw + jute bag + Rhizobium.

Keywords: Finger millet, mulching, biofertilizer, rhizobium, straw mulch

Introduction
Finger millet or ragi (*Eleusine coracana* (L.) Gaernt.) belongs to the family Poaceae. The term 'Eleusine' is derived from 'Eleusis' who is the Greek deity presiding over agriculture. The term 'coracana is derived from kurukkan, the Singhali name of the grain. Ragi is mentioned in ancient Sanskrit literature as Rajika. The word ragi is derived from "Rajika" meaning red Being a hardy crop, finger millet is grown in drylands, under the rainfed situation. It has no preferences of soil types, yet, sandy loams and red loams are best. It has a low water requirement and can be grown with a minimum rainfall of 300-400 mm but can withstand up to 1500 mm. It can tolerate salinity to some extent and is sensitive to waterlogging and frost (Neeruganti, 2021) [8].
Around 4.5 million tons of finger millet are produced worldwide every year. Africa produce 2.5 million tons and India produces 1.2 million tons annually. Finger millet accounts for about 85% of all millets produced in India and is cultivated over 1.19 million hectares in India according to a recent report (Sakamma *et al*., 2018) [10].
Mulching is the process or practice of covering the soil/ground to make more favorable conditions for plant growth, development and efficient crop production. While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the methods and benefits of mulching (Sharma and Bhardwaj, 2017) [12].
Microbial inoculants, also known as biofertilizers, are organic products that contain specific microorganisms obtained from plant roots and root zones. They have been found to boost plants' growth and yield by 10–40%. These bioinoculants colonize the environment when applied to the rhizosphere and the interior of the plant to promote plant growth (Nosheen *et al*, 2021) [9].
The purpose of this research is to determine how different types of mulches and biofertilizers affect soil moisture, temperature regulation, nutrient availability and weed suppression, thereby optimizing the growing conditions for finger millet.

By exploring these interactions, the research seeks to develop cost-effective, eco-friendly solutions that reduce the dependency on chemical inputs, improve soil health and increase the nutritional quality and productivity of finger millet. Ultimately, the goal is to promote sustainable agriculture, improve food security and boost the livelihoods of farmers in vulnerable regions.

Materials and Methods

The experiment was conducted during the *Kharif* season of 2023 at Himalayan University in Itanagar. The Crop Research Farm is located in Jullang on the university campus, situated at 27.14°N latitude and 93.62°E longitude, and an altitude of 320 meters above sea level. The site belongs to the Eastern Himalayan region, and the agro-climatic zone falls under the sub-tropical zone of Arunachal Pradesh.

Table 1: Physio-chemical properties of soil in the experimental field, Himalayan University.

Sl. No	Particulars	Value
1.	Sand (%)	54.2%
2.	Silt (%)	29.5%
3.	Clay (%)	16.3 %
4.	Soil Texture	Sandy Loam
1.	Soil pH	4.25
2.	Organic carbon	1.59 %
3.	Electrical conductivity	0.452 dS/m
4.	Available Nitrogen	613.5 Kg/ha
5.	Available Phosphorus	4.86 Kg/ha
6.	Available Potassium	218.4 Kg/ha

The treatments includes T_1- Control, T_2- Karanj leaf mould + *Azotobacter*, T_3-Karanj leaf mould + *Phosphorus solubilizing bacteria*, T_4- Neem leaf mould + *Azotobacter*, T_5-Paddy straw at + jute bag + *Rhizobium*, T_6-Paddy straw at 5kg/ha + *Phosphorus solubilizing bacteria*, T_7-Black polythene + *Azotobacter* and T_8-Saw dust + *Rhizobium.* The experiment was laid out in a Randomized Block Design (RBD) in the year of 2023. The various methods for calculation of growth parameters are given below:

Plant height (cm)

Plant height from the ground level till the apex of the top leaf was noted at 30, 60, 90 DAT and at harvest and expressed in cm.

No. of leaves plant^{-1}

Number of leaves was recorded from the five selected tagged plants at 30, 60, 90 DAT and at harvest. The average number of leaves plant^{-1} was worked out.

Number of tillers plant^{-1}

The total number of tillers per plant was counted from five hills at random at 30, 60 and 90 DAT and at harvest and the average was worked out.

Dry weight (g)

The sample collected from five randomly selected hills from the destructive sampling area at 30, 60, 90 DAT and at harvest and was used to record the dry matter production. The plant was uprooted and its roots were removed. The aerial parts were chopped and put in a brown paper bag. Then it was dried in the thermostatically controlled oven at 60 °C till the sample was dried and constant weight was recorded.

Results and Discussions

1. Plant height (cm)

Taller plants recorded at 30, 60, 90 DAT and at harvest (31.27, 76.87, 99.20 and100.80 cm, respectively) were noticed with T_5 (Paddy straw+ Jute bag+ *Rhizobium*) followed by T_8 (saw dust + *Rhizobium*) (30.53, 75.40, 97.73 and 99.53 cm, respectively), T_6 (30.33, 74.33, 97.00 and 98.53cm, respectively) and T_7 Black polythene + *Azotobacter* (30.00, 73.60, 94.60 and 96.53 cm). The significantly shorter plants at 30, 60, 90 DAT and at harvest (21.20, 44.47, 61.47 and 63.33 cm, respectively) were recorded with absolute control (T_1). The probable reason for recording higher plant height in T_5 (Paddy straw+ Jute bag+ *Rhizobium*) is due to the usage of two mulching materials i.e straw mulch and jute bag mulch. There are scientific evident that mulching has double actions; controlling weeds and providing soil cover, both of which reduce water loss through decreased evaporation and increased availability of soil moisture contents which increase plant height (Khurshid *et al*., 2006 and Ahmed *et al*., 2007) [5, 1]. The use of rhizobium also contributes to increased plant height. Rhizobium spp. are plant growth-promoting rhizobacteria and some are endophytes that can produce phytohormones, siderophores, HCN, solubilize sparingly soluble organic and inorganic phosphates, and can colonize in the roots of many plants (Sessitsch *et al*., 2002) [11].

2. Number tillers plant^{-1}

Higher number of tillers plant^{-1} at 30, 60, 90 DAT and at harvest (2.33, 2.80, 3.67 and 4.07, respectively) were noticed with T_5 (Paddy straw+ Jute bag+ *Rhizobium*) followed by T_8 (saw dust + *Rhizobium*) (2.27, 2.73, 3.53 and 3.73, respectively), T_6 (2.20, 2.67, 3.40 and 3.77, respectively) and T_7 Black polythene + *Azotobacter* (2.13, 2.60, 3.33, 3.73). The significantly lower tillers plant^{-1} at 30, 60, 90 DAT and at harvest (1.13, 1.67, 2.40 and 2.83, respectively) were recorded with absolute control (T_1). The probable reason for recording highest number of tillers plant^{-1} with T_5 (Paddy straw+ Jute bag+ *Rhizobium*) is because straw mulching might have reduced the fluctuation of soil temperature and increased the soil moisture and resulted in more rapid crop growth and produced more number of tillers. The result was partially similar to the findings of Mishra (2000) [7] who stated that soil mulching significantly enhanced the number of effective tillers plant^{-1}. Studies have shown that Rhizobium inoculation improves various growth parameters by enhancing nitrogen fixation, which subsequently increases the availability of nitrogen in the soil. This increase in nitrogen supports the development of more tillers, as nitrogen is crucial for the formation of new shoots and leaves (Gebremariam and Tesfay, 2021) [3].

3. Number of leaves plant^{-1}

Higher number of leaves plant^{-1} at 30, 60, 90 DAT and at harvest (25.27, 33.40, 38.73 and 32.13, respectively) were noticed with T_5 (Paddy straw+ Jute bag+ *Rhizobium*) followed by T_8 (saw dust + *Rhizobium*) (23.93, 32.93, 36.67 and 30.07, respectively), T_6 (20.80, 32.13, 35.13 and 29.13, respectively) and T_7 Black polythene + *Azotobacter* (20.40, 31.67, 32.87 and 26.47 respectively). The significantly lower leaves plant-^{1} at 30, 60, 90 DAT and at harvest (13.07, 15.13, 18.73 and 15.60, respectively) were recorded with absolute control (T_1). Application of T_5 (Paddy straw+ Jute bag+ *Rhizobium*) recorded highest number of leaves due to the application of paddy straw mulch as it helps in retaining soil moisture by reducing evaporation, which is crucial for plant growth, especially in water-scarce conditions. This moisture retention promotes better root development, leading to increased nutrient uptake and improved plant vigor, which can result in a higher number of leaves (Iqbal *et al*, 2020) [4]. Jute mulch suppresses weed growth, reducing competition for nutrients and water, which allows the main crop to flourish and develop more leaves (Mia, 2022) [6].

4. Dry weight (g)

Higher dry weight of finger millet at 30, 60, 90 DAT and at harvest (8.23, 27.77, 40.64 and 51.06 g) were noticed with T_5 (Paddy straw+ Jute bag+ *Rhizobium*) followed by T_8 (saw dust + *Rhizobium*) (7.67, 26.53, 39.25 and 50.08 g), T_6 (7.07, 23.25, 37.22 and 46.13 g) and T_7 Black polythene + *Azotobacter* (6.80, 22.55, 35.19 and 44.33 g). The significantly lower dry weight at 30, 60 90 DAT and at harvest (3.75, 12.47, 21.46 and 28.03 g) were recorded with absolute control (T_1). The probable reason for highest dry weight of T_5 (Paddy straw+ Jute bag+ *Rhizobium*) is because straw mulch significantly increased soil moisture retention, reduced soil temperature fluctuations, and enhanced soil organic matter content. This created a more favorable environment for crop growth, resulting in increased dry matter production compared to unmulched control plots. As for jute bag mulch, it improved soil moisture retention, reduced soil temperature, and enhanced soil organic matter content. These improvements in soil conditions contributed to increased dry matter production.

Table 2: Effect of different types of mulching and biofertilizer on plant height (cm) of finger millet.

Treatments	Plant height (cm)			
	30 DAT	60 DAT	90 DAT	Harvest
T_1	21.20	44.47	61.47	63.33
T_2	29.73	70.67	91.93	93.47
T_3	29.60	68.40	88.27	90.20
T_4	28.53	66.00	85.07	86.47
T_5	31.27	76.87	99.20	100.80
T_6	30.33	74.33	97.00	98.53
T_7	30.00	73.60	94.60	96.53
T_8	30.53	75.40	97.73	99.53
F Test	NS	S	S	S
SEd (±)	0.36	0.87	1.08	1.09
CD (P=0.05)	2.52	8.21	2.31	9.61

Table 3: Effect of different types of mulching and biofertilizer on number of tillers plant^{-1} of finger millet

Treatments	Number of tillers plant^{-1}			
	30 DAT	60 DAT	90 DAT	Harvest
T_1	1.13	1.67	2.40	2.83
T_2	2.07	2.67	3.13	3.57
T_3	1.93	2.53	3.07	3.37
T_4	1.87	2.40	2.93	3.50
T_5	2.33	2.80	3.67	4.07
T_6	2.20	2.67	3.40	3.77
T_7	2.13	2.60	3.33	3.73
T_8	2.27	2.73	3.53	3.73
F Test	NS	S	S	S
SEd (±)	0.13	0.14	0.18	0.16
CD (P=0.05)	0.27	0.32	0.36	0.33

Table 4: Effect of different types of mulching and biofertilizer on number of leaves plant^{-1} of finger millet

Treatments	Number of leaves plant^{-1}			
	30 DAT	60 DAT	90 DAT	Harvest
T_1	13.07	15.13	18.73	15.60
T_2	19.80	29.80	32.33	25.57
T_3	18.40	24.73	29.33	22.07
T_4	17.47	23.07	26.13	20.53
T_5	25.27	33.40	38.73	32.13
T_6	20.80	32.13	35.13	30.07
T_7	20.40	31.67	32.87	26.47
T_8	23.93	32.93	36.67	29.13
F Test	NS	S	S	S
SEd (±)	0.25	0.60	0.49	0.49
CD (P=0.05)	2.97	5.04	5.05	4.33

Table 5: Effect of different types of mulching and biofertilizer on dry weight (g) of finger millet

Treatments	Dry weight (g)			
	30 DAT	60 DAT	90 DAT	Harvest
T_1	3.75	12.47	21.46	28.03
T_2	6.16	21.97	36.52	43.19
T_3	6.10	20.77	33.92	41.03
T_4	6.08	19.31	32.24	38.56
T_5	8.23	27.77	40.64	51.06
T_6	7.07	23.25	37.22	46.13
T_7	6.80	22.55	35.19	44.33
T_8	7.67	26.53	39.25	50.08
F Test	S	S	S	S
SEd (±)	0.38	0.55	0.73	0.89
CD (P=0.05)	1.14	3.71	4.74	5.78

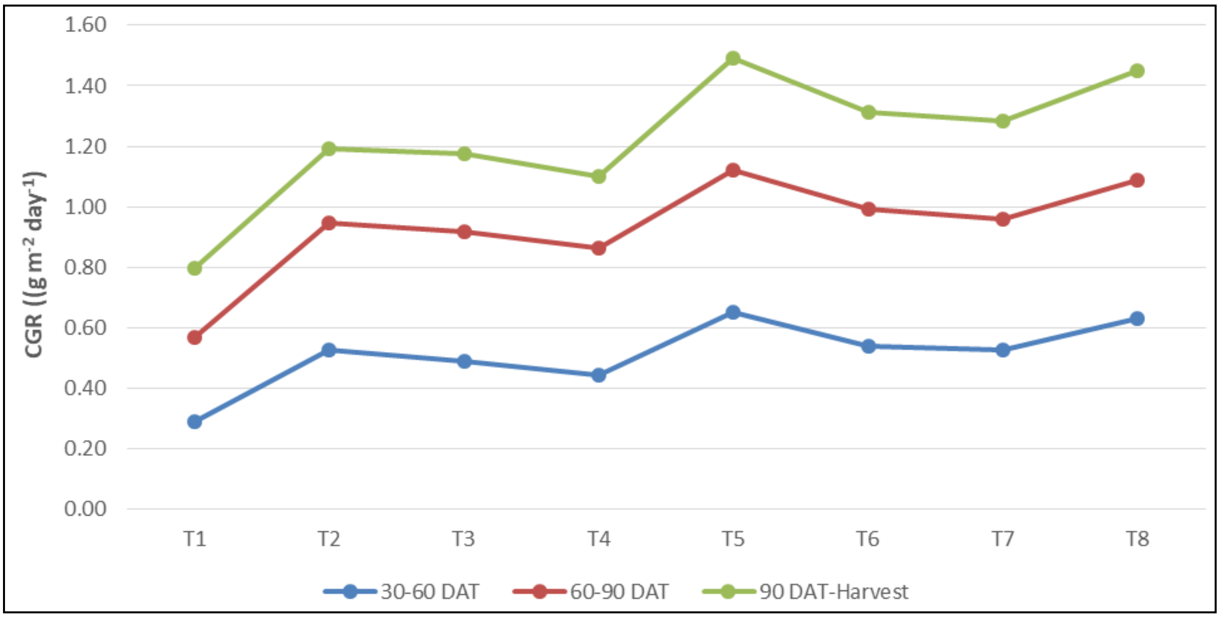

Fig 1: Effect of different types of mulching and biofertilizer on crop growth rate (g m^{-2} day^{-1}) of finger millet at different intervals.

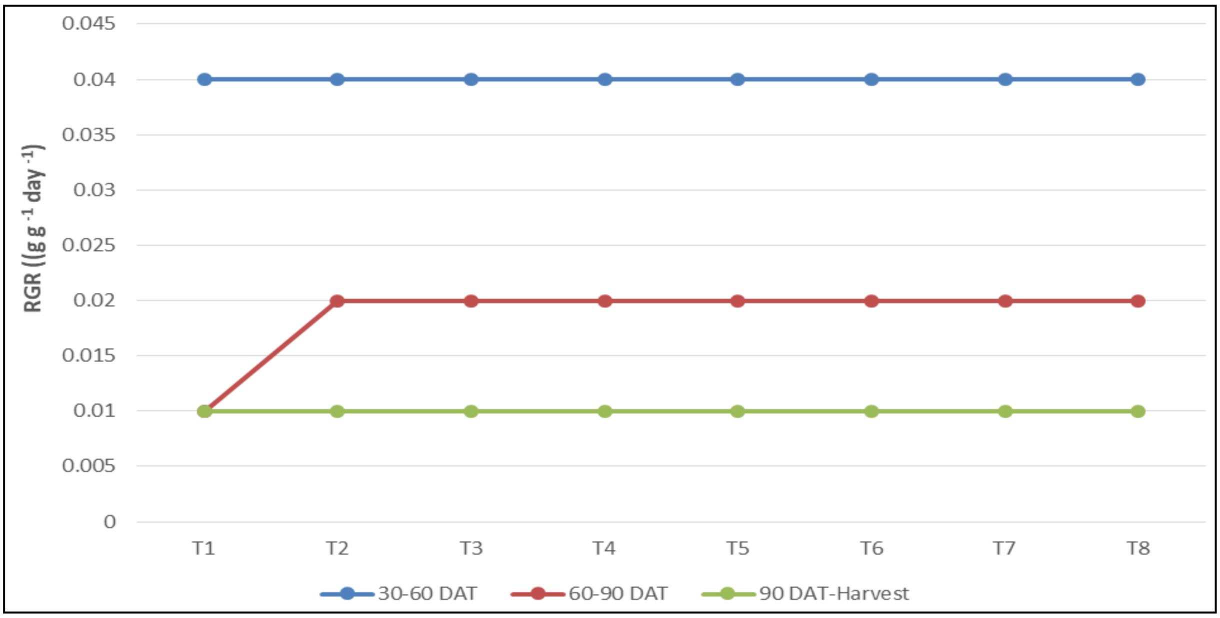

Fig 2: Effect of different types of mulching and biofertilizer on relative growth rate (g g^{-1} day^{-1}) of finger millet at different intervals.

Conclusion

In conclusion, the study clearly demonstrates that the use of mulching and biofertilizers significantly enhances the growth and yield of finger millet. Treatments with paddy straw and jute bag mulch combined with *Rhizobium* (T_5) showed the most notable improvements in plant height (cm), number of tiller $plant^{-1}$, number of leaves $plant^{-1}$ and dry weight (g). Treatment with paddy straw and jute bag mulch combined with *Rhizobium* (T_5) was also observed best in CGR (g m^{-2} day^{-1}) and RGR (g g^{-1} day^{-1}).

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