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Enhancing *kharif* pearlmillet (*Pennisetum glaucum*) growth and yield through integrated approaches: A comprehensive field study on animal dung composts, cow-based bio-enhancers and fertilizer management in loamy sand

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Abstract
Field experiment conducted during the June to November 2021 and 2022. Throughout both years, the trials were carried out at the same location. Results obtained indicated that among the different composts made from different animal dung, goat dung compost at a rate of 100 quintal/ha was found to be superior in the case of pearlmillet height, effective pearlmillet tillers, earhead length, pearlmillets' seed and straw yield. Cow-based bio-enhancers, particularly *Panchagavya*, enhanced pearlmillet height, effective pearlmillet tillers, length of earhead and seed yield and straw yield compared to cow urine and *Jivamrut*. Fertilizer significantly affected plant height, effective tillers and earhead length, with the recommended dose of fertilizer outperforming 75%. Interaction effect revealed synergies between goat dung compost, *Panchagavya* and 100% fertilizer dose, superior plant height, earhead length and seed yield. The study highlights the potential for integrated approaches involving specific compost, cow-based bio-enhancers and fertilizer levels to optimize pearlmillet growth and yield.

Keywords: Animals' dung compost, cow-based bio-enhancer, fertilizer, growth, pearlmillet

1. Introduction
Out of 328.72 million hectares of land, a total of 178.52 million hectares is cultivated in India (Agricultural Land (% of Land Area) - India, 2024) [1]. In the western part of India, mainly states like Gujarat cultivates a wide range of different crop cultivars *i.e.*, during the *kharif* season, bajra, maize, paddy, groundnut and in the *rabi* season, cotton, chickpea, wheat and mustard *etc.* (India at a Glance, 2024) [10]. After rice-wheat-maize, pearlmillet is cultivated the most. India is the worldwide biggest producer of pearlmillet. It occupied 69.3 lakh ha area with an average 86.1 lakh tones production and 1.243 tone/ha productivity during 2018-19 (Directorate of Millets Development, Jaipur Area, Production and Yield of Millets during 2011-12 to 2021-22, 2021). The only cereal crop that can both respond to rigid management requirements and produce a consistent yield in marginal areas is pearlmillet. Its nutritious value of seed is an important food for different animals during scarcity periods. livestock and poultry animals feed on pearlmillet seed. Pearlmillet production, far less than its potential, it's very with rainfall intensity, quantity and spread. Therefore, the focus of the research should be redirected to address the issues causing its low productivity. To popularize millets in order to take use of their nutrient-rich qualities and encourage their farming, The government of India has declared the Year 2018 as the "National Year of Millets" (International Year of Millets (IYM) 2023 Kick Starts with Focussed Activities Being Undertaken by Central Ministries, State Governments and Indian Embassies, 2023) [13], and the Year 2023 was declared as "International Year of Millets" by Food and Agriculture Organization Committee on Agriculture (COAG) forum (International Year of Millet 2023, 2023) [12, 13].

Well-deposed farm yard manure and composts made from different animals' dung were recognized organic source of major and micro nutrients added to the crop production area before chemical fertilizers introduced in the mid-nineteenth century (Hauck, 1982) [9]. Regularly adding of organic materials increases the soil's physical properties, increased aggregate strength and reduced bulk density of soil (Diacono & Montemurro, 2010) [6]. Most astounding organic manures is farm yard manure which maintaining fertility and health of soil in alternative agriculture systems (Järvan *et al*., 2017) [15]. Roughly sixty different types of bacteria were found in cow feces. Among them, *Bacillus sp, Corynebacterium sp, hemicelluloses* and *Lactobacillus sp*. are the bacterial species, *Aspergillus* and *Trichoderma* are the dominant fungal species, roughly hundred kinds protozoa and yeasts of *Saccharomyces* and *Candida*. These *Bacillus* genus check harmful pathogens activities and secret beneficial growth hormones for plant. (Lalitha, Ch. and Krishna, 2019) [19]. Cow based different bio-enhancers *i.e*., *Panchagavya*, *jivamrut* revealed that some amount of all require major nutrients as well as trace elements essential for normal plant and growth hormones like kinetin, gibberellic as well as IAA required for crop growth (Xu, 2001) [43].

Different compost made from mainly animal dung *i.e.*, cow dung compost, buffalo dung compost and goat dung compost, also cow-based various bio-enhancers as supplier of essential crop elements order to maintain ecological stability, maximize soil productivity, and lowering the need for fertilizers made from chemicals. Thus, this study investigates the effect of different composts from different animals' dung, cow-based bio-enhancers and fertilizer levels on pearlmillet under pearlmillet-chickpea cropping sequence on loamy sand.

2. Materials and Methods

Research experiments have been carried out at plot number B-9, at Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar, Banaskantha during *kharif* and *rabi* seasons of 2021-22 and 2022-23. Physico-chemical properties and characteristics of field trial soil are given in Table 1. Split-split plot design have been used in field research, in which five different animal dung composts were selected as the main plot, whereas three cow-based bio-enhancers were selected as sub-plot and two levels of inorganic fertilizer were selected as sub-sub plot. Ultimately, thirty treatment combinations involving five different animal dung compost, three cow-based bio-enhancers and two levels of inorganic fertilizer have been used in this investigation. The following treatments were carried out:

Treatments:

Main plot: Different animal dung compost (M)

M_1. FYM at a rate of 100 quintal ha^{-1}

M_2. Cow dung compost at a rate of 100 quintal ha^{-1}

M_3. Buffalo dung compost at a rate of 100 quintal ha^{-1}

M_4. Goat dung compost at a rate of 100 quintal ha^{-1}

M_5. Goat dung compost at a rate of 50 quintal ha^{-1}

Sub plot: Cow-based bio-enhancers (B)

B_1: Cow urine spray at a rate of 5% at 35 and 60 DAS

B_2: *Panchagavya* spray at a rate of 3% at 35 and 60 DAS

B_3: *Jivamrut* at a rate of 200 lit ha^{-1} at 35 and 60 DAS

Sub-sub plot: Inorganic fertilizer (F)

F_1: 100% RDF

F_2: 50% RDF

Seed inoculation was made with 10 ml *Azotobacter* per kg seed and 10 ml PSB per kg pearlmillet seed. Pearlmillet (*Pennisetum glaucum* L. c.v. GHB 558) were cultivated (on 17th June 2021 and 10th June 2022) at the same field site, while the different composts made from different animal dung added as per treatments to soil and mixed thoroughly with the 20 cm layer of soil depth before 15 days of cultivating *kharif* pearlmillet during both the years of field experiments. Also, cow-based various bio-enhancers and recommended doses of fertilizer (RDF) were added as per treatment combinations.

Table 1: Initial analysis value of experiment site.

Sr. No.	Properties		Value 2021-22	Method employed
1	**Physical soil properties**			
	A	Coarse sand (%)	84.32	International Pipette method (Piper, 2019)
	B	Silt (%)	7.28	
	C	Clay (%)	8.40	
	D	Textural class	Loamy sand	
2	**Chemical soil properties**			
	A	Soil $pH_{1:2.5}$	7.1	Potentiometric method (Jackson, 1973)
	B	Electrical Conductivity (dS m^{-1})	0.13	Schofield method (Jackson, 1973)
	C	Organic carbon (%)	0.27	Walkley and Black's method (Jackson, 1973)
	D	Available N (kg ha^{-1})	148	(Subbiah & Asija, 1956)
	E	Available P_2O_5 (kg ha^{-1})	35.8	(Olsen *et al*., 1954)
	F	Available K_2O (kg ha^{-1})	246	Flame Photometer method (Jackson, 1973)
	G	DTPA- extractable micronutrient cations		
	I.	Fe (mg kg^{-1})	4.07	1. Extraction: 0.005 M DTPA (Lindsay & Norvell, 1978)
	II.	Zn (mg kg^{-1})	0.467	
3.	**Physical properties**			
	A	Bulk density (Mg m^{-3})	1.410	Core sample method (Piper, 2019)
	B	MWHC (%)	25.68	Gravimetric method (Piper, 2019)
4.	**Biological properties (cfu /g of soil)**			
	A	Total bacterial count	78×10^5	Spread plate method (Sanders, 2012)

2.1 Composting method

Different animals dug composts were prepared at Agronomical Instrumental Farm, S. D. Agricultural University, Sardarkrushinagar with the Bangalore method (Paul *et al*., 2019) [29] of composting and dry waste matter of sunhemp 25 cm thick layer was spread in a pit. Three distinct pits containing a thick suspension of goat, buffalo, and cow dung slurry were filled with an alternate layer of dry waste material and dung suspension until the pits rose 0.5 meters above ground. After that, water was sprayed on the pits to moisten them. It was left outside for fifteen days without any protection. After giving it a turning and plastering it with wet mud, it was abandoned for roughly five month, or until needed. Cow dung compost, buffalo dung compost and goat dung compost were spread based on guidance 15 days ahead of seeding and uniformly mixed with soil (Paul *et al*., 2019) [29].

Bio-chemical properties of animals' dung composts as well as cow-based bio-enhancers are presented in Table 2.

Table 2: Composition of different organic inputs used in the experiment

Sr. No.	Different organic sources	Years	Nutrient content (%)			DTPA extractable micronutrient cations (mg/kg or L)		Total bacterial count (10^6 cfu/g soil)
			N	P	K	Fe	Zn	
1	FYM	2021-22	0.48	0.17	0.43	574	137	116
		2022-23	0.51	0.19	0.38	569	122	108
2	Cow dung compost	2021-22	0.83	0.21	0.47	613	154	168
		2022-23	0.79	0.23	0.51	666	162	183
3	Buffalo dung compost	2021-22	0.68	0.19	0.48	567	124	125
		2022-23	0.63	0.15	0.42	601	112	135
4	Goat dung compost	2021-22	1.1	0.30	0.55	862	161	155
		2022-23	1.03	0.25	0.52	712	154	161
5	Cow urine	2021-22	0.97	0.05	0.90	35	24	0.42
		2022-23	0.82	0.06	1.02	28	15	0.76
6	*Panchagavya*	2021-22	0.68	0.08	0.50	45	1.27	34
		2022-23	0.51	0.10	0.65	65	2.34	28
7	*Jivamrut*	2021-22	0.65	0.01	0.10	98	4.23	32
		2022-23	0.64	0.02	0.17	154	5.67	39

2.2 Meteorological trend

The experimental location is situated in the North Gujarat Agro-climatic Zone IV. The zone famous for arid and semi-arid climate condition with a moderately cold winter, while summer is hot. From the middle of June onward, the monsoon comes to an end in the middle of September. South-west monsoon is reason of majority of the precipitation. The Meteorological Observatory kept track of weekly average meteorological data for the highest and lowest temperatures, relative humidity, hours of sunlight, rainfall, and evaporation throughout the duration of the research period, Chimanbhai Patel College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat) and graphically depicted in Fig. 1 and Fig. 2 for the year 2021 and 2022, respectively.

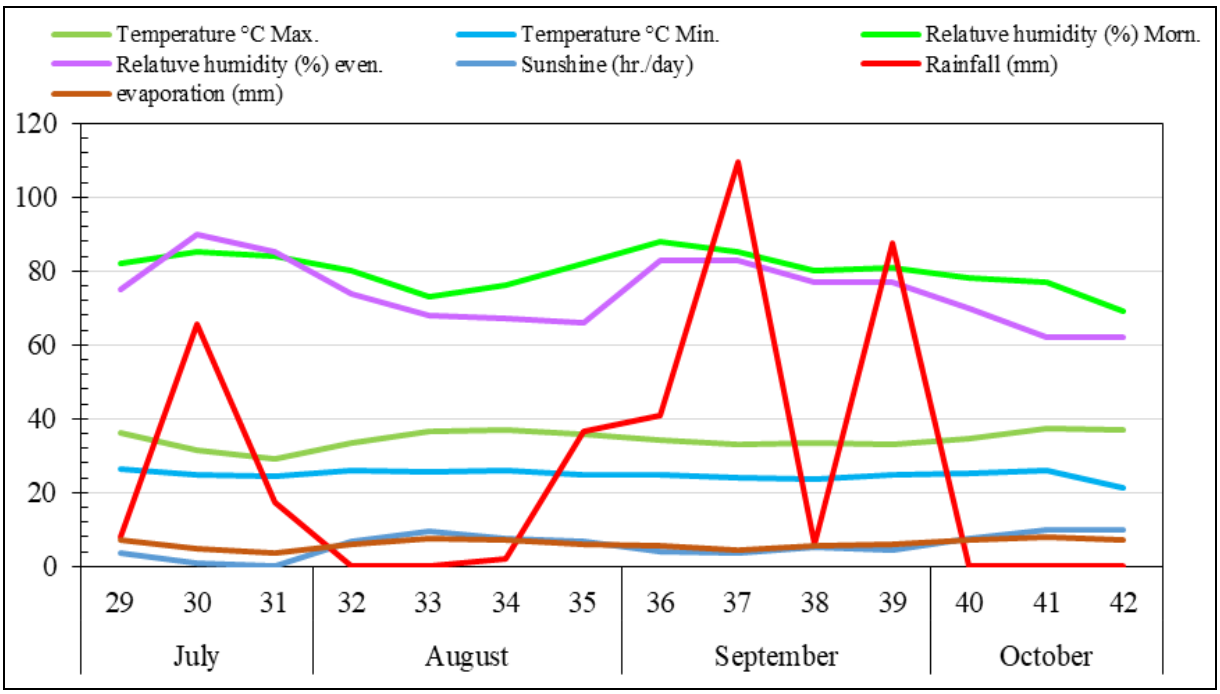

Fig 1: Meteorological data taken during pearlmillet growth period (*Kharif*, 2021)

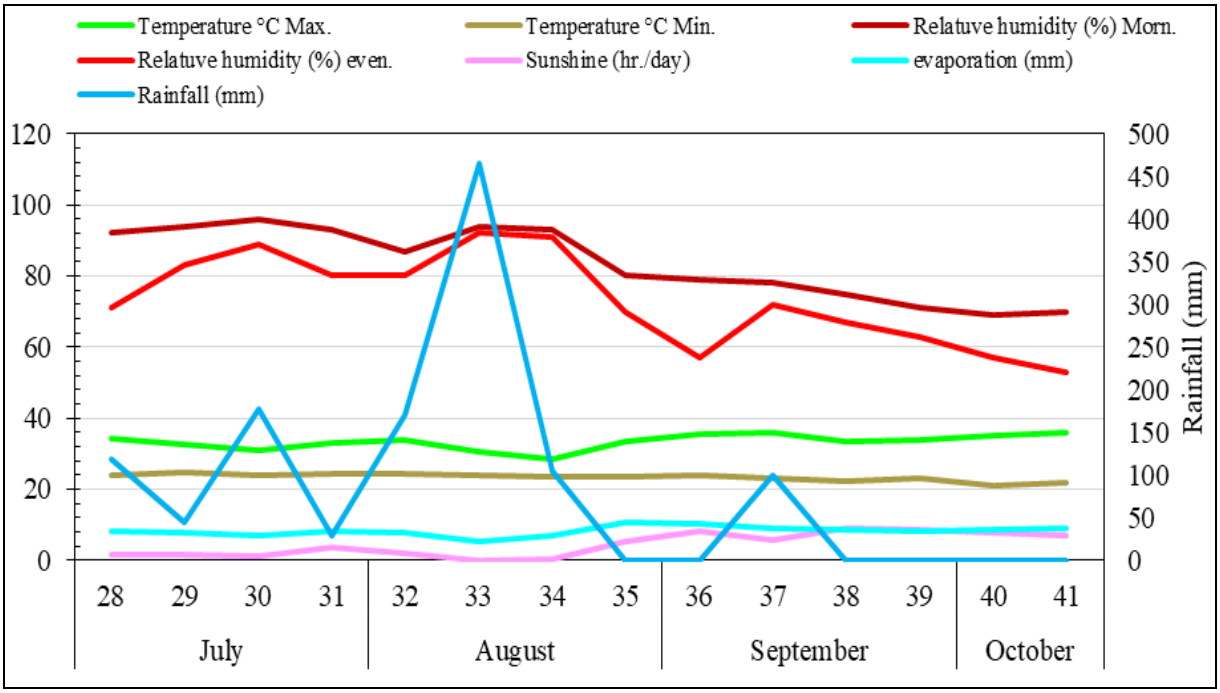

Fig 2: Meteorological data taken during pearlmillet growth period (*Kharif*, 2022)

2.3 Statistical analysis

Using standard software, the statistical analysis of the experimentation data accordance with the standard protocol outlined by (Cochran & Cox, 1992) [5]. A five percent significance level was applied when comparing the variances of the various sources of variation in the "ANOVA" with the value of Table 'F' using the 'F' test. Additionally analysed were S. Em. ±, Critical Differences, and Coefficient of Variance (C.V.%). Because the experiment site was fixed and the treatments were randomly assigned for both years, the pooled experiment research data statistical analysis of the two years of data was completed in accordance with the standard procedure recommended by (Cochran & Cox, 1992) [5].

3. Results and discussion

3.1 Effect of animal dung composts

3.1.1 Pearlmillet population/ metre row length

Effect of applying different animal dung composts are shown in Table 3. Different composts did not have any strong impact on pearlmillet population at 30 DAS and harvested during both the individual years of field experimentation and in the pooled analysis. It might be due to the plant population being directly affected by the seed germination which is a genetic characteristic not affected by different animal dung composts (Oloniruha *et al*., 2021 and Solanki *et al*., 2023) [25, 35].

3.1.2 Plant height (cm)

Table 3 show the data of *kharif* pearlmillets' plant height at 30 days after sowing did not significantly differ under the influence of animal composts during both 2021 and 2022 as well as in pooled results. Because of the initial growing days, plant did not require much nutrient; also, different animal dung composts supplied sufficient plant nutrients at initial stage (Solanki *et al*., 2023) [35]. However, at the time of harvest, crop height has been found statistically higher under the goat dung compost at a rate of 50 quintal ha^{-1} during the year of 2021 and 2022 and in pooled analysis over the rest of the animal composts except 10 t cow dung compost/ha during both years of study and with 10 t buffalo dung compost/ha in the first year of experiment only. At the maturity stage, plant require more quantity of nutrients which are full filled with higher nutrients concentrate compost (Table 2) *i.e.*, goat/cow dung compost (Awodun *et al*., 2007; Maerere *et al*., 2009) [2, 21].

3.1.3 Effective tillers per plant

Statistically analysis data graphically depicted in Fig. 3 reported that among the different animal dung composts, 10 t goat dung compost/ha (M_5) registered significantly higher effective tillers (3.99, 4.04 and 4.01) per plant compared to all other treatments except 10 t cow dung compost/ha during both years and in pooled results and with buffalo dung compost at a rate of 10 t/ha during the year of 2021. (Awodun *et al*., 2007; Ayeni & Oye, 2017) [2, 3] reported that might be attributed to that the decomposition of goat dung compost enhanced mineralization of nutrients in the soil, the more release of nutrient through enhanced mineralization from the richer sources of nutrient (goat dung compost) that resulted in better vegetative growth by producing more effective tiller per plant.

3.1.4 Earhead length (cm)

Significantly higher earhead length (cm) of pearlmillet was influenced by 10 t goat dung compost per ha over different animal dung composts during the years of 2021 and 2022 and in pooled except with treatment M_2 (10 t cow dung compost per ha) during year of 2021, 2022 and in pooled and treatment M_3 (buffalo dung compost at a rate of 10 t/ha) during first year and M_1 (10 t FYM per ha) and M_2 (10 t cow dung compost per ha) during second year (graphically depicted in Fig. 3). It might due higher dose of goat/cow dung compost *i.e.*, 10 t/ha improve the physical condition of soil and could have supplied sufficient N which resulted in better photosynthesis, potassium act as an activator for various enzyme involve in protein synthesis and starch and also high P that can compose a substance known as adenosine triphosphate (ATP) which directly contributes to the energy storage and transfer process involved in plant metabolism and improves the yield component like effective tiller. Similar kind of results found by (Indria Ningsih *et al*., 2019) [11].

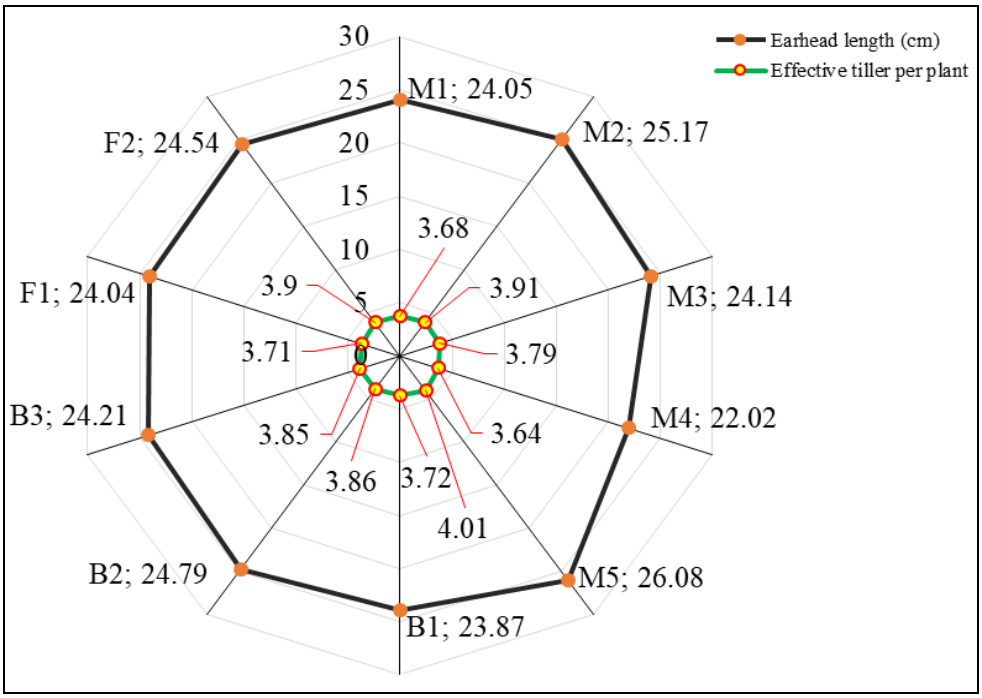

Fig 3: Effective tillers and pearlmillet earhead length as influenced by different treatments

3.1.5 Grain yield (kg/ha)

Research data presented in Table 4 explicitly show that 10 t goat dung compost per ha (M_5) produced statistically higher pearlmillet seed as compared to the rest of the treatments during pooled and two-year study. The magnitude of increase pearlmillet seed production through 10 t goat dung compost per ha (M_5) to the tune of 11.95, 9.96, 12.01 and 13.36 per cent over the application of 10 t FYM per ha (M_1), 10 t cow dung compost per ha (M_2), 10 t buffalo dung compost per ha (M_3) and 10 t goat dung compost per ha^{-1} (M_4), respectively. The significant improvement in grain yield of pearlmillet is also supported that the application of 10 t goat dung compost significantly increased almost all the yield contribute character, especially the number of effective tiller plant^{-1} and earhead length (Jawale *et al*., 2009; Suthamathy & Seran, 2013; Uwah & Eyo, 2014) [16, 39, 41].

3.1.6 Straw yield (kg/ha)

The data presented in Table 4 reveled that B_5 treatment (10 t goat dung compost per ha) demonstrated a significantly superior straw yield. Specifically, the yields were 5610, 5617 and 5613 kg per hectare in 2021, 2022 and in pooled results, respectively. This performance surpassed all other treatments except for cow dung compost at 10 t/ha, observed in both individual years and in the combine results, and buffalo dung compost at 10 t/ha, observed in the second year only. On a pooled basis of statistical analysis, the enhancement in pearlmillet straw yield was a notable increase of 11.28%, 4.21%, 7.03% and 12.10% under the application of 10 t goat dung compost per ha compare to 10 t FYM per ha, 10 t cow dung compost and 10 t buffalo dung compost per ha and goat dung compost 50 quintal ha^{-1}, respectively. Compost made from goat dung might improve the overall bio-chemical properties of soil including supply of the essential plant nutrients (Washaya & Washaya, 2023) [42]. Thus, a good nutrition in a conducive environment may have aided in the development of new tissues and vegetative growth, which in turn enhanced growth of crop and ultimately, the amount of pearlmillet straw (Awodun *et al*., 2007; Jawale *et al*., 2009) [2, 16].

3.2 Effect of cow-based bio-enhancers

3.2.1 Pearlmillet population/ metre row length

The static analysis data displayed in Table 3 indicated that different cow based bio-enhancer had no exert notable impact on the pearlmillet population and at harvest of crop during both the year of field experimentation and as well as the combined results of these two years (pooled results). The spray of bio-enhancers did not have any impact on the germination of the seed because the first spray of cow-based bio-enhancers was applied after germination.

3.2.2 Plant height (cm)

A two-year field experiment data as well as pooled analysis data presented in Table 4 explicitly show that the application of cow-based bio-enhancers did not have any significant effect on plant height at 30 days after sowing of pearlmillet crop. However, at the time of harvest, significantly higher plant heights *viz*., 190.70 and 189.81 cm were recorded during 2021 (1st year) and on pooled basis, respectively under the 5% spray of *Panchagavya* at 35 and 60 DAS over 5% sprays of cow urine at 35 and 60 DAS (B_1) and remained at par with Jivamrut at a rate of 200 l/ha at 35 and 60 DAS (B_3) in soil application. Application of *Panchagavya* through foliar enhanced vegetative growth of pearlmillet because it contains the macro and trace nutrients (Table 2) as well as growth hormones which could increase the production of growth regulator in the plant cell system favouring better cell division and elongation (Swarnam *et al*., 2016; Yadav & Lourduraj, 2006) [40, 44].

3.2.3 Effective tillers per plant

Application of *Panchagavya* at a rate of 5% spray at 35 and 60 DAS during 2021 and in pooled analysis data depicted in Fig. 3 recorded significantly higher effective tillers per plant as compared to 5% two spray of cow urine but remained at par with 200 l *jivamrut* per ha in soil at 35 and 60 DAS. This might be due to the fact that easy transfer of nutrients to plants through for enhancement in number of effective tillers. These results are in close vicinity with the findings of (Somasundaram *et al*., 2003) [36].

3.2.4 Earhead length (cm)
On pooled basis, 5% spray of *Panchagavya* at 35 and 60 days after sowing registered 3.85% and 2.40% higher earhead length over 5% spray of cow urine at 35 and 60 days after sowing and 200 l *Jivamrut*/ha at 35 and 60 days after sowing (Fig. 3). (Mathukia *et al*., 2020; Sutar *et al*., 2018) [22, 38] reported that *Panchagavya* has growth enzymes and growth-promoting substance such as auxin, indole acetic acid, gibberellic acid, cytokinin which increase the earhead length.

3.2.5 Grain yield (kg/ha)
Statistical analysis of two-year field experimentation data is given in Table 4. Indicate that a 5% spray of *Panchagavya* at 35 and 65 days after sowing produced a significantly higher grain yield of *kharif* pearlmillet as compared to cow urine but was found at par with *Jivamrut*. (Saharan *et al*., 2023) [31] reported that *Panchagavya* content kinetin and plant growth regulators which have a role in enhancing chlorophyll content in leaves, and jivamrut increase the beneficial microbes population in the soil which improves available nutrients in the soil.

3.2.6 Straw yield
The increase in straw yield under 5% spray of *Panchagavya* at 35 and 60 days after sowing were to the tune of 220 and 12 kg ha^{-1} over treatment cow urine and *Jivamrut*, respectively. The foliar spray application of an optimal dose of Panchagavya could encourage the easy transfer of nutrients and growth stimulants to plants, ultimately leading to an improvement in yield attributes and yield itself. Lower levels of gibberellic acid and indole acidic acid in *Panchagavya* may have created stimuli in the crop system, boosting the formation of growth regulators in the cell system and their activity in the crop system, promoting the required growth and development and raising the yield of pearlmillet straw (Muthukapalli Krishnareddy *et al*., 2022) [24].

3.3 Effect of fertilizer levels
3.3.1 Pearlmillet population per metre raw length
Data presented in Table 3 showed application of 75% and 100% RDF did not make a significant difference in pearlmillet population during two growth stages.

3.3.2 Plant height (cm)
100% and 75% recommended dose of fertilizer had not significant effect on pearlmillet crop height at 30 days after sowing during the second year as well as pooled analysis but in the first year (2021) statistically higher plant was recorded under the influence of 100% fertilizer over 75%. At harvest, significantly higher plant height was recorded under the influences of 100% compared to 75% dose of fertilizer *i.e.*, 186.95, 188.58 and 187.76 cm during the years of 2021, 2022 and in pooled analysis, respectively (Table. 3). (Sakarvadia *et al*., 2012) [32] reported that better supply of N and P_2O_5 could help plant to utilize other essential plant nutrients in more effective way.

3.3.3 Effective tillers per plant
Pearlmillet plant effective tiller were recorded as 5.40% greater under the treatment of 100% dose of fertilizer during pooled analysis of both year field experiments (Graphically depicted in Fig. 3). Sufficient available nitrogen and phosphorus at the time of requirement increased plant cell number and cell size leading to better growth in term of per plant pearlmillet tillers and plant growth (Gautam *et al*., 2020; Kumar *et al*., 2022; Sakarvadia *et al*., 2012) [8, 17, 32].

3.3.4 Earhead length (cm)
The magnitude of the increase in earhead length of *kharif* pearlmillet crop with the 100% dose of fertilizer over 75% was to the tune of 2.08 per cent. Nitrogen and phosphorus enhanced strong cell wall and therefore better earhead length which might be resulted into profuse earhead of pearlmillet (Gautam *et al*., 2020) [8].

3.3.5 Grain yield (kg/ha)
The augmentation in pearlmillet grain production resultant from the imposition of a complete regimen of 100% dose of fertilizer (F_2), in contrast to the administration of 75% (F_1), manifested an increment of 2.76%, 3.66%, and 3.16% for the respective field experimentation years 2021, 2022, and in the amalgamated findings (Table. 4). Enhanced nitrogen rate, increases the activity of cytokinin in plant which leads to the increased cell-division and elongation resulted in higher photosynthesis better growth of plant and dry-matter production and Nucleic acids (RNA and DNA), nucleoproteins, amino acids, proteins, phospholipids, and various co-enzymes all require phosphorus as a necessary component. These two elements create effective growth and greater tillers per plant resulted higher grain yield of pearlmillet was obtained (Meena & Gautam, 2005; Sakarvadia *et al*., 2012) [8, 32].

3.3.6 Straw yield (kg/ha)
Pearlmillet crop through 100% RDF registered significantly higher straw yield of pearlmillet during the first year of field experiment and in pooled analysis *i.e.*, 5337 and 5314 kg/ha, respectively over 75% fertilizer but straw yield of pearlmillet did not influence significantly under the various fertilizer levels during 2022 (Table. 4).

3.4 Interactions effect of different animal dung composts and cow-based bio-enhancers
The statistically analysis field experiment data graphically illustrated in Fig. 4 revealed that 10 t goat dung compost per ha and two sprays of 5% *panchagavya* at 35 and 60 days after sowing produced significantly higher earhead length during pooled analysis and grain yield during first year of field experimentation compared to rest of treatments combination but in case of earhead length at par with 10 t goat dung compost/ha and jivamrut at a rate 200 l at 35 and 60 days after sowing. (Pati & Udmale, 2016) [28] reported that it because of improves the overall nutrient levels of soil resulted nutrient balance maintain in plant system which improve the grain yield.

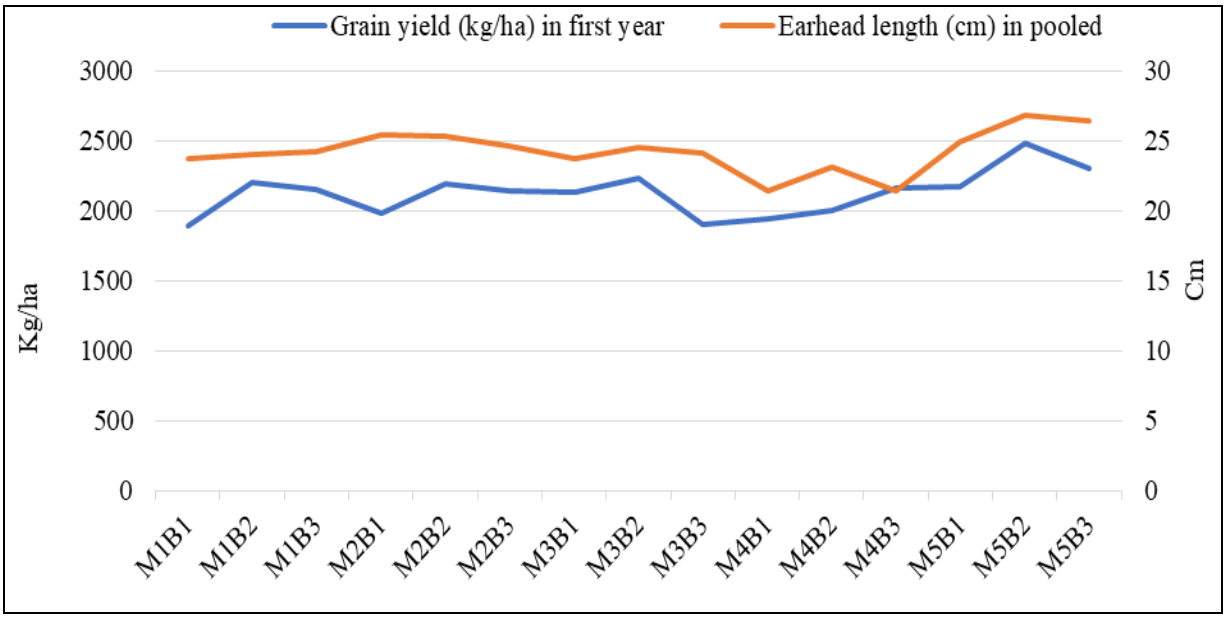

Fig 4: Interaction effect of different animal dung composts and cow based bio-enhancer on grain yield and earhead length

3.5 Interactions effect of different animal dung composts and levels of fertilizer

Treatment combinations 10 t goat dung compost/ha and 100% dose of fertilizer statistically significant plant height during first year and in pooled analysis as well as grain yield during the first year over rest of treatment combination but in case of plant height, it was found at par with 10 t goat dung compost/ha + 75% recommended dose of fertilizer and 100 quintal ha^{-1} buffalo dung compost + 75% recommended dose of fertilizer during the first year of experimentation (Graphically illustrated in Fig. 5). The balanced plant nutrition positively influenced the growth of pearlmillet as it is observed in this work.(Parihar *et al*., 2009; Singh & Chauhan, 2014).

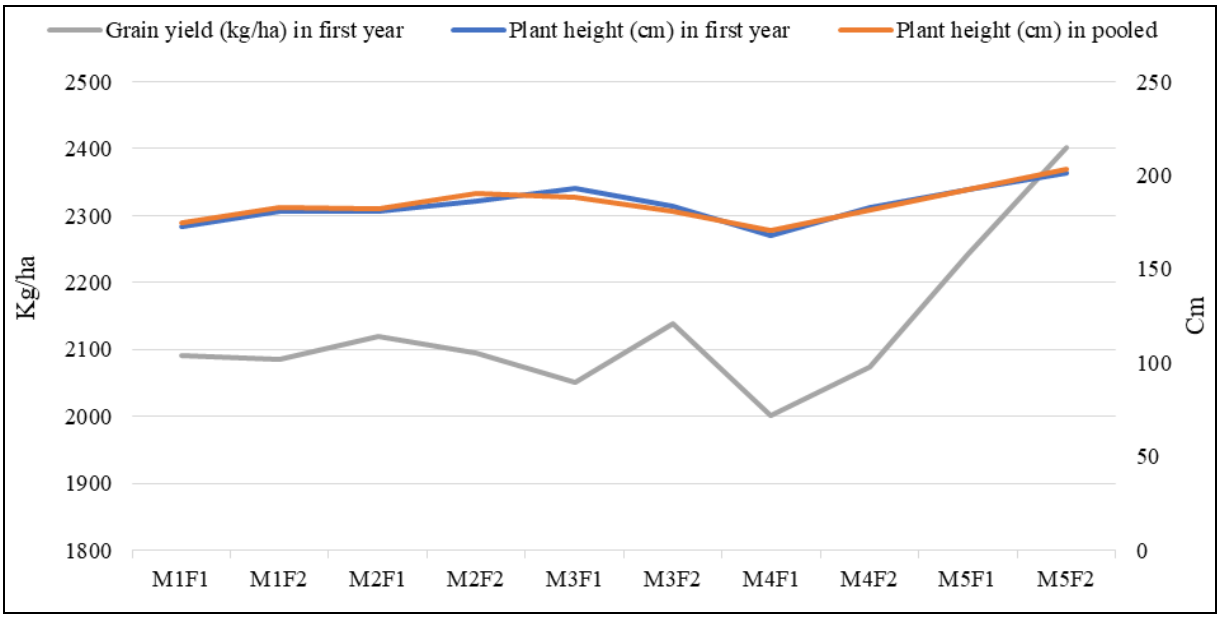

Fig 5: Interaction effect of different animal dung composts and cow based bio-enhancer on plant height and grian yield

3.6 Interaction effect of different animal dung composts, cow-based bio-enhancers and levels of fertilizer

The statistically analysis field experimentation data graphically illustrated in Fig. 6 showed that 10 t goat dung compost/ha + 5% spray of *Panchagavya* at 35 and 60 days after sowing + 100% dose of fertilizer produced significantly higher plant height during the first year, earhead length (cm) during pooled analysis and grain yield during the first year and in pooled results compared to rest of treatments but in case of plant height it was at par with $M_2B_2F_2$, $M_2B_3F_2$, $M_3B_3F_1$, $M_3B_1F_2$, $M_4B_2F_2$, $M_5B_2F_1$ and $M_5B_3F_2$ treatments combinations during first year of experiment and earhead length found at par with treatment $M_5B_3F_2$. This affirms that goat dung compost at a rate of 10 t/ha releases more nutrient for optimum plant growth, its combined use with 100% recommended dose of fertilizer and cow-based bio-enhancer i.e., *Panchagavya* could ensure a balanced nutrition inorganic fertilizer has high N and P concentration also, (Kumawat *et al*., 2013) *Panchagavya* supply plant growth

hormones like auxin, indole acetic acid, gibberellic acid, which enhance plant growth like earhead length, plant height *etc*. as well as the balanced plant nutrition positively influenced on earhead length of pearlmillet as it is observed in this work. Similar results were founded by (Bhawana *et al*., 2023; Pati & Udmale, 2016) [4, 28].

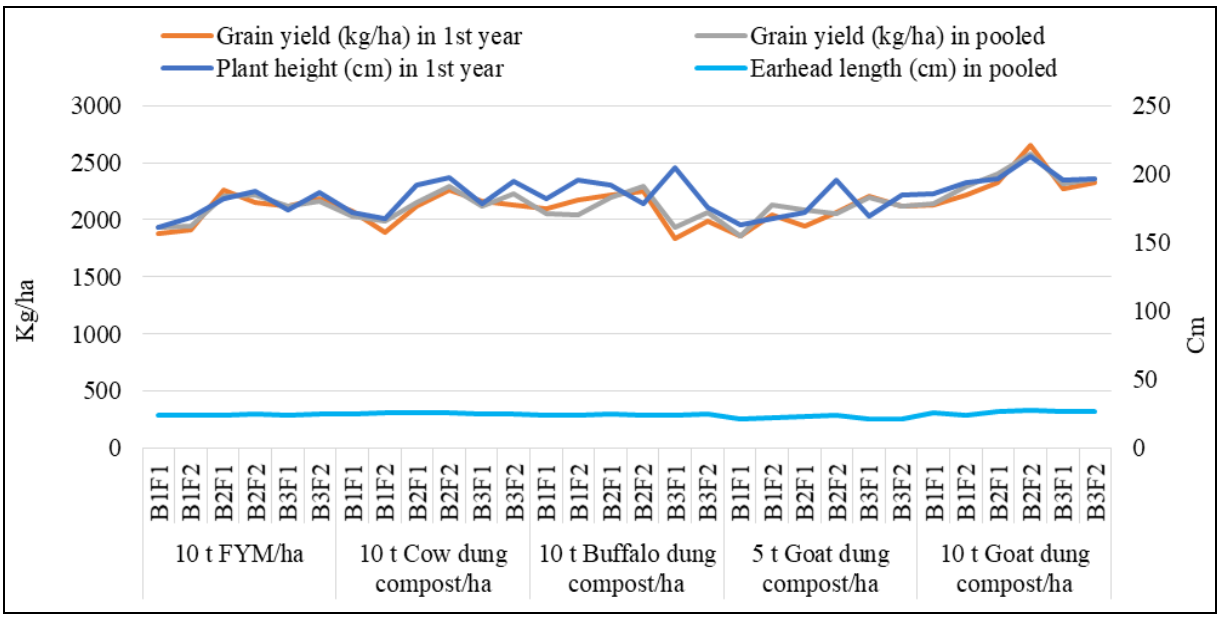

Fig 6: Interaction effect of different animal dung composts, cow-based bio-enhancers and levels of fertilizer on grain yield, plant height and earhead length

Table 3: Plant population and height of pearlmillet as influenced by different treatments

Treatments	Plant population (per metre row length)						Plant height (cm)					
	At 30 DAS			At harvest			At 30 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Main plot: Organic manures (M)												
M_1: FYM at a rate of 100 quintal ha^{-1}	10.09	10.02	10.05	9.80	9.87	9.83	55.91	56.89	56.40	176.64	180.57	178.61
M_2: Cow dung compost at a rate of 100 quintal ha^{-1}	10.02	10.08	10.05	10.01	9.86	9.94	57.32	58.24	57.78	183.66	189.17	186.41
M_3: Buffalo dung compost at a rate of 100 quintal ha^{-1}	10.05	10.06	10.05	9.89	9.95	9.92	56.67	57.94	57.31	188.36	181.28	184.82
M_4: Goat dung compost at a rate of 5 t ha^{-1}	10.02	10.06	10.04	9.90	9.86	9.88	55.72	56.65	56.18	175.50	176.66	176.08
M_5: Goat dung compost at a rate of 100 quintal ha^{-1}	10.06	10.02	10.04	9.84	9.84	9.84	58.07	58.38	58.23	196.86	199.46	198.16
S. Em. ±	0.13	0.13	0.092	0.20	0.19	0.14	1.60	1.62	1.139	4.46	4.33	3.11
C. D. (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	14.55	14.11	9.32
Sub plot: Cow-based bio-enhancers (B)												
B_1: Cow urine spray at a rate of 5% at 35 and 60 DAS	10.07	10.03	10.05	9.92	9.79	9.85	57.26	57.63	57.45	175.83	183.85	179.84
B_2: *Panchagavya* spray at a rate of 3% at 35 and 60 DAS	10.02	10.07	10.04	9.73	9.93	9.83	56.27	57.07	56.67	190.70	188.93	189.81
B_3: *Jivamrut* at a rate of 200 l/ha at 35 and 60 DAS	10.05	10.04	10.05	10.02	9.91	9.97	56.68	58.16	57.42	186.08	183.50	184.79
S. Em. ±	0.10	0.10	0.07	0.11	0.14	0.09	0.46	0.64	0.39	3.19	2.68	2.08
C. D. (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	9.41	NS	5.96
Sub-sub plot: Fertilizer levels (F)												
F_1: 75% RDF	10.02	10.03	10.03	9.92	9.88	9.90	56.17	57.55	56.86	181.46	182.28	181.87
F_2: 100% RDF	10.07	10.06	10.06	9.86	9.88	9.87	57.30	57.69	57.50	186.95	188.58	187.76
S. Em. ±	0.07	0.07	0.05	0.09	0.10	0.07	0.32	0.34	0.23	1.62	1.82	1.22
C. D. (P= 0.05)	NS	NS	NS	NS	NS	NS	0.93	NS	NS	4.69	5.27	3.45
Significant interaction (s)	-	-	-	-	-	-	-	-	-	M×F, M×B×F	-	M×F

Table 4: Grain and straw yield of pearlmillet as influenced by different treatments

Treatments	Grain yield (kg/ha)			Straw yield (kg/ha)		
	2021	2022	Pooled	2021	2022	Pooled
Main plot: Organic manures (M)						
M_1: FYM at a rate of 100 quintal ha^{-1}	2088	2111	2099	5097	4991	5044
M_2: Cow dung compost at a rate of 100 quintal ha^{-1}	2107	2166	2137	5355	5418	5386
M_3: Buffalo dung compost at a rate of 100 quintal ha^{-1}	2095	2101	2098	5228	5259	5244
M_4: Goat dung compost at a rate of 5 t ha^{-1}	2038	2108	2073	5021	4994	5007
M_5: Goat dung compost at a rate of 100 quintal ha^{-1}	2323	2378	2350	5610	5617	5613
S. Em. ±	52.26	46.74	35.06	116	139	90
C. D. (P= 0.05)	170	152	105	377	452	271
Sub plot: Cow-based bio-enhancers (B)						
B_1: Cow urine spray at a rate of 5% at 35 and 60 DAS	2029	2055	2042	5103	5130	5116
B_2: *Panchagavya* spray at a rate of 3% at 35 and 60 DAS	2227	2270	2248	5352	5321	5336
B_3: *Jivamrut* at a rate of 200 l/ha at 35 and 60 DAS	2135	2194	2164	5333	5315	5324
S. Em. ±	32.70	34.94	23.93	65	90	55
C. D. (P= 0.05)	96	103	68	191	NS	158
Significant interaction(s)	MxB	-	-	-	-	-
Sub-sub plot: Fertilizer levels (F)						
F_1: 75% RDF	2101	2134	2118	5188	5221	5204
F_2: 100% RDF	2159	2212	2185	5337	5290	5314
S. Em. ±	14.25	23.29	13.65	45.27	41.93	30.85
C. D. (P= 0.05)	41	67	39	131	NS	87
Significant Interaction(s)	MxF, MxBxF	-	MxBxF	-	-	-

4. Conclusion

In conclusion, the application of different animal dung composts and cow-based bio-enhancers demonstrated varying impacts on pearl millet growth and yield parameters. Among animal dung composts, 10 t/ha of goat dung compost consistently resulted in superior plant height, effective tillers, earhead length, grain yield, and straw yield compared to other composts. This is attributed to the higher nutrient concentration and better soil nutrient release associated with goat dung compost. Cow-based bio-enhancers, particularly Panchagavya, improved plant height, effective tillers, and earhead length compared to cow urine but showed similar results to Jivamrut. The impact of fertilizer levels was less pronounced, with 100% RDF showing a slight advantage in plant height, effective tillers, earhead length, and grain yield over 75% RDF. Interactions between goat dung compost and Panchagavya or Jivamrut were most effective in enhancing earhead length and grain yield, indicating the benefits of combining high-quality compost with bio-enhancers to optimize pearl millet production.

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