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Effect of Nutrient Management and Mulching on Growth Parameters, Yield Attributes and Yield of Pearl Millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz] in Western Region of India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To assessed the effect of nutrient management and mulching on growth parameters, yield attributes and yield of pearl millet. Place and Duration of Study: A field experiment was conducted during two consecutive year 2021 and 2022 at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan).

Study Design and Methodology: The 16 treatment combinations consist different nutrients and mulching sources with replicated four times and laid out in split plot design. Various plant growth parameters, yield attributes and yield were recorded with standard procedures.

Results: Results showed that Mustard straw mulch @ 2.5 t/ha gave significantly higher growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear and number of grains per ear) leading to increased grain yield (1930 kg/ha), stover yield (3748 kg/ha) and biological yield (5678 kg/ha) over control on pooled data basis. Results showed that Liquid *Azospirillium* gave significantly higher growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear and number of grains per ear) leading to increased grain yield (1954 kg/ha), stover yield (3742 kg/ha) and biological yield (5697 kg/ha) over control on pooled data basis. Results further indicated that among nitrogen management practices 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS proved significantly superior for growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear, number of grains per ear and test weight) and grain yield (1919 kg/ha), stover yield (3742 kg/ha), biological yield (5661 kg/ha) over control and remained at par with treatment RDN through urea and 0.2% foliar spray of nano urea on mean pooled data basis. Among all the treatments, 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS, Mustard straw mulch @ 2.5 t/ha and Liquid *Azospirillium* are fond best with respect to growth parameters, yield attributes and yield.

Keywords: Azospirillium; growth; mulching; nutrient; pearl millet; western and yield.

1. INTRODUCTION

"Pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz] is one of the important millet crop of India as well as Rajasthan. Cultivation of pearl millet is mainly confined to semi-arid and arid region of India. In India, pearl millet occupies an area of 6.70 million ha with an average production of 9.62 million tonnes and productivity of 1436 kg/ha" [1]. "Pearl millet crop occupies an area of 4.3 m ha and annual production of 4.30 million tonnes with a productivity of 1001 kg/ha in the state of Rajasthan" [2]. "In Rajasthan, pearl millet is mostly cultivated under harsh condition of frequent drought, high temperature, erratic rainfall and low fertility on marginal and sub marginal soils which are low in nitrogen, phosphorus and organic matter with poor water holding capacity, lead to low yields. Under such adverse growing conditions, selection of appropriate high yielding cultivars, moisture conservation practices and nutrient management practices attains paramount importance. One such common practices of slower evaporation loss from the soil surface, prolonging the moisture availability and reduce water requirement of crop is the use of mulches. Use of mulching in crop fields increases water use efficiency, protect against solar radiation, regulates soil temperature, suppress weed growth, minimizes leaching loss of nutrients, reduces soil erosion, checks excessive evaporation, increase infiltration of rain water and improve soil moisture, production and quality of field crops" [3-5]. "Mustard straw is readily available without much investment in the areas where it is grown particularly in arid and semi-arid zone. Quick decomposition of organic residue helped in increased availability of soil nutrients, which led to enhanced in growth and yield attributes and finally the grain yield" [6-8].

"Besides chemical fertilization, which involves high cost, biofertilizers are cheaper and renewable sources and contribute to the

development strategies which do not lead to rise in consumption of non-renewable forms of energy. The occurrence of nitrogen fixing micro-organism such as *Azospirillium* within the plant of economic importance has been harnessed in Indian agriculture. *Azospirillium* bacteria can promote plant growth. The benefits to plants by inoculation with *Azospirillium* have been primarily attributed to its capacity to fix atmospheric nitrogen, but also to its capacity to synthesize phytohormones, in particular indole-3-acetic acid. Four aspects of *Azospirillium*-plant root interaction are highlighted *viz.,* natural habitat, plant root interaction, nitrogen fixation and biosynthesis of plant growth hormones. *Azospirillium* is recommended for rice, millets, maize, wheat and sorghum etc. and it fixes 20-40 kg N/ha. Nitrogen is deficient in most of the Indian soils particularly the light textured ones. N is involved in the formation of proteins, nucleic acids, growth hormones and vitamins and is an integral part of chlorophyll. An adequate supply of nitrogen is associated with vigorous vegetative growth and dark green color. Nano-fertilizers are a new concept in nutrient management of crops and there is a great thrust area in agriculture for sustainable crop improvement with major importance of nano-nitrogen. The term nano material is based on the prefix nano which originates from Greek word meaning dwarf. More precisely, the word nano means 10^{-9} or one billionth of a metre. The word nanomaterial is generally used for materials with a size ranging between 1 and 100 nm" [9]. "There are lots of advantages of nano fertilizers, like they increase 55-60 times less requirement to chemical fertilizer, 10-12 times more stress tolerant by the crops, complete bio-source so eco-friendly and 18-54% improvement in the crop yield. Nano urea liquid contains nano scale nitrogen particles which have more surface area and number of particles over conventional urea prilled. The uptake efficiency of nano urea is more than 80% in contrast to urea. Therefore, it is required in lesser amount compared to the conventional urea fertilizer to fulfill plant's nitrogen requirement. Nano urea increased the grain, straw yield and nutrient uptake in rice crop" [10, 11]. It was superior in influencing morphology, yield attributes and yield of *rabi* maize [12].

2. MATERIALS AND METHODS

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif* seasons of the 2021 and 2022 to study the Response of hybrid pearl millet to mulching, biofertilizers and nitrogen management practices grown on loamy sand soils of semi-arid eastern plain zone of Rajasthan. The experiment consisted of two mulching (control and mustard straw mulch @ 2.5 t/ha), two biofertilizers (control and liquid *Azospirillium*) and four nitrogen management practices (control, RDN through urea, 0.2 % foliar spray of nano urea and 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS), thereby making sixteen treatment combinations replicated four times in split plot design keeping mulching and biofertilizers in main plots and nitrogen management practices in sub plots. The hybrid pearl millet variety RHB 223 was sown at a spacing 45 cm between rows. All the recommended agronomic and plant protection measures were adopted to raise crop. Observation recorded on following aspects-growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, number of grains per ear, weight of grains per ear and test weight) and yields; grain, stover and biological yield (kg/ha) and harvest index (%). The influence of treatment was tested with 'F' test wherever 'F' test shown their significance. The levels of treatment were compared by critical difference at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The data referring to growth parameters *viz*., plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content are presented in Tables 1 to 4 and Figs 1 to 3.

3.1.1 Effect of mulching

Mulching treatment did not affect significantly the plant height and dry matter accumulation of pearl millet at initial growth stage at 30 DAS. The application of mulching significantly influenced plant height at 60 DAS and at harvest, dry matter accumulation at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content in hybrid pearl millet during both the years over control. The plant height, dry matter accumulation, number of tillers

per plant, number of leaves per plant and chlorophyll content observed significantly higher under application of mustard straw mulch @ 2.5 t/ha during both the years over control as well as on pooled analysis. It alters the microclimate by conserving more moisture through reduced weed growth, decreased evaporation loss, altered soil temperature and reduced need for irrigation. Additionally, appropriate and proper moisture conservation in plants leads to full cell turgidity, increased meristematic activity, higher rate of photosynthetic activity and ultimately more plant growth and development. These results were highly compatible with those published by Lal et al., [13] and Kanwar et al., [14].

3.1.2 Effect of biofertilizers

At 30 DAS plant height and dry matter accumulation was non-significant due to liquid *Azospirillium* during both the years of experimentation and as well as on pooled analysis. However, application of liquid *Azospirillium* recorded higher plant height and dry matter accumulation at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content in hybrid pearl millet as compared to control during both the years of study as well as on pooled analysis. The significant increase in the growth parameters may be due to inoculation of bacterial preparation accelerating plant growth parameters, providing biologically fixed nitrogen to the inoculated plant and also stimulating plant growth by excreting plant growth promoting substances like, auxins, kinetins, vitamins and gibberellins. Similar findings were also reported by Patidar and Mali, [15] and Vamsi and Umesha, [16].

3.1.3 Effect of nitrogen management

“Nitrogen management did not differ significantly in plant height and dry matter accumulation at 30 DAS during both the years of experimentation. Chlorophyll content at 35 DAS treatment RDN through urea was significantly higher with 50% through urea + 0.2% foliar spray of nano urea at 30 DAS, 0.2% foliar spray of nano urea and over control. However, 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS treatment significantly increased plant height at 60 DAS and at harvest and dry matter accumulation per plant at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content at 50 DAS over control and treatments, RDN through urea, 0.2% foliar spray of nano urea and 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS are statistically at par with each other during both the years of study as well as on pooled analysis. It improves plant metabolic processes, encourages meristematic activities, ensures higher apical growth and leaf photosynthetic area, triggers enzymes and induces mesophyll synthesis. This would have maintained continuous supply of nitrogen and increased meristematic activity and stimulated cell elongation in plants” [17]. This is likely due to the small size of nano urea particles, which have a larger surface area and can more easily penetrate into plant leaves, improving nutrient use efficiency and increasing crop dry matter production. Similar results are found with Rose et al., [18] and Sahu et al., [10].

3.2 Yield Attributes

The data referring to yield attributes *viz*., number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) are presented in Tables 5 to 6 and Figs 4 to 5.

3.2.1 Effect of mulching

The application of mulching significantly increased number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) in hybrid pearl millet over control during both the years. The number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) was recorded significantly maximum under application of mustard straw mulch @ 2.5 t/ha over control during both the years of study as well as on pooled analysis. The advantage of mustard straw mulch over control at 2.5 t/ha can be attributed to its ability to reduce evaporation losses by obstructing external evaporation processes and supplying energy to evaporating sites by reflecting some of the solar radiation that hits the soil surface. Mulch is more efficient at reducing evaporative loss, adjusting temperature and controlling weed growth than other landscaping materials. These findings are familiar with those of Kanwar et al., [14] and Rummana et al., [3].

Table 1. Effect of mulching, biofertilizers and N management on plant height of pearl millet

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mulching									
Control	35.0	35.5	35.2	120.3	120.0	120.2	137.4	138.4	137.9
Mustard straw mulch @ 2.5 t/ha	36.3	36.8	36.6	142.7	143.8	143.2	164.4	165.5	164.9
SEm+	**0.7**	**0.8**	**0.6**	**2.5**	**2.6**	**2.1**	**2.9**	**2.6**	**2.2**
CD (P=0.05)	**NS**	**NS**	**NS**	**7.6**	**7.7**	**6.1**	**8.7**	**7.7**	**6.6**
Biofertilizers									
Control	35.0	35.4	35.2	119.4	119.5	119.4	137.5	138.1	137.8
Liquid *Azospirillium*	36.3	36.9	36.6	143.6	144.4	144.0	164.3	165.8	165.0
SEm+	**0.7**	**0.8**	**0.6**	**2.5**	**2.6**	**2.1**	**2.9**	**2.6**	**2.2**
CD (P=0.05)	**NS**	**NS**	**NS**	**7.6**	**7.7**	**6.1**	**8.7**	**7.7**	**6.6**
Nitrogen management									
Control	35.5	35.9	35.7	116.8	117.6	117.2	136.6	137.2	136.9
RDN through Urea	35.8	36.4	36.1	136.9	137.3	137.1	156.8	158.0	157.4
0.2% foliar spray of Nano Urea	35.7	36.1	35.9	133.6	133.7	133.7	152.6	153.6	153.1
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	35.7	36.2	36.0	138.6	139.0	138.8	157.6	159.0	158.3
SEm+	**0.7**	**0.8**	**0.5**	**3.0**	**3.1**	**2.2**	**2.1**	**3.1**	**1.9**
CD (P=0.05)	**NS**	**NS**	**NS**	**8.6**	**8.8**	**6.1**	**5.9**	**8.7**	**5.3**

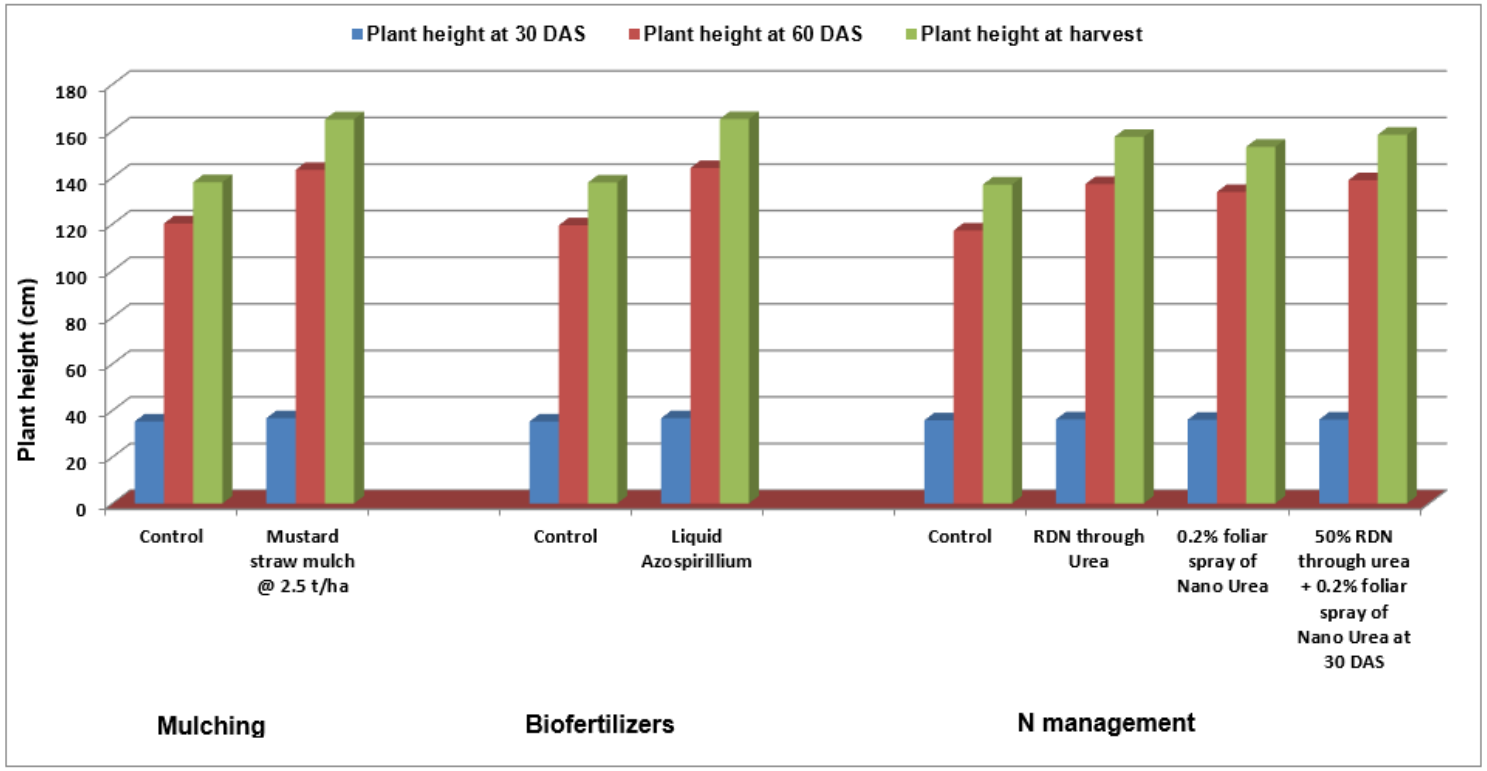

Fig. 1. Effect of mulching, biofertilizers and N management on plant height of pearl millet

Table 2. Effect of mulching, biofertilizers and N management on dry matter accumulation of pearl millet

Treatments	Dry matter accumulation (g/plant)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mulching									
Control	13.89	14.02	13.96	33.49	33.68	33.58	43.30	44.06	43.68
Mustard straw mulch @ 2.5 t/ha	14.18	14.46	14.32	37.29	37.62	37.46	53.46	54.08	53.77
SEm+	**0.25**	**0.27**	**0.21**	**0.35**	**0.47**	**0.34**	**0.89**	**0.77**	**0.68**
CD (P=0.05)	**NS**	**NS**	**NS**	**1.04**	**1.41**	**0.99**	**2.67**	**2.32**	**2.00**
Biofertilizers									
Control	13.82	14.03	13.92	32.61	32.93	32.77	43.33	43.89	43.61
Liquid *Azospirillium*	14.25	14.45	14.35	38.17	38.37	38.27	53.43	54.25	53.84
SEm+	**0.25**	**0.27**	**0.21**	**0.35**	**0.47**	**0.34**	**0.89**	**0.77**	**0.68**
CD (P=0.05)	**NS**	**NS**	**NS**	**1.04**	**1.41**	**0.99**	**2.67**	**2.32**	**2.00**
Nitrogen management									
Control	13.88	13.96	13.92	32.04	32.68	32.36	43.14	43.85	43.50
RDN through Urea	14.19	14.77	14.48	36.62	36.72	36.67	50.65	51.35	51.00
0.2% foliar spray of Nano Urea	13.96	14.00	13.98	36.10	36.22	36.16	48.92	49.65	49.29
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	14.10	14.23	14.17	36.80	36.98	36.89	50.80	51.42	51.11
SEm+	**0.18**	**0.25**	**0.15**	**0.39**	**0.38**	**0.27**	**0.74**	**1.09**	**0.66**
CD (P=0.05)	**NS**	**NS**	**NS**	**1.10**	**1.07**	**0.77**	**2.10**	**3.08**	**1.86**

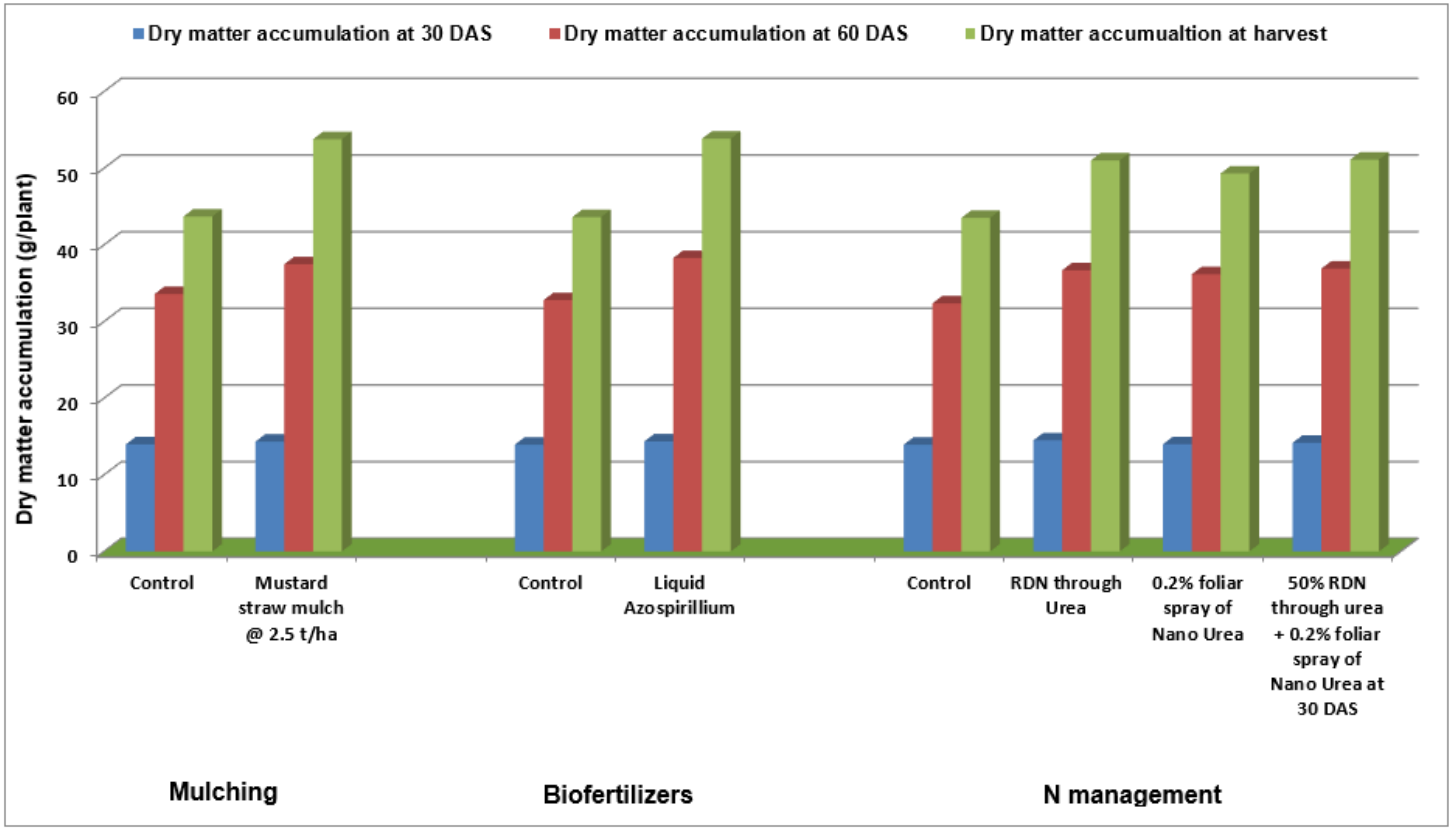

Fig. 2. Effect of mulching, biofertilizers and N management on dry matter accumulation of pearl millet

Table 3. Effect of mulching, biofertilizers and N management on total number of tillers per plant and number of leaves per plant of pearl millet

Treatments	Total number of tillers/ plant			Number of leaves/ plant		
	2021	2022	Pooled	2021	2022	Pooled
Mulching						
Control	2.70	3.13	2.92	9.17	9.19	9.18
Mustard straw mulch @ 2.5 t/ha	3.10	3.51	3.30	11.06	11.20	11.13
SEm+	**0.07**	**0.08**	**0.06**	**0.18**	**0.19**	**0.15**
CD (P=0.05)	**0.21**	**0.23**	**0.18**	**0.54**	**0.56**	**0.44**
Biofertilizers						
Control	2.72	3.11	2.91	9.21	9.30	9.26
Liquid *Azospirillium*	3.08	3.53	3.31	11.02	11.09	11.05
SEm+	**0.07**	**0.08**	**0.06**	**0.18**	**0.19**	**0.15**
CD (P=0.05)	**0.21**	**0.23**	**0.18**	**0.54**	**0.56**	**0.44**
Nitrogen management						
Control	2.43	2.83	2.63	9.09	9.14	9.12
RDN through Urea	3.10	3.49	3.30	10.50	10.59	10.55
0.2% foliar spray of Nano Urea	2.95	3.44	3.20	10.32	10.39	10.36
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	3.12	3.52	3.32	10.55	10.66	10.61
SEm+	**0.05**	**0.09**	**0.05**	**0.19**	**0.19**	**0.13**
CD (P=0.05)	**0.14**	**0.25**	**0.14**	**0.54**	**0.53**	**0.38**

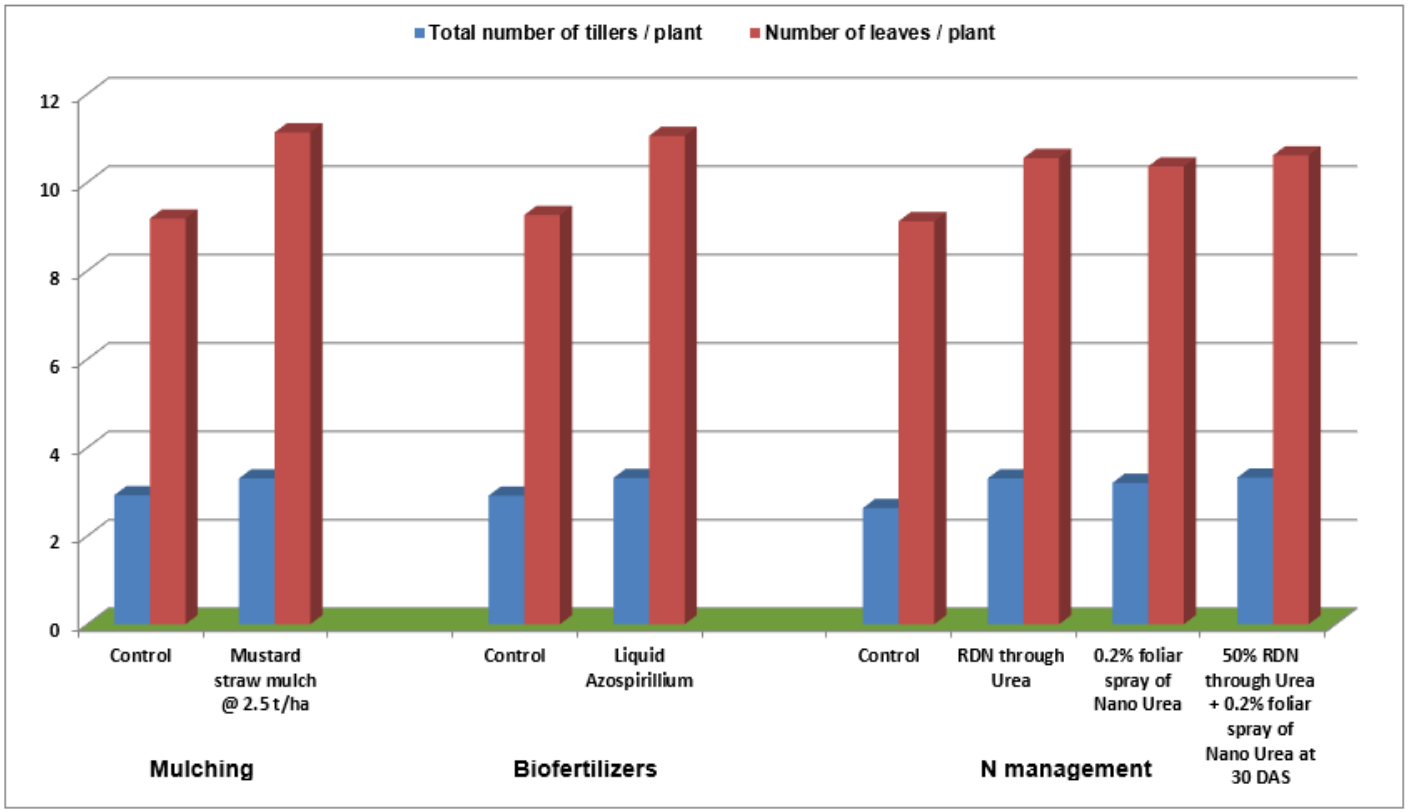

Fig. 3. Effect of mulching, biofertilizers and N management on total number of tillers per plant and number of leaves per plant of pearl millet

Table 4. Effect of mulching, biofertilizers and N management on chlorophyll content of pearl millet

Treatments	Chlorophyll content (mg/g)					
	35 DAS			50 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Mulching						
Control	2.61	2.78	2.70	2.75	2.81	2.78
Mustard straw mulch @ 2.5 t/ha	2.80	2.88	2.84	2.92	2.98	2.95
SEm+	**0.04**	**0.04**	**0.03**	**0.05**	**0.04**	**0.04**
CD (P=0.05)	**0.13**	**0.12**	**0.10**	**0.15**	**0.12**	**0.11**
Biofertilizers						
Control	2.59	2.72	2.66	2.71	2.76	2.73
Liquid *Azospirillium*	2.83	2.94	2.88	2.96	3.03	3.00
SEm+	**0.04**	**0.04**	**0.03**	**0.05**	**0.04**	**0.04**
CD (P=0.05)	**0.13**	**0.12**	**0.10**	**0.15**	**0.12**	**0.11**
Nitrogen management						
Control	2.64	2.76	2.70	2.65	2.69	2.67
RDN through Urea	2.85	2.95	2.90	2.90	2.96	2.93
0.2% foliar spray of Nano Urea	2.68	2.82	2.75	2.86	2.91	2.89
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	2.66	2.80	2.73	2.93	3.02	2.98
SEm+	**0.04**	**0.06**	**0.04**	**0.04**	**0.06**	**0.04**
CD (P=0.05)	**0.12**	**0.16**	**0.10**	**0.11**	**0.17**	**0.10**

Table 5. Effect of mulching, biofertilizers and N management on yield attributes (number of effective tillers per metre row length, ear head length and ear head diameter) of pearl millet

Treatments	Number of effective tillers/ metre row length			Ear head length (cm)			Ear head diameter (cm)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mulching									
Control	16.84	16.94	16.89	24.1	24.1	24.1	5.7	5.8	5.7
Mustard straw mulch @ 2.5 t/ha	19.78	19.93	19.85	26.7	27.0	26.8	6.3	6.4	6.4
SEm±	**0.31**	**0.28**	**0.24**	**0.4**	**0.4**	**0.3**	**0.1**	**0.1**	**0.1**
CD (P=0.05)	**0.93**	**0.84**	**0.71**	**1.2**	**1.1**	**0.9**	**0.3**	**0.3**	**0.2**
Biofertilizers									
Control	16.85	16.94	16.89	24.0	24.1	24.0	5.7	5.8	5.8
Liquid *Azospirillium*	19.77	19.93	19.85	26.8	27.0	26.9	6.3	6.4	6.3
SEm±	**0.31**	**0.28**	**0.24**	**0.4**	**0.4**	**0.3**	**0.1**	**0.1**	**0.1**
CD (P=0.05)	**0.93**	**0.84**	**0.71**	**1.2**	**1.1**	**0.9**	**0.3**	**0.3**	**0.2**
Nitrogen management									
Control	16.98	17.18	17.08	23.4	23.7	23.5	5.6	5.7	5.7
RDN through Urea	18.76	18.89	18.83	26.0	26.1	26.1	6.1	6.3	6.2
0.2% foliar spray of Nano Urea	18.45	18.55	18.50	25.9	26.0	25.9	6.0	6.2	6.1
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	19.05	19.11	19.08	26.3	26.5	26.4	6.2	6.3	6.3
SEm±	**0.36**	**0.33**	**0.25**	**0.4**	**0.5**	**0.3**	**0.1**	**0.1**	**0.1**
CD (P=0.05)	**1.03**	**0.93**	**0.69**	**1.1**	**1.3**	**0.8**	**0.3**	**0.3**	**0.2**

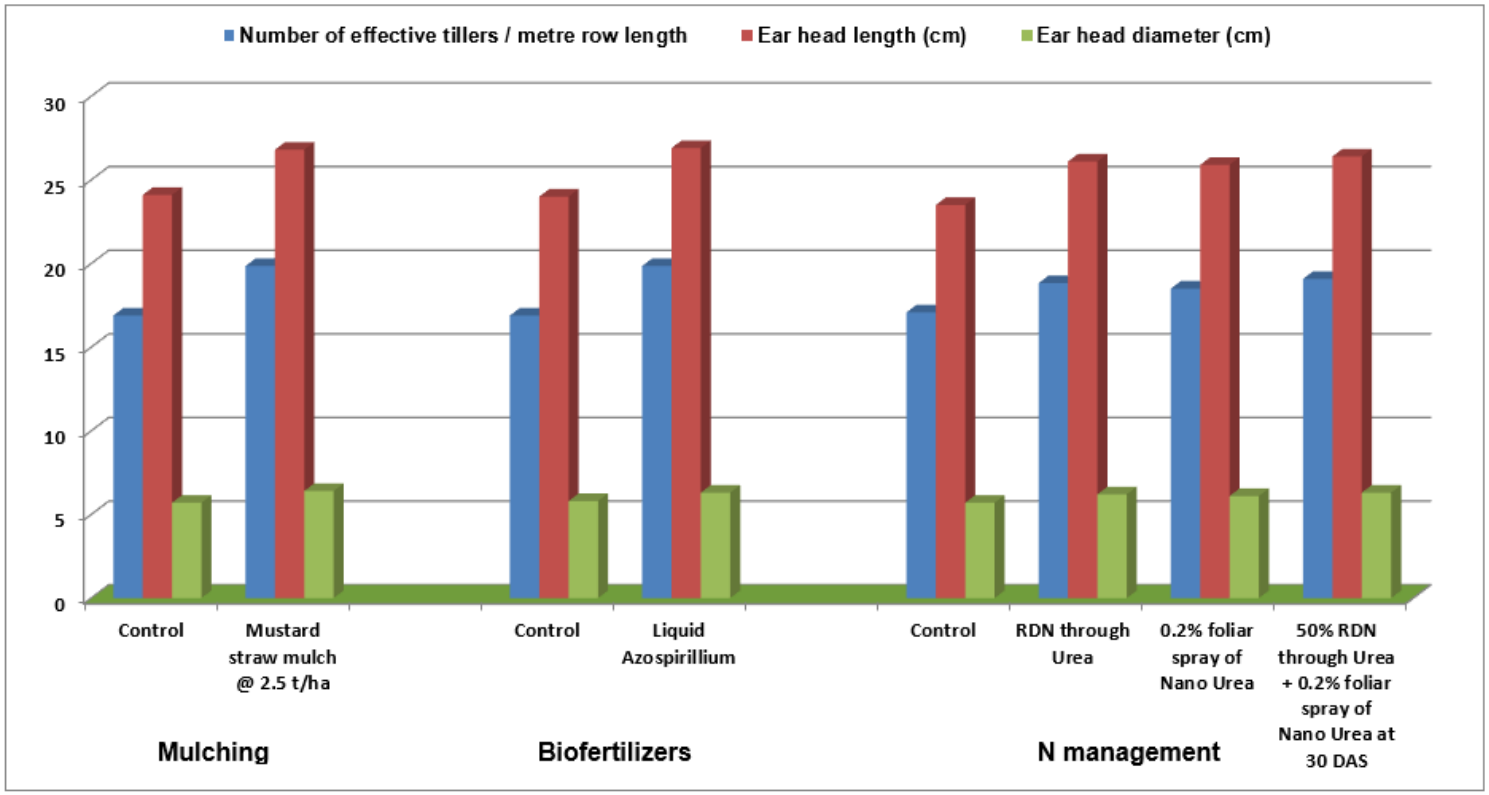

Fig. 4. Effect of mulching, biofertilizers and N management on yield attributes (number of effective tillers per metre row length, ear head length and ear head diameter) of pearl millet

Table 6. Effect of mulching, biofertilizers and N management on yield attributes (number of grains per ear, weight of grains per ear and test weight) of pearl millet

Treatments	Number of grains/ ear			Weight of grains/ ear (g)			Test weight (g)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mulching									
Control	1403	1417	1410	7.34	7.53	7.43	5.90	5.96	5.93
Mustard straw mulch @ 2.5 t/ha	1612	1632	1622	8.55	8.75	8.65	7.13	7.19	7.16
SEm+	**21.89**	**20.70**	**17.40**	**0.12**	**0.12**	**0.10**	**0.07**	**0.11**	**0.07**
CD (P=0.05)	**65.99**	**62.40**	**51.32**	**0.35**	**0.36**	**0.28**	**0.22**	**0.32**	**0.22**
Biofertilizers									
Control	1399	1415	1407	7.25	7.40	7.33	5.88	5.92	5.90
Liquid *Azospirillium*	1616	1635	1626	8.63	8.88	8.75	7.14	7.22	7.18
SEm+	**21.89**	**20.70**	**17.40**	**0.12**	**0.12**	**0.10**	**0.07**	**0.11**	**0.07**
CD (P=0.05)	**65.99**	**62.40**	**51.32**	**0.35**	**0.36**	**0.28**	**0.22**	**0.32**	**0.22**
Nitrogen management									
Control	1385	1405	1395	6.91	7.10	7.01	6.19	6.25	6.22
RDN through Urea	1552	1561	1556	8.31	8.45	8.38	6.66	6.69	6.68
0.2% foliar spray of Nano Urea	1525	1545	1535	8.10	8.39	8.25	6.51	6.60	6.56
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	1568	1588	1578	8.45	8.61	8.53	6.69	6.75	6.72
SEm+	**22.34**	**24.24**	**16.50**	**0.14**	**0.15**	**0.10**	**0.09**	**0.10**	**0.07**
CD (P=0.05)	**63.21**	**68.59**	**46.49**	**0.40**	**0.42**	**0.29**	**0.25**	**0.28**	**0.19**

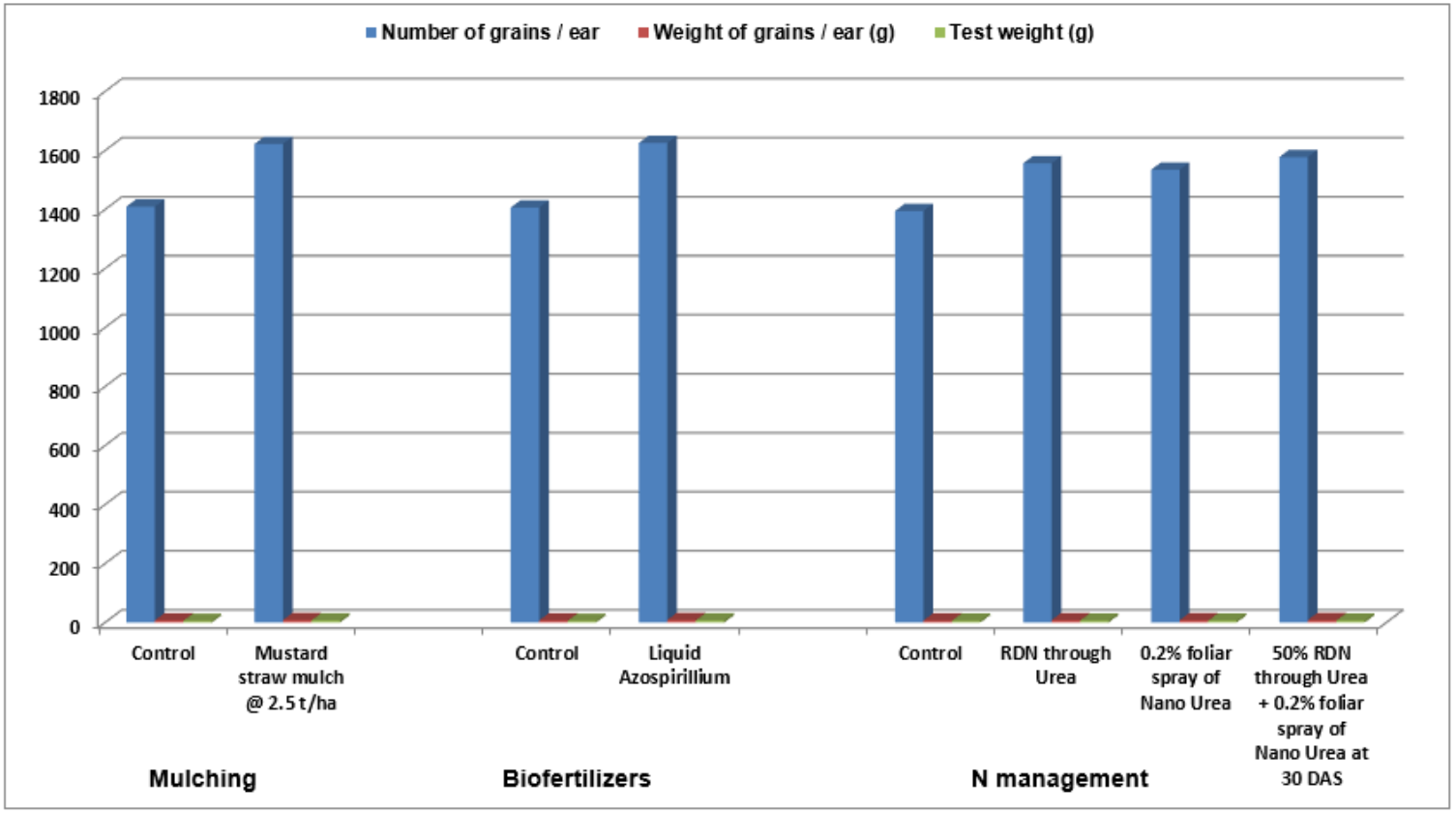

Fig. 5. Effect of mulching, biofertilizers and N management on yield attributes (number of grains per ear, weight of grains per ear and test weight) of pearl millet

Table 7. Effect of mulching, biofertilizers and N management on grain, stover and biological yield and harvest index of pearl millet

Treatments	Grain yield (kg/ha)			Stover yield (kg/ha)			Biological yield (kg/ha)			Harvest index (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Mulching												
Control	1622	1711	1666	3311	3357	3334	4933	5067	5000	32.82	33.69	33.26
Mustard straw mulch @ 2.5 t/ha	1902	1958	1930	3724	3772	3748	5627	5730	5678	33.75	34.10	33.93
SEm+	**38**	**36**	**30**	**54**	**58**	**46**	**87**	**95**	**74**	**0.62**	**0.69**	**0.53**
CD (P=0.05)	**115**	**110**	**90**	**164**	**174**	**135**	**262**	**285**	**219**	**NS**	**NS**	**NS**
Biofertilizers												
Control	1623	1661	1642	3327	3353	3340	4950	5013	4982	32.74	33.10	32.92
Liquid *Azospirillium*	1901	2008	1954	3709	3776	3742	5609	5784	5697	33.83	34.69	34.26
SEm+	**38**	**36**	**30**	**54**	**58**	**46**	**87**	**95**	**74**	**0.62**	**0.69**	**0.53**
CD (P=0.05)	**115**	**110**	**90**	**164**	**174**	**135**	**262**	**285**	**219**	**NS**	**NS**	**NS**
Nitrogen management												
Control	1516	1585	1551	3096	3128	3112	4612	4713	4663	32.81	33.56	33.19
RDN through Urea	1845	1910	1878	3650	3715	3683	5495	5625	5560	33.51	33.89	33.70
0.2% foliar spray of Nano Urea	1795	1896	1846	3610	3645	3628	5405	5541	5473	33.15	34.15	33.65
50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS	1892	1946	1919	3715	3769	3742	5607	5715	5661	33.68	33.98	33.83
SEm+	**38**	**41**	**28**	**70**	**72**	**50**	**100**	**102**	**71**	**0.75**	**0.76**	**0.53**
CD (P=0.05)	**107**	**115**	**79**	**199**	**205**	**142**	**282**	**287**	**201**	**NS**	**NS**	**NS**

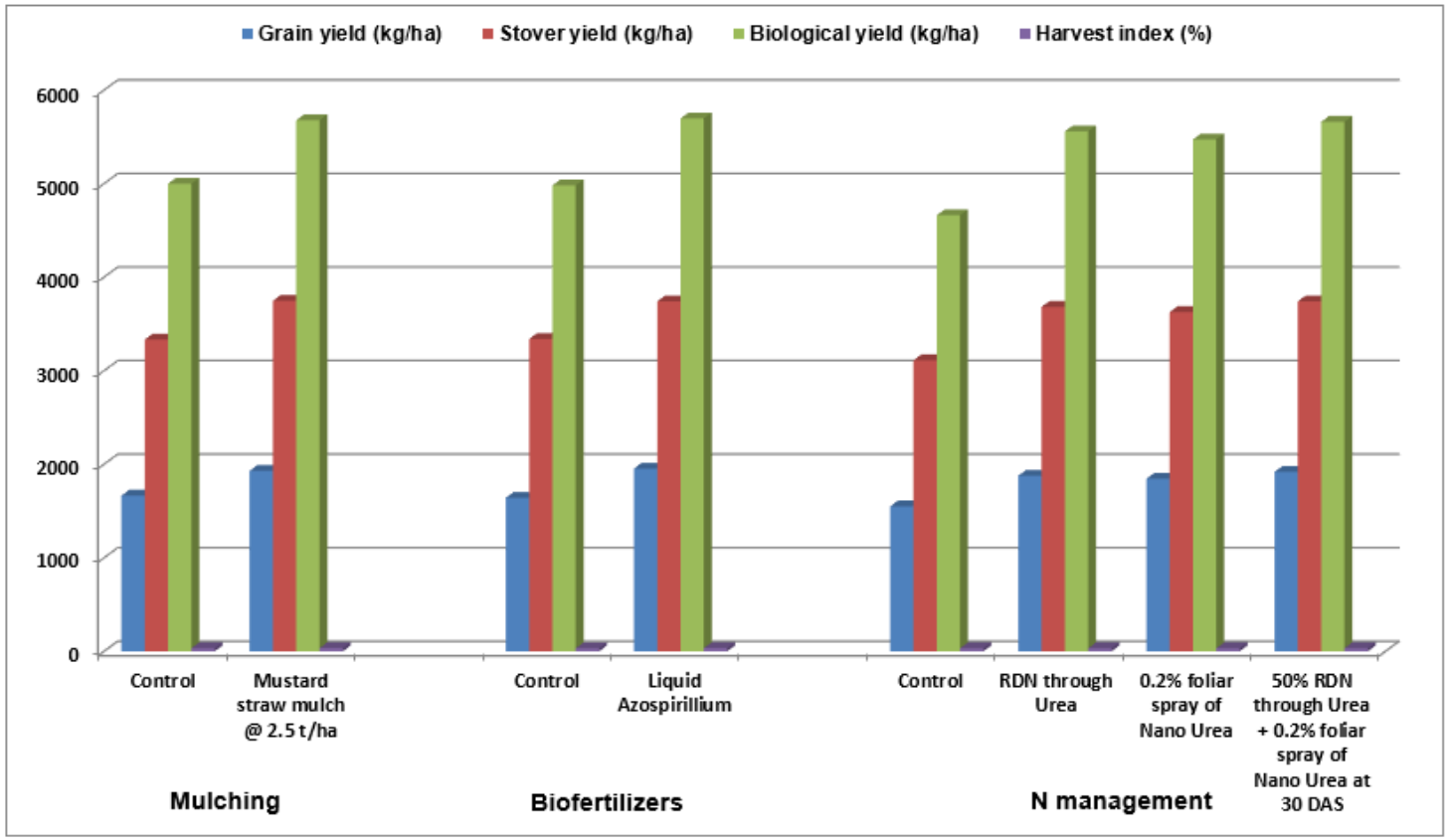

Fig. 6. Effect of mulching, biofertilizers and N management on grain, stover, biological yields and harvest index of pearl millet

3.2.2 Effect of biofertilizers

Yield attributes (number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight) was significantly increased under application of liquid *Azospirillium* over control during both the years of experimentation and as well as on pooled analysis. This might be attributed due to increase height, leaf area and dry matter production which accrued because of positive effects of seed bacterization that is mainly due to nitrogen fixation and other factors like, release of hormones, increase of plant growth promoting substances (PGPS) and nutrient uptake. The results of almost similar nature were reported by Guggari and Kalaghatagi, [19] and Vamsi and Umesha, [16].

3.2.3 Effect of nitrogen management

Number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) was significantly influenced by nitrogen management. Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS was significantly higher over control, however, it remained at par with other two treatments namely, RDN through urea and 0.2% foliar spray of nano urea. Application of nano-urea, which comprises nitrogen particles with a small size and a high density of surfaces that may easily pass through cell walls and reach the plasma membrane, may boost yield qualities. Stomatal pores can be penetrated by large particles. They are also transported to other plant parts by phloem cells via plasmodesmata, which promotes meristematic activities, ensures higher apical growth and leaf photosynthetic area and activates enzymes, amino acids/protein content, chlorophyll content, nucleic acid, photosynthates, etc. in the plant. All of these activities promote plant growth, which in turn increases the number of productive tillers and other yield characteristics. Nutrient treatment to the foliage is crucial when the roots are unable to provide the crop with the essential nutrients. This enables the crop to quickly absorb the nutrients it needs for increased output. These results were highly compatible with those published by Kumar et al., [17] and Sahu et al., [10].

3.3 Yields

The data referring to yields *viz*., grain (kg/ha), stover (kg/ha) and biological yield (kg/ha) are presented in Table 7 and Fig. 6. Harvest index (%) of pearl millet crop did not differ significantly due to application of mulching, biofertilizers and nitrogen management during both the years of experimentation and as well as on mean pooled analysis.

3.3.1 Effect of mulching

The application of mulching significantly influenced grain, stover and biological yield of hybrid pearl millet over control during both the years of study. Application of mustard straw mulch @ 2.5 t/ha recorded significantly higher grain, stover and biological yield over control during both the years of study and as well as on pooled analysis. Mulching increase in soil moisture and altered temperature that led to the addition of nutrients to the soil and a decrease in the number of days needed to reach the necessary heat units for proper vegetative growth and development of plants could be attributed to the improvement in yield attributes and yield of hybrid pearl millet under mulching practices, which in turn improved the yield attributes and yield under light textured soils of semi-arid regions. The highest grain and fodder yield recorded under mulch were because of the fact that mulch plays an important role in changing hydro-thermal regime of soil and conserving soil moisture. Hence, congenial soil moisture is available for favourable growth during major life period of crop and consequently the higher growth and yield attributing characters reflected higher grain and fodder yield of pearl millet. These findings are in conformity with those obtained by Kachhadiya et al., [20], Kumar and Gautam, [17] and Parihar et al., [21].

3.3.2 Effect of biofertilizers

Biofertilizers application significantly influenced grain, stover and biological yield of pearl millet over control during both the years of study. The use of liquid *Azospirillium* observed significantly higher grain, stover and biological yield over control during both the years of experimentation and as well as on pooled analysis. The higher yield obtained as a result of the nitrogen fixed by the plants, which encouraged germination and increased plant biomass. The results obtained with this study are in close agreement with the finding of Bhargava et al., [22], Verma et al., [23], Dalvi et al., [24]. Use of *Azospirillium* significantly influenced the grain yield as this bacteria fixes atmospheric nitrogen and produces growth hormones like IAA, GA and Cytokinin.

Golada et al., [25] also observed that *Azospirillium* application significantly increased pearl millet yield as compared to untreated plots and similar findings were given by Khambalkar et al., [26].

3.3.3 Effect of nitrogen management

Nitrogen management treatments brought a significant improvement in grain, stover and biological yield of pearl millet during both the years of experimentation and on pooled analysis. Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS recorded maximum grain, stover and biological yield of pearl millet over control, however, it remained statistically at par with 0.2% foliar spray of nano urea and RDN through urea during both the years of study on mean pooled basis. Application of nano-urea, which comprises nitrogen particles with a small size and a high density of surfaces that may easily pass through cell walls and reach the plasma membrane, may boost yield qualities. Due to the use of two foliar nano urea sprays, an increase in effective tillers, grain, stover and biological yield was made possible. As it improves plant metabolic processes, encourages greater apical growth, leaf photosynthetic area and stimulates cell elongation in plants, it ultimately results in greater nutrient uptake by the plant, increasing grain and straw yield in pearl millet. These results were highly compatible with those published by Kumar et al., [17], Sahu et al., [10] and Midde et al., [27].

4. CONCLUSION

- Use of mustard straw mulch @ 2.5 t/ha proved superior to obtain significantly higher growth parameters, yield attributes and yield of pearl millet.
- Application of liquid *Azospirillium* recorded significantly maximum growth parameters, yield attributes and yield of pearl millet.
- Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS proved to be the most suitable nitrogen management practice as it provided significantly increased growth parameters, yield attributes and yield of pearl millet over control and it remained at par with 0.2% foliar spray of nano urea and RDN through urea.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Fourth advance estimate of production of food grains for 2021-22. Government of India, Ministry of Agriculture and Farmer Welfare, Department of Agriculture and Farmers welfare, Directorate of Economics and Statistics, New Delhi; 2021-22a.
2. Anonymous. Third advance estimate of production of food grains for 2021-22. Commissionerate of Agriculture, Rajasthan Jaipur, Rajasthan; 2021-22b.
3. Rummana S, Amin AKMR, Ialam MS, Faruk GH. Effect of irrigation and mulching materials on growth and yield of wheat. Bangladesh Agronomy Journal. 2018;21(1):71-76.
4. Yaghi T, Arslan A, Naoum F. Cucumber (*Cucumis sativus* L.) water use efficiency under plastic mulch and drip irrigation. Agricultural Water Management. 2013;128:149-157.
5. Srivastava RP, Kumar S, Singh L, Madhukar M, Singh N, Saxena G, Rustagi S. Major phenolic compounds, antioxidant, antimicrobial, and cytotoxic activities of *Selinum carvifolia* (L.) collected from different altitudes in India. Frontiers in Nutrition. 2023;10:1180225.
6. Kumar N, Gautam RC. Effect of moisture conservation and nutrient management practices on growth and yield of pearl millet (*Pennisetum glaucum*) under rainfed condition. Indian Journal of Agronomy. 2004;49(3):182-185.
7. Singh N, Jiwani G, Rocha LS, Mazaheri R. Bioagents and volatile organic compounds: an emerging control measures for rice bacterial diseases. In Bacterial diseases of rice and their management. Apple Academic Press. 2023;255-274.
8. Chauhan A, Chauhan M, Sethi M, Bodhe A, Tomar A, Shikha, Singh N. Application of flower wastes to produce valuable

products. Valorization of Biomass Wastes for Environmental Sustainability: Green Practices for the Rural Circular Economy. 2024;251-268.

9. Rai M, Ingle A. Role of nanotechnology in agriculture with special reference to management of insect pest. Applied Microbiology and Biotechnology. 2012; 94:287-293.
10. Sahu TK, Kumar M, Kumar N, Chandrakar T, Singh DP. Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under midland situation of Bastar region. The Pharma Innovation Journal. 2022;11(6):185-187.
11. Parshad J, Kumar R, Chhokar V, Patil N, Beniwal V, Singh N, Kumar A. Paddy straw management: alternative strategies and emerging technology for sustainable ecosystem. Pedosphere; 2024.
12. Samui S, Lalichetti S, Tanmoy S, Abha M, Abhikary R, Sagar M, Praharaj S. Growth and productivity of rabi maize as influenced by foliar application of urea and nano-urea. Crop Research. 2022;57(3): 136-140.
13. Lal B. Response of sesame [*Sesamum indicum* (L.)] to vermicompost and moisture conservation practices. M.Sc. (Ag.) Thesis, SKNAU, Jobner, Jaipur, Rajasthan, India; 2017.
14. Kanwar S, Gupta V, Rathore PS, Singh SP. Effect of soil moisture conservation practices and seed hardening on growth, yield, nutrient content, uptake and quality of pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Journal of Pharmacognosy and Phytochemistry. 2017;6(4):110-114.
15. Patidar M, Mali AL. Effect of farm yard manure, fertility levels and biofertilizers on growth, yield and quality of sorghum (*Sorghum bicolar*). Indian Journal of Agronomy. 2004;49(2): 117-120.
16. Vamsi KR, Umesha C. Effect of Bio-fertilizers and Zinc Levels on Growth and Yield of Pearl millet (*Pennisetum glaucum* L.). International Journal of Environment and Climate Change. 2023;13(10): 960-967.
17. Kumar Y, Singh T, Raliya R, Tiwari KN. Nano fertilizers for sustainable crop production, higher nutrient use efficiency and enhanced profitability. Indian Journal of Fertilisers. 2021;17(11): 1206-1214.
18. Rose H, Benzon L, Rosna M, Rubenecia U, Ultra VU, Sang J, Lee C. Nano-fertilizer Affects the Growth, Development and Chemical Properties of Rice. International Journal of Agronomy and Agricultural Research (IJAAR). 2015;7(1):105–117.
19. Guggari AK, Kalaghatagi SB. Effect of fertilizers and biofertilizers on pearl millet (*Pennisetum glaucum*) and pigeonpea (*Cajanus cajan*) intercropping system under rainfed conditions. Indian Journal of Agronomy. 2005;50(1):24-26.
20. Kachhadiya SP, Chovatia PK, Jadav KV, Sanandia ST. Effect of irrigation, mulches and antitranspirant on yield, quality and economics of summer pearl millet. International Journal of Agricultural Sciences. 2010;6(1): 278-282.
21. Parihar CM, Rana KS, Jat ML, Jat SL, Parihar MD, Kantwa SR. Carbon footprint and economic sustainability of pearl millet-mustard system under different tillage and nutrient management practices in moisture stress conditions. African Journal of Microbiology Research. 2012;6(23):5052-5061.
22. Bhargava SS, Rathore RS, Singh RK, Lal M. Response of *Azotobactor* under varying levels of nitrogen in bajra in unirrigated conditions. Agriculture Science Digest. 1981;1:133-134.
23. Verma OPS, Lakshminarayana K, Singh J. Increased bajra production using biofertilizers (*Azotobactor chrococcum*). Haryana Farming. 1991;20:2-3.
24. Dalvi ND, Patile VG, Jadhav AS, Harinarayana G. Nitrogen economy through biofertilizers in pearl millet. Journal of Maharashtra Agriculture University. 1993; 18:466-467.
25. Golada SL, Sharma GL, Varma A, Jain HK. Effect of FYM, nitrogen and *Azospirillum* on yield, economics and soil nutrient status of forage pearl millet. Madras Agricultural Journal. 2012;99(4-6):308-310.
26. Khambalkar PA, Tomar PS, Verma SK. Long-term effects of integrated nutrient management productivity and soil fertility in pearl millet (*Pennisetum glaucum*) – mustard (*Brassica juncea*) cropping sequence. Indian Journal of Agronomy. 2012;52(3):222-228.

27. Midde SK, Perumal MS, Murugan G, Sudhagar R, Mattepally VM, Reddy MB. Evaluation of nano urea on growth and yield attributes of rice (*Oryza sativa* L.) Chemical Science Review and Letters. 2022;11(42):211-214.

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