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Nitrogen Management in *Kharif* Pearlmillet

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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

An experiment was conducted during *kharif*season of the years 2021 to 2023 (Three years) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar having loamy sand soil to study the Nitrogen management in *kharif* pearlmillet. The experiment was laid out in randomized block design and replicated four times with seven treatments. On three years pooled results application of 80 kg N/ha being at par with 75% RDN as chemical fertilizer in addition with 25% RDN through castor cake or vermicompost or FYM recorded significantly higher plant height at 60 DAS, at harvest, length of earhead over rest of treatments. Further, it also significantly increased seed yield (1631 kg/ha) and stover yield (3754 kg/ha). Maximum net realization and benifit : cost ratio (BCR) were registered with application of 80 kg N/ha as chemical fertilizer followed by 75 % RDN as chemical fertilizer + 25 % RDN through castor cake in pooled results. Higher yield and net realization can be secured with the application of either 100% RDN (Recommended Dose of Nitrogen) i.e. 80 kg/ha

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through chemical fertilizer + 25 % RDN through castor cake or vermicompost (20 kg N/ha) in addtion to recommend dose of phosphourus 40 kg/ha as basal under North Gujarat Agro climatic conditions.

Keywords: Pearlmillet; castor cake; vermicompost; RDF; FYM; Nitrogen.

1. INTRODUCTION

"Pearlmillet (*Pennisetum glaucum* L.) is major coarse grain crop among the all grains and considered to be a poor man's food. It belongs to the gramineae family and widely grown in Africa and Asia since pre-historic times. Being a low-pricedgrain, it is mainly consumed by middle and poor-class families. Particularly in Asia, pearl millet is an important cereal crop of India, Pakistan, China and southeastern Asia. Pearl millet is one of the important millet crops which flourish well even under the adverse condition of weather in country like India with the most drought-tolerant crop among cereals and millets" [1-3]. "Pearl millet is adopted instresses intensive conditions, yet it is highly versatile, input responsive andhigh-quality cereal with great potential to become a valuable component of anon-traditional season like summer under irrigated and high input management conditions. The nutritive value of the pearl millet crop is fairly high. It contains moisture (12.4%), protein (11.6%), fat (5%), carbohydrates (67%) and minerals (2.7%). It is also rich in Vit-A, Vit-B and imparts substantial energy (360 calories 100 g^{-1}) for the baby" [4]. "Pearl millet imparts substantial energy to the human body with easy digestibility. In addition to grains, it also supplies fair-quality dry fodder in large bulk. The crop is more successfully grown in the tract having well distributed and low rainfall with few cloudy days. Pearl millet grains are eaten cooked like wheat or "chapaties" prepared out of flour like maize or sorghum flour. In India, Pearl millet popularly known as bajra or bajri, is an important staple food and also occupies an important place in the daily diet of many classes of people in India. India ranks first both in areas and production of pearl millet, it is cultivated over an area of 7.11 million hectares with a production of 8.66 million tonnes and the productivity is 1219 kg ha^{-1}" [5]. "Pearl millet cultivation is dispersed mainly during the *kharif* season across the country. In Gujarat, pearlmillet occupies an area of 0.39 million hectares and production of 0.89 million tonneswith the productivity of 2280 kg ha-1" [5]. "Summer cultivation of pearlmillet in the irrigated areas of North Gujarat has got importance because of the assurance of targeted crop yield. The application of organic manures *viz.,* FYM and castor cake may serve the source of major (N, P and K) and micronutrients (Fe, Mo and Zn *etc*.). Addition of organic manure in the soil is not only act as source of nutrient, but also influences its availability. It improves physical and chemical properties and health of soil such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients, increase in Cation Exchange Capacity (CEC), stimulation of soil flora and fauna *etc.* On an average, FYM contains 0.5 % N, 0.17 % P_2O_5 and 0.55 % K_2O. Castor cake is not used as animal feed as it contains a toxic alkaloids ricinine and ricin. It widely used as concentrated organic manure. Castor cake also supply micronutrients, improve physical properties of soil, immobilize toxic elements like Al and promote Mo activity" [6]. It is a long-term sustainable perspective and should not be thought for a short-term gain.

2. MATERIALS AND METHODS

An experiment was conducted during *kharif* season of the years 2021, 2022 and 2023 (Three years) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar having loamy sand soil to study the nitrogen management in *kharif* pearl millet. The experiment was laid out in randomized block design and replicated four times with seven treatments *viz*., T_1: RDN @ 80 kg N/ha as chemical fertilizer, T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM, T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost, T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake, T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB), T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB) and T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB). Pearl millet variety GHB-558 was used as test crop. The soil of experimental field was loamy sand in texture. Pearl millet seeds (3.75 kg/ha) were sown at a row distance of 45 cm and 10 cm plant to plant distance. Various growth and yield

attributing characters of the crop were measured and studied during the course of investigations. Other management practices were followed as recommended. In addition recommended dose of phosphorus (P_2O_5) was applied commonly 40 kg/ha in all the treatments as basal dose while application of *Azatobacter* & PSB was applied @ 1 lit./ha as soil application along with 100 kg FYM in Treaments T_5, T_6 and T_7. Statistical analysis of the data of various characters studied in present investigation was carried out with the help of computer as per appropriate procedure suggested by Panse and Sukhatme (1985) for the design of experiment.

3. RESULTS and DISCUSSION

3.1 Effect on Growth, Yield Attributes and Yield (Pooled)

The pooled data presented in Table 1 revealed that plant population at 20 DAS and at harvest was not affected significantly by the different nitrogen management practices. Pooled data of three years on plant height (cm) of pearl millet at 30 DAS, 60 DAS and at harvest are presented in Table 2. The data revealed that significantly taller plant height at 60 DAS and at harvest was observed under treatment T_1(RDN @ 80 kg/ha as chemical fertilizer) which remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake), T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost) and T_2 (75% RDN as chemical fertilizer + 25% RDN through FYM). The data presented in Table 3 indicated that use of different nitrogen management had significant effect on length of earhead. Application of RDN @ 80 kg/ha as chemical fertilizer (T_1) recorded significantly taller earhead (20.53 cm) but remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake *i.e.* 19.56 cm), T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost *i.e.* 19.53 cm) treatment and T_2 (75% RDN as chemical fertilizer + 25% RDN through FYM *i.e.* 18.81 cm). Pooled data on test weight and number of grain per earhead are presented on Table 3 was found non-significant.It might be attributed to multifarious role of castor cake and FYM in terms of nutrients supply as well as improvement in physical, chemical and biological properties of soil which finally reflected on growth of plant. The better growth of plant resulted into increased in plant height. The findings are in agreement with those reported by Tomar [7], Singh and Chauhan [8] Chaudhary et al. [9], Alsamowal et al. [10], Krishnaprabu [11] and Bhutadiya et al. [12].

The data on grain yield are presented in Table 4 indicated that application of different nitrogen management had significant effect on grain and stover yield of pearl millet. Application of RDN @ 80 kg/ha as chemical fertilizer (T_1) recorded significantly higher grain (1631 kg/ha) yield and it was remained at par with Treatment T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost *i.e.* 1481 kg/ha) and T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake *i.e.* 1472 kg/ha). “Significantly higher grain yield of pearl millet obtained with organic sources *viz.,* castor cake and vermicompost provide essential nutrients to crop for growth and development. Though, organic manures having low content of nutrients, but when applied them with higher dose they are able to fulfill required major and minor nutrients. Supplementation of nutrients along with better soil physical condition at higher rate of both organic manure increased plant height and length of ear head which resulted into higher grain yield per hectare” [13]. The findings closely followed the results of Tomar [7], Singh and Chauhan [8], Chaudhary et al. [9], Alsamowal et al. [10], Krishnaprabu [11] and Bhutadiya et al. [12].

The data presented in Table 4 indicated that stover yield recorded significantly higher in treatment T_1 (RDN @ 80 kg/ha as chemical fertilizer) which was remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake), treatment T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost) and treatment T_2 (75% RDN as chemical fertilizer + 25% RDN through FYM). Increase in straw yields was mainly because of increase in plant height and length of earhead which resulted from of castor cake that provided balanced nutrition, favourable soil environment and ultimately leads to maximum stover yields. The findings closely followed the results of Tomar [7], Singh and Chauhan [8] Chaudhary et al. [9], Alsamowal et al. [10], Krishnaprabu [11] and Bhutadiya et al. [12]

3.2 Economics

Economics of different treatments (Table 5) showed that maximum gross (Rs 55467/ha) and net return (Rs 22177/ha) with BCR of 1.67 was recorded with treatment T_1 (application of RDN @ 80 kg/ha as chemical fertilizer) followed by treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake) in pooled results.

Table 1. Effect of different nitrogen management treatments on initial and final plant population of *kharif* pearlmillet

Treatments	Plant population per metre row length							
	Initial				At harvest			
	2021	2022	2023	Pooled	2021	2021	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	9.66	9.25	9.46	9.46	8.93	8.79	9.08	8.93
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	9.43	9.15	9.39	9.32	8.96	8.69	9.01	8.89
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	9.54	9.38	9.42	9.45	9.07	8.91	9.04	9.01
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	9.47	9.32	9.52	9.44	9.01	8.85	9.14	9.00
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	9.41	9.36	9.30	9.36	8.94	8.89	8.65	8.83
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	9.76	9.29	9.56	9.54	9.27	8.83	8.89	9.00
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	9.57	9.22	9.20	9.33	9.09	8.76	8.55	8.80
S.Em. ±	0.37	0.33	0.36	0.35	0.33	0.34	0.33	0.33
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV %	7.69	7.20	7.56	7.49	7.23	7.62	7.35	7.40

Table 2. Effect of different nitrogen management treatments on periodical plant height of *kharif* pearlmillet

Treatments	Plant height (cm)											
	At 30 DAS				At 60 DAS				At harvest			
	2021	2022	2023	Pooled	2021	2021	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	57.20	44.93	53.35	51.82	143.04	136.1	140.6	139.9	184.5	163.0	178.4	175.3
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	55.08	43.42	50.93	49.80	138.14	132.2	135.0	135.1	177.6	153.4	170.7	167.3
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	55.36	42.38	51.06	49.59	138.85	129.5	135.5	134.6	178.5	154.3	171.2	168.1
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	54.01	43.74	52.09	49.94	135.68	133.0	137.7	135.4	174.2	158.5	174.4	169.0
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	50.20	38.52	44.82	44.51	122.26	115.5	118.7	118.8	155.5	133.3	148.0	145.6
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	52.06	39.07	46.35	45.82	126.57	116.9	122.4	121.6	161.5	135.3	153.1	149.9
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	50.70	40.16	47.63	46.16	123.48	119.8	125.2	122.8	157.1	139.4	157.0	151.2
S.Em. ±	2.20	1.60	2.04	1.96	4.74	5.21	5.19	5.04	7.09	7.5	7.21	7.27
C.D. at 5%	NS	NS	NS	NS	14.08	15.47	15.42	14.14	21.07	22.3	21.43	20.36
CV %	8.21	7.67	8.23	8.13	7.15	8.26	7.94	7.78	8.35	10.10	8.76	9.02

Table 3. Effect of different nitrogen management treatments on length of earhead, test weight and number of grain per earhead of *kharif* pearlmillet

Treatments	Length of earhead (cm)				Test weight (g)				Number of grain per earhead			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	21.68	19.12	20.77	20.53	7.48	7.02	7.42	7.30	1965	1714	1827	1834
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	19.77	17.17	19.48	18.81	7.33	7.07	7.36	7.25	1676	1464	1659	1600
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	20.95	17.99	19.66	19.53	7.16	7.16	7.14	7.15	1894	1531	1673	1699
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	20.31	18.35	20.02	19.56	7.20	6.83	6.98	7.01	1757	1655	1716	1707
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	16.91	14.49	17.23	16.21	7.02	7.21	7.18	7.13	1389	1212	1350	1316
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	18.10	14.57	17.22	16.63	7.14	7.03	7.02	7.06	1486	1296	1422	1400
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	17.43	15.25	18.03	16.90	6.93	6.98	7.23	7.04	1512	1317	1526	1450
S.Em. ±	0.86	0.79	0.87	0.84	0.22	0.22	0.23	0.13	145.91	118.62	150.42	135.60
C.D. at 5%	2.56	2.34	2.58	2.35	NS	NS	NS	NS	NS	NS	NS	NS
CV %	8.94	9.43	9.18	9.18	6.16	6.24	6.53	6.31	17.49	16.30	18.85	17.24

Table 4. Effect of different nitrogen management treatments on grain yield, straw yield and Harvest Index of *kharif* pearlmillet

Treatments	Grain yield (kg/ha)				Straw yield (kg/ha)				Harvest Index (%)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Mean
T_1: RDN @ 80 kg/ha as chemical fertilizer	1999	1416	1574	1631	4943	2923	3297	3754	28.80	32.06	32.68	31.18
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	1403	1202	1341	1334	4349	2659	2895	3334	24.39	31.63	32.08	29.37
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	1811	1241	1392	1481	4712	2718	2920	3483	27.76	31.35	32.28	30.46
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	1528	1384	1504	1472	4486	2884	3115	3528	25.41	32.42	32.56	30.13
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	1044	976	1057	1076	3829	2195	2569	2897	21.42	32.42	30.61	28.15
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	1292	989	1083	1174	4246	2241	2610	3065	23.34	32.32	30.79	28.82
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	1138	1044	1196	1178	4065	2420	2797	3127	21.87	31.81	31.18	28.29
S.Em. ±	132.0	82.7	98.9	102.8	230.8	167.6	159.4	188.7				
C.D. at 5%	392.3	245.7	293.9	287.8	685.8	497.9	473.7	528.3				
CV %	11.47	14.03	15.14	15.39	10.31	13.01	11.05	11.39				

Table 5. Economics as influenced by different nitrogen management treatments

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	BCR
T_1: RDN @ 80 kg/ha as chemical fertilizer	1631	3754	33291	55467.5	22177	1.67
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	1334	3334	39826	46685	6859	1.17
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	1481	3483	43675	50737.5	7062	1.16
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	1472	3528	39498	50760	11262	1.29
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	1076	2897	39865	38695	-1170	0.97
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	1174	3065	43715	41740	-1975	0.95
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	1178	3127	39290	42140	2850	1.07

Table 6. Effect of different nitrogen management treatments on N, P and K content in grain of *kharif* pearl millet

Treatments	N content in grain (%)				P content in grain (%)				K content in grain (%)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	1.338	1.336	1.414	1.36	0.256	0.329	0.222	0.269	0.512	0.428	0.433	0.457
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	1.383	1.351	1.414	1.38	0.271	0.320	0.195	0.262	0.474	0.420	0.417	0.437
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	1.415	1.424	1.379	1.41	0.259	0.327	0.214	0.267	0.512	0.424	0.432	0.456
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	1.460	1.420	1.316	1.39	0.264	0.323	0.216	0.268	0.541	0.427	0.441	0.469
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	1.495	1.413	1.365	1.42	0.277	0.332	0.210	0.273	0.535	0.436	0.417	0.462
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost +Biofertilizer (*Azatobacter* + PSB)	1.450	1.403	1.365	1.40	0.256	0.326	0.206	0.263	0.553	0.424	0.420	0.465
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	1.488	1.353	1.288	1.37	0.276	0.325	0.213	0.271	0.527	0.412	0.421	0.453
S.Em. ±	0.081	0.036	0.055	0.060	0.010	0.004	0.009	0.008	0.029	0.005	0.005	0.017
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.014	0.016	NS
CV %	11.33	5.19	8.11	8.66	7.74	2.67	8.49	6.17	10.96	2.14	2.49	7.44

Table 7. Effect of different nitrogen management treatments on N, P and K uptake by grain of *kharif* pearl millet

Treatments	N uptake by grain (kg/ha)				P uptake by grain (kg/ha)				K uptake by grain (kg/ha)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	26.79	18.28	21.74	22.27	5.14	4.50	3.38	4.34	10.28	5.84	6.62	7.58
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	19.27	16.65	19.34	18.42	3.79	3.93	2.66	3.46	6.62	5.17	5.70	5.83
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	26.10	17.68	19.18	20.99	4.66	4.06	2.98	3.90	9.24	5.26	6.02	6.83
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	22.29	19.56	19.79	20.55	4.03	4.47	3.26	3.92	8.25	5.90	6.63	6.92
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	15.63	14.88	15.42	15.31	2.88	3.49	2.397	2.92	5.54	4.59	4.72	4.95
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost +Biofertilizer (*Azatobacter* + PSB)	18.62	14.86	15.89	16.46	3.32	3.48	2.400	3.07	6.89	4.54	4.88	5.43
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	16.87	15.24	16.43	16.18	3.15	3.66	2.71	3.17	5.96	4.65	5.36	5.32
S.Em. ±	2.39	1.06	1.52	1.66	0.38	0.28	0.23	0.30	0.65	0.36	0.40	0.49
C.D. at 5%	7.11	3.15	NS	4.89	1.12	NS	0.683	0.847	1.940	NS	1.174	1.364
CV %	23.01	12.66	16.61	17.43	19.56	14.32	16.27	17.08	17.320	14.02	13.854	15.90

Table 8. Effect of different nitrogen management treatments on N, P and K content in straw of *kharif* pearl millet

Treatments	N content in straw (%)				P content in straw (%)				K content in straw (%)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	0.759	1.081	0.788	0.876	0.164	0.217	0.126	0.169	1.693	1.753	1.846	1.76
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	0.797	0.953	0.788	0.846	0.161	0.231	0.137	0.176	1.688	1.538	1.553	1.59
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	0.802	0.924	0.711	0.812	0.168	0.228	0.118	0.171	1.763	1.538	1.606	1.63
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	0.771	0.980	0.774	0.842	0.167	0.236	0.107	0.170	1.775	1.568	1.855	1.73
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	0.791	1.001	0.731	0.840	0.163	0.267	0.123	0.184	1.830	1.440	1.821	1.69
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	0.789	1.016	0.711	0.838	0.159	0.210	0.114	0.161	1.715	1.859	1.677	1.75
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	0.818	0.997	0.756	0.857	0.171	0.217	0.116	0.168	1.788	1.753	1.949	1.83
S.Em. ±	0.045	0.031	0.057	0.045	0.006	0.015	0.014	0.012	0.055	0.017	0.145	0.089
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.051	NS	NS
CV %	11.30	6.21	15.22	10.77	7.88	12.92	23.45	14.45	6.27	2.09	16.46	10.50

Table 9. Effect of different nitrogen management treatments on N, P and K uptake by straw of *kharif* pearl millet

Treatments	N uptake by straw (kg/ha)				P uptake by straw (kg/ha)				K uptake by straw (kg/ha)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	37.60	31.22	24.79	31.20	8.17	6.21	3.99	6.12	83.5	50.70	58.12	64.12
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	34.56	25.36	22.68	27.53	6.99	6.13	4.01	5.71	73.503	40.91	45.02	53.14
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	38.00	25.22	20.67	27.96	7.92	6.20	3.38	5.83	83.33	41.78	46.46	57.19
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	34.48	28.06	24.13	28.89	7.49	6.84	3.32	5.88	79.57	45.18	57.98	60.91
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	30.26	22.01	18.76	23.67	6.23	5.84	3.20	5.09	70.19	31.63	45.94	49.23
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	33.87	22.70	18.45	25.01	6.78	4.71	2.93	4.80	73.13	41.61	43.74	52.82
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	32.93	24.12	21.16	26.07	6.95	5.19	3.26	5.13	72.44	42.31	54.54	56.43
S.Em. ±	2.77	1.82	1.72	2.15	0.57	0.49	0.43	0.50	5.05	2.75	4.07	4.07
C.D. at 5%	NS	5.40	NS	6.03	NS	NS	NS	NS	NS	8.16	NS	11.39
CV %	16.04	14.23	15.94	15.84	15.77	16.74	25.20	18.18	13.20	13.07	16.21	14.46

Table 10. Effect of different nitrogen management treatments on OC of soil after harvest of crop

Treatments	OC (%)			
	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	0.205	0.126	0.241	0.190
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	0.206	0.138	0.241	0.195
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	0.203	0.138	0.224	0.188
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	0.214	0.158	0.234	0.202
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + PSB)	0.218	0.160	0.228	0.201
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB)	0.209	0.153	0.221	0.194
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	0.201	0.143	0.221	0.188
S.Em. ±	0.005	0.010	0.010	0.008
C.D. at 5%	NS	NS	NS	NS
CV %	4.640	13.77	8.40	8.74
Initial	0.219	0.186	0.260	

Table 11. Effect of different nitrogen management treatments on available N, P_2O_5 and K_2O in soil after harvest of crop

Treatments	Avail. N (kg/ha)				Avail. P_2O_5 (kg/ha)				Avail. K_2O (kg/ha)			
	2021	2022	2023	Pooled	2021	2022	2023	Pooled	2021	2022	2023	Pooled
T_1: RDN @ 80 kg/ha as chemical fertilizer	165.1	156.5	161.5	161.0	36.87	46.64	35.29	39.60	153.0	160.4	133.2	148.9
T_2: 75% RDN as chemical fertilizer + 25% RDN through FYM	176.9	169.7	159.5	168.7	39.91	35.49	36.93	37.44	154.6	159.8	134.8	149.7
T_3: 75% RDN as chemical fertilizer + 25% RDN through vermicompost	177.2	166.1	148.6	163.9	38.78	38.46	36.93	38.05	156.1	161.4	132.5	150.0
T_4: 75% RDN as chemical fertilizer + 25% RDN through castor cake	174.6	166.1	173.6	171.5	41.33	42.21	38.58	40.70	158.7	155.1	135.0	149.5
T_5: 50% RDN as chemical fertilizer + 25% RDN through FYM + Biofertilizer (*Azatobacter* + *PSB*)	180.8	174.4	156.4	170.5	42.28	43.75	38.16	41.39	165.8	158.0	137.5	153.7
T_6: 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + *PSB*)	179.5	176.7	158.8	171.6	40.62	33.09	31.60	35.10	162.8	161.7	129.9	151.5
T_7: 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB)	173.7	162.8	157.2	164.6	38.99	32.56	39.40	36.98	161.5	158.1	133.7	151.1
S.Em. ±	3.54	2.85	5.46	4.10	1.944	2.05	3.592	2.64	4.29	1.41	3.4	3.26
C.D. at 5%	NS	8.48	NS	NS	NS	6.09	NS	NS	NS	4.18	NS	NS
CV %	4.04	3.41	6.85	4.90	9.763	10.55	19.578	13.72	5.40	1.77	5.08	4.32
Initial	165.4	169.3	162.9		35.46	30.68	34.74		160.3	141.0	162.9	

This could be due to higher grain and stover yield received under treatments. Results corroborated with the results of Tomar [7], Singh and Chauhan [8] Chaudhary et al. [9], Alsamowal et al. [10], Krishnaprabu [11] and Bhutadiya et al. [12].

3.3 Chemical Studies

3.3.1 Plant analysis

N, P and K content in grain and straw: The perusal of data presented in Tables 6 and 8 revealed that there are no significant variation was observed with respect to N, P and K content in grain and strover of pearlmillet in pooled results.

N, P and K uptake by grain and straw: The data presented in Tables 7 and 9 indicated that N uptake by grain and straw recorded significantly higher in treatment T_1 (RDN @ 80 kg/ha as chemical fertilizer) which was remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake), treatment T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost) and treatment T_2 (75% RDN as chemical fertilizer + 25% RDN through FYM). The data presented in Tables 6 indicated that P and K uptake by grain recorded significantly higher in treatment T_1 (RDN @ 80 kg/ha as chemical fertilizer) which was remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake) and treatment T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost). In case of K uptake by straw recorded significantly higher in treatment T_1 (RDN @ 80 kg/ha as chemical fertilizer) which was remained at par with treatment T_4 (75% RDN as chemical fertilizer + 25% RDN through castor cake), treatment T_3 (75% RDN as chemical fertilizer + 25% RDN through vermicompost), treatment T_2 (75% RDN as chemical fertilizer + 25% RDN through FYM), 50% RDN as chemical fertilizer + 25% RDN through castor cake + Biofertilizer (*Azatobacter* + PSB) and 50% RDN as chemical fertilizer + 25% RDN through vermicompost + Biofertilizer (*Azatobacter* + PSB). P uptake by straw was found non significan. It might be due to the increase in grain and straw yield of pearlmillet due to the application of castor cake. This results corroborated with the results of Jakhar, R.R. [14]. Krishnaprabu, S. [11]. Lasya Mohana Rekha et al. [15].

3.3.2 Soil analysis

Effect of Nitrogen management treatments on soil properties: It is explicit from the data presented in Table 10 that O.C of soil were not affected significantly by different nitrogen management treatments in *kharif* pearlmillet.

Available N, P_2O_5 and K_2O in soil after harvest of pearlmillet: The data presented in Table 11 indicated that no significant variation was observed with respect to available N, P_2O_5 and K_2O in the soil after harvest of pearlmillet during in pooled results.

From three years experimentation it can be concluded that higher yield and net realization can be secured with the application of either 100% RDN (Recommended Dose of Nitrogen) *i.e.* 80 kg/ha through chemical fertilizer or 75% RDN (Recommended Dose of Nitrogen) + 25% RDN through castor cake or vermicompost (20 kg N/ha) in addtion to recommend dose of phosphourus 40 kg/ha as basal under North Gujarat Agro climatic conditions.

4. CONCLUSION

Various growth and yield attributing characters of the crop were measured and studied during the course of investigations. Other management practices were followed as recommended. In addition recommended dose of phosphorus (P_2O_5) was applied commonly 40 kg/ha in all the treatments as basal dose while application of *Azatobacter.*

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 manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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