Response of Organic Manure, Bio Fertilizer, Nano Urea and Nano DAP on Growth, Yield, Nutrient Uptake and Nutrient Contents in Pearl Millet Crop

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Abstract- Excessive fertilizer application in pearl millet cultivation results hazardous environmental issues and deteriorated soil conditions with a great subsidy expense in an Indian agriculture system. The present study evaluates the efficacy of nano-fertilizers in combination with organic manure and biofertilizers on the pearl millet crop yield, nutrient content and nutrient use efficiency of the crop pearl millet. Front line demonstrations on pearl millet (*var.* HHB-272) were conducted in randomized block design comparing nine different treatment groups in the sandy loam soil at Krishi Vigyan Kendra-Rampura (28.18 °N, 76.58 °E), Haryana during the years 2022-2 3 and 2023-24. Conventional soil-applied NPK at 150:60:30 of the recommended dose (RDN) was tested against foliar applications of nano-fertilizers. Results signified improved crop growth parameters with higher value of nutrient content in the crop grains and nutrient uptake by the crop. Combination 9 (Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP) showed best outcome as compared to control treatment (NPK 150:60:30) for both the years. Crop yield in T 9 was increased by 15.12 % and 20.25 % for the years 2023 and 2024 in comparison with T 1. All the tested parameters for the crop pearl millet were found to be highest in T 9 where organic compost, biofertilizer and nano-fertilizers were applied, eliminating the use of conventional fertilizers.

Key words- nano-fertilizers, plant growth promoters, nutrient uptake, food quality, crop yield.

I. INTRODUCTION

Pearl millet [Pennisetum glaucum (L.) R. Br.] is the most widely grown drought tolerant cereal crop consumed as feed and fodder in south Asia and sub-Sahara Africa region. It is also one of the most important food crops after rice, wheat and maize in India. Pearl millet is a C4 plant with a greater photosynthetic rate, higher dry matter capacity with early maturity, drought tolerance and greater biotic and abiotic stress resistance compared to other crops such as sorghum and maize [1]. It is critically important for food and nutritional security as it possess several advantages such as early maturing, drought tolerance and require minimum amount of agriculture inputs. Significantly, the grains have high protein content and rich in iron, zinc and dietary fibre. Besides, adverse agro -climatic conditions, pearl millet has a remarkable ability to counter favourable environmental conditions because of its short duration growth cycle and higher productivity rate [2]. These factors contribute towards its efficient production by making it an excellent crop under improved crop management techniques. On the other hand, fertilizers play a crucial role in crop production improvement and

soil fertility status. Where, Nitrogen based fertilizers (urea) serves as vital factor for Pearl millet plant growth development with efficient amount of nitrogen for enhancing photosynthesis and vegetative growth. For an instance, the utilization of urea has been drastically increased over the years in India and reported as 35.7 million tons of urea consumption in 2022-23 [3]. Urea has contributed effectively in agriculture sector in promoting and maintaining crop health, supplying adequate nitrogen for photosynthesis and higher crop yield. However, persistent and intensified use of urea from many years have also come up with detrimental effects like environmental pollution [4], soil degradation [5], eutrophication [6], water contamination [7] and exploitation of resources which cannot be overlooked. Moreover, it is also important to note that urea has a low nitrogen use efficiency (NUE) of 30-40% which means that the remaining nitrogen leach down and further causes gaseous emissions such as ammonia volatilization resulting in both environmental and economic consequences [8]. Therefore, the urgency to address these challenges and maintain sustainability in pearl millet crop production, precision nutrient management techniques such as optimization of irrigation system, nano-technology, 4R approach and stress management and detection technologies could be applied to alleviate fertilizer efficiency and accelerated agriculture outcomes on the edge of safer environmental practices [9]. Therefore, the present study is focussed on the application of nano-fertilizers on pearl millet crop. From recent years, field trials were conducted to determine the efficacy of nano-fertilizers as they offer promising advantages over conventional urea due to extreme small size and high surface area [10]. Nano-fertilizers have great potential for targeted delivery and controlled release of nutrients into the crops with a higher nutrient uptake efficiency up to 90% [11]. Various studies showed reduction in conventional fertilizers up to 25% in maize, wheat, pearl millet and mustard crops [12-14]. However, certain research work also reported 90% efficiency of nano-urea foliar application on crops as compared to conventional prilled urea [15]. It is evident from numerous studies [12,16-20] that nano-urea and other nano-fertilizers predominantly effect the physiology of crops and stepping towards an alternate eco-friendly approach against toxic high analysis fertilizers. Although these studies are limited to research farm trials to determine the impact of nano-urea on pearl millet crop yield and soil dynamics. Therefore, in response to determine the plant growth parameters, yield, nutrient contents and nutrient uptake efficiency in the crop pearl millet. This study aims to evaluate the response of organic manure and biofertilizers in combination with foliar applications of nano urea and nano-DAP in field conditions at Rewari district of Haryana, for the following years 2022-23 and 2023-24.

II. MATERIALS AND METHODOLOGY

2.1 Trial locations –

On-farm eighty demonstrations were conducted at the location viz. Krishi Vigyan Kendra-Rampura (28.18 °N, 76.58 °E) Haryana, India. The experiments were conducted during the years 2022-23 and 2023-24. The initial soil characteristics includes the sandy loam soil texture with annual rainfall of 400-500 mm and a relative humidity of 61.02 g $m^{-3,}$ respectively. Alkalinity of soil was found to be 7.69 and salinity was found to be 0.31 dSm^{-1}. Total organic carbon content was found to be 0.34 %, total nitrogen content was 112.6 kg ha^{-1}, total phosphorus was found to be 14.26 kg ha^{-1} and total potassium was found to be 184.0 kg ha^{-1}.

2.2 Experiment design –

On-farm experiment was laid out in Randomized Complete Block Design (RBD) with nine treatment combinations and replicated three times. There were twenty-seven plots with a gross plot size of 20 m2 and row spacing of 45 cm, plant spacing of 12 cm at a 3.75 kg ha^{-1} seed rate. The seeds variety chosen for the experimental setup was HHB-272.

2.3 Treatment combinations –

Fields were prepared as per the recommended doses of NPK, organic manure and biofertilizers based on soil health survey. Total nine treatment combinations were imposed in farm experiment for the pearl millet crop production detailed in table I. Treatment 1 as control included 100 % NPK kg ha^{-1} (150:60:30). Combination 2 included 25% NP + 100% K + two foliar spray @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 3 included 25% NP + 100% K + two foliar spray @ 5 ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 4 included 50% NP + 100% K + two foliar spray @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 5 included 50% NP + 100% K + two foliar spray @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 6 included 75% NP + 100% K + two foliar spray @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 7 included 75% NP + 100% K + two foliar spray @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Combination 8 included Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar spray @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP and combination 9 included Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP. Further all the testing parameters were kept similar for both the years 2023 and 2024 for the crop pearl millet.

Table 1: Treatment details for the nine different treatment groups including varied concentrations of organic manure, biofertilizer, nano-urea and nano-DAP.

Treatment details	Treatments
100% NPK	T1
25% NP + 100% K + two foliar sprays @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T2
25% NP + 100% K + two foliar sprays @ 5 ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T3
50% NP + 100% K + two foliar sprays @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T4
50% NP + 100% K + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T5
75% NP + 100% K + two foliar sprays @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T6
75% NP + 100% K + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T7
Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar spray @ 4 ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T8
Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP	T9

2.4 Yield growth parameters –

Crop specific integrant such as crop height (cm), number of effective tillers, length of ear head (cm), test weight (gm), grain yield (t/hac) and stover yield (t/hac) were recorded.

2.5 Nutrient content –

The total nitrogen contents in the grains were determined using Kjeldahl nitrogen analyser nitrogen. For Phosphorus and potassium 0.5gm of grain sample was digested with HNO3, evaporated at 100-120 °C until dried. The sample was then dissolved in 50 mL HNO3, added 10 mL demineralized water to make up the volume, rinsed and filtered using Whatman No. filter paper. 42. The absorption results using an atomic absorption spectrophotometer showed an absorbance of phosphorus at a wavelength of 213.6 nm and for potassium at 766.5 nm.

2.6 Nutrient use efficiency –

The Nitrogen Use Efficiency was calculated using formula PFP = Grain yield in N fertilized treatment (kg ha^{-1}) / fertilizer N applied (kg ha^{-1}). Where PFP is Partial factor Productivity measured as kg grain yield kg^{-1} N applied. In a similar manner, Phosphorus and Potassium uptake efficiency was measured and calculated for the pearl millet crop.

2.7 Statistical analysis –

All the statistical analysis of the observed outcomes were performed using Microsoft Excel V.16.49 software. ANOVA was applied at significant values $p<0.05$ to compare the significant difference among treated groups.

III. RESULTS

3.1 Yield and yield attributes –

Observations from the on-farm trials for the crop pearl millet are laid in table II for the years 2022-23 and 2023-24. Experiment data indicated the doses of nano-fertilizers drastically effected the yield growth parameters. Like, average plant height for T 1 was found to be 165 cm for the year 2023 and 172 cm for the year 2024 respectively. For the T 4, plant height was increased by 11.51 % for the years 2023 and 5.81% for the year 2024 as compared to T 1 (control). The increased percentage for the plant height in T 7 were 15.15% and 10.46% for the years 2023 and 2024 respectively. Further average plant height was increased by 17.57% and 13.95% in T 9 for the years 2023 and 2024 respectively. The number of effective tillers in T 1 was found to be 2.20 for the year 2023 and 2.10 for the years 2024 and was increased by 9.09% and 19.04% in T 4, 18.18 % and 28.57% in T 7 and 22.72% and 33.33% in T 9 for the years 2023 and 2024 respectively. Average length of the earhead for T 1 was found to be 21.60 cm for the years 2023 and 21.80 cm for the year 2024. The length of earhead was increased by 1.48% and 6.88% in T 4 as compared to T 1, 17.26% and 11.0% in T 7, 23.0% and 14.22% in T 9 for the years 2023 and 2024 respectively. Average test weight for T 1 was found to be 2.46 gm for the year 2023 and 1.54 gm for the year 2024. It was increased by 3.25% and 1.99% in T 4, 14.63% and 21.42 % in T 7 and 22.56% and 28.57% for the years 2023 and 2024 respectively. Measurement of the plant height, number of effective tillers, length of earhead, test weight, grain yield and stover yield from all the nine treatment groups has been depicted in table II and graphically illustrated in figures I and II for the comparative analysis of the pearl millet crop yield and yield attribute parameters (2023-24). For both the years all the yield attributing characteristics were found to be significant except for the test weight. Highest yield of 2.74 t ha^{-1} for the year 2023 and 2.85 t ha^{-1} for the year 2024 were recorded under the treatment combination T 9. Lowest yield was observed under the treatment combination T 2 (2.29 t ha^{-1}) for the year 2023 and in T 1 (2.37 t ha^{-1}) for the year 2024.

Table II: Effect of varied doses of organic manure, biofertilizer and nano-fertilizer on the crop pearl millet for the years 2023 and 2024. The data provide the year wise response and increase percentage from the yield growth parameters such as plant height, length of ear head, test weight, grain yield and stover yield of the tested crop.

Treatments	Plant Height (cm)		No. of effective tillers/plant		Length of ear head (cm)		Test wt. (gm)		Grain Yield (t/ha)			Stover Yield (t/ha)			
	Year														
	2023	2024	2023	2024	2023	2024	2023	2024	2023	Increase %	2024	Increase %	2023	Increase %	2024	Increase %
T 1	165	172	2.20	2.10	21.60	21.80	2.46	2.51	2.38		2.37		3.11		3.43	
T 2	174	176	2.30	2.30	21.90	22.40	2.52	2.53	2.29	-0.42%	2.40	1.26%	3.54	13.82%	3.65	6.41%
T 3	181	179	2.30	2.50	20.52	22.80	2.53	2.55	2.38	0	2.41	1.68%	3.59	15.43%	3.68	7.28%
T 4	184	182	2.40	2.50	21.92	23.30	2.54	2.56	2.39	0.42%	2.45	3.37%	3.62	16.39%	3.76	9.62%
T 5	187	184	2.50	2.60	22.90	23.60	2.54	2.58	2.41	1.26%	2.48	4.64%	3.67	18.0%	3.82	11.37%
T 6	189	188	2.50	2.60	24.47	23.90	2.55	2.58	2.53	6.30%	2.52	6.32%	3.72	19.61%	3.89	13.41%
T 7	190	190	2.60	2.70	25.33	24.20	2.56	2.58	2.58	8.40%	2.56	8.01%	3.75	20.57%	3.94	14.86%
T 8	193	193	2.60	2.80	25.89	24.60	2.58	2.60	2.62	10.08%	2.81	18.56%	3.81	22.50%	4.11	19.82%
T 9	194	196	2.70	2.80	26.57	24.90	2.59	2.61	2.74	15.12%	2.85	20.25%	3.89	25.08%	4.15	20.99%
SEm±	5.56	4.42	0.09	0.09	0.64	0.58	0.09	0.09	0.09		0.09		0.14		0.14	
C.D. (P=0.05)	16.66	13.26	0.27	0.28	1.91	1.73	NS	NS	0.26		0.28		0.42		0.42	
CV	5.23	4.15	6.35	6.42	4.79	4.25	6.29	6.28	6.02		6.40		6.60		6.39	

Treatment for the following crop pearl millet are abbreviated as T1 -T9. SEm± is the standard error of mean. C.D (p=0.05) is the critical difference within the groups and CV is the coefficient variation.

Table III: Response of different concentrations of nano-fertilizers, organic manure and biofertilizers on the grain total nutrient content (NPK) for the year 2023 and 2024.

Treatments	N%		P%		K%		N%		P%		K%	
	Grain						Stover					
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
T 1	1.64	1.54	1.12	1.23	1.29	1.12	1.11	1.04	0.28	0.31	0.74	0.76
T 2	1.76	1.65	1.21	1.24	1.46	1.26	1.14	1.08	0.32	0.36	0.82	0.88
T 3	1.81	1.71	1.22	1.25	1.58	1.32	1.16	1.11	0.35	0.39	0.87	0.95
T 4	1.81	1.76	1.26	1.25	1.61	1.49	1.17	1.13	0.37	0.41	0.92	1.03
T 5	1.84	1.81	1.26	1.27	1.65	1.58	1.18	1.18	0.38	0.43	0.98	1.08
T 6	1.86	1.84	1.25	1.27	1.68	1.63	1.20	1.23	0.42	0.45	1.02	1.11
T 7	1.88	1.87	1.26	1.29	1.72	1.68	1.23	1.26	0.44	0.46	1.06	1.13
T 8	1.95	1.96	1.27	1.29	1.83	1.76	1.29	1.35	0.47	0.50	1.12	1.15
T 9	2.01	1.98	1.38	1.49	1.86	1.81	1.31	1.36	0.48	0.52	1.15	1.20
SEm±	0.06	0.07	0.04	0.05	0.06	0.06	0.04	0.04	0.01	0.02	0.04	0.06
C.D. (P=0.05)	0.19	0.20	0.13	0.15	0.18	0.17	0.11	0.13	0.04	0.05	0.13	0.19
CV	6.00	6.39	6.00	6.70	6.46	6.48	5.47	6.44	6.60	6.56	7.89	10.44

Table IV: Response of different concentrations of nano-fertilizers, organic manure and biofertilizers on the nutrient uptake efficiency for the years 2023 and 2024.

Treatments	N (kg/ha)		P (kg/ha)		K (kg/ha)		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	Grain						Stover					
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
T 1	38.97	36.54	26.54	29.06	30.65	26.57	34.45	35.67	8.69	10.63	22.88	26.16
T 2	40.24	39.70	27.62	29.62	33.38	30.31	40.45	39.51	11.36	13.17	29.11	32.09
T 3	43.01	41.39	28.87	30.03	37.54	31.95	41.73	41.02	12.62	14.41	31.18	35.13

T 4	43.29	43.15	30.23	30.72	38.50	36.53	42.38	42.51	13.40	15.43	33.34	38.80
T 5	44.30	44.94	30.42	31.47	39.81	39.23	43.33	45.12	13.96	16.44	35.91	41.30
T 6	47.14	46.45	31.75	32.09	42.57	41.14	44.71	47.93	15.65	17.53	37.84	43.12
T 7	48.45	47.99	32.48	32.85	44.48	43.11	46.24	49.76	16.54	18.17	39.70	44.32
T 8	51.26	55.26	33.49	36.21	48.10	49.62	49.07	55.67	17.97	20.62	42.60	47.19
T 9	55.31	56.67	37.70	42.68	51.18	51.81	50.85	56.68	18.75	21.67	44.66	49.72
SEm±	2.69	3.47	1.55	1.80	2.74	3.00	2.31	3.45	1.11	1.26	1.61	2.64
C.D. (P=0.05)	8.07	10.39	4.64	5.39	8.21	9.00	6.92	10.34	3.32	3.79	4.82	7.92
CV	10.19	13.11	8.64	9.51	11.65	13.37	9.16	12.99	13.39	13.31	7.91	11.52

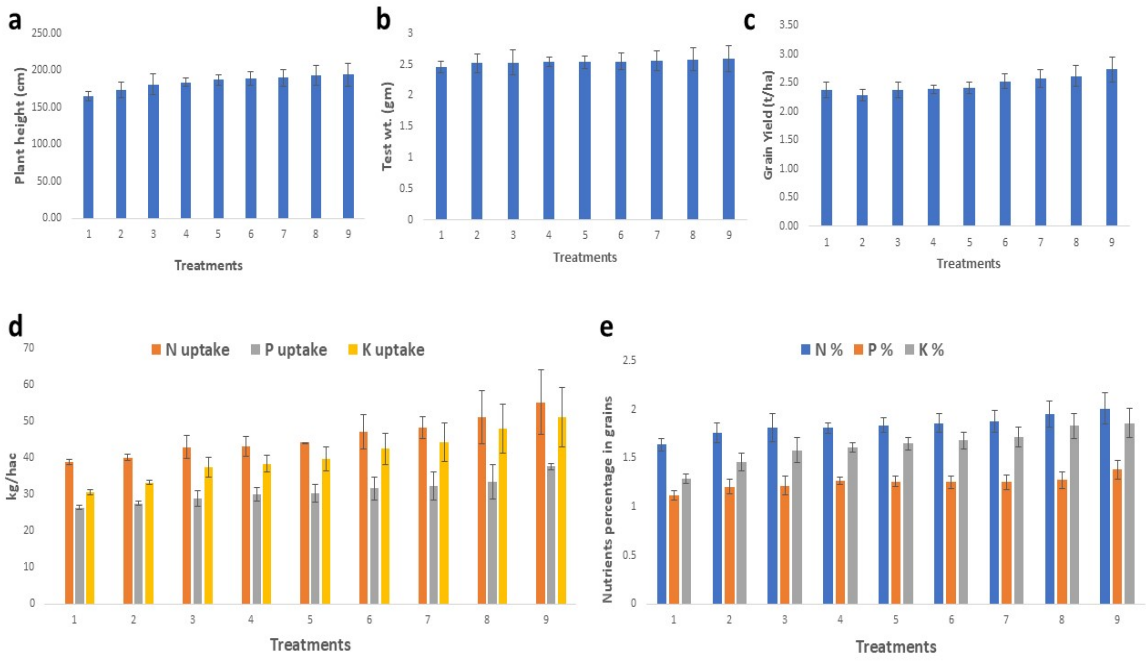

Figure I: Depicts the comparative analysis of treatment wise plant height (a), test weight (b), grain yield (c), Nutrient uptake efficiency (d) and nutrient content percentage in grains (e) for the crop pearl during the year 2023.

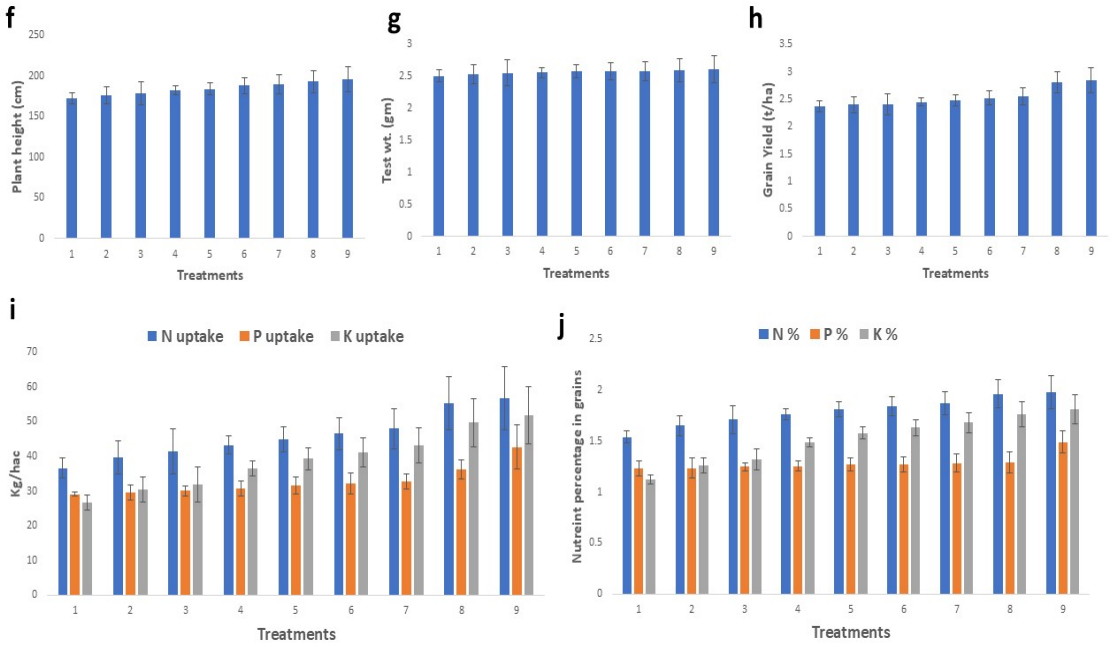

Figure II: Depicts the comparative analysis of the treatment wise plant height (f), test weight (g), grain yield (h), Nutrient uptake efficiency (i) and nutrient content percentage in grains (j) for the crop pearl millet during the year 2024.

3.2 Nutrient content –

For the analysis of grain nutrient contents, total content of Nitrogen, Phosphorus and Potassium were determined and tabulated in table III. Lowest N, P and K percentage in T 1 was found to be 1.64%, 1.12% and 1.29% respectively for the year 2023, whereas, 1.54%, 1.24% and 1.12% was recorded for the year 2024. Total nitrogen contents were increased by 10.36% in treatment combination T 4 for the year 2023 and increased by 14.28 % for the year 2024. N content was increased by 14.63% and 21.42% in T 7 and 22.56 % and 28.57% in T 9 for the consecutive years 2023 and 2024. Similar trend was observed while the total phosphorus content was increased by 12.5% in T 4 and T 7 for the year 2023 whereas, it was increased by 1.62% under the treatment combination T4 and 4.03% under the treatment combination T 7 for the year 2024. For treatment combination T 9 total P was increased by 23.4% and 21.13% for the years 2023 and 2024 respectively. Total potassium percentage was increased by 24.80 % in T 4 for the year 2023 and 33.03% for the year 2024. For T 7 was increased by 33.33% in 2023 and 50% in 2024. Again, under the treatment combination T 9 total potassium was increased by 44.18% for the year 2023 and 61.60% for the year 2024. The highest Nitrogen (2.01% and 1.98%), Phosphorus (1.38% and 1.49%) and Potassium (1.86% and 1.81%) in grains were found in treatment combination T 9 for both the years 2023 and 2024. Lowest content of NPK in grains was observed in T 1 where recommended dose of urea and conventional fertilizers were applied.

3.3 Nutrient use efficiency/nutrient uptake –

For the nutrient uptake efficiency total Nitrogen, Phosphorus and Potassium $kg\ ha^{-1}$ were calculated and depicted in table IV. The total N uptake observed in treatment T 1 was found to be 38.97 $kg\ ha^{-1}$ for the year 2023 and 36.54 $kg\ ha^{-1}$ for the year 2024. Experimental data regarding N uptake indicated that an increase of 11.08% (2023) and 18.08% (2024), 24.32% (2023) and 31.33% (2024), as well as 41.92% (2023) and 55.09% (2024) under the treatment combinations T4, T7 and T9 respectively were observed. Highest N uptake was recorded in the treatment combination T 9 for the years, and T 9 was found to be significant among all treatment combinations for nutrient use efficiency. For phosphorus uptake, Total P in T 1 was found to be 26.54 $kg\ ha^{-1}$ for the year 2023 and 29.06 $kg\ ha^{-1}$ for the year 2024. Similarly, experimental data regarding P uptake indicated that an increase of 13.90% (2023) and 5.71% (2024), 22.38% (2023) and 13.04% (2024), as well as 42.04% (2023) and 46.86% (2024) under the treatment combinations T4, T7 and T9 respectively were observed. The research data regarding Potassium uptake indicated 30.65 $kg\ ha^{-1}$ and 26.57 $kg\ ha^{-1}$ total K content for the year 2023 and 2024 respectively. An increase of 25.61% (2023) and 37.48% (2024), 45.12% (2023) and 62.25% (2024), as well as 66.98% (2023) and 94.99% (2024) over the control under the treatment combinations T4, T7 and T9 were observed. Highest potassium uptake was recorded under the treatment combination T 9 for both the years as shown in figures I and II.

IV. DISCUSSION AND CONCLUSION

In order to optimize the pearl millet yield, nitrogen fertilizer (urea) is required. However, using traditional prilled urea reduces nitrogen use efficiency, which increases the expenditure of government subsidies and accounts for environmental loss. This study investigated the alternate nutrient management practices to reduce fertilizer input without compromising pearl millet grain yields, given the necessity to maximize nano-fertilizer to sustain productivity. By increasing NUE and simultaneously decreasing dependency on conventional urea applied, in the present study nano fertilizers such as nano urea and nano-DAP were utilized, and exhibited lower nutrient losses and higher absorption efficiency offering sustainable alternative and promising effects of nutrient management for future food needs. Our study showed the importance of foliar application of nano-urea and nano-DAP in the crop pearl millet. Results from the on-farm trials depicted that the combination of organic manure and compost, biofertilizers and foliar spray of nano-fertilizers at different growth stages provides higher grain yield, stover yield, nutrient content and nutrient uptake as described in table II, III and IV. Evaluation of one- and two-times foliar spray of nano-urea (4 ml/lt and 5 m/lt) and nano -DAP (2.5 ml /lt) were studied in combination with vermicompost and seed treatment with biofertilizer. However, applying conventional $NPK_{100\%}$ showed the lowest yield and stover yield in comparison with the treatment (T 9) which included Vermi compost @ 2.5 t/ha + seed treatment with bio fertilizer + two foliar sprays @ 5ml/lt of Nano urea and 2.5 ml /lt Nano DAP. In this research treatment combination T 9 determined the promising effects of foliar sprays of nano-urea and nano-DAP conducted at the right time duration and vegetative growth stages of the crop pearl millet. From the insights of above-mentioned outcomes, significant crop biomass was achieved by employing the integrated nutrient management model corresponding natural and unexpensive resources with nanotechnology. The nanoparticles/nano-nutrients/nano-fertilizers have played significant role in promoting the crop productivity when applied as foliar spray [21] whereas, organic manure and biofertilizers participated in improving soil fertility as observed in the analogous treatments [22]. The absorption of nano-fertilizers was maximized by aerosol-mediated foliar spray [23,24]. As, the plants contain a bidirectional vascular system pathway along the photosynthetic gradient and are subsequently used to move nanoparticles from shoot to root [25, 26]. Therefore, it is apparent from the expanded cereal crop that nano-fertilizers have initiated the uptake of soil additives by crops. However, several studies also reported that foliar applications of metal nanoparticles dramatically improve the content of chlorophyll in plants [27-30]. Therefore, nanoparticles in agriculture have the potential to deliver environmentally friendly nutrients and safer food products, irrespective of the high expenses associated with conventional farming practices.

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