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Effect of integrated nutrient management on content, uptake and quality of summer pearlmillet (*Pennisetum glaucum* L.) under south Gujarat condition

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Abstract
A field experiment was conducted during summer season of 2018 at Collage Farm, N. M. Collage of Agriculture University, Navsari, Gujarat, to study the effect of integrated nutrient management on summer pearl millet under south Gujarat condition. Two levels of manure (no compost and vermicompost @ 10 t/ha), three fertilizer levels (no RDF, 75 per cent RDF and 100 per cent RDF) and two levels of biofertilizer (no seed inoculation and seed inoculation with *Azotobacter* @ 2 ml/kg seeds) were compared. Application of 10 tonnes vermicompost/ha recorded significantly higher nutrient (N, P_2O_5 and K_2O) content, uptake, protein content and protein yield over control. Improvement in nutrient content, uptake, protein content and protein yield were also noticed with 100 per cent RDF. Seed inoculation with *Azotobacter* also increased nutrient content, uptake, protein content and protein yield of pearlmillet over control.

Keywords: Vermicompost, pearlmillet, biofertilizer

Introduction
Pearlmillet (*Pennisetum glaucum* L.) is one of the important millet crops of India. Among the millets, it comes next to sorghum in area and production. Rajasthan ranks first in area and production of pearlmillet. Besides being a staple diet of about 10 per cent population of our country, it is an important fodder crop also. It is the only cereal crop that is capable of producing a reliable yield under the marginal environments and simultaneously responds to high management conditions. Its nutritious grain forms the important component of human diet and stover forms the principal maintenance ration for ruminant livestock during the dry poultry. It is nutritionally better than many cereals as it is a good source of protein (12.6 per cent), minerals, particularly iron (2.8 per cent) and fat (5 per cent). In India, it is annually grown on 8.74 million ha area producing nearly 8.83 million tonnes of grains with productivity of 1011 kg/ha (Anon., 2011) [1].

Material and Methods
In order to accomplish the objectives, the present field experiment entitled, "Effect of integrated nutrient management in summer pearlmillet (*Pennisetum glaucum* L.) under south Gujarat condition" was conducted during summer season of 2018 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The campus is geographically located at 20˚-57′ N latitude and 72˚-54′ E longitude at an altitude of 10 meters above the mean sea level. According to agro-climatic conditions, Navsari is located in south Gujarat heavy rainfall zone-I (Agro-ecological situation-III). The climate of this zone is typically tropical, characterized by humid and warm monsoon with heavy rain, quite cold winter and fairly hot summer. The average annual rainfall of the tract is about 1500 mm. The soil of experimental field was clayey in texture, having pH 7.8 with normal electrical conductivity (0.36 dsm^{-1}), low in organic carbon content (0.72%), low in available nitrogen (150.23 kg ha^{-1}), medium in available phosphorus (49 kg ha^{-1}) and fairly rich in available potassium (307.81 kg ha^{-1}).

The treatments consisted of two levels of manure (no compost and vermicompost @ 10 t/ha), three fertilizer levels (no RDF, 75 per cent RDF and 100 per cent RDF) and two levels of biofertilizer (no seed inoculation and seed inoculation with *Azotobacter* @ 2 ml/kg seeds). These treatments were evaluated in randomized block design with factorial concept (FRBD) and replicate three times. Pearlmillet variety GCH-732 was sown in furrows at 45 cm row spacing using a seed rate of 3.75 kg/ha. Application of fertilizers (120:60:00 NPK kg/ha) was applied as per treatment. Half dose of N and full dose of P and K applied basal at the time of sowing and remaining half dose of N at 30 and 60 days after sowing. Vermicompost (1.74% N, 0.89% P, 0.86% K and 12:1 C: N ration) was mixed in soil at the time of field preparation as per treatment. Seed was uniformly coated with *Azotobacter* @ 2 ml/kg seeds as per treatments. The results were analysed using standard statistical procedure given by Panse and Sukhatme (1985) [13].

Result and Discussion

Effect of Manure

Significant effect of vermicompost was observed on content, uptake and quality of pearlmillet. A significant increase in concentration of N, P_2O_5 and K_2O in grain (1.83, 0.33 per cent and 0.65 per cent, respectively) and straw (0.66, 0.17 per cent and 0.99 per cent, respectively) of pearlmillet was observed due to application of vermicompost @ 10 t/ha. The application of manures significantly increased the concentration (N, P_2O_5 and K_2O) in grain and straw. It can chiefly be associated with the better growth of the crop due to favorable nutritional environment mainly for supply of most of the macro and micro nutrients in balanced and available form throughout the growing period of the crop and in adequate amounts.

Since, the significantly highest N, P_2O_5 and K_2O uptake of nutrients in grain (92.72, 16.96 kg/ha and 33.15 kg/ha, respectively), straw (73.75, 19.71 kg/ha and 112.10 kg/ha, respectively) and total uptake of N, P_2O_5 and K_2O by grain and straw (166.48, 36.68 and 145.23 kg/ha, respectively) was recorded in application of vermicompost @ 10 t/ha (M_2)

The uptake is a function of their concentration and yield, the increase in grain and straw yield coupled with increased nutrient concentration also resulted in higher uptake of nitrogen, phosphorus and potassium with the application of vermicompost @ 10 t/ha. Use of organic manures (vermicompost) has also been known to help in reducing the soil pH to some extent by producing organic acids while their decomposition that may also be the reason of greater availability and mobility of nutrients mainly of micronutrients. This could have also helped in additional uptake of the nutrients by plants. The findings of the present investigation are in agreement with those of Kathuria *et al.* (2003) [8] in pearlmillet, Kumawat and Jat (2005) [9] in barley and Vandana *et al.* (2008) [19] in pearlmillet and Jadhav *et al.* (2011) [6] in pearlmillet.

Protein content and protein yield was significantly influenced due to manure. Vermicompost @ 10 t/ha recorded higher value of protein content (11.43 per cent) and protein yield (579.57 kg/ha) in grain of pearlmillet as compared to no compost. The increase in protein content and protein yield was ascribed to the fact that the protein content and protein yield in grain is infect a manifestation of nitrogen concentration in grain as discussed in nutrient content and uptake. The increased concentration of nitrogen in grain directly resulted in high protein content recorded with application of vermicompost 10 t /ha in comparison to no compost. The findings of the present investigation are in agreement with those of Vidyadharan (2008) [20] in barley and Jadhav *et al.* (2011) [6] in pearlmillet.

Effect of fertilizer

N, P_2O_5 and K_2O content and uptake of grain and straw were influenced by fertilizer application. Significantly higher N, P_2O_5 and K_2O content in grain (1.76, 0.31 per cent and 0.65 per cent, respectively) was recorded with application of 100 per cent RDF (F_3). The significantly lowest N, P_2O_5 and K_2O content in grain registered with application of no RDF (F_1). Significantly higher N, $P_2O_5$0 and K_2O content in straw (0.61, 0.17 per cent and 0.95 per cent, respectively) was recorded with application of 100 per cent RDF (F3). The significantly lowest N, P_2O_5 and K_2O content in straw registered with application of no RDF (F_1).

The N, P_2O_5 and K_2O uptake by grain (77.82, 14.11 kg/ha and 28.43 kg/ha, respectively) was recorded significantly higher with application of 100 per cent RDF (F_3). The significantly lowest N, P_2O_5 and K_2O uptake by grain (42.16, 7.35 kg/ha and 14.59 kg/ha) registered with application of no RDF (F_1).

Significantly higher N, P_2O_5 and K_2O uptake by straw (60.46, 18.86 kg/ha and 94.44 kg/ha, respectively) and total uptake of N, P_2O_5 and K_2O by grain and straw (138.28, 30.97 and 122.87 kg/ha, respectively) was recorded with application of 100 per cent RDF (F_3). The significantly lowest N, P_2O_5 and K_2O uptake by straw (34.98, 8.44 kg/ha and 47.02 kg/ha) was registered with application of no RDF (F_1). The higher removal of N, P_2O_5 and K_2O with this level might be due to better development of root and shoot resulted in higher N, P_2O_5 and K_2O uptake. These findings were supported by Rathore *et al.* (2006) [14], Narolia and Poonia (2011) [12], Shrivastava and Arya (2017) [15] in pearlmillet and Duhan (2013) [4] in sorghum.

The quality parameters *viz*., protein content and protein yield in grain significantly due to fertilizer application in pearlmillet. However, numerically higher protein content (10.97 per cent) and yield (486.38 kg/ha) in grain was recorded higher in treatment 100 per cent RDF (F_3). The significantly lowest protein content and yield in grain registered with application of no RDF (F_1). These findings are in close conformity wi th those of Tripathi and Kushwaha (2013) [18], Chanrda *et al.* (2014) [3] in pearlmillet, Gangwar and Niranjan (1991) [5] in fodder sorghum.

Effect of biofertilizer

Seed inoculation with *Azotobacter* significantly enhanced N, P_2O_5 and K_2O concentration in grain (1.76, 0.31 per cent and 0.63 per cent, respectively) and straw (0.60, 0.17 per cent and 0.91 per cent, respectively) and N, P_2O_5 and K_2O uptake in grain (70.71, 12.73 kg/ha and 25.50 kg/ha, respectively), straw (54.99, 15.46 kg/ha and 83.79 kg/ha, respectively) and total uptake of N, P_2O_5 and K_2O by grain and straw (125.70, 28.19 and 109.29 kg/ha, respectively) over without inoculation. The concentration and uptake of any nutrient in the plant is directly related to its availability in the root zone and growth of the plant. Use of *Azotobacter* significantly increased the N, P_2O_5 and K_2O concentration in grain and straw that might mainly be attributed to their availability in soil in appreciable amount and in the available form due to this microbial inoculant. It also promotes secretion of growth promoting substances which also resulted in better utilization of other nutrients like P_2O_5 by plants. The greater uptake of N, P_2O_5 and K_2O are directly related with the increased

concentration of these nutrients in seed and straw and significantly higher seed and straw yields observed under inoculation of seed with *Azotobacter* treatment than without inoculation. These results also corroborate with the findings of Wani *et al.* (1998) [21], Togas *et al.* (2015) [17] in pearlmillet.

Protein content and protein yield was significantly influenced due to biofertilizer. Seed inoculation with *Azotobacter* recorded higher value of protein content (10.99 per cent) and protein yield (441.97 kg/ha) in grain of pearlmillet as compared to no seed inoculation. The increase in protein content and protein yield was ascribed to the fact that the protein content and protein yield in grain is infect a manifestation of nitrogen concentration in grain as discussed in nutrient content and uptake. The increased concentration of nitrogen in grain directly resulted in high protein content recorded with application of seed inoculation with *Azotobacter* in comparison to no seed inoculation. The findings of the present investigation are in agreement with those of Nanda *et al.* (2001) [11] in sorghum and Suke *et al.*(2011) [16] in sorghum.

Interaction effect

N, P_2O_5 uptake by grain and P_2O_5 uptake by straw was significantly influenced by interaction effect of manure and fertilizer (M x F). It was also significantly influenced due to manure and biofertilizer (M x B). The treatment combination remarkably increased the N, P_2O_5 uptake by grain (111.16 kg/ha and 20.81 kg/ha) and P_2O_5 uptake by straw (24.43 kg/ha) and noted higher under M_2F_3 (Vermicompost @ 10 t/ha + 100 per cent RDF). Maximum N, P_2O_5 uptake by grain (101.91 kg/ha and 18.84 kg/ha) and P_2O_5 uptake by straw (22.55 kg/ha) were produced under treatment combination of M_2B_2 (Vermicompost @ 10 t/ha + seed inoculation with *Azotobacter*).

K_2O uptake by grain and N, K_2O uptake by straw was significantly persuaded due to interaction effect of manure and fertilizer (M x F). The treatment combination of M_2F_3 (Vermicompost @ 10 t/ha + 100 per cent RDF) showed higher effect on K_2O uptake by grain (40.13 kg/ha) and N, K_2O uptake by straw (86.83 kg/ha and 135.81 kg/ha).

Total uptake of N, P_2O_5 and K_2O by grain and straw was significantly influenced by interaction effect of manure and fertilizer (M x F). It was also significantly influenced due to manure and biofertilizer (M x B). The treatment combination remarkably increased the total uptake of N, P_2O_5 and K_2O by grain and straw (197.99, 45.24 and 176.04 kg/ha) noted higher under M_2F_3 (Vermicompost @ 10 t/ha + 100 per cent RDF). Maximum total uptake of N, P_2O_5 and K_2O by grain and straw (181.24, 41.39 and 158.44 kg/ha) were produced under treatment combination of M_2B_2 (Vermicompost @ 10 t/ha + seed inoculation with *Azotobacter*). Since, the uptake of nutrients in grain and straw is a function of their concentration and yield, the increase in grain and straw yield coupled with increased nutrient concentration also resulted in higher total uptake of N, P_2O_5 and K_2O with the application of M_2F_3. Bhalerao *et al.* (2002) [2] in sorghum and Jain *et al.* (2018) [7] in pearlmillet also reported similar results.

Protein yield was significantly influenced by interaction effect of manure and fertilizer (M x F). It was also significantly influenced due to manure and biofertilizer (M x B). The treatment combination remarkably increased the protein yield (694.78 kg/ha) and noted higher under M_2F_3 (Vermicompost @ 10 t/ha + 100 per cent RDF). Maximum number of protein yield (636.91 kg/ha) were produced under treatment combination of M_2B_2 (Vermicompost @ 10 t/ha + seed inoculation with *Azotobacter*). The increase in protein yield was ascribed to the fact that the protein yield in grain is infect a manifestation of nitrogen concentration in grain as discussed in nutrient content and uptake. The increased concentration of nitrogen in grain directly resulted in high protein yield recorded with application of M_2F_3. These results supported the observation made by Bhalerao *et al.* (2002) [2] in sorghum and Lattief (2011) [10] in pearlmillet.

Table 1: N, P_2O_5 and K_2O content in grain and straw of pearlmillet as influenced by integrated nutrient management

Treatments	Nutrient content in grain (%)			Nutrient content in straw (%)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
(A) Manure (M)						
No compost (M_1)	1.58	0.26	0.56	0.52	0.13	0.76
Vermicompost @ 10 t/ha (M_2)	1.83	0.33	0.65	0.66	0.17	0.99
S.Em. ±	0.02	0.004	0.01	0.01	0.002	0.01
C.D. at 5%	0.05	0.01	0.03	0.03	0.01	0.04
(B) Fertilizer (F)						
No RDF (F_1)	1.62	0.27	0.56	0.54	0.13	0.75
75 per cent RDF (F_2)	1.75	0.30	0.61	0.61	0.16	0.92
100 Per cent RDF (F_3)	1.76	0.31	0.65	0.61	0.17	0.95
S.Em. ±	0.02	0.005	0.01	0.01	0.003	0.02
C.D. at 5%	0.06	0.02	0.03	0.03	0.01	0.04
(C) Biofertilizer (B)						
No seed inoculation (B_1)	1.65	0.28	0.58	0.57	0.14	0.84
Seed inoculation with *Azotobacter* (B_2)	1.76	0.31	0.63	0.60	0.17	0.91
S.Em. ±	0.02	0.004	0.01	0.01	0.002	0.01
C.D. at 5%	0.05	0.01	0.03	0.03	0.01	0.04

Table 2: N, P_2O_5 and K_2O uptake by grain and straw of pearlmillet as influenced by integrated nutrient management

Treatments	Nutrient uptake by grain (kg/ha)			Nutrient uptake by straw (kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
(A) Manure (M)						
No compost (M_1)	35.56	5.81	12.65	28.00	7.21	41.62
Vermicompost @ 10 t/ha (M_2)	92.72	16.96	33.15	73.75	19.71	112.10
S.Em. ±	1.32	0.33	0.62	1.66	0.39	2.20
C.D. at 5%	3.88	0.97	1.82	4.87	1.15	6.46
(B) Fertilizer (F)						
No RDF (F_1)	35.56	5.81	12.65	34.98	8.44	47.02
75 per cent RDF (F_2)	92.72	16.96	33.15	57.19	15.08	88.09
100 Per cent RDF (F_3)	1.32	0.33	0.62	60.46	16.86	94.44
S.Em. ±	3.88	0.97	1.82	2.04	0.48	2.70
C.D. at 5%	42.16	7.35	14.59	5.97	1.41	7.91
(C) Biofertilizer (B)						
No seed inoculation (B_1)	35.56	5.81	12.65	46.77	11.46	69.91
Seed inoculation with *Azotobacter* (B_2)	92.72	16.96	33.15	54.99	15.46	83.79
S.Em. ±	**1.32**	**0.33**	**0.62**	**1.66**	**0.39**	**2.20**
C.D. at 5%	**3.88**	**0.97**	**1.82**	**4.87**	**1.15**	**6.46**

Table 3: Total uptake of N, P_2O_5 and K_2O by grain and straw of pearlmillet as influenced by integrated nutrient management

Treatments	Total nutrient uptake by grain and straw (kg/ha)		
	N	P_2O_5	K_2O
(A) Manure (M)			
No compost (M_1)	63.56	13.01	54.28
Vermicompost @ 10 t/ha (M_2)	166.48	36.68	145.23
S.Em. +	2.23	0.59	2.37
C.D. at 5%	6.55	1.72	6.96
(B) Fertilizer (F)			
No RDF (F_1)	77.14	15.78	62.62
75 per cent RDF (F_2)	129.64	27.78	113.77
100 Per cent RDF (F_3)	138.28	30.97	122.87
S.Em. +	2.74	0.72	2.91
C.D. at 5%	8.03	2.11	8.52
(C) Biofertilizer (B)			
No seed inoculation (B_1)	104.34	21.50	90.21
Seed inoculation with *Azotobacter* (B_2)	125.70	28.19	109.29
S.Em. +	2.23	0.59	2.37
C.D. at 5%	6.55	1.72	6.96

Table 4: Protein content and protein yield in grain of pearlmillet as influenced by integrated nutrient management

Treatments	Protein content (%)	Protein yield (kg/ha)
(A) Manure (M)		
No compost (M_1)	9.90	222.30
Vermicompost @ 10 t/ha (M_2)	11.43	579.57
S.Em. +	0.11	8.25
C.D. at 5%	0.32	24.21
(B) Fertilizer (F)		
No RDF (F_1)	10.11	263.52
75 per cent RDF (F_2)	10.91	452.92
100 Per cent RDF (F_3)	10.97	486.38
S.Em. +	0.13	10.11
C.D. at 5%	0.39	29.65
(C) Biofertilizer (B)		
No seed inoculation (B_1)	10.33	359.90
Seed inoculation with *Azotobacter* (B_2)	10.99	441.97
S.Em. +	0.11	8.25
C.D. at 5%	0.32	24.20

Table 5: Interaction effects on N uptake by grain of pearlmillet

Treatments	N uptake by grain (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	F_1	F_2	F_3	B_1	B_2
M_1	21.58	40.63	44.47	31.61	39.52
M_2	62.73	104.27	111.16	83.54	101.91
S.Em. ±	2.29			1.87	
C.D. at 5%	6.72			5.48	

Table 6: Interaction effects on P_2O_5 uptake by grain of pearlmillet

Treatments	P_2O_5 uptake by grain (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	F_1	F_2	F_3	B_1	B_2
M_1	3.39	6.61	7.41	4.99	6.62
M_2	11.30	18.78	20.81	15.09	18.84
S.Em. ±	0.57			0.47	
C.D. at 5%	1.67			1.37	

Table 7: Interaction effect on K_2O uptake by grain of pearlmillet

Treatments	K_2O uptake by grain (kg/ha)		
	Fertilizer (F)		
Manure (M)	F_1	F_2	F_3
M_1	7.18	14.05	16.73
M_2	21.10	37.31	40.13
S.Em. ±	1.08		
C.D. at 5%	3.15		

Table 8: Interaction effect on N uptake by straw of pearlmillet

Treatments	N uptake by straw (kg/ha)		
	Fertilizer (F)		
Manure (M)	F_1	F_2	F_3
M_1	18.01	31.91	34.08
M_2	51.96	82.47	86.83
S.Em. ±	2.88		
C.D. at 5%	8.44		

Table 9: Interaction effects on P_2O_5 uptake by straw of pearlmillet

Treatments	P_2O_5 uptake by straw (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	F_1	F_2	F_3	B_1	B_2
M_1	4.06	8.27	9.29	6.05	8.37
M_2	12.82	21.90	24.43	16.88	22.55
S.Em. ±	**0.68**			**0.56**	
C.D. at 5%	**1.20**			**1.63**	

Table 10: Interaction effects on K_2O uptake by straw of pearlmillet

Treatments	K_2O uptake by straw (kg/ha)		
	Fertilizer (F)		
Manure (M)	**F_1**	**F_2**	**F_3**
M_1	25.25	46.50	52.89
M_2	70.68	129.51	135.81
S.Em. ±	3.82		
C.D. at 5%	11.21		

Table 11: Interaction effects on total N uptake by grain and straw of pearlmillet

Treatments	Total N uptake by grain and straw (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	**F_1**	**F_2**	**F_3**	**B_1**	**B_2**
M_1	39.59	72.54	78.56	56.97	70.16
M_2	114.69	186.75	197.99	151.71	181.24
S.Em. ±	3.87			3.16	
C.D. at 5%	11.35			9.27	

Table 12: Interaction effects on total P_2O_5 uptake by grain and straw of pearlmillet

Treatments	Total P_2O_5 uptake by grain and straw (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	**F_1**	**F_2**	**F_3**	**B_1**	**B_2**
M_1	7.46	14.88	16.71	11.04	14.99
M_2	24.11	40.68	45.24	31.96	41.39
S.Em. ±	1.02			0.83	
C.D. at 5%	2.98			2.43	

Table 13: Interaction effects on total K_2O uptake by grain and straw of pearlmillet

Treatments	Total K_2O uptake by grain and straw (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	**F_1**	**F_2**	**F_3**	**B_1**	**B_2**
M_1	32.49	60.63	69.69	48.41	60.14
M_2	92.75	166.89	176.04	132.02	158.44
S.Em. ±	4.11			3.36	
C.D. at 5%	12.05			9.84	

Table 14: Interaction effects on protein yield of pearlmillet

Treatments	Protein yield (kg/ha)				
	Fertilizer (F)			Biofertilizer (B)	
Manure (M)	**F_1**	**F_2**	**F_3**	**B_1**	**B_2**
M_1	134.90	253.96	277.96	197.57	246.97
M_2	392.07	651.72	694.78	522.13	636.91
S.Em. ±	14.31			11.65	
C.D. at 5%	41.96			34.26	

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