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Effect of different fertilizer levels and method of jeevamrut application on yield and economics of broccoli (*Brassica oleracea* var. *italica*) cv. Palam Samridhi

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Abstract
The present investigation entitled, "Effect of different fertilizer levels and method of jeevamrut application on yield and economics of broccoli (*Brassica oleracea* var. *italica*) cv. Palam Samridhi" was carried out during *rabi* season of 2020-21 and 2021-22 at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, District: Mehsana, Gujarat. Combination of 27 treatments was laid out in Randomized Block Design with factorial concept (FRBD). The parameters observed were fresh weight of curd (g), sprout weight per plant (g), yield per plot (kg) and yield per hectare (q). The benefit: cost ratio of different treatments was also worked out. The treatment 80% recommended dose of nitrogen, phosphorous and potash with soil + foliar application of jeevamrut produced superior results for all the parameters observed including benefit: cost ratio.

Keywords: Broccoli, Palam Samridhi, NPK, Jeevamrut, yield, B: C ratio

Introduction
Sprouting Broccoli (*Brassica oleracea* L. var. *italica* Planck 2n=2x=18) is one of the important and potential cole crops belonging to the Brassicaceae family with originated in the Mediterranean region where it has been cultivated since Roman times. It is a rich source of vitamins and minerals. In fact, it contains more vitamin A than cabbage and cauliflower and the highest amount of proteins among the cole crop. It also contains anti-cancerous compounds and antioxidants. Broccoli is a rich source of sulforaphane which is associated with reducing the risk of cancer (Guo *et al.*, 2001) [6]. Nutritionally, it is rich in vitamin 'A' (2500 I.U.), vitamin 'C' (113 mg), protein (3.6 g), carbohydrates (5.9 g) and minerals like calcium (103 mg), iron (1.1 mg), phosphorous (78 mg), potassium (382 mg) and sodium (15 mg) per 100 g of edible portion (Rana, 2008) [19].

The escalating prices of chemical fertilizers and their injurious impact on the soil health, environment and human health forced the farmers to adopt alternative sources of nutrients as a substitute for vegetable production. Moreover, chemical fertilizers deteriorate the quality of the produce and leads to the reduction in net profit and returns to the farmers. Due to awareness regarding decline in soil health and excessive use of chemical fertilizers in modern day farming, there was shift from conventional method to integrated nutrient management system (Kumar and Srivastava, 2006) [11]. With the use of synthetic fertilizers, nitrate accumulation takes place in broccoli which can have detrimental health effects in humans. To reduce these nitrate accumulates, organic manures can be used in place of synthetic fertilizers (Hammad *et al.*, 2019) [8]. The present international situation of environment is alarming and firmly prioritizes the urgency to adopt ecologically-safe agricultural operations for reducing environmental hazards and sustainable food production. The cost of chemical fertilizers is rising at a faster rate and they are inaccessible to many small and marginal farmers. The jeevamruth is eco-friendly organic preparations made from cow products which are easily available in farm. The use of organic liquid preparations flourishes growth, quantity and quality of crops (Palekar, 2006; Sreenivasa *et al.*, 2010) [17, 24].

Therefore, considering the above facts in view the present investigation has been undertaken in North Gujarat condition.

Materials and Methods

The research was conducted at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, District: Mehsana, Gujarat during *rabi* season of 2020-21 and 2021-22. The experimental area was 426.06 m^2, each plot was 4.86 m^2 (2.70 m × 1.80 m). Thirty six plants were spaced at 45 cm × 30 cm in each plot. Present investigation comprising of three factors *viz.*, three levels of nitrogen *i.e.*, 40% recommended dose of nitrogen (n_1), 60% recommended dose of nitrogen (n_2) and 80% recommended dose of nitrogen (n_3), three levels of phosphorous and potash *i.e.*, 40% recommended dose of phosphorous and potash (p_1), 60% recommended dose of phosphorous and potash (p_2) and 80% recommended dose of phosphorous and potash (p_3) and three method of jeevamrut application *i.e.*, soil application (m_1), foliar application (m_2) and soil + foliar application (m_3). Thus, there were total 27 treatment combinations under study. The experiment was laid out in Randomized Block Design with factorial concept with three replications.

Common dose of FYM @ 15 t/ha was given in all the treatments at the time of land preparation. NPK/ha Half dose of nitrogen (through urea) and full dose of phosphorous (through single super phosphate) and potash (through murate of potash) was given as a basal dose and remaining half dose of nitrogen was applied as a top dressing at 30 DAT as per treatments. Jeevamrut was given in soil through drenching @ 500 l/ha at the time of sowing and 30 DAT as per treatments. Jeevamrut was sprayed @ 4% at 25 and 50 DAT as per treatments. Common spray of micronutrients @ 30 g/ 15 liter (500 l/ha) was given at 30 and 45 DAT.

Ten plants from each net plot were randomly selected and labeled. These tagged plants were used for recording yield parameters during the period of study and their average value was taken for statistical analysis and interpretations.

Results and Discussion

Yield attributing characters such as fresh weight of curd (g), sprout weight per plant (g), yield per plot (kg) and yield per hectare (q) were significantly influenced by different nitrogen levels, levels of phosphorous and potash and methods of jeevamrut application are presented in Table 1 and 2.

The application of 80% recommended dose of nitrogen (n_3) exhibited significantly maximum fresh weight of curd (214.19, 210.58 and 212.38 g), maximum sprout weight per plant (22.30, 22.38 and 22.34 g), highest yield per plot (3.41, 3.27 and 3.34 kg) and highest yield per hector (157.75, 151.61 and 154.68 q) during 2020-21, 2021-22 and in pooled analysis, respectively.

Amongst the yield parameters, significantly maximum fresh weight of curd (203.78, 198.74 and 201.26 g), maximum sprout weight per plant (21.21, 21.11 and 21.16 g), highest yield per plot (3.29, 3.15 and 3.22 kg) and highest yield per hector (152.16, 145.86 and 149.01 q) recorded during 2020-21, 2021-22 and in pooled analysis, respectively were obtained from 80% recommended dose of phosphorous and potash (p_3).

El-Saady and Omar (2018) [3] asserted that the augmentation in crop yield and its constituent elements can be attributed to the beneficial roles of NPK nutrients in advancing photosynthesis and facilitating the formation of essential organic compounds such as carbohydrates and proteins. These organic components subsequently accumulate and intensify within the consumable parts of the plant, thereby leading to an overall improvement in productivity. Comparable findings supporting this phenomenon were also documented by Sharma *et al.* (2008) [22], Islam *et al.* (2010) [10], Giri *et al.* (2013) [4], Neethu *et al.* (2015) [16], Singh *et al.* (2015) [23], and Doklega and Abd El-Hady (2017) [2] in broccoli; Naher *et al.* (2014) [14] in cabbage; Narayanamma *et al.* (2005) [15], El-Saady and Omar (2018) [3] and Sahito *et al.* (2018) [22] in cauliflower.

Significantly maximum fresh weight of curd (194.15, 190.21 and 192.18 g), maximum sprout weight per plant (20.12, 20.20 and 20.16 g), highest yield per plot (3.17, 3.04 and 3.11 kg) and highest yield per hector (146.63, 140.89 and 143.76 q) recorded during 2020-21, 2021-22 and in pooled analysis, respectively with soil + foliar application of jeevamrut (m_3).

As per Hazarika *et al.* (2006) [9], jeevamrut serves a dual purpose, functioning as both a fertilizer (75 percent) and a bio-pesticide (25 percent). It is recommended for soil treatment, playing a role in soil enrichment by providing beneficial microflora that promotes plant growth, influencing both vegetative and yield parameters. These findings align to some extent with the results reported by Chandrakala *et al.* (2007) [1] in chilli; Gore and Sreenivasa (2011) [24] in tomato; Hameedi *et al.* (2018) [7] in bell pepper; Patel *et al.* (2018) [18] in groundnut, and Safiullah *et al.* (2018) [20] in sweet corn.

Looking to the interaction effect (Table 1.2, 2.1 and 2.2), the treatment combination of n_3p_3 (80% recommended dose of nitrogen × 80% recommended dose of phosphorous and potash) reveals significantly maximum fresh weight of curd (237.19, 229.80 and 233.51 g), highest yield per plot (3.62, 3.50 and 3.56 kg) during both years as well as in pooled analysis and higher yield per hector (167.67 and 164.87 q) was found in 2020-21, in pooled analysis and non significant during year 2021-22.

Whereas, the interaction effects between n × m (levels of nitrogen × method of jeevamrut application), p × m (levels of phosphorous and potash × method of jeevamrut application) and n × p × m (levels of nitrogen × levels of phosphorous and potash × method of jeevamrut application) on all the yield parameters were found non significant.

Economics

The regional adaptability of any cultivation practices of any crop completely based on the economic value of a treatment. Therefore, it is necessary to workout the economics of different treatments for valid comparison of different treatments. The details of economics *i.e.*, cost of cultivation, gross return, net return and benefit cost ratio on data basis for different treatments have been calculated and presented in Table 3.

That maximum gross return of ₹ 3,41,886.00 per hectare, net return of ₹ 2,47,700.00 per hectare and highest benefit cost ratio of 3.6 were recorded from the treatment combination of n3p3m3. Manjunatha *et al.* (2009) [13] were opinion that lowest benefit cost ratio of the treatment having recommended dose of fertilizer might be due to higher selling price of the fertilizers used. According to them, application of jeevamrut was economically beneficial as it increased the microbial activity in soil thereby solubilizing nutrients in the soil resulting in higher uptake and increased productivity. The result of the present study was also in partial agreement with that of Islam *et al.* (2010) [10], Latha *et al.* (2017) [12] and Hameedi *et al.* (2022) [7] in broccoli.

Table 1: Effect of nitrogen levels, levels of phosphorous and potash and method of jeevamrut application on Fresh weight of curd and Sprout weight per plant

Treatment	Fresh weight of curd (g)			Sprout weight per plant		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Nitrogen levels (N)						
n_1	157.54	152.94	155.24	16.87	16.65	16.76
n_2	184.62	179.13	181.88	19.45	19.25	19.35
n_3	214.19	210.58	212.38	22.30	22.38	22.34
S.Em. ±	2.76	2.32	2.76	0.40	0.36	0.40
C.D. at 5%	7.83	6.58	5.10	1.15	1.02	0.76
Phosphorous and potash levels (P)						
p_1	162.22	158.02	160.12	17.37	17.20	17.29
p_2	190.35	183.04	188.12	20.03	19.56	20.00
p_3	203.78	198.74	201.26	21.21	21.11	21.16
S.Em. ±	2.76	2.32	1.82	0.40	0.36	0.27
C.D. at 5%	7.83	6.58	5.10	1.15	1.02	0.76
Method of jeevamrut application (M)						
m_1	183.88	178.23	181.05	19.44	19.19	19.31
m_2	178.32	174.21	176.26	19.06	18.90	18.98
m_3	194.15	190.21	192.18	20.12	20.20	20.16
S.Em. ±	2.76	2.32	1.82	0.40	0.36	0.27
C.D. at 5%	7.83	6.58	5.10	NS	1.02	0.76
C.V. %	7.73	6.66	7.29	10.76	9.57	10.23
Interaction effect						
n × p	13.57	11.39	8.83	NS	NS	NS
n × m	NS	NS	NS	NS	NS	NS
p × m	NS	NS	NS	NS	NS	NS
n x px m	NS	NS	NS	NS	NS	NS

Table 2: Effect of nitrogen levels, levels of phosphorous and potash and method of jeevamrut application on yield per plot and yield per hector

Treatment	Yield per plot (kg)			Yield per hector (q)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Nitrogen levels (N)						
n_1	2.72	2.59	2.65	125.72	120.01	122.86
n_2	3.07	2.94	3.00	142.23	136.00	139.12
n_3	3.41	3.27	3.34	157.75	151.61	154.68
S.Em. ±	0.04	0.04	0.04	1.90	1.86	1.90
C.D. at 5%	0.12	0.11	0.08	5.40	5.28	3.79
Phosphorous and potash levels (P)						
p_1	2.79	2.66	2.73	129.23	123.10	126.16
p_2	3.12	2.95	3.06	144.31	136.76	141.49
p_3	3.29	3.15	3.22	152.16	145.86	149.01
S.Em. ±	0.04	0.04	0.03	1.90	1.86	1.35
C.D. at 5%	0.12	0.11	0.08	5.40	5.28	3.79
Method of jeevamrut application (M)						
m_1	3.04	2.91	2.97	140.66	134.54	137.60
m_2	2.99	2.86	2.92	138.41	132.19	135.30
m_3	3.17	3.04	3.11	146.63	140.89	143.76
S.Em. ±	0.04	0.04	0.03	1.90	1.86	1.35
C.D. at 5%	0.12	0.11	0.08	5.40	5.28	3.79
C.V. %	6.97	7.12	7.16	6.97	7.12	7.16
Interaction effect						
n × p	0.20	NS	0.14	9.36	NS	6.57
n × m	NS	NS	NS	NS	NS	NS
p × m	NS	NS	NS	NS	NS	NS
n x px m	NS	NS	NS	NS	NS	NS

Table 2.1: Interaction effect of nitrogen levels and levels of phosphorous and potash on fresh weight of curd (g)

	Year – 2020-21				Year – 2021-22				Pooled			
n/p	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**
p_1	141.80	154.78	190.08	162.22	134.98	149.63	189.46	158.02	138.39	152.20	189.77	160.12
p_2	157.96	197.84	215.26	190.35	153.17	192.01	212.48	185.89	155.56	194.93	213.87	188.12
p_3	172.86	201.25	237.23	203.78	170.65	195.76	229.80	198.74	171.75	198.50	233.51	201.26
Mean	157.54	184.62	214.19	185.45	152.94	179.13	210.58	180.88	155.24	181.88	212.38	183.17
	n	p	n × p	CV %	n	p	n × p	CV %	n	p	n × p	CV %
S.Em. ±	2.76	2.76	4.78	7.73	2.32	2.32	4.01	6.66	1.82	1.82	3.15	7.29
C.D. 5%	7.83	7.83	13.57		6.58	6.58	11.39		5.10	5.10	8.83	

Table 2.2: Interaction effect of nitrogen levels and levels of phosphorous and potash on yield per plot (kg)

	Year – 2020-21				Year – 2021-22				Pooled			
n/p	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**
p_1	2.50	2.64	3.23	2.79	2.36	2.55	3.06	2.66	2.43	2.60	3.14	2.73
p_2	2.75	3.23	3.37	3.12	2.64	3.08	3.26	3.00	2.70	3.15	3.32	3.06
p_3	2.89	3.35	3.62	3.29	2.77	3.18	3.50	3.15	2.83	3.26	3.56	3.22
Mean	2.72	3.07	3.41	3.07	2.59	2.94	3.27	2.93	2.65	3.00	3.34	3.00
	n	p	n × p	CV %	n	p	n × p	CV %	n	p	n × p	CV %
S.Em. ±	0.04	0.04	0.07	6.97	0.04	0.04	0.07	7.12	0.03	0.03	0.05	7.16
C.D. 5%	0.12	0.12	0.20		0.11	.011	NS		0.08	0.08	0.14	

Table 2.3: Interaction effect of nitrogen levels and levels of phosphorous and potash on yield per hector (q)

	Year – 2020-21				Year – 2021-22				Pooled			
n/p	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**	**n_1**	**n_2**	**n_3**	**Mean**
p_1	115.91	122.29	149.48	129.23	109.47	118.23	141.61	123.10	112.69	120.26	145.54	126.16
p_2	127.50	149.34	156.10	144.31	122.28	142.57	151.14	138.66	124.89	145.95	153.62	141.49
p_3	133.74	155.07	167.67	152.16	128.27	147.22	162.08	145.86	131.01	151.14	164.87	149.01
Mean	125.72	142.23	157.75	141.90	120.01	136.00	151.61	135.87	122.86	139.12	154.68	138.89
	n	p	n × p	CV %	n	p	n × p	CV %	n	p	n × p	CV %
S.Em. ±	1.90	1.90	3.30	6.97	1.86	1.86	3.23	7.12	1.35	1.35	2.34	7.16
C.D. 5%	5.40	5.40	9.36		5.25	5.28	NS		3.79	3.79	6.57	

Table 3: Effect of nitrogen levels, levels of phosphorous and potash and method of jeevamrut application on economics of different treatment

Treatment combination	Yield/hectare (q)	Total cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	BCR
n_1 p_1 m_1	111.86	86723.00	223724.00	137001.00	2.6
n_1 p_1 m_2	107.92	85523.00	215834.00	130311.00	2.5
n_1 p_1 m_3	118.29	86773.00	236572.00	149798.00	2.7
n_1 p_2 m_1	124.77	88034.00	249545.00	161512.00	2.8
n_1 p_2 m_2	122.83	86834.00	245657.00	158823.00	2.8
n_1 p_2 m_3	127.08	88084.00	254151.00	166067.00	2.9
n_1 p_3 m_1	130.64	89344.00	261284.00	171940.00	2.9
n_1 p_3 m_2	129.07	88144.00	258135.00	169991.00	2.9
n_1 p_3 m_3	133.31	89394.00	266625.00	177231.00	3.0
n_2 p_1 m_1	115.67	89119.00	231348.00	142229.00	2.6
n_2 p_1 m_2	114.69	87919.00	229373.00	141454.00	2.6
n_2 p_1 m_3	130.42	89169.00	260839.00	171670.00	2.9
n_2 p_2 m_1	145.45	90430.00	290893.00	200463.00	3.2
n_2 p_2 m_2	144.39	89230.00	288780.00	199550.00	3.2
n_2 p_2 m_3	148.03	90480.00	296057.00	205577.00	3.3
n_2 p_3 m_1	151.21	91740.00	302412.00	210672.00	3.3
n_2 p_3 m_2	148.55	90540.00	297108.00	206568.00	3.3
n_2 p_3 m_3	153.67	91790.00	307340.00	215550.00	3.3
n_3 p_1 m_1	140.85	91516.00	281706.00	190191.00	3.1
n_3 p_1 m_2	139.32	90316.00	278633.00	188317.00	3.1
n_3 p_1 m_3	156.46	91566.00	312928.00	221362.00	3.4
n_3 p_2 m_1	154.20	92826.00	308397.00	215571.00	3.3
n_3 p_2 m_2	151.00	91626.00	302000.00	210374.00	3.3
n_3 p_2 m_3	155.66	92876.00	311317.00	218441.00	3.4
n_3 p_3 m_1	163.72	94136.00	327446.00	233310.00	3.5
n_3 p_3 m_2	159.95	92936.00	319896.00	226960.00	3.4
n_3p_3 m_3	170.94	94186.00	341886.00	247700.00	3.6

Note: Selling price of broccoli ₹ 20 per kg

Conclusion

On the basis of experimental evidence, higher yield and profitable income from broccoli cultivation can be obtained with the combined application of 80% recommended dose of nitrogen, phosphorous and potash with the soil as well as foliar application of jeevamrut.

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