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Response of integrated nutrient management of broccoli (*Brassica oleracea* var. *italica*) in acidic soil of Nagaland

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Abstract
Sprouting broccoli (*Brassica oleracea* var. *italica*) belonging to the family Brassicaceae is an important cole crop after cabbage and cauliflower. It is one of the most nutritious cole crops and contains vitamin A rather than 130 times and 22 times higher than cauliflower and cabbage. The field experiment was conducted under ICAR-All India Coordinated Research Project on vegetable crops, Department of Horticulture, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema campus, Nagaland during *rabi* season in the consecutive years 2018-2019, 2019-2020 and 2020-2021. The experiment consisted with the combination of nine treatments in randomized block design and replicated three times. The pooled results of three years revealed that the highest growth, quality and yield parameters was observed in treatment T_7 (Vermicompost @ 2.5 t ha^{-1} + ½ NPK through chemical fertilizer) with maximum no. of leaves (17.40), head length (16.74 cm), head width (16.04), gross head weight (464.16 g), net head weight (404.09 g) and net yield (147.31 q ha^{-1}) of broccoli which was found significantly superior over other treatments except T_3 (FYM @ 10 t ha^{-1} + ½ NPK through fertilizer). However, due to very high cost involved in treatment T_7, vermicompost @ 2.5 t ha^{-1} + ½ NPK through fertilizer in spite of recording maximum net yield, the B:C ratio was lower (2.27) as compared to treatment T_3 *i.e.,* FYM @ 10 t ha^{-1} + ½ NPK through fertilizer which recorded with B:C ratio 3.24. Overall, treatment T_3 *i.e.,* FYM @ 10 t ha^{-1} + ½ NPK through fertilizer performed better in all the parameters therefore this treatment can be recommended for cultivation of broccoli under acidic soil condition in Nagaland.

Keywords: Acidic soil, broccoli, growth, integrated nutrient management, yield

Introduction
Vegetables are a rich source of nutrition and provide a balanced diet of carbohydrates, proteins, fats, vitamins, minerals and fiber. Vegetables are considered to be the best complement to food safety as they are the cheapest source of dietary supplements. It is a laxative, anti-diabetic, diuretic, contributes to good heart function and provides many health benefits to our body. It also possesses unique combination of bioflavonoids and anti-bioflavonoids that remove free radicals and reduce the risk of cancer. In recent years, domestic vegetable production has increased significantly, with 2019-2020 statistics showing that 10.31 million hectares of land produce approximately 188.28 million tonnes (NHB, 2019) [1]. And among these vegetables, broccoli stands out because it is very nutritious, rich in minerals, delicious and has antioxidant properties. However, broccoli production is very low compared to other large cabbage. So, adopting the principles of integrated nutrient management and using both inorganic and organic source of nutrients which are locally available. Hence, an investigation was carried out to assess the effect of integrated nutrient management with different treatments on growth, yield and economics of broccoli to opt out best ones under acidic soil condition, Nagaland.

Materials and Methods
The experiment was carried out at Instructional cum Research farm, ICAR-All India Coordinated Research Project on vegetable crops, Department of Horticulture, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema campus, Nagaland during *rabi* seasons of 2018-2019, 2019-2020 and 2020-2021. The field is located at an altitude of 304.8 m above the mean sea level and is positioned geographically at latitude of 20°45'43" N and a longitude of 93°53'04" E, under sub-tropical humid climatic condition

experiencing distinct cool winter season. The initial status of the soil was highly acidic with a pH of 4.4, 1.25% of organic carbon and available NPK of 176.23 kg ha^{-1}, 9.20 kg ha^{-1} and 118.32 kg ha^{-1} respectively. The experiment comprised of 9 treatments *viz.*, T_1 (Full dose of NPK through chemical fertilizer), T_2 (FYM @ 20 t ha^{-1}), T_3 (FYM @ 10 t ha^{-1} + ½ NPK through chemical fertilizer), T_4 (Neem cake @ 5 q ha^{-1}), T_5 (Neem cake @ 2.5 q ha^{-1} + ½ NPK through chemical fertilizer), T_6 (Vermicompost @ 5 t ha^{-1}), T_7 (Vermicompost @ 2.5 t ha^{-1} + ½ NPK through chemical fertilizer), T_8 (Poultry manure @ 5 t ha^{-1} and T_9 (Poultry manure @ 2.5 t ha^{-1} + ½ NPK through chemical fertilizer) in randomized block design (RBD) with three replications. The variety selected for the experiment was captain 488. Seeds were sown singly at 2-3 cm depth, @ 500-600 kg ha^{-1}, maintaining a spacing of 40 cm plant to plant and 60 cm row to row. Recommended dose of N, P, K in the ratio 120:60:60 kg ha^{-1} respectively were applied through Urea, SSP and MOP. Full dose of manures, P, K and half dose of N were applied at the final land preparation. The other half dose of N was applied 30 days after sowing. The treatments were evaluated on the basis of growth, yield and yield attributes and economics. The mean of each treatment was replicated in three times and each parameter was worked out statistically by the method of analysis of variance using RBD. The data obtained during the period of study were analyzed by the variance method (Panse and Sukhatme, 1989) [2] and the significance sources of variation were tested by error mean square using Fisher Shedecor 'F' test of probability at 5% level.

Results and Discussion

Growth parameters

The effect of different nutrient treatment on growth parameters of broccoli is shown in table 1. Maximum no. of leaves (17.40), head length (16.74 cm) and head width (16.04) were observed and also statistically at par with T_7. The growth parameters were highly influenced by application of nitrogenous fertilizers. It may also be due to better availability of plant nutrients throughout the growth period (Mahala *et al*., 2011) [3], better uptake of nutrients, better nutrient absorption and utilization thereby resulting in higher vegetative growth. Comparable findings were stated by other researchers (Walling *et al*., 2022; Kayesh *et al.*, 2019; Wani *et al*., 2010) [4, 5, 9].

Yield and yield attributes

Integrated use of fertilizers and organic manures significantly increased yield and yield attributing characters of broccoli compared to control (Table 2 and 3). Maximum gross head weight (464.16 g), net head weight (404.09 g) and net yield (147.31 q ha^{-1}) were observed in T_7. Treatment (T_3) was also statistically at par with T_7. Yield and yield attributes were directly proportional to vegetative growth. High in growth parameters recorded higher yield. Increased yields can be attributed to better vegetative growth, higher activity of beneficial microorganism in the soil and better response to nutrients. Adequate supply of N and P plays vital role in metabolic process of photosynthesis and carbohydrate metabolism which helps in increasing the vegetative growth thereby increasing its yield per plot. Similar observations were obtained by other researchers (Walling *et al*., 2022; Arjun *et al*., 2018; Changkiri *et al*., 2015) [4, 7, 8].

Economics

It is evident from Table 4 that highest net return and cost benefit ratio was recorded in T_3 *i.e.*, FYM @ 10 t ha^{-1} + ½ NPK through fertilizer with Rs. 3,08,566 and 1:3.24 respectively. Due to very high cost involved in the treatment, T_7 (Vermicompost @ 2.5 t ha^{-1} + ½ NPK through fertilizer) in spite of recording maximum net yield, the B:C was lower (2.27) as compared to treatment T_3.

Table 1: Effect of integrated nutrient management on growth of broccoli (pooled data over three years)

Treatment details	No. of leaves plant^{-1}			Pooled mean	Head length (cm)			Pooled mean	Head width (cm)			Pooled mean
	2018-19	2019-20	2020-21		2018-19	2019-20	2020-21		2018-19	2019-20	2020-21	
T_1: Full dose of NPK through chemical fertilizer	16.53	12.82	17.10	15.48	15.48	14.81	16.61	15.63	14.13	13.50	13.20	13.61
T_2: FYM @ 20 t/ha	14.97	11.28	15.20	13.82	13.58	12.91	12.80	13.10	11.84	11.98	11.57	11.80
T_3: FYM @ 10t/ha + ½ NPK through fertilizer	16.54	13.01	16.70	15.42	14.57	14.06	14.81	14.48	15.99	14.81	15.72	15.51
T_4: Neem cake @ 5q/ha	14.36	11.29	15.31	13.65	13.27	12.61	12.50	12.79	11.27	11.27	11.00	11.18
T_5: Neem cake @ 2.5 q/ha + ½ NPK through fertilizer	15.60	12.55	13.41	13.85	13.87	13.08	13.90	13.62	13.07	12.89	12.80	12.92
T_6: Vermicompost @ 5 t/ha	14.00	10.85	12.70	12.52	13.99	13.32	13.20	13.50	12.42	12.47	12.15	12.35
T_7Vermicompost @ 2.5 t/ha+ ½ NPK through fertilizer	18.93	14.87	18.40	17.40	16.68	15.74	17.80	16.74	16.32	15.75	16.05	16.04
T_8: Poultry manure @ 5t/ha	13.51	9.46	12.83	11.93	13.80	13.14	13.02	13.32	14.69	14.02	15.42	14.71
T_9: Poultry manure @ 2.5 t/ha+ ½ NPK through fertilizer	16.51	13.28	18.80	16.20	15.62	13.95	15.89	15.15	13.47	13.17	13.20	13.28
C.D (5%)	3.05	2.74	2.9	1.37	1.33	1.88	1.61	0.91	1.07	1.29	1.18	0.61
C.V	11.24	13.04	12.14	5.46	5.30	7.91	6.61	3.69	4.53	5.59	5.06	2.63

Table 2: Effect of integrated nutrient management on yield and yield attributes of broccoli (pooled data over three years)

Treatment details	Gross head weight along with leaves & stalk (g)			Pooled mean	Net head weight excluding leaves & stalk (g)			Pooled mean
	2018-19	2019-20	2020-21		2018-19	2019-20	2020-21	
T_1: Full dose of NPK through chemical fertilizer	400.47	416.17	399.10	405.25	333.30	329.97	330.60	331.29
T_2: FYM @ 20 t ha^{-1}	322.47	361.04	320.77	334.76	285.83	305.83	303.13	300.49
T_3: FYM @ 10 t ha^{-1} + ½ NPK through fertilizer	425.61	439.61	424.01	429.74	369.90	367.23	370.30	369.14
T_4: Neem cake @ 5 q ha^{-1}	315.76	340.89	314.06	323.57	266.80	273.80	264.10	268.23
T_5: Neem cake @ 2.5 q ha^{-1} + ½ NPK through fertilizer	390.84	405.84	394.14	396.94	314.50	304.50	316.80	311.93
T_6: Vermicompost @ 5 t ha^{-1}	369.00	397.65	372.30	379.65	304.80	314.80	307.10	308.90
T_7: Vermicompost @ 2.5 t ha^{-1} + ½ NPK through fertilizer	455.40	478.39	458.70	464.16	401.10	407.77	403.40	404.09
T_8: Poultry manure @ 5 t ha^{-1}	371.17	387.29	339.57	360.45	295.73	269.06	280.46	277.30
T_9: Poultry manure @ 2.5 t ha^{-1} + ½ NPK through fertilizer	375.20	406.12	343.50	369.38	322.70	311.03	305.00	307.91
C.D. (5%)	13.36	19.26	16.31	15.40	14.18	25.64	19.91	9.07
C.V.	2.05	2.76	2.41	2.31	2.57	4.62	3.6	1.64

Table 3: Effect of integrated nutrient management on yield and yield attributes of broccoli (pooled data over three years)

Treatment details	Net yield (kg plot^{-1})			Pooled mean	Net yield (q ha^{-1})			Pooled mean
	2018-19	2019-20	2020-21		2018-19	2019-20	2020-21	
T_1: Full dose of NPK through chemical fertilizer	7.00	6.93	6.94	6.96	121.52	120.31	120.48	120.77
T_2: FYM @ 20 t ha^{-1}	6.00	6.42	6.37	6.31	106.65	111.51	110.58	109.58
T_3: FYM @ 10 t ha^{-1} + ½ NPK through fertilizer	7.77	7.71	7.78	7.75	134.89	133.91	135.06	134.62
T_4: Neem cake @ 5 q ha^{-1}	5.60	5.75	5.55	5.63	97.27	99.82	96.35	97.81
T_5: Neem cake @ 2.5 q ha^{-1} + ½ NPK through fertilizer	6.60	6.39	6.65	6.55	114.63	110.99	115.44	113.69
T_6: Vermicompost @ 5 t ha^{-1}	6.40	6.61	6.45	6.49	111.10	114.75	111.97	112.61
T_7: Vermicompost @ 2.5 t ha^{-1} + ½ NPK through fertilizer	8.42	8.56	8.47	8.48	146.23	148.66	147.04	147.31
T_8: Poultry manure @ 5 t ha^{-1}	6.27	5.65	5.89	5.82	102.94	98.08	102.25	101.09
T_9: Poultry manure @ 2.5t/ha+ ½ NPK through fertilizer	6.78	6.54	6.41	6.47	112.26	113.47	111.28	112.34
C.D. (5%)	0.30	0.54	0.42	0.19	5.20	9.37	7.29	3.30
C.V.	2.58	4.63	3.61	1.64	2.58	4.64	3.61	1.64

Table 4: Effect of integrated nutrient management on economics of different treatments (pooled data over three years)

Treatment details	Net yield (q ha^{-1})	Gross income (Rs. 30 kg^{-1})	Cost of cultivation	Net income (Rs.)	B:C
T_1: Full dose of NPK through chemical fertilizer	120.77	362310	99865	262445	2.63
T_2 : FYM @ 20 t ha^{-1}	109.58	328740	97500	231240	2.37
T_3: FYM @ 10 t ha^{-1} + ½ NPK through fertilizer	134.62	403860	95294	308566	3.24
T_4: Neem cake @ 5 q ha^{-1}	97.81	293430	107500	185930	1.73
T_5: Neem cake @ 2.5 q ha^{-1} + ½ NPK through fertilizer	113.69	341070	100294	240776	2.40
T_6: Vermicompost @ 5 t ha^{-1}	112.61	337830	177500	160330	0.90
T_7:Vermicompost @ 2.5 t ha^{-1} + ½ NPK through fertilizer	147.31	441930	135294	306636	2.27
T_8: Poultry manure @ 5 t ha^{-1}	101.09	303270	82500	220770	2.68
T_9:Poultry manure @ 2.5 t ha^{-1} + ½ NPK through fertilizer	112.34	337020	87794	249226	2.84

FYM: Rs.1000 t^{-1}, Poultry manure: Rs.1000 t^{-1}, Vermicompost: Rs. 20000 t^{-1}, Neem cake: Rs. 6000 q^{-1}

Conclusion

The practice of vermicompost integration with half dose of inorganic fertilizers may be exploited the better economic yield of broccoli. From a sustainable agricultural approach, gives optimal yield and cost benefit ratio of broccoli in acidic soil of Nagaland. Hence, it can be recommended to the farmers for ecofriendly cultivation and also retaining the fertility status of the soil.

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