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Effect of N and P Levels on Nutrient Content and Quality Parameters of Broccoli (*Brassica oleracea* L. Var. *italica*) under South Gujarat Soil Conditions

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ABSTRACT: *A field experiment was undertaken during winter2012-13 at Polytechnic College (Hort.) Farm, N.A.U., Navsari under South Gujarat heavy rainfall zone (AES-III) with four levels of nitrogen viz. 80 (N_1), 120 (N_2), 160 (N_3) and 200 (N_4) kg N ha^{-1} and three levels of phosphorus viz. 40 (P_1), 60 (P_2) and 80 (P_3) kg P_2O_5 ha^{-1} in FRBD to find out the suitable doses of N and P for higher nutrient content and good quality broccoli flower head.There were twelve treatments replicated three times. The crude fibre and nitrate content in broccoli flower head were not affected significantly by various treatments of N and P, while crude protein content (5.44 %) was found significantly higher with the application of N @ 200 kg ha^{-1} (N_4) followed by N_3 (160 kg N ha^{-1}). Total carbohydrate and vitamin "C" content decreased with the increasing levels of N and P. Significantly higher content of N, P, K, S Fe, Mn, Cu and Zn by the crop were found under the treatments N_4 (200 kg N ha^{-1}) and P_3 (80 kg P_2O_5 ha^{-1}).*

Key words: *Broccoli, Flower head yield, FRBD and Yield attributes*

INTRODUCTION

Broccoli is said to have originated in the Mediterranean where it can still be seen today, growing wild along the Mediterranean coast. The seeds that sprouted the U.S. industry came from Italy and were planted in 1923 in California **[1].** Broccoli, (*Brassica oleracea*L.var. *italica*) belonging to the family of Cruciferae is a delicious vegetable and more nutritious than any other vegetables of the same genus **[17]**. Broccoli can be grown in wide variety of soils but, deep loamy soil is best suited. Soil should be well drained and sufficiently fertilized. The soil pH 5.0 to 6.5 is optimum for this crop. Nitrogen is an essential element and important determinant in growth and development of crop plants. It plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division as well as cell elongation. Phosphorus is called the "Key to life". It is an important constituent of ATP having significant role in energy transformation in plants and also in various physiological processes **[19]**. Phosphorus also helps in nutrients uptake by promoting root growth and thereby ensuring a good yield through the increase in total dry matter **[15]**. Being a heavy feeder, it removes large amount of macro nutrients from the soil **[14]**. Broccoli has a great demand to nitrogenous fertilizer. The early and rapid vegetative growth of the plant is necessary for soft and succulent head as well as stem for a quality crop that is influenced by the nitrogenous fertilizer. Investigations carried out by different workers have showed that the head yield of broccoli is greatly influenced by N application **[7]**.A number of quality characteristics and diseases/disorders of broccoli are influenced by fertilizer management practices. Increasing rates of applied nitrogen can increase the incidence of hollow stem **[23]** and bacterial head rot in broccoli **[6]**. Balanced dose of nitrogenous, phosphate and potassium is required to increase crop productivity without any adverse effect on environment. Proper application of nitrogenous, phosphate and potassium fertilizers could materially reduce nitrate accumulation in crops **[27]**. The amount of applied nutrients regarded as optimal for broccoli may vary over a wide range depending on soil, climate, plant density and methods of

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cultivation.Thus, the present study was undertaken to understand the effect of different combinations of N and P fertilizers on broccoli nutrient content and quality parameters in clayey soil of South Gujarat.

MATERIAL AND METHODS

The experiment was laid out in a randomized complete block design with three replications having four nitrogen levels viz. 80 (N_1), 120 (N_2), 160 (N_3) and 200 (N_4) kg N ha^{-1}along with three levels of Pviz. 40 (P_1), 60 (P_2) and 80 (P_3) kg P_2O_5 ha^{-1}.There were 12 treatment combinations all together. The Urea, SSP and MOP were the source of N, P and K, respectively for the crop. A 50 % dose of N and full dose of P was applied as basal,while second dose of N (25%) was applied 30 days after transplanting (DATP) and third dose of N (25%) was applied before head emergence.A common dose of biocompost and potassium was applied @ 10 t ha^{-1} and 60 kg ha^{-1}, respectively. The 30 days old healthy seedlings of broccoli cv. TSX-0788 F1 were purchased from Regional Horticultural Research Station, Navsari Agricultural University and transplanted with a spacing of 45×30 cm on a gross plot of 4.5×3.6 m (10 lines each of 12 plants) and net plot of 3.6×3.0 m (8 lines each of 10 plants) size. Irrigation with good quality water was applied during the growth period of the crop as flood irrigation.

QUALITY PARAMETERS

The dried samples were analyzed for various quality parameters. The procedure followed for each parameter are described here under:

1. Crude fibre content: Crude fibre content (%) on dry matter basis was estimated as per the procedure (Filter bag technique) described in A.O.A.C. **[2]**.

Crude fibre (% on DM basis) = Wr -Wa

Wd

(Wr = Weight of dried residue (g), Wa =Weight of ash (g), Wd =Weight of dried sample (g))

2. Crude protein content: Crude protein content (%) was calculated from the N estimation of representative oven dried flower head samples. Nitrogen estimation was done by MicroKjeldahl's method **[10]**. Crude protein per cent was computed by multiplying the percentage of nitrogen with the factor 6.25 **[4].**

3. Total carbohydrate content: Total carbohydrate content (%) of dried representative flower head samples was estimated in Autoanalyzer using Anthrone reagent method **[24]**.

4.Vitamin 'C' content: Vitamin "C" content (mg g^{-1}) of flower head was determined by dichlorophenol indophenols (DCPIP) titration procedure **[16]**. The vitamin "C" content (mg g^{-1}) was determined using the following formula:

$$\text{Vitamin "C" content (mg g}^{-1}) = \frac{0.1 \times V_2 \times 20}{V_1 \times 10}$$

(V_1= Dye consumed by 0.1 mg vitamin "C", V_2= Dye consumed by 10 ml test solution)

5. Nitrate content: Nitrate content (mg kg^{-1}) in flower head samples were determined using Nitrate selective electrode (Thermo Orion 9700 BNWP) as described by Kalra **[11]**. The nitrate content (mg kg^{-1}) was determined using the following formula,

Nitrate content (mg kg^{-1}) = Nitrate extract reading-Blank reading

NUTRIENT CONTENT

The flower heads, leaves and stems of five plants from each plot were collected for plant analysis. Dry samples were ground and used for the determination of macro and micro nutrients using standard procedures.

RESULTS AND DISCUSSION

Quality Parameters

1. Crude fibre content (%): Results on crude fibre content of broccoli flower head (Table 1) showed more or less similar values of its content due to the impose of various levels of N but, the higher crude fibre content of 2.64 % was attained with the lower level of N *i.e.* N_1 (80 kg N ha^{-1}). The various levels of P had a non-significant effect on crude fibrecontent of broccoli flower head.

Increasing the rate of N application decreased the dietary fibre of broccoli, which could be related to the decrease in the cellulose, hemicellulose, lignin and pectin contents with increase in N fertilizer **[3]**. Sorenson **[20]** also noticed similar decrease in crude fibre content of cabbage with increased N fertilization.

2. Crude protein content (%): Crude protein content of broccoli flower head is numerically depicted in Table 1. Application of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1} (P_3) observed significantly higher crude protein content in flower head exhibiting its 72.15 and 12.77 per cent higher value over the N_1 (80 kg N ha^{-1}) and P_1 (40 kg P_2O_5 ha^{-1}), respectively. Higher crude protein content in broccoli plant indicates its better quality which was reflected in the treatments with higher level of N and P fertilizer.

Increase in N level might have provided more N for making amino acids which leads to the higher protein content in broccoli flower head. These results are supported through the similar results of Brahma *et al.* **[5]**. Many investigators also reported that increasing levels of P improved the plant growth, yield and head quality of broccoli **[9]**.

3. Total carbohydrate content: Table 1 revealed that the total carbohydrate content of broccoli flower head reported maximum values of 7.81 and 7.26 per cent due to the impose of treatment N_1 (80 kg P_2O_5 ha^{-1}) and P_1 (40 kg P_2O_5 ha^{-1}), respectively. Slightly lower values of total carbohydrate content in broccoli flower head were observed under the lower levels of N and P. These results are maintained by the results of Hara **[8]** and Takebe *et al.* **[22]**.

4. Vitamin "C" content: Vitamin "C" content in broccoli flower head was found in the range of 737 to 975 mg kg^{-1}, however, its higher value of 975 and 874 mg kg^{-1} were attained due to the application of 80 kg N ha^{-1} (N_1) and 40 kg P_2O_5 ha^{-1} (P_1), respectively (Table 1). Sorenson **[21]** as well as Babik and Elkner **[3]** who found out that increasing nitrogen application lowered the vitamin "C" content in broccoli and cabbage. Applied P levels increases tissue N levels and as a result, with increasing levels of P, vitamin "C" content also gets fall down.

4. Nitrate content: If broccoli flower head contains a higher amount of nitrate content, then it is a major limitation for its utilization as nutritive food. The highest nitrate content in broccoli flower head is resulted by the highest level of N and P *i.e.* $N_4$and P_3 (Table 1). Its values were found in the range of 259 to 342 as well as 289 to 308 mg kg^{-1} for N and P treatments, respectively which shows the beneficial effect of various levels of N and P on quality of broccoli flower head because, values of nitrate content obtained was within the recommended range for nitrate content (1000 mg kg^{-1}) in fresh broccoli according to EFSA (European Food Safety Authority).

Nutrient Content

Macro nutrient content (%): The effect of various levels of N and P on macro nutrient content of broccoli flower heads, leaves and stem depicted in the Table 2.Impose of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1} (P_3) noted 30 and 9.40., 27.53 and 4.60 as well as 32.06 and 5.15 per cent higher N content in broccoli flower head, leaves and stem over N_1 (80 kg N ha^{-1}) and P_1 (40 kg P_2O_5 ha^{-1}), respectively.

The data in the Table 2 revealed 28.91 and 15.95; 19.56 and 8.16 as well as 15.47 and 12.04 per cent higher P content in broccoli flower head, leaves and stem were resulted by the treatments N_4 (200 kg N ha^{-1}) and P_3 (80 kg P ha^{-1}) over N_1 (80 kg N ha^{-1}) and P_1 (40 kg P_2O_5 ha^{-1}), respectively. While, the P content in broccoli leaves was recorded at par with N_3 (160 kg N ha^{-1}).

Application of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1} (P_3) significantly increased the K content in broccoli plants. The per cent increase in K content under the treatments N_4 and P_3 were 13.18 and 3.99 as well as 22.33 and 4.16 in broccoli flower head and leaves over N_1 and P_1, respectively. But, the K content in flower head was found statistically at par with N_3 (160 kg N ha^{-1}). Its content in broccoli stem was found

Table 1
Effect of various levels of N and P on the quality parameters of broccoli flower head (FW)

Treatments	*Crude fibre content (%)*	*Crude protein content (%)*	*Total carbohydrate content (%)*	*Vitamin "C"content (mg kg^{-1})*	*Nitrate content (mg kg^{-1})*
(A) Nitrogen (kg ha^{-1}) (N)					
N_1: 80	2.64	3.16	7.81	975	259
N_2: 120	2.51	4.05	7.28	882	283
N_3: 160	2.36	4.67	6.78	804	309
N_4: 200	2.22	5.44	6.60	737	342
S.Em. ±	0.06	0.07	0.06	6	2
C.D. at 5%	0.16	0.20	0.19	18	6
(B) Phosphorus (kg P_2O_5 ha^{-1}) (P)					
P_1: 40	2.49	4.07	7.26	874	289
P_2: 60	2.44	4.33	7.10	853	297
P_3: 80	2.37	4.59	7.00	822	308
S.Em. ±	0.05	0.06	0.06	5	2
C.D. at 5%	NS	0.17	0.16	16	5
Interaction (N×P)					
S.Em. ±	0.10	0.12	0.11	11	3
C.D. at 5%	NS	NS	NS	NS	NS
CV %	6.86	4.73	2.71	2.17	2.01

Table 2
Effect of various levels of N and P on macro nutrient content (%) of broccoli flower head, leaves and stem (DW)

Treatments	*N*			*P*			*K*			*S*		
	Flower head	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*
(A) Nitrogen (kg ha^{-1})												
N_1: 80	3.70	2.76	3.43	0.83	0.46	0.84	4.17	1.97	3.64	0.10	0.13	0.10
N_2: 120	3.92	2.96	3.60	0.96	0.49	0.84	4.63	2.14	4.37	0.12	0.15	0.10
N_3: 160	4.53	3.27	4.35	1.02	0.52	0.87	4.72	2.31	4.54	0.13	0.18	0.10
N_4: 200	4.81	3.52	4.53	1.07	0.55	0.97	4.81	2.41	4.12	0.14	0.20	0.11
S.Em. ±	0.07	0.04	0.05	0.007	0.01	0.02	0.05	0.03	0.07	0.003	0.003	0.002
C.D. at 5%	0.20	0.11	0.16	0.020	0.03	0.06	0.15	0.08	0.21	0.008	0.009	0.005
(B) Phosphorus (kg P_2O_5 ha^{-1}) (P)												
P_1: 40	4.04	3.04	3.88	0.94	0.49	0.83	4.51	2.16	3.96	0.12	0.16	0.09
P_2: 60	4.26	3.17	3.98	0.97	0.51	0.88	4.54	2.21	4.19	0.12	0.17	0.10
P_3: 80	4.42	3.18	4.08	0.99	0.53	0.93	4.69	2.25	4.35	0.14	0.18	0.11
S.Em. ±	0.06	0.03	0.05	0.006	0.01	0.02	0.05	0.02	0.06	0.002	0.003	0.002
C.D. at 5%	0.17	0.09	0.14	0.017	0.03	0.06	0.13	0.07	0.18	0.007	0.008	0.005
Interaction (N×P)												
S.Em. ±	0.12	0.07	0.10	0.012	0.01	0.03	0.09	0.05	0.12	0.005	0.01	0.002
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	4.84	3.67	4.13	2.11	4.69	7.48	3.44	3.65	5.07	6.61	5.90	5.03

Table 3

Effect of various levels of N and P on micro nutrient content (mg kg^{-1}) of broccoli flower head, leaves and stem (DW).

Treatments	*Fe*			*Mn*			*Cu*			*Zn*		
	Flower head	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*	*Flower head*	*Leaves*	*Stem*
(A) Nitrogen (kg ha^{-1})												
N_1: 80	98.98	91.94	3.43	31.96	31.07	0.84	10.45	9.82	3.64	54.52	44.06	0.10
N_2: 120	108.88	98.70	3.60	34.12	33.06	0.84	11.61	11.32	4.37	58.27	47.57	0.10
N_3: 160	119.08	113.16	4.35	39.58	35.03	0.87	12.70	12.42	4.54	62.53	49.20	0.10
N_4: 200	129.58	120.03	4.53	43.48	38.70	0.97	13.76	13.35	4.12	65.22	51.16	0.11
S.Em. ±	1.26	1.21	0.05	0.61	0.44	0.02	0.13	0.16	0.07	0.63	0.42	0.002
C.D. at 5%	3.71	3.54	0.16	1.78	1.28	0.06	0.39	0.48	0.21	1.85	1.23	0.005
(B) Phosphorus (kg P_2O_5 ha^{-1}) (P)												
P_1: 40	110.68	103.40	3.88	35.88	33.47	0.83	11.80	11.33	3.96	58.89	46.88	0.09
P_2: 60	114.36	105.93	3.98	37.55	34.41	0.88	12.11	11.71	4.19	60.27	48.23	0.10
P_3: 80	117.35	108.55	4.08	38.42	35.53	0.93	12.48	12.15	4.35	61.25	48.89	0.11
S.Em. ±	1.09	1.05	0.05	0.53	0.37	0.02	0.12	0.14	0.06	0.54	0.36	0.002
C.D. at 5%	3.21	3.07	0.14	1.54	1.11	0.06	0.34	0.42	0.18	1.60	1.07	0.005
Interaction (N×P)												
S.Em. ±	2.19	2.09	0.10	1.05	0.76	0.03	0.23	0.28	0.12	1.09	0.73	0.002
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	3.32	3.42	4.13	4.89	3.81	7.48	3.32	4.19	5.07	3.14	2.62	5.03

24.72 and 9.84 per cent higher under the treatments N_3 (160 kg N ha^{-1}) and P_3 (80 kg P_2O_5 ha^{-1}) over N_1 and P_1, respectively.

Impose of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1}(P_3) recorded 40.00 and 16.66; 53.84 and 12.50 as well as 10.00 and 22.22 per cent higher S content over N_1 and P_1 in broccoli flower head, leaves and stem, respectively.

From the above description, it is clear that with increasing doses of N and P, the macro nutrient content of broccoli flower head, leaves and stem also get increased. It can be attributed to the fact that the nitrate ion carries one negative charge, the plant may take up potassium (which carries one positive charge) to ensure that the internal electrical status remains neutral *i.e.* Nitrogen application increases the K content in broccoli plant. These results are in conformity with the results of Lesic*et al.* [13]. The increase of K content in broccoli flower head with increase in levels of N was also reported by Yoldas*et al.* [26]. The data obtained in this study concur with those of Karitonas [12] who showed that mineral soil N fertilization increased N, P and K concentrations in leaves of broccoli. The S content in different parts of broccoli also got increased slightly with increasing levels of N and P might be due to the application of different P doses through SSP which contains S. The results obtained from this experiment also agreeing with the results of Riley and Vagen [18].Micro nutrient content (mg kg^{-1}): Results as shown in Table 3revealed superiority of treatments N_4 (200 kg N ha^{-1}) and P_3 (80 kg P_2O_5 ha^{-1}) indicating 30.91 and 6.02., 30.55 and 4.98 as well as 13.34 and 5.77 per cent higher Fe content in broccoli flower head, leaves and stem over N_1 and P_1, respectively.However, the Fe content in broccoli stem due to the N_4 level was statistically found similar with N_3 (160 kg N ha^{-1}).

Application of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1} (P_3) significantly increased the Mn content in broccoli. The per cent rise in Mn content under the treatments N_4 and P_3 were 36.04 and 7.07; 24.55 and 6.15 as well as 27.04 and 8.89 over N_1 and P_1 in broccoli flower head, leaves and stem, respectively. Results of the study revealed the superiority of treatments N_4 (200 kg N ha^{-1}) and P_3 (80 kg P_2O_5 ha^{-1}) indicating 31.67 and 5.76., 35.94 and 7.23 as well as 22.14 and 5.20 per cent higher Cu content than N_1 and P_1 in broccoli flower head, leaves and stem, respectively.

Use of 200 kg N ha^{-1} (N_4) and 80 kg P_2O_5 ha^{-1} (P_3) exhibited the increase to the tone of 19.62 and 4.00., 16.11 and 4.28 as well as 17.98 and 6.04 per cent Zn content over N_1 and P_1 in broccoli flower head, leaves and stem, respectively. However, the Zn content in broccoli stem resulted by the N_4 level was noticed at par with the application of N @ 160 kg ha^{-1} (N_3).

Results of this study is in accordance with the results of Yoldas *et al.* [26] who stated that Fe and Zn content in broccoli flower head increased with the increase in N. The results of the present study are also is in conformity with the study of Yildrim *et al.*[25] indicating that soil N fertilization increased the content of almost all nutrients in leaves and heads of broccoli.

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