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EFFECT OF DIFFERENT NPK LEVELS ON QUALITY PARAMETERS OF BROCCOLI (*Brassica oleracea* L) UNDER SOUTH GUJARAT CONDITION

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ABSTRACT
A three years field experiment was conducted to study the effect of NPK levels on quality parameters of Broccoli under South Gujarat condition. There were different nineteen treatments including controls. Out of them, eighteen treatments comprising of three nitrogen levels [80 kg N ha^{-1} (N1), 120 kg N ha^{-1} (N2) and 160 kg N ha^{1} (N3)] combined with three phosphorus levels [40 kg P2O5 ha^{-1} (P1), 60 kg P2O5 ha^{-1} (P2) and 80 kg P2O5 ha^{1} (P3)] along with two levels of potassium [control (K1) and 60 kg K2O (K2)]. The results revealed that the crude protein (2.18%), TSS (0.97ºBrix) and crude fibre (2.13%) were recorded significantly higher in treatment N1 whereas level N2 resulted significantly the highest Vitamin C content (79.17 mg kg-1) in broccoli. While among P level, crude protein (2.18%) and crude fibre (2.08 %) were recorded significantly higher in treatment P1 whereas level P2 resulted significantly higher Vitamin C content (73.72 mg kg^{-1}) and TSS (1.01ºBrix). Treatment combination, N2P3K2, N1P2K2 , N2P3K1 and N1P2K2 recorded significantly higher value of crude protein content (2.37%), TSS content (1.22 ºBrix), vitamin "C" content (83.13 mg $100g^{-1}$) and crude fiber content (2.97 %) respectively.

INTRODUCTION

Broccoli (*Brassica oleracea* L.) is said to have originated in the Mediterranean where it can still be seen today, growing wild along the Mediterranean coast (Decoteau, 2000). It is a member of cabbage family and a close relative of cauliflower, has many strong branches or arms that grown from the main stem, each one sprouting a sturdy budding cluster surrounded by leaves. China is the top producer of broccoli and the second position goes to India.

Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas *et al*., 2008). It is a good source of dietary fiber and chock full of vitamins and minerals *i.e.*, Vitamins A, C, K, E (Alpha Tocopherol), B6, Folate, Niacin, Pantothenic Acid, Ca, Fe, Mg, P, K and Zn. There are three types of broccoli viz., Green, White, and Purple. Green type is the most nutritive and popular because it contains phytochemicals, such as sulforaphane that help prevent cancer and anti-oxidants which are compounds in plant foods that offer health benefits.

A number of quality characteristics of broccoli are influenced by fertilizer management practices. Investigations carried out by different workers have showed that the head yield and quality of broccoli is greatly influenced by N application (Haque *et al*., 1996). In studies of balanced fertilization, N, P and K fertilizer plays a more important role than other elements in improving crop quality and reducing environmental pollution (Barnes *et al*., 1976) and (Reid *et al*., 2016). The application of K fertilizer also promotes carbohydrate and N metabolism and thus improves the quality of crop products, for example by increasing the protein content of grain crops (Gaj *et al*., 2013), crude fat and palmitic acid content of oil crops (Gao *et al*., 2010), starch and sugar content of potatoes and sugar crops (Westermann *et al*.,1994), and the fiber length, strength and fineness of fiber crops and cotton (Pervez *et al*., 2004). 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 cultivation. The requirement of fertilizer, which varies according to environmental conditions, has to be determined by actual field trial for any particular soil and climate. Although, broccoli is a high value vegetable crop of the world, but there is lack of research, particularly under field condition to show the effects of nutrient levels on quality parameters. Therefore, the current experiment was conducted to understand the effect of different combinations of N, P and K fertilizers on quality parameters of broccoli in clayey soil of South Gujarat.

MATERIALS AND METHODS

A three years field experiment was conducted in Rabi season at the college farm, Navsari Agricultural University, Navsari to study the "Effect of different NPK levels on various quality parameters of Broccoli (*Brassica oleracea* L) under south Gujarat condition".The experimental field belongs to AES-III of South Gujarat with the predominant deep black soil. The initial pH, EC and OC of soil were 7.46, 0.78 dS/m and 0.50 % respectively. Year wise cultural operations like nursery preparation, transplanting, gap filling, weeding, irrigation,

spray for plant protection etc were carried out properly.

Total eighteen treatments comprising of three nitrogen levels [80 kg N ha^{-1} (N1), 120 kg N ha^{-1} (N2) and 160 kg N ha^{-1} (N3)] combined with three phosphorus levels [40 kg P2O5 ha^{-1} (P1), 60 kg P2O5 ha^{-1} (P2) and 80 kg P2O5 ha^{-1} (P3)] along with two levels of potassium [control (K1) and 60 kg K2O (K2)]. The experiment was laid out in factorial RBD with three replications. The Urea, SSP and MOP were used as the source of N, P and K respectively. A 50% dose of each N & K and full dose of P fertilizer was applied at the time of transplanting while the second and third dose (25% each) of N and K were applied at 25 and 50 days after transplanting respectively. A common dose of biocompost was applied @ 5 t/ha. The 30 days old healthy seedlings of broccoli 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 and net plot of 2.7×2.4 m size.

Quality Parameters

The procedure followed for each parameter is described here under:

Crude fibre content

Crude fibre content (%) on dry matter basis was estimated as per the procedure (Filter bag technique) described by Association of Official Analytical Chemists (A.O.A.C.) Washington, D. C.

$$\text{Crude fibre(\% onDM basis)} = \frac{wr - wa}{wd}$$

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

Determination of TSS

About 10 g samples were blended and the juice was used to measure the total soluble solids (TSS) by using a standard ATAGO Hand-held refracto-meter (model MASTER-10M, ATAGO Co., Ltd., Tokyo,Japan).

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 (Jackson 1979). Crude protein per cent was computed by multiplying the percentage of nitrogen with the factor 6.25 given by Bhuiya and Chowdhary in 1974.

Vitamin 'C' content

Vitamin "C" content (mg $100g^{-1}$) of flower head was determined by dichlorophenol indophenols (DCPIP) titration procedure given by Rangana, 1977), The vitamin "C" content (mg 100g-1) was determined by using

$$\text{Vitamin "C" (mg } 100g^{-1}) = \frac{0.1 x V_2 x 20}{V_1 x 10}$$

(V1 = Dye consumed by 0.1 mg vitamin "C", V2 = Dye consumed by 10 ml test solution)

RESULTS AND DISCUSSION

The result on quality parameters of broccoli are given as under-

Crude Protein content (%)

The data presented in Table 1 revealed significant variation in crude protein content of broccoli flower head due to different treatments of N indicating it's significantly higher value of 2.18 per cent in N1treatment which was at par with N2 2.16 %) and the lowest value (2.11 %) in N3 treatment under pooled analysis.

It is evident from the data (Table 1) that significantly the higher

Table 1: Crude protein content and TSS in broccoli head (fresh weight)

	Crude protein (%)				TSS (°brix)			
N- Levels	2014	2015	2016	Pooled	2014	2015	2016	Pooled
N1	2.33	2.26	1.94	2.18	0.92	1.08	0.91	0.97
N2	2.31	2.26	1.92	2.16	0.79	0.92	0.86	0.86
N3	2.19	2.22	1.91	2.11	0.91	0.98	0.99	0.96
S.Em ±	0.02	0.02	0.03	0.01	0.02	0.04	0.03	0.02
C.D. @ 5%	0.06	NS	NS	0.04	0.07	0.11	0.08	0.05
P-Levels								
P1	2.3	2.27	1.97	2.18	0.83	0.93	0.91	0.89
P2	2.23	2.22	1.88	2.11	0.99	1.07	0.97	1.01
P3	2.3	2.26	1.92	2.16	0.8	0.98	0.88	0.89
S.Em ±	0.02	0.02	0.03	0.01	0.02	0.04	0.03	0.02
C.D. @ 5%	0.06	NS	NS	0.04	0.07	0.11	NS	0.05
K-Levels								
K1	2.25	2.25	1.9	2.13	0.89	0.97	0.94	0.93
K2	2.31	2.25	1.95	2.17	0.85	1.01	0.9	0.92
S.Em ±	0.02	0.02	0.02	0.01	0.02	0.03	0.02	0.01
C.D. @ 5%	0.05	NS	NS	0.03	NS	NS	NS	NS
Treatment Mean	2.28	2.25	1.93	2.15	0.87	0.99	0.92	0.93
Control	2.01	1.97	1.9	1.96	0.61	0.97	0.75	0.78
Control v/s Rest								
S.Em ±	0.04	0.04	0.05	0.04	0.04	0.07	0.05	0.05
C.D. @ 5%	0.11	0.1	NS	0.11	0.12	NS	0.13	0.15
Control v/s treatment								
S.Em ±	0.05	0.05	0.06	0.06	0.06	0.09	0.06	0.07
C.D. @ 5%	0.15	0.14	NS	0.16	0.16	NS	0.18	0.2
C.V %	4.11	3.8	5.86	4.56	11.68	16.05	12.09	13.65

Table 2: Interaction effect of N, P and K levels on Crude protein content and TSS in broccoli head (fresh weight)

	Crude protein content (%)							TSS (brix)					
NPK	N1		N2		N3		NPK	N1		N2		N3	
	K1	K2	K1	K2	K1	K2		K1	K2	K1	K2	K1	K2
P1	2.26	2.14	2.21	2.16	2.2	2.13	P1	0.88	0.91	0.83	0.73	0.97	1.04
P2	2.03	2.16	2.21	2.18	2.02	2.06	P2	0.95	1.22	0.96	0.84	1.06	1.01
P3	2.34	2.15	1.85	2.37	2.09	2.17	P3	0.72	1.13	1.01	0.78	1.03	0.64
SEm±	0.03	CD at 5%		0.09			SEm±	0.04	CD at 5%		0.12		

Table 3: Ascorbic acid and fibre content in broccoli head as influenced by different treatments

	Ascorbic acid (mg/100g)				Crude fiber content (%)			
N- Levels	2014	2015	2016	Pooled	2014	2015	2016	Pooled
N1	58.69	61.02	56.91	58.87	2.11	2.21	2.14	2.13
N2	76.12	88	73.38	79.17	1.49	1.62	1.52	1.51
N3	60.87	62.84	60.79	61.5	1.19	1.23	1.16	1.19
S.Em ±	1.14	1.42	0.77	0.66	0.01	0.05	0.04	0.02
C.D. @ 5%	3.29	4.09	2.22	1.86	0.03	0.15	0.13	0.06
P-Levels								
P1	54.33	62.52	58	58.28	2.08	2.12	2.05	2.08
P2	72.84	76.62	71.7	73.72	1.44	1.58	1.44	1.45
P3	68.51	72.72	61.39	67.54	1.26	1.35	1.33	1.29
S.Em ±	1.14	1.42	0.77	0.66	0.009	0.052	0.044	0.023
C.D. @ 5%	3.29	4.09	2.22	1.86	0.027	0.15	0.127	0.064
K-Levels								
K1	61.85	74.22	65.37	67.14	1.76	1.82	1.74	1.76
K2	68.61	67.02	62.02	65.88	1.43	1.55	1.47	1.46
S.Em ±	0.93	1.16	0.63	0.54	0.01	0.04	0.04	0.02
C.D. @ 5%	2.69	3.34	1.81	NS	0.02	0.12	0.1	0.05
Treatment Mean	65.23	70.62	63.69	66.51	1.59	1.68	1.61	1.61
Control	45.61	49.44	45.21	46.75	1.1	1.14	1.07	1.11
Control v/s Rest								
S.Em ±	2	2.47	1.39	2	0.03	0.09	0.08	0.07
C.D. @ 5%	5.73	7.08	3.99	5.59	0.09	0.26	0.23	0.2
Control v/s treatment								
S.Em ±	2.75	3.4	1.91	2.75	0.04	0.13	0.11	0.1
C.D. @ 5%	7.79	9.62	5.42	7.72	0.12	0.36	0.31	0.28
C.V %	7.45	8.56	5.15	7.31	2.526	13.118	11.642	10.481

Table 4: Interaction effect of N, P and K levels on Ascorbic acid and Crude fiber content content in broccoli head (Pooled)

	Ascorbic acid (mg/100g)							Crude fiber content (%)					
NPK	N1		N2		N3		NPK	N1		N2		N3	
	K1	K2	K1	K2	K1	K2		K1	K2	K1	K2	K1	K2
P1	33.98	36.31	73.2	80.31	59.79	66.1	P1	2.47	2.39	2.48	1.77	2.23	1.18
P2	75.13	66.44	80.24	81.4	73.14	65.96	P2	2.02	2.97	0.97	0.86	0.71	1.17
P3	76.1	65.29	83.13	76.71	49.6	54.41	P3	1.92	1.03	1.89	1.07	1.17	0.68
SEm±	1.62	CD at 5%		4.54			SEm±	0.06	CD at 5%		0.16		

crude protein content of 2.18 per cent in broccoli flower head was recorded with the application of 40 kg P_2O_5 ha^{-1}(P1) and at par with the treatment P3 (80 kg P_2O_5 ha^{-1}) (2.16 %) and the lowest (2.11%) under P2 (60 kg P_2O_5 ha^{-1}).

Interaction between N and P,N and K and P and K treatments showed significant difference in crude protein content of the broccoli flower head during first year and in pooled analysis. N2P3K2 recorded significantly higher crude protein content (2.37%) and was at par with N1P3K1 (2.34%) treatment combination (Table 2).

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. The results of protein are in tune with Singh *et al*. (2010) and Paliwal and Singh (2014). 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 and Phookan (2006). Many investigators also reported that increasing levels of P improved the plant growth and quality of broccoli (Neethu *et al*., 2015 and Islam *et al*., 2010).

Total Soluble Solids (TSS) content

Treatments of N to broccoli were succeeded to produce significant effect on TSS content in the flower head during three years and in pooled data indicating its significantly the higher content (0.97°Brix) under the treatment N1 (80 kg N ha^{-1}) which was at par (0.97°Brix) with the treatment N3 (160 kg N ha^{-1}) and the lowest content of 0.86°Brix was obtained with the treatment N2 (120 kg N ha^{-1}).

Different P levels exhibited significant effect on TSS content of

broccoli flower head in first, second and in pooled data. TSS was recorded highest (1.01ºBrix) under the treatment P2 (60 kg P2O5 ha^{-1}). It's significantly the lowest value (0.89ºBrix) was noted under the treatment P1 (40 kg P2O5 ha^{-1}) and P3 (80 kg P2O5 ha^{-1}) in pooled analysis.The differences in TSS content of broccoli flower head due to various levels of K were found non-significant during individual years as well as in pooled analysis.

The N×P and N×P×K interaction had succeeded to give significant effect on the TSS content of broccoli flower head in year 2014, 2015 and in pooled analysis. Interaction N1P2K2 recorded significantly higher TSS content (1.22 ºBrix) and was at par with N1P3K2 (1.22 ºBrix) treatment combination (Table 2).

Ascorbic Acid (Vitamin C) content

Vitamin "C" content in the broccoli in relation with different levels of NPK treatments were determined and presented in Table 3. Application of 120 kg N ha^{-1} (N2) resulted significantly the highest Vitamin C content (79.17 mg $100g^{-1}$) in broccoli flower head and the lowest content of 58.87 mg $100g^{-1}$ was recorded by the treatment N1 (80 kg N ha^{-1}).The treatment P2 (60 kg P2O5 ha^{-1}) caused highest vitamin "C" content of 73.72mg $100g^{-1}$in broccoli flower head. Sorenson(1984) as well as Babik and Elkner (2002) who found out that increasing nitrogen application lowered the vitamin "C" content in broccoli and cabbage. Similar finding was also observed by Duttaray et al in pomegranate in 2014. Application of 40 kg P2O5 ha-1(P1) recorded significantly the lowest vitamin "C" content (58.28mg $100g^{-1}$) in broccoli flower head. The application of potash showed non-significant difference in vitamin "C" content of the broccoli flower head in pooled analysis.

The result in table 3 showed that the values of vitamin "C" content of broccoli flower head in various interactions arising from the integration of N, P and K treatments were observed significant. Treatment combination N2P3K1 recorded significantly higher vitamin "C" content (83.13 mg $100g^{-1}$) and was at par with N2P1K2 , N2P2K2 and N2P2K1 treatment combination (Table 4).

Crude fiber content

Crude fiber content in broccoli flower head was determined and the results obtained are presented in Table 3. Results regarding crude fiber content in broccoli flower head as influenced by different levels of N showed significant difference during experimental period and in pooled analysis. The crude fiber content of 2.11 per cent in the broccoli flower head was found significantly highest under the treatment N1 (80 kg N ha^{-1}). Significantly lower value of crude fiber content (1.19 %) was observed in treatment N3 (160 kg N ha^{-1}). Sorenson (1984) and Neethu *et al*. (2015) also noticed similar decrease in crude content of cabbage with increased N fertilization. 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 (Babik and Elkner, 2002).

fibre content of cabbage with increased N fertilization. Significantly higher value of crude fiber content (2.08 %) in broccoli was recorded due to the application of 40 kg P2O5 ha^{-1}(P1), while its significantly lower content (1.26 %) was associated with the treatment P3(80 kg P2O5 ha^{-1}).The treatment K1 (0 kg P2O5 ha^{-1}) caused significantly the highest crude fiber content (1.75 %) in broccoli flower head. Application of 60 kg P2O5 ha^{-1} (P1) recorded significantly the lowest crude fiber content (1.44 %) in broccoli flower head.Treatment combination N1P2K2 recorded (Table 4) significantly higher crude fiber content (2.97 %) .

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