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Effect of different NPK levels on growth and yield attributes 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 Nitrogen, Phosphorus and Potassium levels on yield and growth attributes of Broccoli under South Gujarat condition. There were different nineteen treatments including control. 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)]. In control, only biocompost is applied @ 5t/ha. The experiment was laid out in factorial RBD with three replications. P fertilizer was applied 100% while N and K fertilizer were applied 50% at the time of transplanting. Need based control measures were taken for the pest and disease management. The results revealed that the higher dose of N (N₃- 160 kg N /ha) recorded significantly higher values of number of leaves (18.53) and plant height (37.68 cm) per plant of broccoli. The combination P₃N₃ (40.34 cm) and P₃K₂ (36.98 cm) recorded significantly higher plant height. The interaction effect of all the factors (N x P x K) was also found significant on average head weight and the combination (P₃N₃K₁) recorded significantly higher average head weight (211 g) and remained at par with P₃N₃K₂ (192 g). The treatment N₃ (10181, 9902 and 6159 kg/ha) recorded significantly the higher head yield of broccoli, respectively during all the three years. The treatment combination N₃P₃K₂ (160:80:60) recorded significantly higher values of av. head weight, polar diameter and equatorial diameter of head as well as significantly highest head yield (10120 kg/ha) than rest of the treatment combinations.

Keywords: Broccoli, yield, growth, NPK

1. Introduction

Broccoli (*Brassica oleracea L.*) is a member of the Brassicaceae family as a wild form and said to have originated in the Mediterranean where it can still be seen today, growing wild along the Mediterranean coast (Decoteau, 2000) [3]. The seeds that sprouted the U.S. industry came from Italy and were planted in 1923 in California (Penn State Cooperative Extension Report 2000). Today, broccoli is grown in nearly every country. 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. It is mostly cultivated in the hilly region of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and northern plains of India.

Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas *et al*, 2008) [12]. It is one of the most nutrient-dense foods known which 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. It also have protein 3.3 per cent, thiamine and riboflavin. 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.

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 (Haque *et al.*, 1996) [4]. 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 (Zhou *et al.*, 2000). 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 yield and growth parameters. Therefore, the current experiment was conducted to study the Effect of different levels of NPK on growth and yield of broccoli (*Brassica oleracea L.*).

2. 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 yield and growth 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 soil of the experimental field was clay in texture having medium to poor drainage, medium in available nitrogen, available phosphorus and potash. 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)]. In control, only biocompost is applied @ 5t/ha. 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. Need based control measures were taken for the pest and disease management. 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 and net plot of 2.7×2.4 m size.

3. Bio-metric observations

Five plants from each net plot of each replication were selected randomly and tagged for recording periodical observations. Bio-metric observations recorded during the course of investigation are described here under:

Plant height

The plant height (cm) of previously selected five plants from each treatment was measured at harvest and its average was worked out and recorded for each plot.

No. of leaves plant⁻¹

Number of leaves per previously selected five plants from each treatment was recorded a day before harvest. The mean number of leaves per plant was worked out and recorded for each plot.

Size of flower head

The equatorial and polar diameter (mm) of the flower heads from previously selected five plants of each plot was measured after harvest of the crop using vernier caliper. The average diameter was worked out and recorded for each plot.

Weight of flower head

The fresh weight (g) of flower head of broccoli from net area of each plot was taken at the time of harvesting and the weight plot⁻¹ was converted to weight ha⁻¹.

4. Result and discussion

The result on growth characters, yield attributes and yield of broccoli are given as under-

4.1. Growth and yield attributes

4.1.1 Effect of NPK level

The pooled analysis of three years result of effect of different levels of NPK is given in table 4.1.

The result revealed that individual effect of N was found significant on growth parameters of broccoli. The higher dose of N (N₃-160 kg N/ha) recorded significantly higher values of number of leaves per plant (18.53) and plant height (37.68 cm) of broccoli as compared to 80 and 120 kg N/ha. The yield attributes *viz.*, av. head weight, polar diameter and equatorial diameter were also affected significantly by different levels of nitrogen. Higher dose of N fertilization recorded significantly higher values of head weight (189 g), equatorial diameter (90.00 mm) and polar diameter (83.94 mm) whereas in case of equatorial diameter, N₃ and N₂ levels remained at par with each other. Neethu *et al.* (2015) [7] and Yildirim *et al.* (2007) [11] reported that soil nitrogen fertilization increased the plant height of broccoli cultivars in all experimental years. Similar finding were also reported by Nkoa *et al.* (2002) [8] and Babik and Elkner (2002) [1]. An increase in N supply induced more leaves per plant. This might be due to the fact that N had influenced the vegetative growth of the plant. Moniruzzaman *et al.* (2007) [6] found similar results in broccoli.

Similar trend was observed in with respect to application of phosphorus; the higher the dose of phosphorus (P₃-80 kg P₂O₅ ha⁻¹) recorded significantly taller plant height (36.16 cm) and head weight (176gm) of broccoli whereas significantly higher numbers of leaves were recorded with P₂ level, 60 kg P₂O₅ ha⁻¹) which was at par with P₃ level. Different P levels failed to exert significant effect on yield attribute except in case of average head weight. The application of increase in level of P could be ascribed to its role in photosynthesis, energy storage, cell division and enlargement. (Singh 1996) [9].

In case of application of potash, only plant height was affected significantly and higher value was recorded with K₂ level (60 kg K/ha). The other yield attributes were not affected significantly with respect to application of potash.

The control *v/s* rest analysis inferred that the mean values of treatments of all the growth and yield attributes were significantly higher as compared to control treatment.

Table 4.1: Growth and yield attributes of broccoli as affected by different treatments

N- Levels	Number of leaves	Plant height (cm)	Av. Head weight (g)	Equatorial diameter of head (mm)	Polar diameter of head (mm)
N1	16.97	32.35	144	78.70	74.55
N2	16.70	34.45	174	88.03	79.09
N3	18.53	37.68	189	90.00	83.94
SEm ±	0.31	0.33	5.07	1.57	1.34
CD at 5%	0.88	0.92	14	4.41	3.75
P-Levels					
P1	16.56	33.07	165	84.72	78.67
P2	17.96	35.25	165	84.16	77.67
P3	17.69	36.16	176	87.84	81.24
SEm ±	0.31	0.33	5.07	1.57	1.34
CD at 5%	0.88	0.92	14	NS	NS
K-Levels					
K1	17.65	34.32	168	84.96	78.77
K2	17.15	35.34	170	86.18	79.62
SEm ±	0.26	0.27	4.14	1.28	1.09
CD at 5%	NS	0.75	NS	NS	NS
Treatment Mean	17.40	34.83	169	85.57	79.19
Control	13.22	26.43	88	61.70	62.46
Control v/s Rest					
SEm ±	0.96	1.02	15.41	4.89	4.18
CD at 5%	2.68	2.85	43	13.64	11.67
Control v/s treatment					
SEm ±	1.32	1.40	21.21	6.73	5.75
CD at 5%	3.70	3.93	59	18.85	16.12
C.V %	13.27	12.35	17.07	13.50	12.41
Sig. Interactions	-	P x N P x K	P x N N x P x K	P x N N x P x K	P x N N x P x K

4.1.2 Interaction effect

The pooled analysis of three years result of interaction effect of different levels of NPK is given in table 4.2 to table 4.8.

The interaction effect of N x P and P x K were significant on plant height in pooled analysis (table 4.2). The combination N₃P₃ (40.34 cm) and P₃K₂ (36.98 cm) recorded significantly higher plant height than rest of the respective combinations. The treatment P₃K₂ was found at par with P₂K₂. Similarly, the N x P effect was found significant in case of average head weight (table 4.3), the treatment P₃N₃ recorded significantly higher average head weight (201.51 g) than rest of the respective combinations of various treatments.

The interaction effect of all the factors (N x P x K) was also found significant on average head weight (table 4.4) and the combination (P₃N₃K₁) recorded significantly higher average head weight (211 g) than rest of the combinations but it remained at par with P₃N₃K₂ (192 g).

The result showed in table 4.5 to 4.8 showed that another yield attributes like equatorial and polar diameter of the head were also affected significantly due to different interaction effects of N x P, P x K and N x P x K, and almost similar trend was observed that observed on average head weight.

The interaction effect of P x N and P x K were significant on equatorial diameter (table 4.5) and polar diameter (table 4.7) of the head in pooled analysis. The combination N₃P₁ (94.39 mm) and P₃K₁ (89.88 mm) recorded significantly higher equatorial diameter of the head than rest and similarly the combination N₃P₃ (89.24 mm) and P₃K₁ (81.36 mm) recorded significantly higher polar diameter of the head than rest of the respective combinations. These results are in conformity with the findings of Brahma *et al.* (2006)^[2] and Moniruzzaman *et al.* (2007)^[6] in broccoli.

The interaction effect of all the factors (N x P x K) was also found significant on equatorial and polar diameter of the head (table 4.6 and 4.8). The combination P₁N₃K₁ recorded significantly higher equatorial diameter (99.49 mm) and P₃N₃K₁ recorded significantly higher polar diameter (92.12 mm) of the head than rest of the combinations.

Table 4.2: P x N and P x K Interaction effect of plant height (Pooled of three years)

N x P	N1	N2	N3	P x K	K1	K2
P1	30.61	33.18	35.43	P1	33.32	32.83
P2	33.54	34.91	37.28	P2	34.29	36.20
P3	32.88	35.27	40.34	P3	35.34	36.98
	SEm ±	0.57		SEm ±	0.46	
	C.D. at 5%	1.59		C.D. at 5%	1.30	

Table 4.3: P x N Interaction effect on average head weight (g) (Pooled of three years)

	N1	N2	N3
P1	126.86	175.95	192.65
P2	152.17	170.30	173.03
P3	151.67	175.30	201.51
	SEm ±	8.7807	
	C.D. at 5%	24.63	

Table 4.4: N x P x K Interaction effect on average head weight (g) (Pooled of three years)

NPK	N1		N2		N3	
	K1	K2	K1	K2	K1	K2
P1	119	135	174	177	204	181
P2	154	150	169	171	157	189
P3	151	152	170	180	211	192
SEm±	12.42		CD at 5%	35		

Table 4.5: P x N and P x K Interaction effect on equatorial diameter of head (mm) (Pooled of three years)

P x N	N1	N2	N3	P x K	K1	K2
P1	75.09	84.67	94.39	P1	84.90	84.55
P2	79.84	89.21	83.44	P2	80.11	88.21
P3	81.15	90.19	92.16	P3	89.88	85.79
	SEm ±	2.723			2.22	
	C.D. at 5%	7.64			6.24	

Table 4.6: N x P x K Interaction effect on equatorial diameter of head (mm) (Pooled of three years)

	N1	K2	N2	K2	N3	K2
	K1		K1		K1	
P1	73.97	76.32	81.33	88.02	99.49	89.30
P2	80.75	78.92	85.72	92.71	73.87	93.01
P3	79.85	82.46	91.12	89.26	98.68	85.64
SEm±	3.85		CD at 5%	10.80		

Table 4.7: P x N and P x K Interaction effect on polar diameter of head (mm) (Pooled of three years)

P x N	N1	N2	N3	P x K	K1	K2
P1	72.32	77.64	86.07	P1	80.61	76.74
P2	75.68	80.80	76.53	P2	74.35	80.99
P3	75.65	78.84	89.24	P3	81.36	81.13
	SEm ±		2.32			1.89
	C.D. at 5%		6.50			5.31

Table 4.8: N x P x K Interaction effect on polar diameter of head (mm) (Pooled of three years)

	N1	K2	N2	K2	N3	K2
	K1		K1		K1	
P1	72.68	71.95	78.56	76.72	90.59	81.54
P2	77.29	74.06	76.62	84.97	69.12	83.93
P3	70.88	80.43	81.08	76.60	92.12	86.36
SEm±	3.28		CD at 5%	9.19		

4.2. Head yield of broccoli

4.2.1 Effect of NPK level

The result presented in table 4.9 revealed that the individual effect of different levels of nitrogen (N) was found significant on head yield of broccoli during first, second and third year as well as in pooled analysis. The treatment N₃ (10181, 9902 and 6159 kg/ha) recorded significantly the higher head yield of broccoli, respectively during all the three years as compared to N₂ (9076, 8569 and 5256 kg/ha) and N₁ (6288, 7113 and 4558 kg/ha). Similar trend was also reflected in pooled analysis.

In case of phosphorus fertilizer levels, during first year as well as in pooled analysis the effect of different levels on head yield was found as non significant but during second and third year, the, it was observed that higher dose of P (P₃-80 kg/ha) recorded significantly higher values of head yield of broccoli (9433 and 5722 kg/ha respectively).

Thakur *et al.* (1991)^[10] reported that higher N level increased the dry matter production and accumulation. The P fertilization might have influenced the head initiation and development of broccoli. The co-limitation of N and P nutrients can significantly influence plant productivity (Hong *et al.* 2011). Phosphorus at different levels had influenced the yield and yield contributing characters of broccoli (Brahma & Phookan, 2006)^[2] and (Islam *et al.* 2010)^[5] Increases in total yields from high rates of N were obtained only when an adequate rate of P was applied.

Head yield of broccoli was not affected significantly with different levels of potash (K) application.

Table 4.9: Head yield of broccoli as affected by different treatments

3N- Levels	Year-1	Year-2	Year-3	Pooled
N1	6288	7113	4558	5987
N2	9076	8569	5256	7634
N3	10181	9902	6159	8747
SEm ±	317.32	313.89	207.98	164.14
C.D. @ 5%	912	902	598	460
P-Levels				

P1	7978	7611	4848	6812
P2	8802	8540	5353	7565
P3	8766	9433	5772	7990
SEm ±	317.32	313.89	207.98	164.14
C.D. @ 5%	NS	902	598	NS
K-Levels				
K1	8269	8380	5294	7314
K2	8761	8676	5355	7597
SEm ±	259.09	256.29	169.81	134.02
C.D. @ 5%	NS	NS	NS	NS
Treatment Mean	8515	8528	5325	7456
Control	2442	2442	3221	2702
Control v/s Rest				
SEm ±	553.76	548.23	387.83	502.53
C.D. @ 5%	1588	1572	1112	1403
Control v/s treatment	0.00	0.00	0.00	0.00
SEm ±	762.25	754.63	533.84	691.73
C.D. @ 5%	2159	2138	1512	1939
C.V %	15.81	15.62	16.57	16.18
Sig. Int.	N x P	N x P	N x K	N x P, N x P x K

4.2.2 Interaction effect

The interaction between N x P, P x K and N x P, N x K, P x K, N x P x K were found significant head yield during first, second, third year and in pooled analysis, respectively.

The combination N₃P₃ (table 4.10) recorded significantly higher fresh had yield (9493kg/ha) of broccoli as compared to the rest of the respective combinations.

The treatment combinations of N₃P₃K₂ recorded significantly higher head yield (10120 kg/ha) than rest of the treatment combinations.

Control v/s rest analysis, in all the cases the treatment mean recorded was higher head yield of broccoli as compared to control.

Conclusions

Growth Character, yield attributes and yield of broccoli viz., plant height, and average head weight, equatorial and polar diameter as well as head yield significantly increased with increase of N and P levels. However application of K recorded non-significant effect on above mentioned character except for plant height. Treatment combination N₃P₃K₂ (160:80:60) recorded significantly higher values of av. head weight, polar diameter and equatorial diameter of head as well as significantly highest head yield (10120 kg/ha) and net return of Rs 284385/ha than rest of the treatment combinations.

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