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Nutrient management for quality seed production of broccoli in Assam

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ABSTRACT

The experiment was conducted during 2018-19 to evaluate the effect of different levels of nitrogen (80,100, 120 kg/ha), potassium (60, 80 kg/ha), and method of nitrogen application (applied in 2 and 3 splits) on the seed quality and yield of broccoli variety 'Pusa Broccoli KTS-1' in Assam condition having high sub-tropical humid with hot summer and cold winter. In two splits, 50% nitrogen was applied as basal and the rest at 40 days after transplanting, and in three split doses, 50% was used as basal, 25% at 30 DAT, and the rest at the flower initiation stage. The control included the application of FYM only. The treatments significantly affected various crop growth and seed quality parameters, *viz*., plant height; canopy spread; leaf length, width, and chlorophyll content; head diameter; days to heading, flowering and seed maturity; the number of siliquas/plants; the number of seeds/siliqua; seed yield/plant; leaf NPK content; seed test weight; mean germination time, germination index and percent, seed vigour index-I and II, fresh and dry weight of seedling. High doses of nitrogen (120 kg/ha), potassium (80 kg/ha), and three split dosages of nitrogen application significantly enhanced various crop growth, seed yield, and germination parameters while reducing the time taken for heading, flowering, and seed maturity. In addition, higher doses resulted in higher leaf N, K, and chlorophyll content that were again positively associated with plant growth and seed yield.

Keywords: Broccoli seed production, NPK doses, seed quality, split application

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica)* is a winter vegetable crop belonging to the *Brassicaceae* family and resembling cauliflower but usually have green head which can be harvested for longer time than cauliflower. Broccoli is a very nutritious crop containing carbohydrates, protein, vitamin-A, thiamine, riboflavin, ascorbic acid, calcium and phosphorus, and also contains anti-cancer compound 'sulforaphane'.

India, after China, is the second largest broccoli producer. The world productivity of cauliflower and broccoli increased from 18.71 t/ha in 2002 to 1 8.78 t/ha in 201 6 whereas in India during the same period the productivity increased from 18.11 t/ha to 19.25 t/ha (Saxena, 18). In India it is generally grown in hilly areas of Himachal Pradesh, Jammu and Kashmir, Nilgiri hills, Uttar Pradesh and Northern Plains, however, now becoming popular in other parts of the India including Assam, with prospects of increasing production and productivity. The weather and climatic condition of Assam is sub-tropical humid with hot summer and cold winter, having pre-monsoon showers from mid-March to May and the monsoon from June to September with the minimum rainfall during December- January. This condition favours production of broccoli head as well as seeds (Gogoi *et al.,* 8) hence broccoli is becoming a popular crop of Assam.

Broccoli absorbs a large amount of nutrients from the soil (Magnifico *et al.,* 14) and hence requires a huge amount of chemical fertilizers as well as organic manures. Since Nitrogen (N) fertilizers promote vegetative growth, excess N stimulates vegetative growth at the expense of reproductive growth resulting in delay or inhibition of flower production and fruit set. Hence, in the early developmental stage of the crop, C: N ratio should be low to promote vegetative growth but just prior to flower the C: N ratio should be increased to promote flowering and fruit set. Split application of N enhances the nutrient use efficiency, promotes optimum yield, mitigates the loss of nutrients i.e., it synchronizes nitrogen supply with plants ability to utilize nutrients. Potassium (K) needed for the formation of amino acid and protein from amino ions absorbed from the soil. It also helps in photosynthesis, translocation of food from leaf to roots. Phosphorus (P) deficiency may restrict the growth of shoots and roots however in broccoli it was found that there is no effect of P on seed production (Cardoso *et al.,* 6). There are studies reporting significant effect of NPK on broccoli crop and seed yield however reports are not available for Assam in respect to quality seed production of broccoli. Hence, to estimate the amount of nutrient required to produce good quality broccoli seed in Assam, the crop was

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supplied with different doses of N and K, also the N was applied in two methods.

MATERIALS AND METHODS

The experiment was conducted during 2018-19 at Assam Agricultural University, Jorhat situated at 26°45' N latitude, 94°12' E longitude and altitude of 87 m above mean sea level. Nutrient status of experimental plot was estimated before planting of broccoli. The status of soil organic matter (0.84%) and available phosphorus (24.4 kg/ha) was within the normal range. Estimation was done by Wet Digestion Method and Bray's method (Jackson, 13) respectively. Available nitrogen (263.4 kg/ha) and potassium (94.9 kg/ha) estimated by Modified Kjaldahl method and Flame Photometric method (Jackson, 13) respectively. The soil pH of experimental plot was 5.58.

The weather of the experimental site was hot and humid in summer and, cold and humid in winter. During the broccoli growing season, the maximum temperature was between 30.6^{0}C to 21.3^{0}C and the minimum temperature was between 8.1^{0}C to 23.0^{0}C, similarly maximum RH ranged from 90% to 99% and minimum humidity between 53% and 78%. Total rainfall was recorded between 0 to 34.3 mm throughout the broccoli seed production period.

The breeder seed of variety Pusa Broccoli KTS-1 was sown on 5th October 2018 and transplanted on 30th October 2018 in a randomized block design with thirteen treatment combinations in three replications. A spacing of 60cm × 40cm with plot size of 3 m × 2 m was used for experimental purpose. 20 t/ha FYM applied in experimental plot. Nitrogen was applied at doses 80, 100 and 120 kg/ha, potassium at 60 and 80 kg/ha, phosphorus at 60 kg/ha only. N was applied in 2 and 3 splits. In two split application, 50% of N was applied as basal and rest after 40 DAT. In three splits, 50% was applied as basal, 25% at 30 DAT and rest at flower initiation stage. In control, only FYM was applied. Bavistin was sprayed twice @ 2g/lit at an interval of 7 days as protection measure against blight caused by *Alternaria* species. Scooping central portions of the heads at maturity was done to reduce compactness. It resulted in better flower stalk initiation, flower formation and hence seed formation. The crop was harvested by cutting the whole plant at ground level from 25th March 2019 to 5th April 2019.

Crop growth parameters observed were plant height, measured at heading and at seed maturity stage from the ground level to the tip of the longest leaf and panicle respectively; canopy spread as horizontal distance between edges of two outermost leaves on either side of plant at head initiation stage; leaf length and width measured at head initiation stage, leaf length was measured from leaf blade tip to petiole, leaf width by measuring the widest part of the leaf; head diameter at marketable maturity which was measured in crossed way and average was taken; days to heading, flowering (as appearance of the 1st flower) and seed maturity; number of siliquae/plant and seeds/siliqua; leaf NPK content, estimated by Micro-Kjeldahl's method (Humphires, 11), wet digestion method and flame photometric method (Jackson, 13) respectively, for which fresh full grown leaf just before flowering was collected, dried and grounded; leaf chlorophyll content just prior to flowering recorded with SPAD-502; seed yield/plant; seed test weight. Germination parameters *viz.*, mean germination time (MGT), germination index (GI) and percentage, seed vigour index (SVI) I and II, fresh and dry weight of seedling were recorded after harvesting of the crop. Germination test was done on top of paper method as per ISTA procedure (ISTA, 12) in three replications. SVI-I was calculated as suggested by Abdul Baki and Anderson, (1), whereas, SVI-II by multiplying germination percent with mean seedling dry weight. GI and MGT was calculated as given below.

$$GI = \sum \frac{GtGt}{TtTt} = \frac{\text{Number of seeds germinated}}{\text{Days of 1st count}} + ... + = \frac{\text{Number of seeds germinated}}{\text{Days of final count}} = \frac{\text{Number of seeds germinated}}{\text{Days of 1st count}} + ... + \frac{\text{Number of seeds germinated}}{\text{Days of final count}}$$

Where, Gt= number of seeds germinated on day t, Tt= number of days

$$MGT = \frac{n_1 \times d_1 + n_2 \times d_2 + n_3 \times d_3 + ...}{\text{Seeds germinated of days d}}$$

Where, n= number of seeds newly germinated on that day, d= number of days from the beginning of germination test.

The mean data recorded on different parameters were analyzed by factorial randomized block design by using MS Excel. The mean values were compared by least significant difference based on ANOVA (Gomez and Gomez, 9).

RESULTS AND DISCUSSION

Many researchers validated the importance of nitrogen (N) for yield and quality of broccoli. *Brassica* genotype requires higher amount of N than other crop species for optimum growth and yield. Beverly *et al.*, (3) recommended 350 kg N/ ha to achieve 20 t broccoli/ ha. In the present investigation N was applied in the form of urea in three different doses (80, 100 and 120 kg/ha). With the increase in nitrogen levels, the plant height, canopy spread, leaf length, leaf width, chlorophyll content, head diameter, number of siliquas/plant and seeds/siliqua, seed yield/plant, seed test weight, leaf NPK content, germination percentage, GI, SVI-I, SVI-II, seedling fresh and dry weight also increased though no effect of nitrogen doses was observed on leaves number per plant and MGT. The best result was obtained at 120 kg/ha (Table 1 and Table 2). The reduced days to heading, flowering and seed maturity at 120 kg/ha might be due to proper utilization of carbohydrates in shorter time. Singh *et al.,* (19) when carried out similar experiment by applying N ranging from 100 to 140 kg/ ha, observed maximum plant height, number of leaves/plant, leaf length and width, plant spread, curd diameter and other yield parameters but minimum days to curd formation in 120 kg N with 60 kg P_2O_5 40 kg K_2O and15 kg boron per ha but there was detrimental effect in plant growth when N was applied at more than 120 kg/ha which may be due to toxicity. They opined that increase in different plant growth and yield parameters at 120 kg N/ha might be because of higher protein synthesis, chlorophyll and carbohydrates production in crop whereas, Brahma *et al.,* (5).Microelement like boron helps in optimum NPK accumulation and translocation in leaves, which may increase leaf length and width. Similarly, higher plant height, plant spread, leaf size in higher dose of N (120 kg/ ha) was attributed to the improve photosynthetic efficiency of plants leading to more metabolites accumulation for faster cell division and elongation in the meristematic region to increase plant height in broccoli, also there would be more carbohydrate production, protein synthesis that allowed the plant to grow faster and more vigorously in broccoli (Dufault, 7). In the present investigation higher seed yield and quality in higher N dose was might be due to increased leaf N content in high N dose which in turn might have enhanced the leaf chlorophyll content, as leaf N content and leaf chlorophyll showed very high degree of association (Table 3). As already discussed earlier high chlorophyll content might have enhanced photosynthesis and more accumulation of metabolites.

The study revealed better crop growth, seed yield and quality at higher dose of potassium (80 kg/ha) applied in the form of MOP than the lower dose of 60 kg/ha (Table 1, Table 2). However, leaves number/ plant and MGT were not affected by potassium fertilizer. Similarly, Singh *et al.,* (19) observed higher crop growth and curd yield of broccoli in higher dose of K (60 kg/ha) than lower dose (40 kg/ha). Better plant growth and higher seed yield can be attributed to efficient protein synthesis, better N and K uptake of the plant due to high concentration of K (Sawan *et al.,* 17), to efficient use of water and carbohydrate metabolism due to K (Singh *et al.,* 19), to increased photosynthetic rates of leaves, CO_2 assimilation rate, carbon movement and increased respiration resulting in better fruit formation (Sangakkara *et al.,* 16). Potassium found to activate enzymes that are involved in carbohydrate metabolism and also it activates metabolism of nucleic acids, proteins, vitamins and growth substances (Singh *et al.* 19) as a consequence, seed yield and quality were favorably affected.

Nitrogen fertilizer applied in different splits plays an important role in productive and efficient nutrient management. The total nitrogen application when divided into two or more applications enhances nutrient use efficiency and mitigates nutrient loss. When N applied in 3 splits, plant height at seed maturity, leaf length, head diameter, siliquas number per plant, 1000 seed weight, SVI-I, SVI-II and seedling dry weight were found better though other traits were not affected by methods of N application (Table 1, Table 2) Nitrogen may get lost due to denitrification, leaching or volatilization when supplied as a single dose ahead of crop growth (Grant *et al*., 10) and if applied after flowering, there will be no further leaf expansion, hence N should be applied before flowering for improvement of photosynthetic efficiency and yield potential of the crop(Ahmad *et al.,* 2). For judicious use of nitrogen, it must be applied in splits and before initiation of flowering. For long duration crop split should be more and vice versa and since broccoli seed production takes longer time, split should be more, in the present investigation it was 3 splits ensuring adequate amounts of nutrients to the crop during the entire growth and development stages, leading to higher crop growth and seed yield. N supply in split doses also resulted in better utilization of carbohydrate to form more protoplasm leading to larger cells (Black, 4), which again leads to increased leaf area. Increased leaf area intercepts more sunlight resulting in more accumulation of dry matter due to more photosynthesis.

The seed yield was the most important aspect for present investigation which is highly influenced by genotype × environment interaction and many associated traits affect it directly or indirectly (Malek, 15). The seed yield was found to be positively associated with all the parameters, and with leaf width, seed number per siliqua, 1000 seed weight, leaf N content, SVI-I and seedling fresh weight, a very strong association was observed (r= $\geq$0.9) (Table 3). Thus, it is possible that plant selected for these traits will also increase seed yield. The negative correlation of seed yield with days to heading, flowering and maturity, indicated that shorter the duration of crop, higher will be the seed yield, hence these traits

Table 1. Treatments effect on different traits of broccoli.

Factors		Means											
		Plant height (cm)		Canopy spread (cm^2)	Leave no./ plant	Leaf length (cm)	Leaf width (cm)	Chlorophyll content	Days to heading	Head diameter (cm)	Days to flowering	Days to seed maturity	No. of pods/ plant
		At heading	At maturity										
Treatment		59.13	105.63	6035.45	19.44	29.51	18.96	67.74	55.48	20.34	81.03	150.56	269.63
Control		43.36	75.91	4134.76	18.40	23.6	17.6	60.8	60.1	18.7	85.7	156.0	101.89
N method	2 split	59.94	104.49	6066.01	19.56	29.07	18.84	67.64	55.68	19.63	81.18	151.34	256.13
	3 split	58.32	106.77	6004.89	19.32	29.95	19.08	67.84	55.28	21.04	80.88	149.78	283.13
N doses @ kg/ ha	80	58.29	100.16	5617.54	19.10	28.16	18.16	65.43	56.68	19.10	82.13	152.43	222.67
	100	59.08	105.29	5903.90	19.35	29.40	18.61	68.16	55.30	19.76	80.97	150.90	233.11
	120	60.02	111.45	6584.92	19.87	30.96	20.11	69.64	54.47	22.16	79.98	148.35	353.11
K doses @ kg/ha	60	57.70	103.68	5917.68	19.32	28.95	18.65	67.05	55.85	20.06	81.41	151.41	233.30
	80	60.56	107.59	6153.22	19.56	30.07	19.28	68.44	55.12	20.62	80.64	149.71	305.96
$CD_{5\% \text{ (treat.)}}$		7.94	2.31	917.78	NS	1.770	1.036	2.06	2.37	1.42	0.89	4.88	168.72
$CD_{5\% \text{ (treat. vs. control)}}$		7.94	2.31	917.78	NS	1.770	1.036	2.06	2.37	1.42	0.89	4.88	168.72
$CD_{5\% \text{ (Nmethod)}}$		NS	0.94	NS	NS	0.723	NS	NS	NS	0.58	NS	NS	NS
$CD_{5\% \text{ (Ndoses)}}$		NS	1.16	458.89	NS	0.885	0.518	2.06	1.18	0.71	0.44	2.4	84.36
$CD_{5\% \text{ (Kdoses)}}$		NS	0.94	NS	NS	0.723	0.423	0.84	NS	NS	0.36	NS	68.88
$CD_{5\% \text{ (NxM)}}$		NS	NS	NS	NS	NS	NS	NS	NS	1.0	NS	NS	NS
$CD_{5\% \text{ (NxK)}}$		NS	NS	648.97	NS	NS	NS	NS	NS	NS	NS	NS	NS
$CD_{5\% \text{ (K × M)}}$		NS	NS	NS	NS	NS	NS	NS	NS	0.82	NS	NS	NS
$CD_{5\% \text{ (MxNx K)}}$		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= non-Significant

Table 2. Treatments effect on different traits of broccoli.

Factors		Means												
		No. of seed/ pod	Seed yield/ plant	1000 Seed weight	Leaf N	Leaf P	Leaf K	Germination %	GI	MGT	SVI-I	SVI-II	Seedling weight (mg)	
													fresh	dry
Treatment		8.38	1.63	1.96	0.39	0.75	5.37	73.11	23.53	2.29	359.02	176.45	3.25	2.30
Control		7.11	1.2	1.50	0.17	0.6	3.4	56.00	19.06	3.64	231.80	83.90	2.37	1.50
N method	2 split	8.27	1.60	1.91	0.38	0.74	5.26	72.44	22.98	2.26	337.86	162.83	3.25	2.22
	3 split	8.49	1.66	2.01	0.40	0.77	5.48	73.78	24.08	2.32	380.19	190.08	3.25	2.38
N doses @ kg/ ha	80	7.40	1.24	1.66	0.27	0.68	4.84	66.17	20.95	2.31	276.01	124.55	2.70	1.87
	100	7.96	1.48	1.95	0.35	0.77	5.16	74.83	24.20	2.28	348.19	175.78	2.86	2.11
	120	9.79	2.17	2.27	0.54	0.81	6.12	78.33	25.45	2.29	452.87	229.03	4.19	2.92
K doses @ kg/ ha	60	8.24	1.54	1.89	0.39	0.76	4.73	71.33	22.72	2.30	329.44	163.93	3.16	2.10
	80	8.52	1.73	2.02	0.39	0.75	6.01	74.89	24.34	2.29	388.60	188.97	3.34	2.50
$CD_{5\% \text{ (treat.)}}$		0.59	0.17	0.15	0.07	0.11	0.79	4.47	3.09	0.36	38.91	23.67	0.43	0.21
$CD_{5\% \text{ (treat. vs. control)}}$		0.59	0.17	0.15	0.07	0.11	0.79	4.47	3.09	0.36	38.91	23.67	0.43	0.21
$CD_{5\% \text{ (Nmethod)}}$		NS	NS	0.06	NS	NS	NS	NS	NS	NS	38.91	9.66	NS	0.09
$CD_{5\% \text{ (Ndoses)}}$		0.30	0.09	0.08	0.03	0.05	0.40	2.23	1.54	NS	15.88	11.83	0.21	0.11
$CD_{5\% \text{ (Kdoses)}}$		0.24	0.07	0.06	NS	NS	0.32	1.82	1.26	NS	19.45	9.66	NS	0.09
$CD_{5\% \text{ (NxM)}}$		NS	NS	NS	NS	NS	NS	NS	NS	NS	15.88	16.73	NS	NS
$CD_{5\% \text{ (NxK)}}$		0.42	0.12	NS	NS	NS	NS	NS	2.18	NS	27.51	16.73	NS	NS
$CD_{5\% \text{ (K × M)}}$		NS	NS	NS	NS	NS	NS	NS	NS	NS	22.46	NS	NS	0.12
$CD_{5\% \text{ (MxNxK)}}$		NS	NS	NS	NS	NS	NS	NS	3.09	0.36	38.91	23.67	NS	NS

NS= non-Significant

Table 3. Pearson's correlation coefficients among the plant growth and seed yield parameters of the broccoli.

	PH1	PH2	CS	LN	LL	LW	CHL	DH	HD	DF	DSM	SNP	SNS	SY	LN%	LP%	LK%
PH2	0.82**																
CS	0.84**	0.91**															
LN	0.68**	0.72**	0.83**														
LL	0.78**	0.96**	0.90**	0.65*													
LW	0.52	0.79**	0.83**	0.78**	0.83**												
CHL	0.75**	0.95**	0.90**	0.73**	0.94**	0.83**											
DH	-0.80**	-0.98**	-0.93**	-0.78**	-0.95**	-0.83**	-0.97**										
HD	0.23	0.58*	0.53	0.58*	0.57*	0.71**	0.58*	-0.60**									
DF	-0.79**	-0.99**	-0.90**	-0.70**	-0.97**	-0.80**	-0.98**	0.97**	-0.59*								
DSM	-0.63*	-0.87**	-0.87**	-0.68**	-0.93**	-0.92**	-0.86**	0.91**	-0.70**	0.87**							
SNP	0.69**	0.78**	0.90**	0.74**	0.84**	0.90**	0.78**	-0.82**	0.61*	-0.78**	-0.93**						
SNS	0.44	0.73**	0.79**	0.75**	0.76**	0.96**	0.79**	-0.77**	0.68**	-0.75**	-0.83**	0.82**					
SY	0.41	0.73**	0.73**	0.72**	0.74**	0.95**	0.79**	-0.75**	0.72**	-0.75**	-0.80**	0.76**	0.97**				
LN%	0.49	0.80**	0.82**	0.73**	0.80**	0.91**	0.85**	-0.81**	0.68**	-0.82**	-0.80**	0.75**	0.96**	0.95**			
LP%	0.42	0.75**	0.73**	0.52	0.75**	0.74**	0.85**	-0.80**	0.44	-0.79**	-0.73**	0.60*	0.79**	0.74**	0.84**		
LK%	0.69**	0.84**	0.79**	0.67*	0.87**	0.85**	0.87**	-0.84**	0.63*	-0.87**	-0.85**	0.84**	0.75**	0.79**	0.73**	0.59*	
TSW	0.55*	0.83**	0.84**	0.75**	0.84**	0.93**	0.91**	-0.87**	0.75**	-0.86**	-0.86**	0.81**	0.94**	0.94**	0.94**	0.84**	0.84**

* Significant at 5%, **Significant at 1
(PH1, PH2= Plant height at heading and maturity stage, CS= canopy spread, LN= leaf number, LL= leaf length, LW= leaf width, CHL= leaf chlorophyll content, DH=days to heading, HD=head diameter,DF=days to flowering, DSM= days to seed maturity, SNP= no. of siliquas/plant, SNS= no. of seeds/siliqua, SY= seed yield/plant, LN, LP, LK= leaf NPK content (%), TSW= 1000 seed weight)

could be used for negative selection for increased seed yield.

Leaf N and K content were positively and strongly associated with all the plant growth and seed yield except days to heading, flowering and seed maturity, where negative association was observed. As discussed earlier, higher leaf N and K content was obtained at higher dose of nitrogen and potash respectively, thus can be concluded that by managing N and K nutrient, the leaf N and K content can be enhanced which other hand will enhance seed yield. A very strong association was also observed between leaf N and chlorophyll content of the leaf measured by SPAD 502.

The present study established that the agroclimatic condition of Assam is suitable for broccoli quality seed production and can be concluded that N application in 3 splits at 120 kg/ha and K at 80 kg/ha enhanced crop growth, seed yield and quality of broccoli significantly. Also, by managing N and K nutrient, higher leaf N, K and chlorophyll content could be achieved which other hand would enhance seed yield and quality.

AUTHORS' CONTRIBUTION

Conceptualization (MB); Designing of the experiments (MB); Field/ lab work and data collection (PG); Valuable suggestions and facilities provided for field/ lab work (PKB, SG, NB); Statistical analysis (MB, PG, PKB); Manuscript preparation (MB, PG).

DECLARATION

The authors declare no conflict of interest.

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REFERENCES

1. Abdul-Baki, A.A. and Anderson, J.D. 1973. Relationship between decarboxylation of glutamic acid and vigour in soybean (*Glycine max* L.). *Crop Sci.* **13**: 227-32.
2. Ahmad, A.,Abrol, Y.P. and Abdin, M.Z. 1999. Effect of split application of sulphur and nitrogen on growth and yield attributes of *Brassica* genotypes differing in time of flowering. *Can. J. Plant Sci.* **79**: 175-80.
3. Beverly, R.B., Jarrell, W.M. and Letey, J.1986. A nitrogen and water response surface for sprinkler irrigated broccoli. *Agron J.* **78**: 91–94.
4. Black, C.A. 1967. *Soil–plant relationship*. 2nd edition John Wiley & Sons Inc., New York.
5. Brahma, S.,Phookan, D.B., Gautam, B.P. and Bora, D.K. 2002b. Effect of nitrogen, phosphorus and potassium on growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) cv. KTS-I. *Indian J. Agric. Sci. Soc.* **15**: 104-06.
6. Cardoso, AII., Claudio, M.T.R., Nakada-Freitas, P.G.,Magro, F.O., Tavares, A.E.B. 2016. Phosphate fertilization over the accumulation of macronutrients in cauliflower seed production. *Hortic. Bras.* **34**: 196-201.
7. Dufault, Robert, J. 1988. Nitrogen and phosphorus requirements for greenhouse broccoli production. *Hort Sci.* **23**: 576-78.
8. Gogoi, S., Das, M.R., Bora, P., Mazumdar, N. and Das, B.K. 2016. Effect of sowing dates and spacing on broccoli (*Brassica oleracea* var. *italica*) seed production. *J. Agric. Sci.* **50**: 350-53.
9. Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research, 2nd edition. John Wiley and Sons, New York. pp. 28-192.
10. Grant, C.A., Wu, R.,Selles, F., Harker, K.N., Clayton, G.W., Bittman, S.,Zebarth, B.J. and Lupwayi, N.Z. 2012. Crop yield and nitrogen concentration with controlled release urea and split applications of nitrogen as compared to non-coated urea applied at seeding. *Field Crops Research* **127**: 170–180.
11. Humphires, L.C. 1956. Mineral Compounds and Ash Analysis in Modern Methods of Plant Analysis. Springs-Verlag, Berlin. pp. 237–48.
12. International Seed Testing Association Zurich, Switzerland. 1999. International Rules for Seed Testing. *Supplement to Seed Science & Technolgy* p. 27.
13. Jackson, M.L. 1973. Soil chemical analysis, Prentice Hall, New Delhi. pp. 111-26.
14. Magnifico, V., Lattanzio, V. and Sarli, G. 1979. Growth and nutrient removal by broccoli. *Journal of the American Society for Horticultural Science* **104**: 201-03.
15. Malek, M.A., Rafii, M.Y., Afroz, M.S.S., Nath, U.K. and Mondal, M.M.A. 2014. Morphological Characterization and Assessment of Genetic Variability, Character Association, and

Divergence in Soybean Mutants. *The Scientific World Journal,* Volume 2014, Article ID 968796, 12 pageshttp://dx.doi.org/10.1155/2014/968796.

16. Sangakkara, U.R., Frehner, M., Nosberger, J. 2000. Effect of soil moisture and potassium fertilizer on shoot water potential, photosynthesis and partitioning of carbon in mungbean and cowpea. *J. Agron. Crop. Sci.* **185**: 201–07.
17. Sawan, Z.M., Fahmy, A.H. and Yousef, S.E. 2009. Direct and residual effects of nitrogen fertilization, foliar application of potassium and plant growth retardant on Egyptian cotton growth, seed yield, seed viability and seedling vigor. *Acta Ecologica Sinica* **29**: 116-123.
18. Saxena, M. 2018. *Horticultural Statistics at a glance*. Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Horticulture Statistics Division. pp. 4 39.
19. Singh, M.K., Chand, T., Kumar, M., Singh, K.V., Lodhi, S.K., Singh, V.P. and Sirohi, V.S.2015. Response of different doses of NPK and boron on growth and yield of broccoli (*Brassica oleracea* L. var. *italica*). *Int. J. Bio-resour. Stress Manag.* **6**: 108-112.

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