Original Research Article

"Effect of spacing and nutrition on soil nutrient status and uptake of Broccoli (*Brassica oleracea* var. *italica*)"

Abstract

A field experiment was conducted to study the influence of spacing and nutrient on soil nutrient status and uptake of broccoli and investigation entitled on **"Effect of spacing and nutrition on soil nutrient status and uptake of Broccoli"** was carried out during Rabi season 2021-22 at sanjeevini vatika, Department of Horticulture, College of Agriculture, GKVK, Bengaluru (KARNATAKA). The experiment consists of three levels of spacing i.e., S1 (45cnx30cm), S2 (45cmx45cm), S3 (60cmx45cm) and three levels of nutrient i.e., N1 (100% RDF), N2 (75%RDF), N3 (125%RDF). It was designed in FRCBD includes nine treatment combinations with three replications. The analyzed experimental data showed that the available nutrient in the soil and nutrient uptake by the plant after harvesting of Broccoli. Increasing the spacing and nutrient levels favors in increasing the nitrogen, phosphorus and potassium availability in the soil and uptake by the Broccoli after harvesting. The maximum availability of Nitrogen (296.57kg/ha), phosphorus (116.54kg/ha) and Potassium (72.85kg/ha) in the soil was recorded in the spacing level of S3 (60cmx45cm). The higher availability of Nitrogen (275.20kg/ha), phosphorus (104.88kg/ha) and Potassium (71.37kg/ha) in the soil was recorded in the nutrient level of N3 (125%RDF). The higher nitrogen (160.16kg/ha), phosphorus (127.13kg/ha) and potassium uptake (65.83kg/ha) by the Broccoli was reported in the wider level of spacing S3 (60cmx45cm). The maximum nitrogen (158.09kg/ha), phosphorus (127.94kg/ha) and potassium uptake (65.84kg/ha) by Broccoli was observed in the nitrient level of N3 (125%RDF).

(key words: Broccoli, available nutrients, nutrient uptake, spacing)

Introduction

Broccoli (*Brassica oleracea* L. var. *Italica*) belongs to the Brassicaceae family and grows in the Mediterranean region (Decoteau, 2000). Broccoli is an Italian vegetable native to the Mediterranean region that was cultivated in ancient Rome and around 1720 in England. In the United States, it first appeared in 1806, but commercial cultivation of broccoli began

around 1923. (Decoteau, 2000). It is low in sodium, fat and calories, high in vitamin C and a good source of vitamin A, vitamin B2 and calcium (Decoteau, 2000). Broccoli has recently gained popularity due to its numerous applications and high nutritional value (Salunkhe & Kadam, 1998). Typically, large amounts of inorganic fertilizers are used on vegetables to increase production (Stewart et al., 2005), maximize growth potential (Dauda et al., 2008) and excessive uptake by the plants. However, using inorganic fertilizers excessively could have negative effects for both the environment and human health. As a result, inorganic fertilizer is regarded as a major source of plant nutrients and it should be used in sufficient quantities. Spacing also one of the important factor for quality of Broccoli production. Wider spacing between plants occurs less population per hectare and lesser spacing between plants occurs more number of plants per hectare, more competition among plants for nutrients, air, sunlight and soil moisture. The purpose of this study was to see how different levels of nutrients and spacing affected soil nutrient status and Broccoli nutrient uptake.

Material and Methods

A field experiment was conducted in the Sanjeevini Vatika block of the Department of Horticulture at the University of Agricultural Sciences, Bangalore, during the Rabi season 2021–2022. The Factorial Randomized Complete Block Design (FRCBD) was used to plan and lay out the three different spacing's, S1 (45x30cm), S2 (45x45cm) and S3 (60x45cm), as well as the three levels of nutrients, N1 (120: 80: 60 Kg NPK/ha (100 percent RDF)), N2 (90: 60: 45 Kg NPK/ha (75 percent RDF)) and N3 (150:100:75Kg NPK/ha (125% RDF)). The land was repeatedly ploughed and harrowed to a fine tilth. After clearing the land, the layout was carried out in accordance with the treatments, and seedlings that were thirty days old and had grown uniformly were used for transplanting. The different spacing and nutrient levels were combined when transplanting. After the transplants were made, a light irrigation was given. The transplanting was done in the evening. To grow a successful crop, we adhered to the rest of the recommended agronomic practices and packages. Five tagged plants were chosen from each treatment and the results are being recorded for the following parameters availability of Nitrogen, Phosphorus and Potassium in the soil after harvesting of broccoli and Nitrogen, Phosphorus and Potassium uptake by the Broccoli.

Soil Collection and Analysis

The soil samples up to depth of 15 cm were taken from field after harvesting of the crop, soil samples were collected from each treatment. After collection of soil samples were

air dried, crushed, passed through 2mm sieve and stored in poly bags for chemical analysis. Available nutrient content was analyzed.

Plant sample Collection and Analysis

Above ground parts of five tagged broccoli plants from each plot was harvested and then oven dried at 65°C. The dried samples were powdered and sieved in 1mm mesh and nutrient uptake was analyzed.

RESULTS AND DISCUSSION

Effect of spacing and nutrition on soil nutrient status and uptake of broccoli

Soil Nutrient Status after Harvesting of Broccoli

Available Nitrogen (kg ha^{1})

The effect of various levels of spacing, nutrients and their interaction on available Nitrogen content in the soil after crop harvest is displayed in the Table 1. and depicted in Figure the 1.0.

Effect of spacing

The effect of different level of spacing on available Nitrogen content in the soil after harvesting of crop was shown significant and results are displayed in the Table 1 and depicted in Figure the 1.0. The maximum available nitrogen content in the soil after harvesting of broccoli (296.57kg ha^{1}) was recorded in the spacing level of S3 (60cnx45cm) and the minimum available nitrogen content in the soil after harvest of broccoli (258kg ha^{1}) was found in the spacing level of S1 (45cmx30cm).

Effect of nutrient

The impact of various levels of nutrients on available Nitrogen content in the soil after harvest of broccoli was shown significant and results are displayed in the Table 1 and depicted in Figure the 1.0. The highest available nitrogen content in the soil after harvesting of broccoli (275.20kg ha^{1}) was found in the nutrient level of N3 (125% RDF) and the lowest

available nitrogen content in the soil after harvesting of broccoli (267.42kg ha^1) was found in the nutrient level of N2 (75% RDF). A comparable study was done by Rauniyar and Bhattarai 2017, Naresh *et al* 2022**,** Khumukcham *et al*. 2020, Prativa and Bhattarai 2011 and Thingujam *et al*. 2016.

Interaction effect of spacing and nutrient

The interaction effect of spacing and nutrient on available nitrogen in the soil after harvesting of broccoli was shown non-significant and results are presented in the Table 1 and depicted in Figure the 1.0. The highest available nitrogen content in the soil after harvest of broccoli (302.45kg ha^1) was observed in the S3N3 treatment and the lowest available nitrogen content in the soil after harvest of broccoli (253.07kg ha^1) was recorded in S2N2.

Available Phosphorus (kg ha^1)

The effect of different levels of spacing, nutrients and their interaction on available Phosphorus content in the soil after crop harvest is depicted in the Table 1 and depicted in Figure the 1.1.

Effect of spacing

The impact of various levels of spacing on available Phosphorus content in the soil after crop harvest was shown significant and results are depicted in the Table 1 and depicted in Figure the 1.1. The maximum available Phosphorus content in the soil after harvest of broccoli (116.54kg ha^1) was found in the spacing level of S3 (60cmx45cm) and the minimum available phosphorus content in the soil after harvest of broccoli (89.18kg ha^1) was observed in the spacing level of S1 (45cmx30cm).

Effect of nutrient

The effect of various levels of nutrients on available Phosphorus content in the soil after harvest of broccoli was shown significant and results are displayed in the Table 1 and depicted in Figure the 1.1. The highest available phosphorus content in the soil after harvest of broccoli (104.88kg ha^1) was observed in the nutrient level of N3 (125% RDF), while lowest available phosphorus content in the soil after harvest of broccoli (93.70kg ha^1) was observed in the nutrient level of N2 (75% RDF). A comparable study was done by Rauniyar

and Bhattarai 2017, Naresh *et al*. 2022, Khumukcham *et al*. 2020, Prativa and Bhattarai 2011, Thingujam *et al*. 2016.

Interaction effect of spacing and nutrient

The interaction effect of spacing and nutrient on available phosphorus content in the soil after harvest of broccoli was shown non-significant and results are presented in the Table 1 and depicted in Figure the 1.1. The highest available phosphorus content in the soil after harvest of broccoli (126.14kg ha^1) was reported in S3N3 and the lowest available phosphorus content in the soil after harvest of broccoli (85.00kg ha^1) was recorded in S1N2.

Available Potassium (kg ha^1)

The impact of different levels of spacing, nutrients and their interaction on available Potassium content in the soil after crop harvest is presented in the Table 1 and depicted in Figure the 1.2.

Effect of spacing

The impact of various levels of spacing on available potassium content in the soil after harvesting of broccoli was found significant and results are presented in the Table 1 and depicted in Figure the 1.2. The highest available Potassium content in the soil after harvest of broccoli (72.85kg ha^1) was observed in the spacing level of S3 (60cmx45cm) and the lowest available potassium content in the soil after harvest of broccoli (63.16kg ha^1) was observed in the spacing level of S1 (45cmx30cm).

Effect of nutrient

Effect of varying nutrient levels on Potassium availability in the soil that after the harvest of broccoli was shown significant and results are presented in the Table 1 and depicted in Figure the 1.2. The highest available potassium content in the soil after harvest of broccoli (72.85kg ha^1) was revealed in the nutrient level of N3 (125% RDF), while lowest available potassium content in the soil after harvest of broccoli (62.32kg ha^1) was found in the nutrient level of N2 (75% RDF). A comparable study was done by Rauniyar and Bhattarai 2017, Naresh *et al*. 2022, Khumukcham *et al*. 2020, Prativa and Bhattarai 2011 and Thingujam *et al*. 2016

Interaction effect of spacing and nutrient

The interaction effect of various levels of spacing and nutrient on available potassium content in the soil after harvesting of broccoli was shown non-significant and results are displayed in the Table 1 and depicted in Figure the 1.2. The maximum available potassium content in the soil after harvesting of broccoli (77.92kg ha^{1}) was found in the S3N3 and the lowest available phosphorus content in the soil after harvest of broccoli (59.17kg ha^{1}) was recorded in the S1N2.

Nutrients uptake by the plant

Above ground parts of five tagged broccoli plants from each plot was harvested and then oven dried at 65°C. The dried samples were powdered and sieved in 1mm mesh and nutrient uptake was analyzed.

Nitrogen uptake by the plant

The effect of various levels of spacing, nutrients and their interaction on Nitrogen uptake by the broccoli is depicted in the Table 1 and depicted in Figure the 1.3.

Effect of spacing

The impact of various levels of spacing on Nitrogen uptake by the broccoli was shown significant and the analysed data is presented in Table 1 and depicted in Figure the 1.3. The maximum nitrogen uptake by the broccoli (160.16kg/ha) was observed in the spacing level of S3 (60cmx45cm) and the lowest nitrogen uptake by the broccoli (139.63kg/ha) was observed in the spacing level of S1 (45cmx30cm). A comparable study was done by Choudhari and More 2001.

Effect of nutrient

The effect of different levels of nutrient on Nitrogen uptake by the broccoli was significant and the data is depicted in the Table 1 and depicted in Figure the 1.3. The nutrient level of N3 (125% RDF) was recorded highest nitrogen uptake by the broccoli (158.09kg/ha), whereas the lowest nitrogen uptake by the broccoli (142.17kg/ha) was observed in the nitrogen level of N2 (75% RDF). A comparable study was done by Chaitanya *et al*. 2013

Interaction effect of spacing and nutrient

The interaction effect of various levels of spacing and nutrients on nitrogen uptake by the broccoli was found non-significant and data is displayed in the Table 1 and depicted in

Figure the 1.3. The highest nitrogen uptake by the broccoli (168.85kg/ha) was found in the S3N3 treatment and the lowest nitrogen uptake by the broccoli (127.00kg/ha) was observed in the S1N2.

Results indicate that the wider level of spacing S3 was recorded maximum nitrogen uptake by the broccoli as compared to the lower spacing level i.e. S2 and S1 and also increased the level of spacing favoured nitrogen uptake in broccoli.

The application of higher levels of nutrients (N3) was recorded higher nitrogen content in the broccoli as compared to the lower level of nutrient i.e., N1 and N2 and this was due to the application of higher level of nutrient favored in the higher nitrogen uptake in the broccoli. Similar results were reported by Debbarma and Bhatt 2022, Kumar *et al.* 2013 and Singh *et al.* 2017.

Phosphorus uptake by the plant

The effect of different levels of spacing, nutrients and their interaction on Phosphorus uptake by the broccoli is presented in Table 1 and depicted in Figure the 1.4.

Effect of spacing

The impact of different levels of spacing on phosphorus uptake by the broccoli was shown significant and the data is presented in Table 1 and depicted in Figure the 1.4. The highest phosphorus uptake by the broccoli (127.13kg/ha) was found in the spacing level of S3 (60cmx45cm), whereas the lesser phosphorus uptake by the broccoli (122.25kg/ha) was observed in the spacing level of S1 (45cmx30cm). A comparable study was done by Choudhari and More 2001.

Effect of nutrient

The effect of various levels of nutrients on phosphorus uptake by the broccoli was found significant and the data is presented in Table 1 and depicted in Figure the 1.4. The highest phosphorus uptake by the broccoli (127.94kg/ha) was observed in the nutrient level of N3 (125% RDF) and the lower phosphorus uptake by the broccoli (122.89kg/ha) was observed in the nutrient level of N2 (75% RDF). A comparable study was done by Chaitanya *et al*. 2013.

Interaction effect of spacing and nutrient

The combined effect of different levels of spacing and nutrients on phosphorus uptake by the broccoli was non-significant and the results are displayed in Table 1 and depicted in Figure the 1.4. The maximum phosphorus uptake by the broccoli (131.59kg/ha) was observed in the S3N3 and the minimum phosphorus uptake by the broccoli (120.62kg/ha) was observed in the S1N2.

Among various levels of spacing, the wider spacing of S3 (60cmx45cm) was recorded maximum phosphorus uptake by the broccoli as compared to the lesser levels of spacing S1 (45cmx30cm), this might be due to the increase in uptake of phosphorus with increased levels of spacing and better availability of nutrients in root zone.

The application of higher levels of nutrient N3 was found higher phosphorus uptake by the broccoli as compared to the lower level of nutrient i.e., N1 and N2 and this was due to the application of higher level of nutrient favors in the higher phosphorus uptake in the broccoli and the increase in uptake of phosphorus with increasing the percentage level of nutrient. Similar findings have also been reported by Debbarma and Bhatt 2022.

Potassium uptake by the plant

The effect of various levels of spacing, nutrient and their interaction on potassium uptake by the broccoli is presented in Table 1 and depicted in Figure the 1.5

Effect of spacing

The impact of various levels of spacing on potassium uptake by the broccoli was found significant and results are presented in the Table 1 and depicted in Figure the 1.5. The highest potassium uptake by the broccoli (65.83kg/ha) was found in the spacing level of S3 (60cmx45cm), whereas the lowest potassium uptake by the broccoli (62.65kg/ha) was observed in the S1 (45cmx30cm).

Effect of nutrient

The effect of various levels of nutrients on potassium uptake by the broccoli was significant and the data is presented in Table 1 and depicted in Figure the 1.5. The maximum potassium uptake by the broccoli (65.84kg/ha) was reported in the nutrient level of N3 (125% RDF) and the minimum potassium uptake by the broccoli (62.86kg/ha) was found in the N2 (75% RDF). A comparable study was done by Chaitanya *et al*. 2013.

Interaction effect of spacing and nutrient

The combined effect of different levels of spacing and nutrients on potassium uptake by the broccoli was non-significant and the data is presented in Table 1 and depicted in Figure the 1.5. The highest potassium uptake by the broccoli (68.01kg/ha) was found in the S3N3 and the lowest potassium uptake by the broccoli (61.18kg/ha) was revealed in the S1N2.

Among various levels of spacing, the wider spacing of S3 (60cmx45cm) was reported highest potassium uptake by the broccoli as compared to the lesser levels of spacing of S1 (45cmx30cm) and S2 (45cmx45cm), this might be due to the increase in uptake of potassium with increased levels of spacing and hence, better availability of nutrients in root zone.

The application of higher levels of nutrient N3 was recorded higher potassium uptake by the broccoli as compared to the lower level of nutrient i.e., N1 and N2 and this was due to increased level of nutrient with increased potassium uptake in broccoli from vegetative stage to harvesting stage. Similar findings have also been reported by Debbarma and Bhatt 2022, Singh *et al.* 2017 and Kumar *et al.* 2013.

Conclusion

It can be concluded from the present investigation that the effect of spacing and nutrition on the growth, quality and yield parameters of broccoli was significant. The application of 125 percent of RDF with spacing of (60x 45cm) proved to be most effective in increasing the vegetative growth quality and curd yield per plant characters of broccoli while, the spacing level of 45 x 45cm with 125 percent of RDF induces the higher curd yield per plot and curd yield per hectare of broccoli under Bengaluru condition.

Future scope

- The investigation should be repeated to confirm the findings.
- In the future, different nutrient levels and spacing levels may be tested.
- In the future, repeat the experiment in other districts of Karnataka.

Treatment	Available nutrients in the soil after harvest			Nutrients uptake by the plant (kg/ha)		
	Available Nitrogen (kg ha^{1})	Available Phosphorus (kg ha^{1})	Available Potassium (kg ha^{1})	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Spacing (S)						
S1	**258.00**	**89.18**	**63.16**	**139.63**	**122.25**	**62.65**
S2	**259.06**	**91.26**	**64.96**	**154.85**	**125.63**	**64.57**
S3	**296.57**	**116.54**	**72.85**	**160.16**	**127.13**	**65.83**
F-test	*	*	*	*	*	*
S.E m+	**1.08**	**1.20**	**1.14**	**3.59**	**1.01**	**0.35**
CD (5%)	**3.23**	**3.58**	**3.41**	**10.77**	**3.03**	**1.03**
Nutrient (N)						
N1	**271.01**	**98.39**	**67.27**	**154.38**	**124.18**	**64.35**
N2	**267.42**	**93.70**	**62.32**	**142.17**	**122.89**	**62.86**
N3	**275.20**	**104.88**	**71.37**	**158.09**	**127.94**	**65.84**
F-test	*	*	*	*	*	*
S.E m+	**1.08**	**1.20**	**1.14**	**3.59**	**1.01**	**0.35**
CD (5%)	**3.23**	**3.58**	**3.41**	**10.77**	**3.03**	**1.03**
Interaction (SXN)						
S1N1	**258.16**	**89.67**	**63.63**	**140.59**	**120.77**	**62.57**
S1N2	**256.38**	**85.00**	**59.17**	**127.00**	**120.62**	**61.18**
S1N3	**259.48**	**92.87**	**66.67**	**151.31**	**125.36**	**64.19**
S2N1	**260.44**	**92.25**	**65.86**	**161.13**	**126.78**	**64.81**
S2N2	**253.07**	**85.89**	**59.49**	**149.31**	**123.25**	**63.60**
S2N3	**263.66**	**95.64**	**69.53**	**154.11**	**126.85**	**65.31**
S3N1	**294.45**	**113.26**	**72.33**	**161.42**	**125.01**	**65.68**
S3N2	**292.80**	**110.21**	**68.30**	**150.22**	**124.78**	**63.79**
S3N3	**302.45**	**126.14**	**77.92**	**168.85**	**131.59**	**68.01**
F-test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S.E m+	**1.86**	**2.07**	**1.97**	**6.22**	**1.75**	**0.60**
CD (5%)	**5.59**	**6.21**	**5.91**	**18.65**	**5.25**	**1.79**

Table 1. Effect of various levels of spacing, nutrient and their interaction on available NPK after harvesting and Nutrient uptake by Broccoli.

NOTE: The application of FYM 20 tonnes per hectare was common for all the treatments.

NS = non-significant * = significant

S1- 45cmx30cm N1- 120:80:60Kg NPK/ha (100% RDF)

S2- 45cmx45cm N2- 90:60:45Kg NPK/ha (75% RDF)

S3-60cmx45cm N3- 150:100:75Kg NPK/ha (125% RDF)

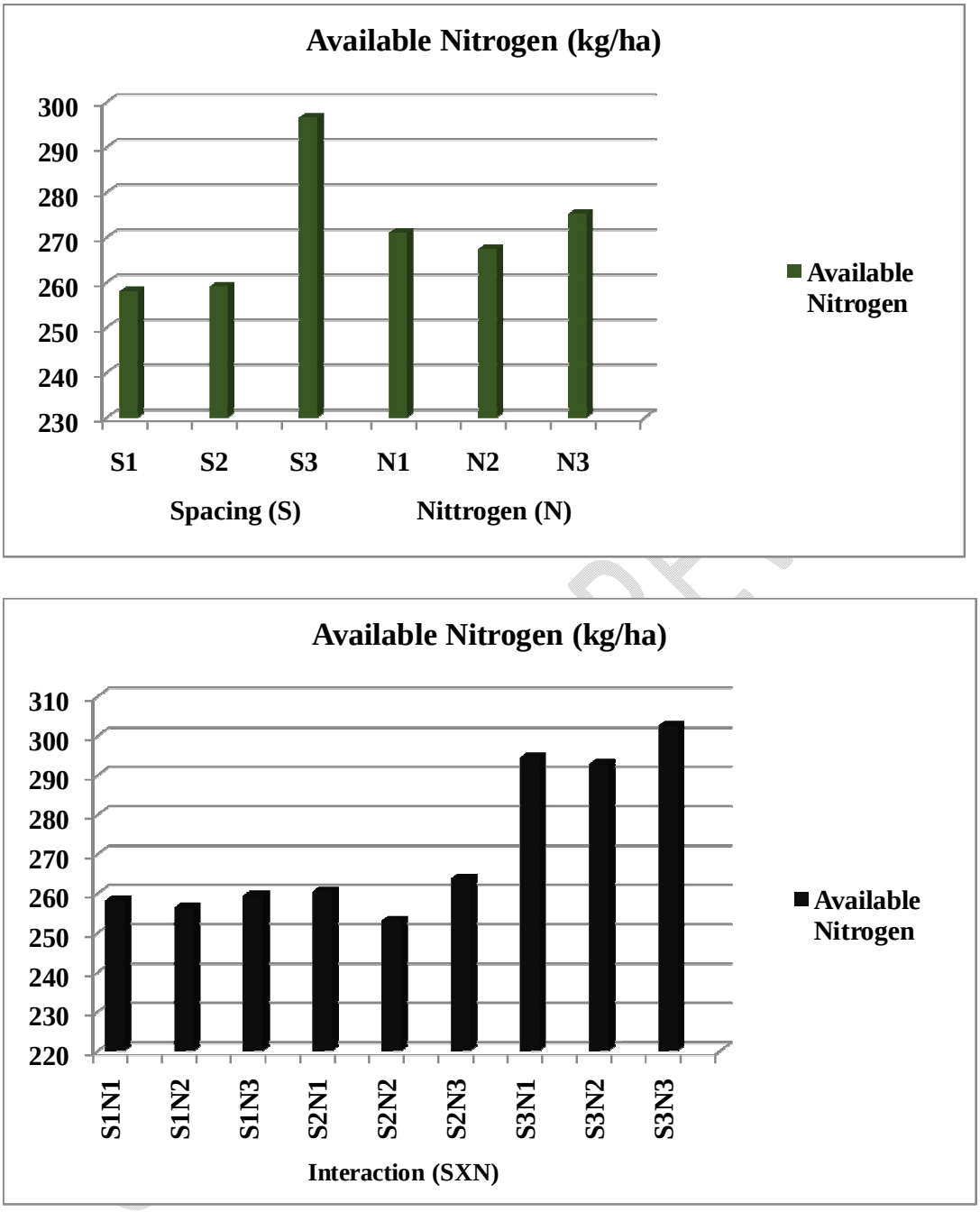
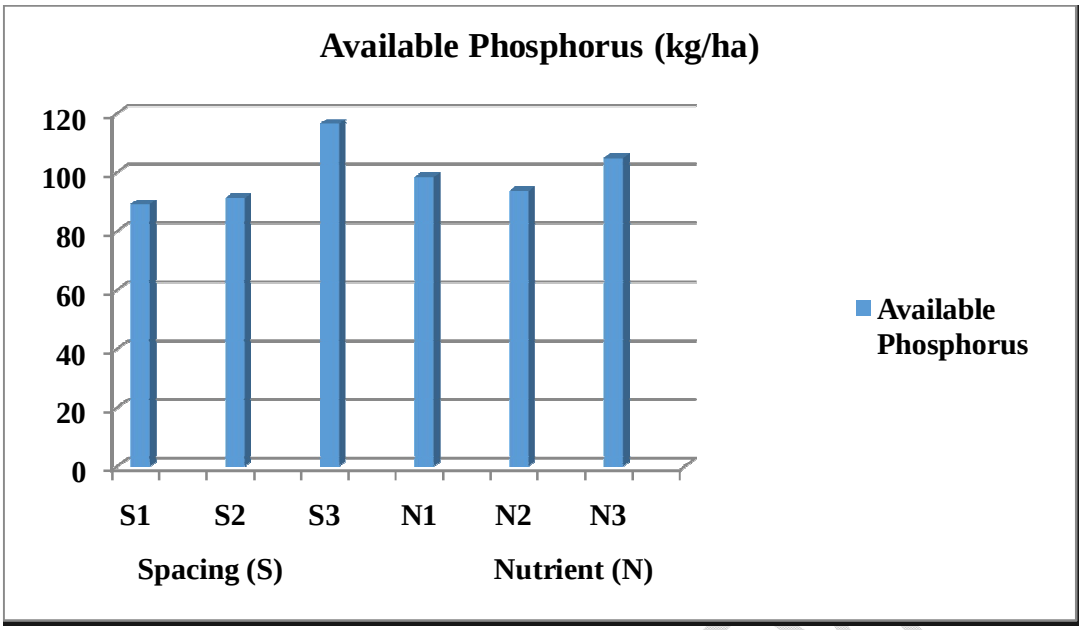


Figure 1.0 Effect of various levels of spacing, nutrient and their interaction on available Nitrogen



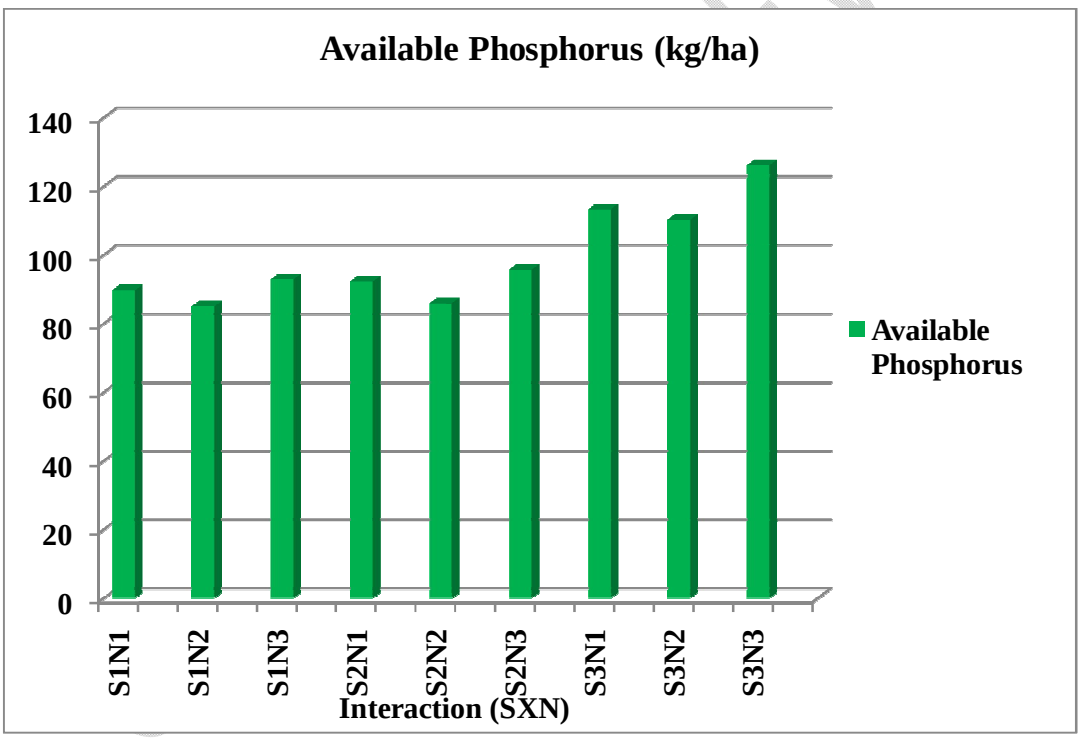


Figure 1.1. Effect of various levels of spacing, nutrient and their interaction on available Phosphorus

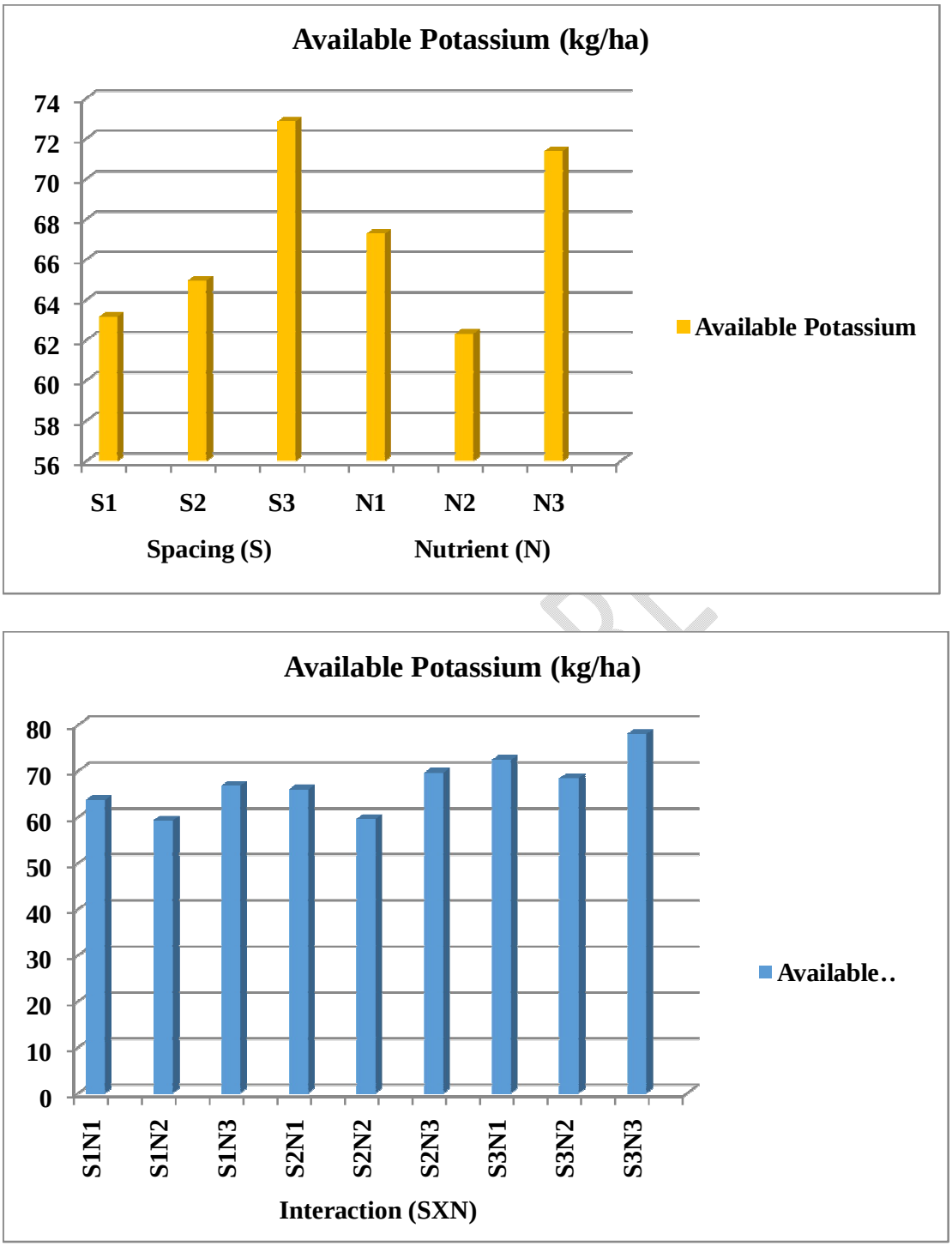


Figure. 1.2. Effect of various levels of spacing, nutrient and their interaction effect on available Potassium

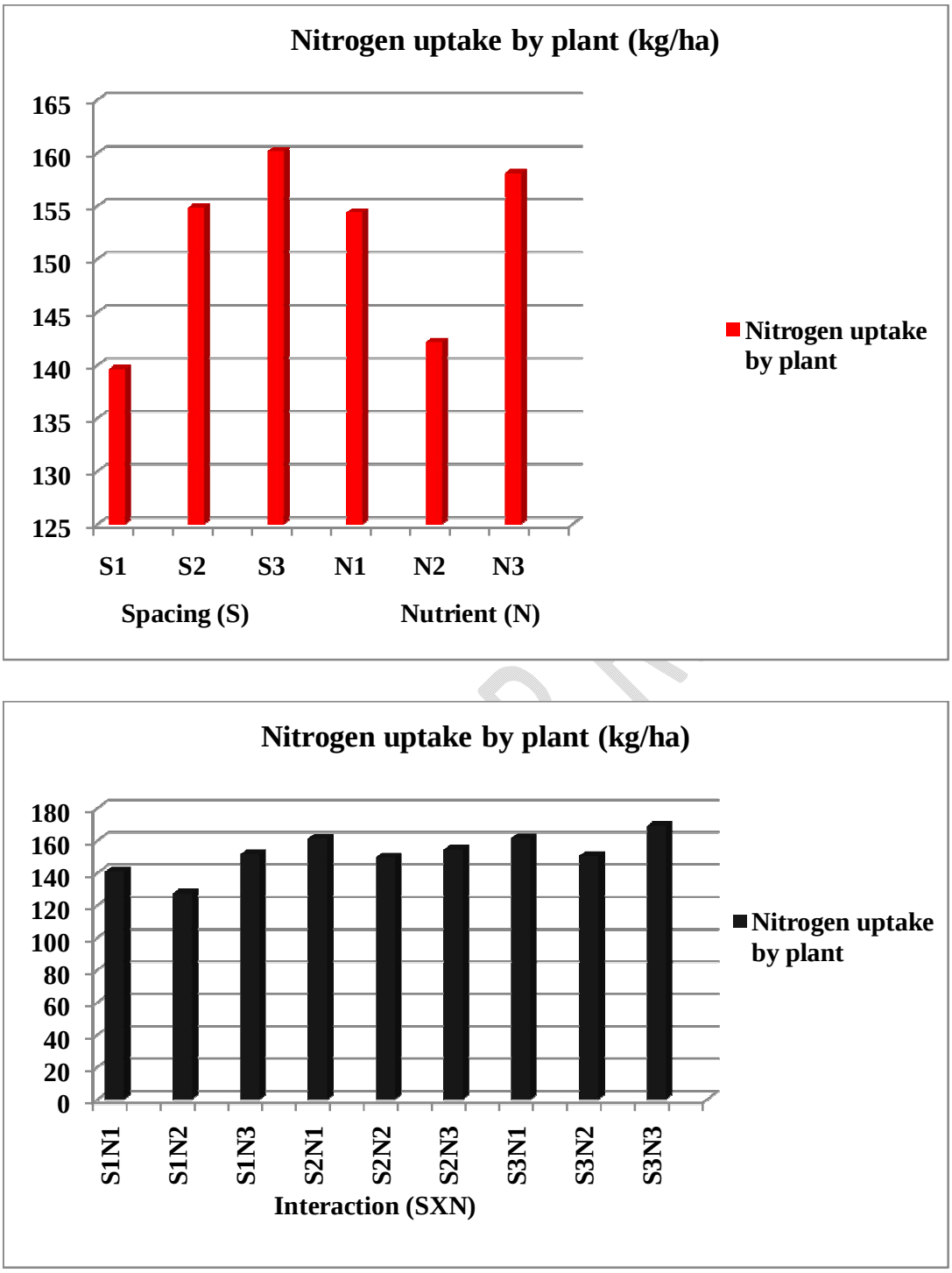
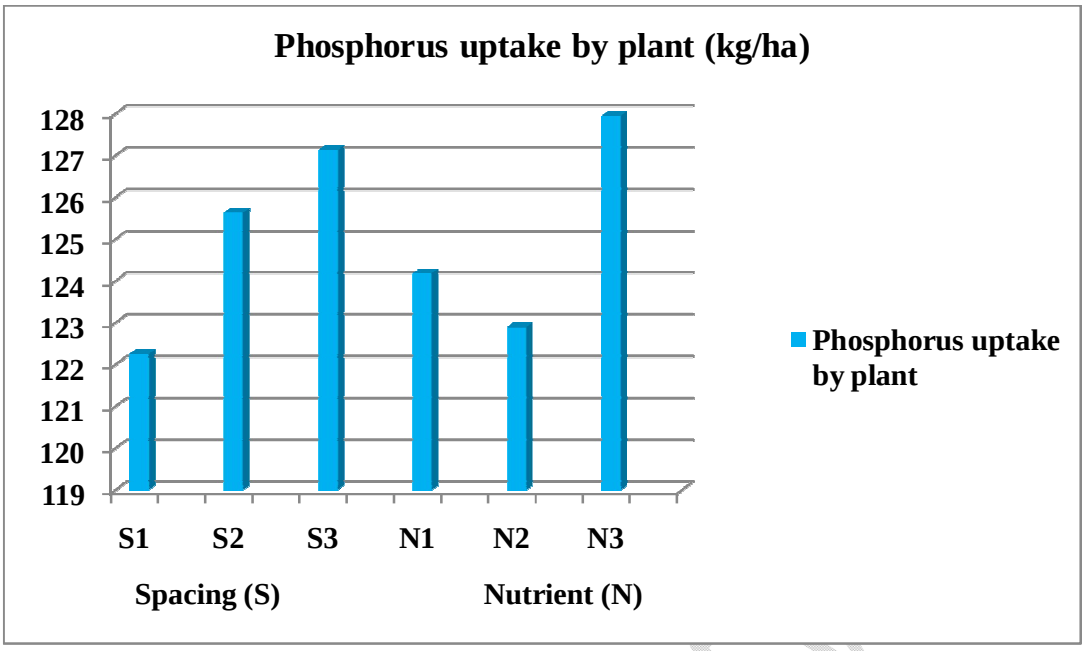


Figure. 1.3. Effect of levels of spacing, nutrition and their interaction on Nitrogen uptake by the broccoli



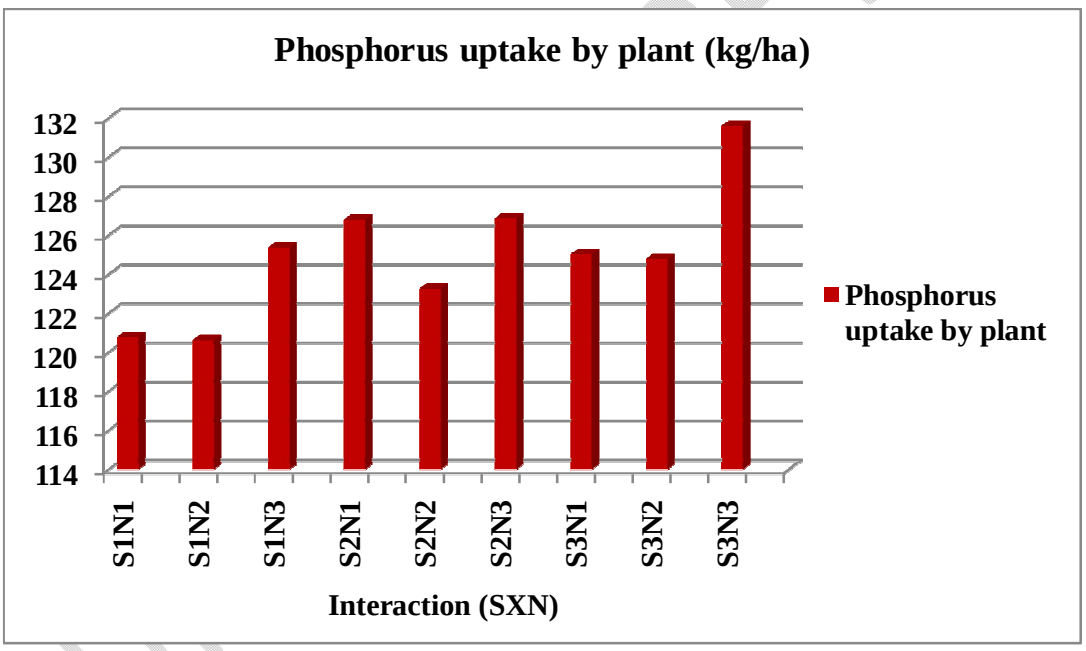


Figure 1.4. Effect of levels of spacing, nutrition and their interaction effect on Phosphorus uptake by the broccoli

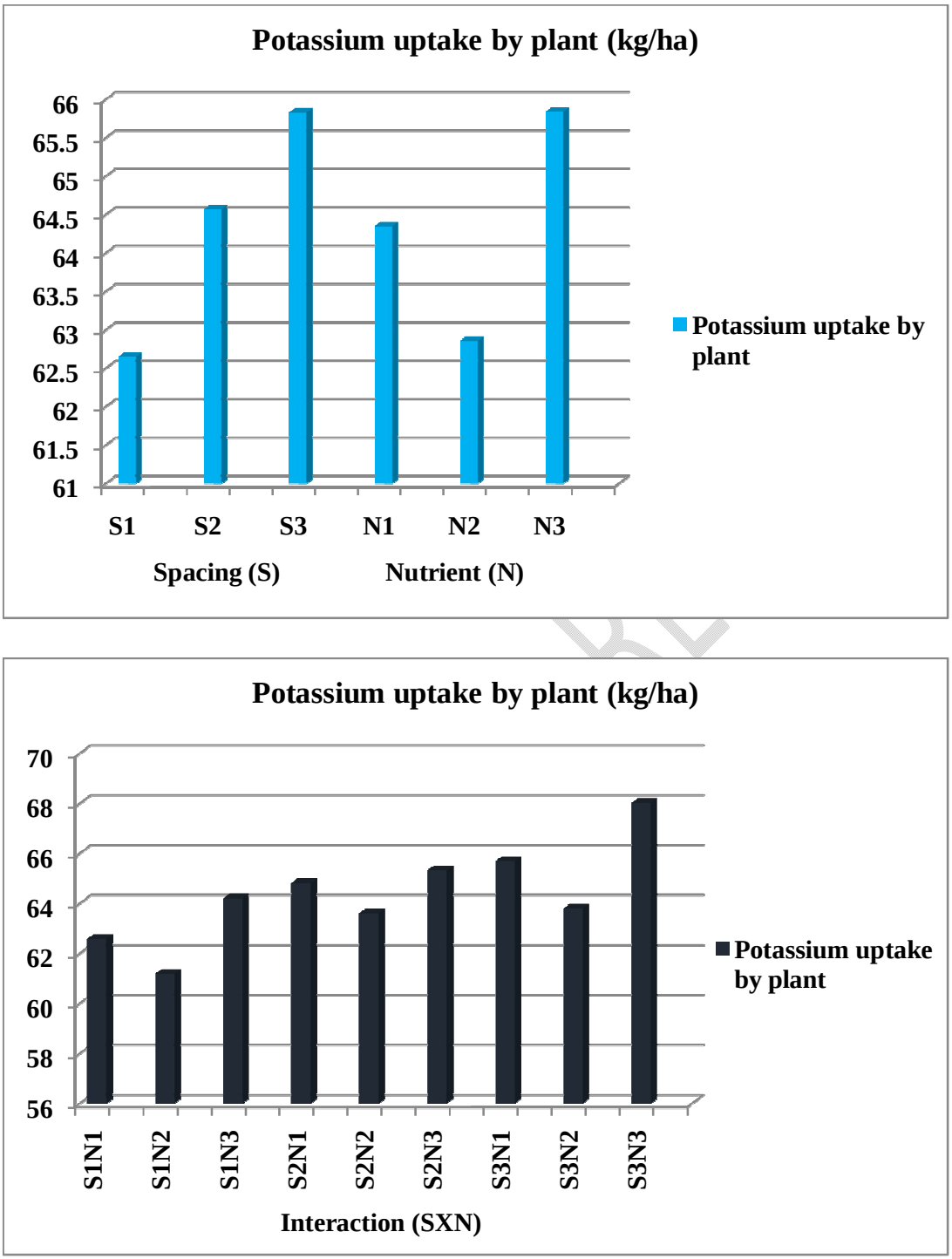


Figure 1.5. Effect of levels of spacing, nutrition and their interaction on Potassium uptake by the broccoli

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