Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 10, pp.39595-39599, October, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

CABBAGE GENOTYPES FOR INTERNAL TIPBURN RESISTANCE: A CALCIUM RELATED NON-PATHOGENIC DISEASE UNDER RAIN SHELTER IN KERALA

*Ningappa Kirasur and Indira, P.

Department of Olericulture, College of Horticulture, Vellanikkara, KAU, Thrissur, India 680656

ARTICLE INFO

Article History:
Received 10th July, 2016
Received in revised form
15th August, 2016
Accepted 08th September, 2016
Published online 30th October, 2016

Key words:

Tipburn, Calcium foliar sprays,
Rain shelter, Cabbage genotypes.

ABSTRACT

Cabbage (*Brassica oleracea* L. var. *capitata*) is more susceptible to internal tipburn a calcium related physiological disorder, especially under protected conditions. Being a genotype specific disorder, the present experiment was carried out inside rainshelter with seven cabbage F_1 hybrids and three levels of calcium foliar applications (0%, 0.5% and 1.5%). The interaction effects of calcium treatments were also observed. There was a significant difference among the genotypes with respect to number of wrapping leaves, non-wrapping leaves, stalk length, gross head weight, net head weight, head breadth and yield per plot. Different levels of Ca foliar application and interaction effect also exhibited non-significant difference. However calcium foliar application can minimize the internal tipburn incidence. All the genotypes were resistant to internal tipburn except the F_1 hybrid NS 43(G_1).Internal tipburn symptoms were noticed only in the plots sprayed with 1.5% $CaNO_3$ while control treatments and plots with 0.5% $CaNO_3$ foliar spray did not exhibited tipburn symptoms.

Citation: Ningappa Kirasur and Indira, P. 2016. "Cabbage genotypes for internal tipburn resistance: A calcium related non-pathogenic disease under rain shelter in Kerala", *International Journal of Current Research*, 8, (10), 39595-39599.

INTRODUCTION

Cabbage (*Brassica oleracea* L.var. *capitata*) belonging to the family Brassicaceae, is a cool season crop which thrives well in a relatively cool and moist climate. It is the most popular winter vegetable grown throughout India for its leafy heads in an area around 3.85 lakh ha with a production of 85.84 lakh tones (NHB, 2015). It is mainly consumed as raw or cooked vegetable, being rich source of vitamins (A, C and K), fibre, proteins and also anti-cancer property due to the presence of "Inole-3-carbinol" (Singh *et al.,* 2010). It is grown commercially in northern parts of India during winter months (November to January) for vegetable purpose. In Kerala, earlier cabbage and cauliflower were cultivated only in the high ranges of Wayanad, Idukki and Palakkad districts. With the introduction of many tropical F_1 hybrids, their cultivation has spread to the plains also.Studies conducted in the Department of Olericulture, College of Horticulture have revealed that cabbage can be cultivated successfully during rainy season (off-season) inside the rain shelter. It was also found that the ideal planting time for off-season production of cabbage is 15th of May inside rain shelter. But when compared to on- season the net head weight and yield of cabbage were less during off-season. The two reasons attributed to this are loose head formation and incidence of internal tip burn, which is a calcium related physiological disorder.

**Corresponding author: Ningappa Kirasur,*
Department of Olericulture, College of Horticulture, Vellanikkara, KAU, Thrissur, India 680656.

MATERIALS AND METHODS

The present research was conducted in the Department of Olericulture, College of Horticulture, Vellanikkara during the period between May and September 2015. The site is located at an altitude of 22.25m above mean sea level, $10^0 31'$N latitude, and $76^0 13'$E longitude. This area enjoys atropical warm humid climate and receives an average rainfall of 2663mm per year. The soil of the experimental plot is sandy loam with acidic reaction. A rain shelter with floor area of 200 m^2 was used for the study. The frame of rain shelter was constructed using G. I pipes and it was cladded with UV stabilized polythene sheet of 200 micron thickness. The experiment was laid out in Randomized Block Design (RBD) with two replications. Seven F_1 hybrids of cabbage were used for the study. (G_1) -NS 43, (G_2) -Green Challenger, (G_3) -Super Ball 50, (G_4) - F_1 border 777, (G_5) - Green Voyager, (G_6) -Mahy 118, (G_7) - Saint. The crop was raised as per the KAU package of practices recommendation (KAU, 2011). The Urea, Factamphos and Muriate of potash were used as source materials for supplying nutrients viz, N, P_2O_5 and K_2O respectively, as per the package of practices recommendation (KAU, 2011) for cabbage is N: P_2O_5: K_2O 150: 100: 125 kg ha^{-1}. These nutrients were mixed based on pre-experiment soil test report recommendation. Only 75%N, 25% P_2O_5 and 75% K_2O were applied. Full dose of $P_2O_5$and half dose of N and K_2Owere applied as basal dose and remaining half dose of N and K_2Owereapplied one month after transplanting. Soil samples were collected from earmarked experimental plots at

0-15cm depth before raising the cabbage inside rain shelter. Soil samples were analysed for organic carbon (Walkley and Black, 1934), soil pH, electric conductivity (EC), available K, Ca and Mg by (Jackson, 1958). Available P (Bray and Kurtz, 1945; Watanabe and Olsen, 1965), available Fe, Mn, Zn and Cu (Sims and Johnson, 1991), available S by (Williams and Steinbers, 1959), available B (Berger and Troug, 1939; Gupta, 1972).Calcium nitrate was used as source of calcium foliar spray. Calcium nitrate at 5g/litre was used for 0.5% foliar spray (C_1) and 15g/litre for 1.5% foliar spray (C_2). In the control plot (C_0) calcium was not sprayed. The intercultural operations likeweeding, earthing up, irrigation and pest and disease management were done as and when necessary. The observations were recorded on growth parameters (plant spread, number of wrapping and non-wrapping leaves, stalk length), yield parameters (head length, head breadth, gross head weight, net head weight, and yield per plot) and internal tipburn incidence. Thestatistical analysis of data was done on vegetative and yield parameters of cabbage inside rain shelter. The initial macro and micro nutrient status in soil was analysed by using the statistical package (OP-STAT).

RESULTS AND DISCUSSION

Plant spread

There was no significant difference with respect to plant spread among genotypes. However genotype G_1 recorded maximum plant spread (50.70cm) and it was least for G_8 (45.10cm). Among the different levels of calcium application maximum plant spread was in the treatment C_2 (47.50 cm) and other treatments were on par. There was no significant interaction effect with respect to plant spread anddifferent levels of calcium foliar application. However maximum plant spread was in G_1C_0 (52.10 cm) and it was minimum in the G_7C_2 (44.60 cm). According to Suseela (2002) the maximum plant spread in cauliflower was associated with increased yield per plant. Here also more plant spread was recorded by genotype G_1(NS 43) which recorded higher yield also. Similar results were presented by Chaurasia *et al.* (2008). They reported that the increased plant spread in cauliflower might be due to the more availability of nitrogenous compounds to plants which increases the foliage and thereby increase photosynthetic rate resulting in increased plant spread (Table 1).

Table 1. Effect of cabbage genotypes and different calcium treatments on plant spread (cm)

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	52.10	49.40	50.60	50.70
G_2 -Green Challenger	47.70	46.50	49.30	47.83
G_3 -Super Ball 50	46.20	45.30	46.00	45.83
G_4 -F_1 Border 777	47.40	47.40	45.50	46.76
G_5 -Green voyager	45.70	45.90	51.00	47.53
G_6 -Mahy 118	46.70	45.80	45.50	46.00
G_7 -Saint	45.00	45.70	44.60	45.10
Mean (Treatments)	47.25	46.57	47.50	
Factors		C D ($p<0.05$)		
Factor(G)		NS		
Factor(C)		NS		
Factor(G X C)		NS		

Number of wrapping leaves

There was a significant difference among the genotypes with respect to number of wrapping leaves. The maximum number of wrapping leaves (14.23) was in the genotype G_7 which was on par with G_3 (13.73 cm) followed by G_7(13.03 cm) and the lowest (8.60) was in G_1. Different levels of calcium foliar application showed no significant effect and the control treatment (C_0) had maximum number of wrapping leaves (12.00) (Fig. 1). The increased photosynthetic activity in broccoli was associated with higher N availability in the soil which resulted in increased number of green leaves (Acharya *et al.,* 2015).

Number of non-wrapping leaves

There was a significant variation among the genotypes with respect to number of non-wrapping leaves. The genotype G_1 recorded maximum number of non-wrapping leaves (9.26) and it was minimum (7.70) for G_7. Different calcium foliar treatments didn't show any significant difference. However maximum number of non-wrapping leaves (8.75) was noticed in the control (C_0) and it was lowest (8.37) in the (C_2) treatment (Table 2). There was no significantinteraction effect among the genotypes and different levels of calcium foliar application. However the lowestnumber ofnon-wrapping leaves was recorded in G_7C_0 (7.10) and maximum (9.60) in G_4C_1interaction. Agarwal *et al.* (1972) reported that the increased number of non-wrapping leaves on the cabbage heads is an unacceptable horticultural trait. The increasednumber of non-wrapping leaves in cabbages may be due to the more availability of nitrogenous compounds to the plants from organic manures applied to soil which increases the foliage and therebyincreases number of non-wrapping leaves (Chaurasia *et al.,* 2008). Similar results were obtained by Acharya *et al.* (2015) in broccoli.

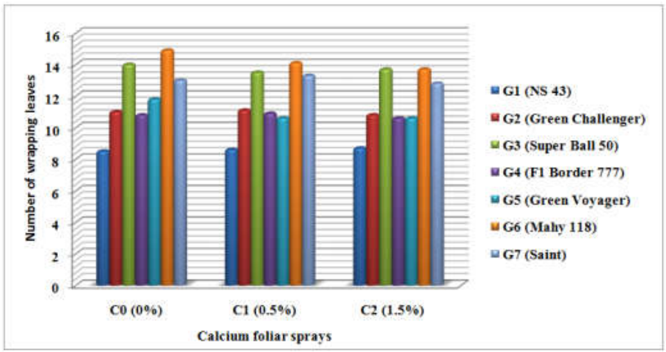

Fig. 1. Effect of calcium foliar application on number of wrapping leaves

Stalk length

There was a significant variation among the genotypes with regard to stalk length. The mean value of stalk length was maximum (7.63 cm) in the genotype G_6 which was on par with G_3 (7.35 cm) followed by G_7, G_2, and G_1. The lowest stalk length was recorded by G_4 5.58 cm. Different levels of calcium foliar treatment had no significant effect on stalk length. But the effect among genotypes and different levels of calcium foliar application was significant. The maximum stalk length (8.20 cm) was recorded in G_6C_0, which was on par with G_3C_0 (7.90 cm), G_2C_1 (7.80 cm), G_6C_2 (7.50 cm) followed by G_3C_2 (7.35 cm), G_6C_1 (7.20 cm), while the lowest stalk length (5.25 cm) was in G_4C_0 (Table 3). Similar findings were reported by Acharya *et al.* (2015). Physical, chemical and biological conditions of the soil provide necessary plant nutrients throughout the crop growth which lead to increased plant height in broccoli.

Table 2. Effect of cabbage genotypes and different calcium treatments on number of non-wrapping leaves

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	9.30	9.00	9.30	9.20
G_2 -Green challenger	9.50	9.00	8.70	9.06
G_3 -Super Ball 50	8.80	8.20	7.00	8.00
G_4 -F_1 Border 777	8.90	9.60	9.30	9.26
G_5 -Green voyager	9.50	9.20	8.80	9.16
G_6 -Mahy 118	8.20	8.20	7.80	8.06
G_7 -Saint	7.10	8.30	7.70	7.70
Mean (Treatments)	8.75	8.78	8.37	
Factors		C D (p<0.05)		
Factor(G)		0.65		
Factor(C)		NS		
Factor(G X C)		NS		

Table 3. Effect of cabbage genotypes and different calcium treatments on stalk length (cm)

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	6.50	7.20	5.90	6.53
G_2 -Green challenger	6.25	7.80	6.45	6.83
G_3 -Super Ball 50	7.90	6.80	7.35	7.35
G_4 -F_1 Border 777	5.25	5.90	5.60	5.58
G_5 -Green voyager	5.35	6.10	5.60	5.68
G_6 -Mahy 118	8.20	7.20	7.50	7.63
G_7 -Saint	6.95	7.05	6.90	6.96
Mean (Treatments)	6.62	6.86	6.47	
Factors		C D (p<0.05)		
Factor(G)		0.55		
Factor(C)		NS		
Factor(G X C)		0.95		

Head length

There was no significanteffect among genotypes for head length. However the genotype G_1 had the maximum head length (12.91cm) and it was lowest in the genotype G_5 (11.56 cm). Foliar application of calcium did not show any significant effect. The treatment mean for head length were on par. The interaction G_4C_0 recorded the maximum head length of 13.25 cm and it was lowest (10.90 cm) in G_5C_1. The interaction effect was also non-significant (Table 4). The increased curd length in cauliflower might be associated with high rate of photosynthesis from a larger leaf area and their translocation towards curd resulting in maximum curd length (Chaurasia *et al.,* 2008).

Head breadth

Genotypes significantly differed for head breadth. The genotype G_1 had the highest mean head breadth (13.40 cm) and the minimum was in the genotype G_4(9.61 cm) which was on par with G_6 (10.61 cm), G_3 (10.88 cm), G_5 (11.36 cm) and G_2 (11.81 cm). Different levels of calcium treatments and interaction effect were non-significant. However maximum head breadth (13.90 cm) was recorded in the G_1 C_2 and minimum head breadth (9.60 cm) was in G_4C_1 and G_4C_2 respectively (Table 5). Similar results were obtained by (Chaurasia *et al.,* 2008). They reported that the increased curd breadth in cauliflower was associated with high rate of photosynthesis from larger leaf area and their translocation towards curd resulted in maximum curd breadth.

Table 4. Effect of cabbage genotypes and different calcium treatments on head length (cm)

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	12.75	13.05	12.95	12.91
G_2 -Green challenger	12.85	12.65	12.40	12.63
G_3 -Super Ball 50	12.55	12.90	11.60	12.35
G_4 -F_1 Border 777	13.25	12.15	12.45	12.61
G_5 -Green voyager	11.85	10.90	11.95	11.56
G_6 -Mahy 118	12.30	12.15	12.15	12.20
G_7 -Saint	11.25	13.00	11.90	12.05
Mean (Treatments)	12.40	12.40	12.20	
Factors		C D (p<0.05)		
Factor(G)		NS		
Factor(C)		NS		
Factor(G X C)		NS		

Table 5. Effect of cabbage genotypes and different calcium treatments on head breadth (cm)

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	12.95	13.35	13.90	13.40
G_2 -Green challenger	12.05	12.10	11.30	11.81
G_3 -Super Ball 50	10.85	11.70	10.10	10.88
G_4 -F_1 Border 777	9.65	9.60	9.60	9.61
G_5 -Green voyager	11.05	11.35	11.70	11.36
G_6 -Mahy 118	10.60	10.60	10.65	10.61
G_7 -Saint	9.90	10.65	9.85	10.13
Mean (Treatments)	11.00	11.33	11.01	
Factors		C D (p<0.05)		
Factor(G)		0.62		
Factor(C)		NS		
Factor(G X C)		NS		

Gross head weight

There was a significant difference among genotypeswith respect to gross head weight. Maximum gross head weight was noticed in the genotypeG_1 (1136.66 g) followed by G_5 (1005.83 g) and G_2 (1003.66 g), while the lowestwas recorded in G_4(831.66 g). Different levels of calcium foliar application had no significant effect on gross head weight. But the minimum gross head weight (926.00g) was in the control (C_0) plot and maximum (989.85 g) was in (C_1) treatment (Table 6). There was significantinteraction effect among the genotypes and different levels of calcium foliar application. The maximum gross head weight (1365 g) was recorded in G_1C_2, and it was minimum (790 g) in G_4C_1. The increased net head weight in cabbage was due to larger leaf area associated with higher photosynthetic rate and translocation of photosynthates towards cabbage heads. Similar results were obtained by Chaurasia *et al.* (2008) in cauliflower.

Net head weight

Genotypes exhibited significant difference with respect to net head weight.Maximumnet head weight was recorded in the genotype G_1 (787.33 g) and the minimum was in the genotype G_4 (561.00 g) followed by G_6, G_7, G_3 and G_2 respectively (Fig. 2). There was no significant difference among different levels of calcium foliar application. The maximum net head weight was registered in the treatment (C_1) with 677.14g and lowest net head weight (631.28 g) was in the control treatment (C_0). The interaction effect was also non-significant. The highest net head weight (930g) was recorded in G_1C_2 and least net head weight was in G_4C_1 of (524 g). The higher net head weight might be associated with larger leaf area which increased the photosynthetic rate and higher will be the photosynthetic accumulation in the cabbage heads. Our findings were in line with Shashidhara (2000) and Chaurasia *et al.* (2008).

Table 6. Effect of cabbage genotypes and different calcium treatments on gross head weight (g)

Genotypes	C_0 (0%)	C_1 (0.5%)	C_2 (1.5%)	Mean (Genotypes)
G_1 - NS 43	935.00	1110.00	1365.00	1136.66
G_2 -Green challenger	936.00	1065.00	1010.00	1003.66
G_3 -Super Ball 50	963.00	1068.00	820.00	950.33
G_4 -F_1 Border 777	890.00	790.00	815.00	831.66
G_5 -Green voyager	861.00	1055.00	1101.50	1005.83
G_6 -Mahy 118	985.00	951.00	892.00	942.66
G_7 -Saint	912.00	890.00	902.50	901.50
Mean (Treatments)	926.00	989.85	986.57	
Factors		C D (p<0.05)		
Factor(G)		122.08		
Factor(C)		NS		
Factor(G X C)		211.46		

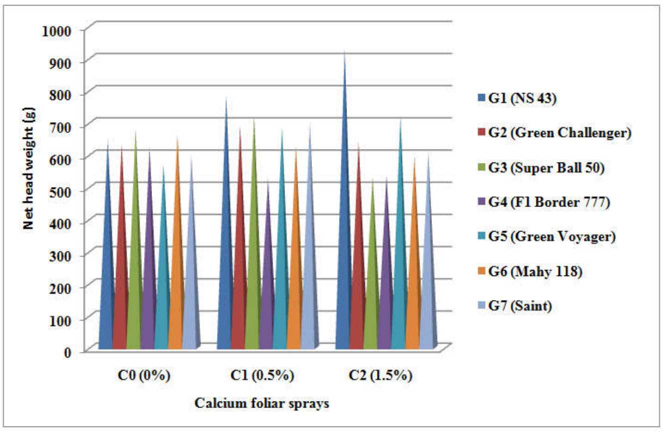

Fig. 2. Effect of calcium foliar application on net head weight (g)

Yield per plot

Significant difference was observed among genotypes for yield per plot (kg /3 m2). The genotype G_5 recorded maximum yield per plot (6.40 kg) which was on par with G_1 (6.02 kg) and it was minimum (4.65 kg) in the genotype G_7. The genotype G_2 and G_3 were statistically on par. Among different levels of calcium application there was no significant difference (Fig. 3). Interaction effect was also non-significant, the interaction G_5C_2 showed the maximum yield (6.79 kg) and the lowest yield was recorded by the interaction G_7C_0 (4.28 kg).

Internal tipburn incidence

There was no significant difference among genotypes and different levels of calcium foliar treatments on internal tipburn incidence. Among the seven genotypes G_1, only the genotype G_1recorded a slight incidence of tipburn (4.16 %). Among the different Ca foliar application, only in the (C_2) treatment slight incidence of tipburn was noticed with 1.78 per cent. Interaction effect was also non-significant, only the interaction G_1C_2 recorded 12.50 per cent of tipburn over the other interactions (Fig 4.). However the minimum incidence of tipburn might be due to lower relative humidity which ranged from 80 to 89.66 per cent inside rain shelter during off-season. The lower relative humidity increased the transpiration rate associated with increased Ca uptake through roots form the soil. Similar results were revealed by Gislerod *et al.* (1987). The increased relative humidity of 90-95 per cent showed lesser Ca content in tomato plants and the low relative humidity 70-75 per cent was associated with increased Ca content.Foliar application of calcium does not minimize the tipburn incidence. Increasing air humidity reduces transpiration rate and transport of Ca (Ehret and Ho, 1986), which may lead to Ca deficiency symptoms in the upper and rapidly expanding leaves (Winsor and Adams, 1987). Our findings were in line with the results presented by Rosen (1990) who reported that the bestmethod to control tipburn in cauliflower was to use resistant cultivars.Soil application of $CaSO_4$or foliar application of $Ca(NO_3)_2$ or $CaC1_2$ did not decrease the incidence of tipburn in the collard cv. Vates as reported by Johnson (1991).

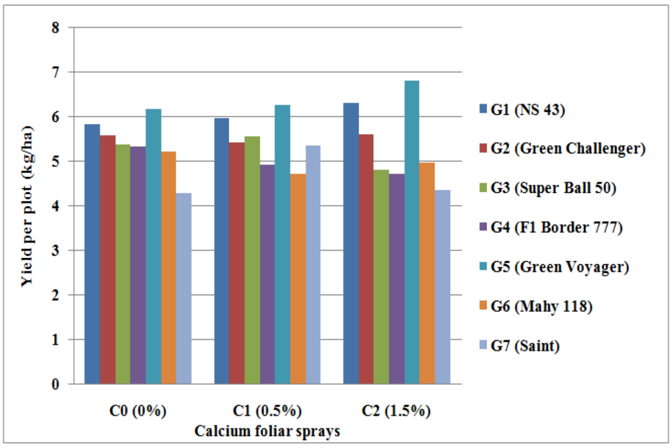

Fig 3. Effect of calcium foliar application on yield per plot

Table 7. Initial soilnutrient status

Treatments	Soil pH	Electric conductivity (ds. m^{-1})	Organic carbon (%)	Available phosphorus kg ha^{-1}	Available potassium kg ha^{-1}	Available sulphur kg ha^{-1}
C_0 (0%)	5.60	0.36	1.85	91.88	285.60	18.40
C_1 (0.5%)	5.85	0.46	1.75	81.61	249.20	30.50
C_2 (1.5%)	5.30	0.43	1.84	161.05	282.24	19.70
C.D. (p<0.05)	NS	NS	NS	NS	NS	NS

Table 8. Initial soil nutrient status

Treatments	Available calcium mg kg^{-1}	Available magnesium mg kg^{-1}	Available iron mg kg^{-1}	Available manganese mg kg^{-1}	Available copper mg kg^{-1}	Available zinc mg kg^{-1}	Available boron mg kg^{-1}
C_0 (0%)	816.25	169.50	31.77	51.02	10.05	1.51	0.18
C_1 (0.5%)	954.12	239.25	29.96	51.33	11.71	1.51	0.25
C_2 (1.5%)	938.00	236.75	31.20	46.13	10.51	3.33	0.31
C.D. (p<0.05)	NS	NS	NS	NS	NS	NS	NS

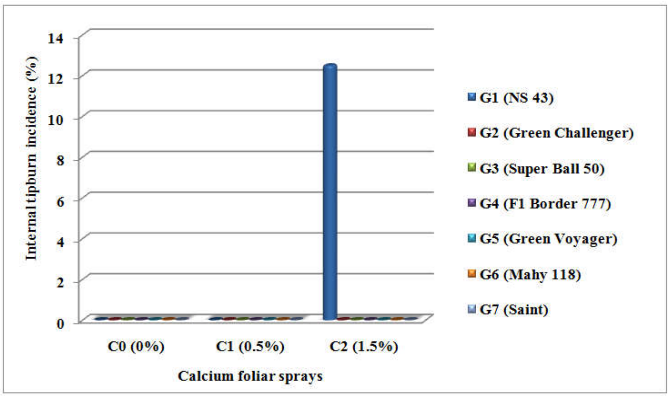

Fig 4. Effect of calcium foliar application on internal tipburn incidence

Soil nutrient status

There was no significant variation among the earmarked plots with respect to soil pH, organic carbon and electric conductivity. However the experimental plots were medium fertility range having soil pH ranged from 5.30 to 5.85, organic carbon content 1.75 to 1.85 per cent and electric conductivity 0.36 to 0.46 ds. m^{-1} among the plots before raising the crop.

Soil macro nutrients

Here also there was no significant variation among the experimental plots for available phosphorus, potassium, calcium, magnesium and sulphur content in soil. The available P content in the soil ranged from 81.61 to 161.05 kg ha^{-1} and available Kcontent in the soil ranged from 249.20 to 285.60 kg ha^{-1}. The available Cacontent in the soil ranged from 816.25 to 954.12 mg kg^{-1}, available Mgcontent in the soil ranged from 169.50 to 239.25 mg kg^{-1} and available sulphur in soil ranged from 18.40 to 30.50 mg kg^{-1} (Table 7).

Soil micro nutrients

Soil micro nutrients exhibited non-significant variation among the earmarked plots before raising the cabbage. The available Fe content in the soil ranged from 29.96to 31.77 mg kg^{-1} and available Mn content ranged from46.13 to 51.33 mg kg^{-1}. Copper content in soilranged from 10.05 to 11.71 mg kg^{-1}, zinc content ranged from 1.51 to 3.33 mg kg^{-1} and boron content in soil ranged from 0.18 to 0.31 mg kg^{-1}. Hence in the present study all the soil nutrients were in sufficient quantity except for boronwhich was deficient in the soil (Table 8).

Conclusion

In the present investigation, foliar application of calcium had positive influence on plant spread, stalk length, gross and net head weight and yield per plot. But the responses varies with genotypes. All the genotypes showed resistance to internal tipburn except the genotype G_1 (NS 43) which showed slight tipburn incidence in C_2 (1.5 %) Ca foliar application. Soil macro and micro nutrients were also in sufficient range except boron which was below critical level as per the initial soil test report.

REFERENCES

Acharya, U., Thapa, S. and Rimal, N. S. 2015. Study on the growth, yield and soil nutrient status of broccoli (*Brassica oleraceae*var. *italica*) under organic nutrient management. *Int. J. Current Res.* 7(2): 13029-13032.

Agarwal, M. L., Singh, C. N., Bhan, C., and Singh, H. N. 1972.Effect of nitrogen, phosphorus, phosphate and potash on cabbage. In: *Proc. Third Int. Symp. Trop. Subtrop. Hort.* Bangalore, Feb.1972.pp142-143.

Berger, K. C. andTroug, E. 1939. Boron determination in soils and plants.*Indian Eng. Chem. Anal. Ed.*11: 540-542.

Chaurasia, S. N. S., Singh, A. K., Singh, K. P., Rai, K. and Rai, M. 2008. Effect of integrated nutrient management on yield and quality of cauliflower (*Brassica oleracea* var. *botrytis*) variety Pusa Snow Ball-K-1.*Veg. Sci*. 35(1): 41-44.

Ehret, D.L. and Ho,L.C. 1986: Translocation of calcium in relation to tomato fruit growth. *Ann. Bot.,* 58: 679-688.

Gislerod, H.R., Selmer, A.R. and Mortensen, L.M. 1987: The effect of air humidity on nutrient uptake by some greenhouse plants. *Plant Soil,* 102: 193-196.

Gupta, U. C. 1972. Effect of boron and limestone on cereal yields and on B and N concentrations of plant tissue. *Soil Sci. Pl. Anal.,* 6: 439-450.

Johnson, J. R.1991. Calcium Accumulation, Calcium Distribution and Biomass Partitioning in Collards.J. *Amer. Soc. Hort. Sci*., 116(6):991-994.

KAU[Kerala Agricultural University]. 2011. *Package of Practices Recommendations: Crops* (14thEd.). Kerala Agricultural University, Thrissur, 360p.

NHB [National Horticulture Board]. 2015. Indian Horticulture Database-2015. National Horticulture Board, Gurgaon, 289p.

Rosen, C.J. 1990. Leaf tipburn in cauliflower as affected by cultivar, calcium spray, and nitrogen nutrition. *Hort. Sci.,* 25:660-663.

Sharma, R. P., Sharma, A.and Sharma, J. K. 2005. Productivity, nutrient uptake, soil fertility and economics as affected by chemical fertilizers and farm yard manures in broccoli (*Brassica oleracea* var. *italica*) in an Entisol. *Indian J. Agric. Sci*., 75(9): 576-579.

Shashidhara, G. B. 2000. Integrated nutrient management for chilli (*Capsicum annuum* L.) in Alfisops of Northern Transition Zone of Karnataka.M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India.

Singh, B.K., Sharma, S.R., Singh, B. 2010. Variation in mineral concentrations among cultivars and germplasms of cabbage (*Brassica oleracea*var. *Capitata* L.). *J. Plant Nutr.,* 33: 95-104.

Suseela, P. 2002. Effect of Height and Ventilation of greenhouse on Microclimate under tropical conditions and its Impact on Crop growth. M.Sc. (Ag. Eng.) Thesis, Tamil Nadu Agricultural University, 165p.

Williams, C. H. and Steinbers, A. 1959.Soil sulphur fractions as chemical indices of available sulphur in some Australian soils.*Aust. J. Agric. Res.,* 29(4): 342-348.

Winsor, G.W. and Adams, P. 1987. *Diagnosis of Mineral Disorders in Plants*. Glass-house Crops, Vol. 3, HMSO, London, 150p.

****