Influence of Starter Fertilizer and Calcium Nitrate Rates on Vegetative Growth, Yield and Nutrational Quality of Cabbage

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ABSTRACT

Two field experiments were carried out to study effect of starter fertilizer as soil application, calcium nitrate as foliar application and its interaction on the growth, yield and chemical components of cabbage. Each experiment included four rates of starter fertilizer (SF);SF_0: 0-0-0, SF_1: 19-54-19, SF_2: 38-73-38 and SF_3: 76-111-76 gm N-P_2O_5-K_2O 100 $l^{-1}$and three rates of calcium nitrate (1, 2 and 3 g l^{-1}) as well as its interactions effect. The results showed that soil application of SF_2 or SF_3 increased the vegetative growth and head yield characters of cabbage plant. However, SF_1 or SF_2 gave the highest mean value nutrition quality of cabbage head. Three different foliar calcium applications did not effect on head characters and total yield. In general Foliar of calcium nitrate at 1 or 2 g l^{-1}, improved some head quality character, in the two growing seasons.

Key words: Starterfertilizer, calcium nitrate, cabbage, yield, quality.

INTRODUCTION

Cabbage (*Brassica* oleraceaL.) is an important a cole crops, member of the family *Cruciferae* and the winter leafy vegetable in Egypt. It has good nutritional value of many vitamins (A, B1, B2 and C). It is rich in minerals like Ca, Mg, P, K, Na and S (Verma and Nawange, 2015). It's also an important of antioxidant such as carotenoids, polyphenols and ascorbic acid (Riad *et al*., 2009).

The most important problems facing the cabbage growers in Egypt are represented in production transplanting through the nursery ground. This method leads to lost most roots of the transplanting during transfer the transplanting from the nursery to a sustainable field (El-Sharkawy and Abdel-Razzak,2010). As well as loss of a large proportion of cabbage yield as a result of tip burn that occur with deficiencies of calcium (Ca). Improving the management agricultural practices of cabbage production by using the starter fertilizes (SF) rich in P and foliar application of Ca; will contribute to increase the availability and uptake both of P and Ca may be a key to the strong roots formation and decreasing tip burn, respectively, thereby increasing the cabbage yield.

Starter fertilizer is an innovative technology to reduce fertilizer, simultaneously increase productivity of fertilization, and increase nutrients available to plants, and reducing pollution of the plant (Latifah *et al*., 2016). SF is a small amount of NPK fertilizers rich in P applied near the seed or seedling for readily available nutrients until the plant's root system develops (Burns, *et al*., 2010). Most beneficial effect of SF is obviouswhen crop are planted into cold and wet soil in nearly spring or late fall season, regardless of soil fertility. The purpose of soil application of SF is to supply the nutrients in the early stages of growth before the root system is sufficiently developed to reach banded fertilizer, hence increasing the plant's capacity to absorb more nutrients from the soil (Susila *et al*., 2011 and Feleafel *et al*., 2014). Injection of SF significantly boosted early growth and overall yield of cabbage, cherry tomato, sweet pepper, chili pepper and Chinese cabbage (Ma and Kalb, 2006, Burns*et al*., 2010 and El-Afifi*, et al.,* 2014), especially when applied on soils with low to medium P and K status (Stone, 1998 and Stone *et al*., 1999).

Calcium plays a critical role in strengthening the plant's cell walls and membranes, which makes it harder for pathogens to invade the plant (Shear, 1975; Naphun *et al.,* 1997; Kadir, 2004 and Kazemi, 2014). Ca application usually leads to an increase in Ca concentration that may affect the structure and functions of cell walls, membranes and certain aspects of cell metabolism that delays leaf senescence (Poovaiah, 1979 and Glenn, *et al*., 1988). In addition, loss of quality in leafy vegetable may be due to structural failure of tissues can associated primarily with the deficiency of Ca in cell walls. During ripening, there are major changes in the pectin-rich middle lamella region of cells where calcium ions have a role in linking adjacent acidic pectin polymers (Seymour *et al*., 1993). Foliar application of Ca whether pre and postharvest in many fruits and vegetables may becontribute to increase the quality, reducing postharvest decay and controlling the physiological disorder (NaPhun *et al*., 1997).

The main objective of this study was to identify how respond the growth, development of head and quality of head of cabbage plants to NPK starter fertilizer and calcium as foliar application.

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MATERIALS AND METHODS

Two field experiments were carried out, during the winter seasons of 2014/2015 and 2015/2016, at the Experimental Station Farm of the Faculty of Agriculture Abies, Alexandria University; Alexandria, Egypt. To investigate the effects of four rates of NPK starter fertilizer (SF);SF_0: 0-0-0, SF_1: 19-54-19, SF_2: 38-73-38 and SF_3: 76-111-76 gm N $P_2O_5K_2O$ 100 $l^{-1}$and three rates of calcium nitrate (1, 2 and 3 g l^{-1}) as well as its interactions effect.

Before the trial, some physical and chemical properties of the two experimental soil up to 30 cm depth were determined according to methods described by (Page1982) andare presented in Table (1).

The experimental layout was split plots system in a Randomized Complete Blocks Design with three replications. Each replicate included 12 treatments, which were the combinations of four SF and three rates of calcium nitrate as foliar application. Cabbage cv. Balady was transplanted on middle of October in the soil, in both seasons. Transplants were planted with 40 cm apart between plants. The SF rates were, randomly, arranged in the main plots, while Ca rates were, randomly, distributed in the sub-plots. Each sub-plot consisted of 12 ridges; each ridge was 4 m length and 0.7 m width. SF was used as a drench to the seedling root area, one week after seeding, at rate 0.2 l $plant^{-1}$. The control plants were treated with tap water. However, Ca as foliar application was added at two times, i.e., after 50 and 65 days from transplanting after adding Tween 20 (0.5%) as a wetting agent. The experimental soil was received 60 kg fed^{-1} calcium super phosphate (15.5%P_2O_5) as one dose before transplanting. Ammonium nitrate (33.5% N) at 80 kg fed^{-1} was added at two time after 21 and 50 days after transplanting and Potassium sulphate (48% K_2O) at 60 kg fad^{-1} was added at two times, i.e., after 50and 80 days from transplanting. Other recommended agricultural practices were followed as commonly used in the commercial production of cabbage plant outlined by Ministry of Agriculture and Reclamation-Arab Republic of Egypt.

Data recorded

Vegetative growth characteristics

At harvest, in both seasons, five randomly chosen plants from each sub plot, to measured stem length (cm), stem diameter (cm), wrapper leaves number $plant^{-1}$. Dry matter of leaves (%) was determined after drying the leaves at 70^o C for 48 h.

Yield and head characters

The same plant sample taken to recording the vegetative features were used to measure head fresh weight (kg), head diameter (cm), head length (cm) and total yield fed^{-1} (ton).

Table 1. Soil physical and chemical properties of the experimental sites in the two growing seasons of 2014/2015 and 2015/2016 *

Properties \ Seasons	2014/2015	2015/2016
pH	8.01	7.97
E.C. (dS.m^{-1})	3.01	3.00
Sand %	34.80	33.90
Silt %	24.00	24.80
Clay %	41.20	41.30
Soil texture	Clay loam	Clay loam
Soluble cations (m.eq l^{-1})		
Ca^{++}	1.60	1.80
Mg^{++}	1.39	1.60
Na^{+}	2.00	1.50
K^{+}	0.35	0.38
Soluble anions (m.eq l^{-1})		
CO_3^{--}	zero	zero
HCO_3^{-}	1.20	1.28
Cl^{-}	1.10	1.30
SO_4^{--}	3.20	3.11
Total N (%)	0.14	0.15
Available P (ppm)	0.28	0.30

Head nutritional quality

Random samples of the inner leaves of heads were collected, from each sub plot, to determine the nitrates content according to (Cataldo et al., 1975), total soluble phenols according to (Scalbert *et al*., 1989) and expressed as mg.g^{-1}fresh weight. Plant vitamin C was measured by titration with iodide potassium (Ranganna, 1986).Total nitrogen and phosphorus were determined colorimetrically; using spectrophotometer at 662 and 650 nanometer; according to (Evenhuis, 1976), and calcium, and potassium was determined by flam photometer as described by (Cottenie,1982) of the leaves were expressed as a percentage on the dry weight basis.

Statistical analysis

All the data recorded throughout the study was exposed to the analysis of variance techniques according to the design used by the CoStat software package for Windows. Treatment means were separated and compared using the L.S.D test at 0.05 level of significance according to (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Vegetative growth characters

The results concerning the differences between the two studied factors as well as their interactions on the vegetative growth characters of cabbage plants which included length and diameter of stem,number of outer leaves, outer and inner leaves thickness are shown in Tables (2 and 3). The results clarified the presence of some significant increment on the vegetative growth characters of cabbage as a result to soil application of SF, in both growing seasons. Generally, SF_2: 38-73-38 and SF_3: 76-111-76 gm N- P_2O_5-K_2O 100 l^{-1} treatments resulted in shorter stem length, increments in stem diameter, outer leaves number and outer and inner leaves thickness, in both seasons.This can be clarified based on SF rich in P used as a drench to the seedling root area after transplanting enhanced root development and increasing the plant's ability to absorb more nutrients from a larger volume of soil. The availability of these elements in the early growth stage could encourage the vegetative growth, accelerate the photosynthetic rate, increasing the meristematic activity and building protein molecules (Marschner, 1995; Stone 1999; Burns *et al*., 2010 and Feleafel*et al*., 2014).

Data in Tables (2and3) indicated that the foliar application of Ca on cabbage plants had a positive significantly effect on all previously mentioned characters of the vegetative growth, in the two growing seasons, except, the average of stem diameter in two seasons and thickness inner leaves in the second season were not significantly affected by the different rates of Ca. The current results are in harmony with those reported by (Hepler, 2005 and Kazemi, 2014).The beneficial effect of Ca in increasing vegetative growth characters might be due to Ca plays a key role in cell division through its contribution in the formation of cell wall, photosynthesis and hormone metabolism, which promotes synthesis of auxin that is essential for plant growth (Liang *et al.*, (2008)

The interaction effects between SF and the different rates of Ca on the vegetative growth characters were found to be significant, but with different magnitudes, in both growing seasons. The results illustrated that the SF_0 treatment (control) combined with Ca_1 rate gave the significant highest mean vales of stem length character, in both seasons.In addition, the results illustrated that the SF_3 treatment combined with using Ca_1 rate gave the significant highest mean values of stem diameter of cabbage, in both growing seasons.Moreover,the SF_2 or SF_3 with Ca_1 rate reflected the significant highest mean value of outer and inner leaves thickness, in the two seasons Tables (2and3).

Yield and head characters

The results in Table (4) clearly demonstrate that soil application of SF revealed that all SF treatments resulted in highly significant increases in head weight compared with the control treatment. Whereas, SF_2 and SF_3 treatments gave the highest significant increase in head diameter compare with other treatments, in both growing seasons.

According to the results in Table (5), there were significant differences among the starter fertilizer in relation to their effects on total yield fad^{-1},in both growing seasons. The results reflected that the SF_2 or SF_3 resulted in corresponding increases total yield, in both growing seasons. This result agreed with (El-Afifi *et al.*, 2014), who reported that use of the starter fertilizer gave highly significant increases of chinese cabbage head yield.The increase in head yield might be attributed to theenough nutrients and better absorption to plants caused increased activity on photosynthetic activity and physiology of plant related to growth and yield development (Susila *et al*., 2011 and Latifah *et al*., 2016).

On the other hand, the results in Tables (4and5) showed that using of three different foliar calcium application did not effect on head characters of cabbage (head weight, diameter and length) and total yield, in the two growing seasons.

Table 2. Influence of starter fertilizer, calcium nitrate rates and their interaction on plan height, stem length and diameter, during the winter seasons of 2014/2015 and 2015/2016

Treatments	Stem length (cm)		Stem diameter (cm)	
	2014/2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)				
SF_0	17.20 a	17.20 a	4.02 d	4.02 c
SF_1	15.55 c	15.31 c	4.44 c	4.46 b
SF_2	15.25 d	15.31 d	4.67 b	4.70 a
SF_3	16.36 b	16.41 b	4.75 a	4.73 a
Calcium nitrate concentration (g l^{-1})				
Ca_1	15.83 c	15.92 b	4.46 a	4.47 b
Ca_2	16.06 b	16.00 b	4.48 a	4.49 a
Ca_3	16.38 a	16.56 a	4.46 a	4.47 ab
(SF)×(Ca)				
SF_0×(Ca_1)	17.13 b	17.10 b	4.02 g	4.02 jk
SF_0×(Ca_2)	17.03 b	17.00 b	4.01 g	4.03 j
SF_0×(Ca_3)	17.43 a	17.50 a	4.04 g	4.02 k
SF_1×(Ca_1)	15.33 f	15.53gh	4.39 f	4.42 i
SF_1×(Ca_2)	14.96 g	15.36 hi	4.47 e	4.49 g
SF_1×(Ca_3)	16.36 d	16.33 de	4.46 e	4.47 h
SF_2×(Ca_1)	15.00 g	15.00 j	4.66 cd	4.68 c
SF_2×(Ca_2)	15.73 e	15.16 ij	4.70 bcd	4.72 c
SF_2×(Ca_3)	15.03 g	15.76 fg	4.64 d	4.70 e
SF_3×(Ca_1)	15.86 e	16.06 ef	4.78 a	4.75 a
SF_3×(Ca_2)	16.53 cd	16.50 cd	4.74 ab	4.73 b
SF_3×(Ca_3)	16.70 c	16.66 c	4.72 bc	4.71 d

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Table 3. Influence of starter fertilizer, calcium nitrate rates and their interaction on number of outer leaves, thickness of outer and inner leaves, during the winter seasons of 2014/2015 and 2015/ 2016

Treatments	Number outer leaves		Thickness outer leaves (mm)		Thickness inner leaves (mm)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)						
SF_0	10.27 d	10.45 d	0.546 b	0.480 b	0.356 b	0.364 b
SF_1	10.76 c	10.90 c	0.644 a	0.662 a	0.384 ab	0.392 ab
SF_2	11.53 b	11.64 b	0.633 a	0.685 a	0.408 a	0.420 a
SF_3	12.53 a	12.72 a	0.674 a	0.651 a	0.365 ab	0.378 b
Calcium nitrate concentration (g l^{-1})						
Ca_1	11.09 b	11.23 b	0.677 a	0.651 a	0.387 a	0.388 ab
Ca_2	11.25 a	11.40 b	0.578 b	0.616 b	0.381 a	0.371 b
Ca_3	11.48 a	11.65 a	0.618 ab	0.590 c	0.367 a	0.406 a
(SF)× (Ca)						
SF_0×(Ca_1)	10.33 f	10.50 fg	0.536 de	0.530 i	0.323 c	0.330 d
SF_0×(Ca_2)	10.00 ef	10.13 g	0.460 e	0.480 j	0.360 bc	0.373 cd
SF_0×(Ca_3)	10.50 de	10.73 ef	0.643 bcd	0.430 k	0.386 abc	0.390 bc
SF_1×(Ca_1)	10.50 de	10.56 f	0.740 ab	0.743 b	0.373 bc	0.386 bc
SF_1×(Ca_2)	10.83 cd	11.00 de	0.570 cde	0.696 c	0.380 abc	0.383 cd
SF_1×(Ca_3)	10.96 c	11.13 de	0.623bcd	0.546 h	0.400 ab	0.406 abc
SF_2×(Ca_1)	11.16 c	11.33 cd	0.663 abc	0.650 e	0.443 a	0.440 ab
SF_2×(Ca_1)	11.66 c	11.73 bc	0.623 bcd	0.620 f	0.373 bc	0.363 cd
SF_2×(Ca_1)	11.76 b	11.86 b	0.613 cd	0.786 a	0.410 ab	0.456 a
SF_3×(Ca_1)	12.36 a	12.53 a	0.770 a	0.683 cd	0.386 abc	0.396 bc
SF_3×(Ca_2)	12.53 a	12.73 a	0.660 abc	0.670 d	0.356 bc	0.366 cd
SF_3×(Ca_3)	12.70 a	12.90 a	0.593 cd	0.600 g	0.353 bc	0.373 cd

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Table 4. Influence of starter fertilizer, calcium nitrate rates and their interaction on head weight, diameter and length, during the winter seasons of 2014/2015 and 2015/2016

Treatments	Head weight (kg)		Head diameter (cm)		Head length (cm)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)						
SF_0	2.81 b	2.79 b	18.77 c	18.66 c	19.45 d	19.71 d
SF_1	4.60 a	4.58 a	21.66 b	21.88 b	22.00 c	22.35 c
SF_2	4.95 a	4.96 a	24.11 a	24.33 a	23.52 b	23.65 b
SF_3	5.16 a	5.15 a	23.77 a	23.66 a	24.35 a	24.72 a
Calcium nitrate concentration (g l^{-1})						
Ca_1	4.65 a	4.62 a	21.75 a	21.75 a	22.01 b	22.30 b
Ca_2	4.32 a	4.34 a	22.58 a	22.70 a	22.40 a	22.72 a
Ca_3	4.16 a	4.16 a	21.91 a	21.95 a	22.80 a	22.80 a
(SF)× (Ca)						
SF_0×(Ca_1)	3.46 cd	3.41 cd	18.33 d	18.00 e	19.40 e	19.46 e
SF_0×(Ca_2)	1.93 e	1.96 e	19.00 d	19.00 e	19.40 e	19.93 e
SF_0×(Ca_3)	3.03 de	3.01 de	19.00 d	19.00 e	19.56 e	19.73 e
SF_1×(Ca_1)	4.60 abc	4.57 abc	19.66 d	20.00 de	21.06 d	21.46 d
SF_1×(Ca_2)	5.33 a	5.32 a	23.66 ab	23.83 abc	22.40 c	22.83 c
SF_1×(Ca_3)	3.86 bcd	3.86 bcd	21.66 c	21.83 cd	22.53 c	22.76 c
SF_2×(Ca_1)	5.15 ab	5.12 ab	24.33 ab	24.66 a	23.26 b	23.50 b
SF_2×(Ca_1)	4.86 ab	4.90 ab	23.66 ab	23.66 abc	23.60 b	23.63 b
SF_2×(Ca_1)	4.83 ab	4.85 ab	24.33 ab	24.66 a	23.70 b	23.83 b
SF_3×(Ca_1)	5.40 a	5.40 a	24.66 a	24.33 ab	24.33 a	24.76 a
SF_3×(Ca_2)	5.16 ab	5.16 ab	24.00 ab	24.33 ab	24.20 a	24.50 a
SF_3×(Ca_3)	4.93 ab	4.90 ab	22.66 bc	22.33 bc	24.53 a	24.90 a

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Table 5. Influence of starter fertilizer, calcium nitrate rates and their interaction on total yield and dry matter of head, during the winter seasons of 2014/2015 and 2015/2016

Treatments	Total yield (kg.fed^{-1})		Dry matter of head (g)	
	2014/ 2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)				
SF_0	26.55 c	26.66 c	10.77 c	10.68 c
SF_1	46.44 b	46.77 b	12.84 ab	12.78 b
SF_2	49.33 a	49.88 a	13.13 a	13.16 a
SF_3	50.55 a	50.88 a	12.68 b	12.58 b
Calcium nitrate concentration (g l^{-1})				
Ca_1	42.23 a	43.25 a	12.26 b	12.15 b
Ca_2	43.75 a	43.33 a	12.35 ab	12.33 ab
Ca_3	43.08 a	44.08 a	12.46 a	12.43 a
(SF)× (Ca)				
SF_0×(Ca_1)	26.00 e	26.00 e	10.70 b	10.63 f
SF_0×(Ca_2)	27.00 e	26.00 e	10.83 b	10.73 f
SF_0×(Ca_3)	26.66 e	28.00 d	10.80 b	10.70 f
SF_1×(Ca_1)	45.66 d	47.00 bc	12. 60 a	12.53 de
SF_1×(Ca_2)	47.33 cd	45.66 c	12.90 a	12.83bcd
SF_1×(Ca_3)	46.33 d	47.66 b	13.03 a	13.00 abc
SF_2×(Ca_1)	49.00 bc	49.66 a	13.00 a	13.06 abc
SF_2×(Ca_2)	49.66 ab	50.33 a	13.10 a	13.13 ab
SF_2×(Ca_3)	49.33 ab	49.66 a	13. 30 a	13. 30 a
SF_3×(Ca_1)	50.66 ab	50.33 a	12.76 a	12.40 e
SF_3×(Ca_2)	51.00 a	51.33 a	12.56 a	12.63 de
SF_3×(Ca_3)	50.00 ab	51.00a	12.73 a	12.73 cde

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Head nutritional quality

Concerning the effect of the starter fertilizer on head nutritional quality characters, the results demonstrated that the comparison among mean values were significant in both growing seasons (Tables 6and7).

The results in Table (6) showed generally that the soil application of SF, significantly, increased the mean values head nutritional quality characters, relative to that of the control treatment, in both seasons. The highest mean values of the dry matter of head and vitamin C were obtained from SF_2 followed by SF_1. However, SF_3gave the highest mean value of total phenol content, in both growing seasons. Concerning total carbohydrate character, the results illustratedthat significant difference among the mean values of this character under effect of SF, but with different magnitudes, in the first season. The obtained results showed also that the SF_3 reflected the significant highest mean values on nitrate accumulation, the phosphorus (%) and calcium (%), in the two seasons.

The results concerning the main effects of the Ca on dry matter, total phenols, V.C and total carbohydrate of head during the two growing seasons are presented in Table (6). The results indicated that the differences among the mean values of total phenols for the three rates of Ca were found to be significant; whereas, insignificant, differences were noticed in total carbohydrate of head, in the two seasons. However, Ca_1 and Ca_2 produced high total carbohydrate of head, comparing with Ca_3 , in both growing seasons.

The results in Table (7) clearly demonstrate that soil application of SF revealed that all SF treatments resulted in highly significant increases in nitrate content, phosphorus and calcium (%) compared with the control treatment. Whereas, SF_3 and SF_2 treatments gave the highest significant increase in nitrate content, phosphorus and calcium (%)compare with other treatments, in both growing seasons. The availability of these elements in the early growth stage could, accelerate the photosynthetic rate, increasing the meristematic activity and building protein molecules (Marschner,1995; Stone 1999; Burns *et al*., 2010 and Feleafel*et al*., 2014).

Table 6. Influence of starter fertilizer, calcium nitrate rates and their interaction on total carbohydrate, total phenol and vitamin C, during the winter seasons of 2014/2015 and 2015/2016

Treatments	Total carbohydrate (%)		Total phenol ($\mu g.g^{-1}f.w$)		V.C ($\mu g.100g^{-1}f.w$)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)						
SF_0	3.75 a	3.75 b	0.478 d	0.478 d	30.23 c	30.22 c
SF_1	4.08 a	4.10 ab	0.575 c	0.568 c	32.34 ab	32.33 a
SF_2	4.22 a	4.25 a	0.680 b	0.641 b	32.46 a	32.47 a
SF_3	4.13 a	4.02 ab	0.844 a	0.819 a	32.14 b	32.13 b
Calcium nitrate concentration (g l^{-1})						
Ca_1	4.10 a	4. 01 a	0.608 c	0.699 c	31.90 a	31.89 a
Ca_2	4.16 a	4.06 a	0.648 b	0.617 b	31.87 a	31.86 a
Ca_3	3.98 a	4.03 a	0.676 a	0.664 a	31.61 b	31.62 b
(SF)× (Ca)						
SF_0×(Ca_1)	3.76 ab	3.70 b	0.477 k	0.478 j	30.16 fg	30.22 de
SF_0×(Ca_2)	3.66 b	3.66 b	0.471 jk	0.470 k	30.46 f	30.40 d
SF_0×(Ca_3)	3.83 ab	3.89 ab	0.487 j	0.487 i	30.06 g	30.05 e
SF_1×(Ca_1)	4.13 ab	4.17 ab	0.554 i	0.551 h	32.46 abc	32.43 ab
SF_1×(Ca_2)	4.26 ab	4.24 ab	0.578 h	0.576 g	32.40abcd	32.40 ab
SF_1×(Ca_3)	3.86 ab	3.89 ab	0.592 g	0.577 g	32.16 cde	32.17 bc
SF_2×(Ca_1)	4.36 a	4.36 a	0.614 f	0.601 f	32.70 a	32.66 a
SF_2×(Ca_1)	4.23 ab	4.24 ab	0.680 e	0.621 e	32.53 ab	32.56 a
SF_2×(Ca_1)	4.06 ab	4.16 ab	0.745 d	0.701 d	32.16 cde	32.20 bc
SF_3×(Ca_1)	4.13 ab	4.80 ab	0.788 c	0.765 c	32.26bcde	32.23 bc
SF_3×(Ca_2)	4.10 ab	4.10 ab	0.864 b	0.801 b	32.10 de	32.10 c
SF_3×(Ca_3)	4.16 ab	4.17 ab	0.880 a	0.891 a	32.06 e	32.06 c

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Table 7. Influence of starter fertilizer, calcium nitrate rates and their interaction on nitrate content, phosphorus and calcium (%), during the winter seasons of 2014/2015 and 2015/2016

Treatments	Nitratecontent ($mg.kg^{-1}$ FW)		P (%)		Ca (%)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
Starter fertilization (SF)						
SF_0	299.50 c	299.33 d	0.362 b	0.356 b	0.435d	0.413 d
SF_1	309.53 b	309.66 c	0.387 ab	0.394 ab	0.525 c	0.536 c
SF_2	312.82 b	313.22 b	0.398 ab	0.400 a	0.596 b	0.606 b
SF_3	320.48 a	320.11 a	0.417 a	0.422 a	0.637 a	0.643 a
Calcium nitrate concentration ($g\ l^{-1}$)						
Ca_1	305.21 b	305.25 b	0.378 b	0.381 a	0.515 b	0.522 b
Ca_2	306.57 b	307.08 b	0.401 a	0.400 a	0.550 a	0.556 a
Ca_3	319.96 a	319.41 a	0.395ab	0.399 a	0. 571 a	0.570 a
(SF)× (Ca)						
SF_0×(Ca_1)	289.50 f	289.33 f	0.330 h	0.330 i	0.363 h	0.353 i
SF_0×(Ca_2)	292.33 f	292.66 f	0.373 g	0.353 h	0.447 g	0.413 h
SF_0×(Ca_3)	316.66 c	316.00 c	0.383 fg	0.386 f	0.490 f	0.473 g
SF_1×(Ca_1)	304.66 e	305.00 e	0.373 g	0.380 fg	0.503 f	0.516 f
SF_1×(Ca_2)	307.33 de	307.66 de	0.393 ef	0.403 de	0.540 e	0.546 e
SF_1×(Ca_3)	316.60 bc	316.33 bc	0.396 de	0.400 e	0.536 e	0.546 e
SF_2×(Ca_1)	312.16 cd	312.33 cd	0.406 cd	0.413 cd	0.573 d	0.583d
SF_2×(Ca_1)	306.63 de	308.33 de	0.416 bc	0.416 bc	0.606 c	0.616 c
SF_2×(Ca_1)	319.66 b	319.00 b	0.373 g	0.370 g	0.610 bc	0.620 c
SF_3×(Ca_1)	314.53 bc	314.33 bc	0.403 de	0.400 e	0.623 b	0.636 b
SF_3×(Ca_2)	320.00 b	319.66 b	0.420 ab	0.426 b	0.640 a	0.650 a
SF_3×(Ca_3)	326.93 a	326.33 a	0.430 a	0.440 a	0.650 a	0.643 ab

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Data in Table (7), indicated that the foliar application of Ca on cabbage plants had a positive significantly effect on the nitrate content, phosphorus and calcium (%) of cabbage, in the two growing seasons, except, the phosphorus (%)in thesecond seasons was not significantly affected by the different rates of Ca.

The results of the comparisons presented in Table (7) showed generally that the interaction effects between the SF and the different rates of Ca on nitrate accumulation and the phosphorus (%), the results illustrated that the SF_3 treatment combined with using foliar Ca_3 on plants gave the significant highest mean vales in both growing seasons (Table7). The results also, illustrated that the SF_3 combined with using Ca_2 foliar on plants gave the significant highest mean values on calcium (%), character, of cabbage in both growing seasons.

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الملخص العربي

تأثير الأسمدة البادئة ومعدلات نترات الكالسيوم على النموالخضري والمحصول والجودة الغذائية للكرنب

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نفذت هذه الدراسة على محصول الكرنب– الصنف البلدي– تحت ظروف الأراضي الطينية بمزرعة كلية الزراعة– الشاطبى– منطقة أبيس بالإسكندرية وذلك خلال موسمي شتاء عامي ٢٠١٤- ٢٠١٥ و٢٠١٥ - ٢٠١٦ وذلك بهدف دراسة تأثير ثلاث معدلات من الأسمدة البادئة (١٩-٥٤-١٩، ٣٨-٧٣-٣٨، ٧٦-١١١- ٧٦ جم من نتروجين- فوسفور- بوتاسيوم لكل ١٠٠ لتر ماء بالإضافة لمعاملة الكنترول، وثلاث مستويات رش بسماد نترات الكالسيوم(١، ٢، ٣جم للتر) والتداخل بينهم على صفات النمو الخضري، وصفات المحصول ومكوناته وصفات الجودة والتي اشتملت على بعض المكونات الكيميائية للكرنب.

وأظهرت النتائج أيضا أن الإضافة الأرضية للسماد البادئ بمعدل(٣٨-٧٣-٣٨) أواستخدام المعدل الثاني (٧٦-١١١-٧٦) قد أعطى زيادة معنوية فى قيمة المتوسط لصفات النمو الخضري وصفات المحصول ومكوناته ،أما استخدام المعدل الأول(١٩-٥٤-١٩) أوالمعدل الثاني (٣٨-٧٣-٣٨) أعطى اعلي القيم لصفات الجودة والمحتوى الكيميائي للكرنب.

أيضا أوضحت النتائج أن الرش باستخدام نترات الكالسيوم لم يؤثر معنويا على صفات النمو الخضري أو المحصول الكلى ومكوناته. بينما أدى استخدام معدل الرش الأول والثانى(١، ٢ جم للتر)أدى إلى تحسن بعض الصفات الكيماوية الرؤوس.