

## Calcium and Potassium Fertilization May Enhance Potato Tuber Yield and Quality

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### ABSTRACT

Field experiment was carried out in a private farm in Delta Nile region, Menofia Governorate, Egypt, during 2013 and 2014 seasons, in order to investigate the effect of calcium and potassium application on vegetative growth, and yield quality of Potato (*Solanum tuberosum*, L.) cv. Spounta. The calcium nitrate was used at rates of 0, 10, 20 kg as net calcium per feddan. The potassium nutrient was added in the form of potassium sulfate ( $K_2SO_4$ ) at rate of 0, 25, 50, 75 kg as net potassium per feddan. Data collected were stem length, number of branches, Plant dry weight, chlorophyll content, and tuber yield. Average tuber weight, tuber specific gravity, percent of infected tubers with internal brown spots and plant chemical content were also determined. Results indicated that, the level of 50 and 75 net K kg per feddan improved plant growth and chemical content significantly of potato in both seasons. The same results were obtained with 10, 20 net Ca kg per feddan. Concerning, the effect of interaction between calcium and potassium treatment, the results revealed that 20 net calcium kg/faddan with 75 net potassium kg /feddan were the best treatment for vegetative growth and yield of potato plants. It was concluded that calcium and potassium fertilization may enhance potato tuber yield and quality.

**Key words:** Potato, Calcium, Potassium, Growth, Yield.

### Introduction

Potato (*Solanum tuberosum*, L.) is an important commercial cash crop of the world. It is basically a cool season crop in origin and has been grown traditionally under conditions that prevail in the northern latitudes of Europe and America and in tropical highlands such as the Andean region in South America or the Himalayan, Karakoram, Hindukush valleys of the Indo-Pak subcontinent. Now potato is successfully grown in tropical, subtropical and temperate climate and is adapted to diverse socio-economic conditions (Malik, 1995).

Fertilization is an important factor in potato production technology to achieve optimum yield and quality of tubers. The potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers at the unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium, as well as micro elements (Fit and Hangan, 2010).

Adequate calcium is a critical aspect of the mineral nutrition of potatoes. Calcium is involved in both the structure and function of all plant cell walls and membranes. Inadequate supplies of calcium cause growth abnormalities like internal brown spot and hollow heart. Adequate calcium nutrition can also improve skin color in red potatoes. Abundant tissue calcium also increases the tubers' resistance to soft rot during storage and may improve the performance of seed potatoes (Waterer, 2005). Calcium has role in cell signaling by acting as secondary messenger and maintains the integrity of plasma membrane. It plays a regulatory role in the balance of cation anion. Calcium sensing proteins are involved in many cellular processes like cytoplasmic streaming, organelles and vesicles transport, microtubules dynamics, cell division, chromosome segregation, cell elongation, tip growth and morphogenesis (Reddy, 2001). Calcium influence cellular pH and also act as a regulatory ion in the source sink translocation of Carbohydrates through its effects in cells and cell walls. Calcium is needed for cell wall strengthening and provides protection against biotic and abiotic stresses (Hirschi, 2004; Aranda-Peres *et al.*, 2009). Likewise, potassium is required for turgor build up in plants and maintains the osmotic potential of cells, which in guard cells governs the opening of stomata. It affects the cell extension and cell walls thickness and stability (Schroeder *et al.*, 2001). The  $K^+$  plays role in enzyme activation, protein synthesis and photosynthesis (Mezei *et al.*, 1995; Tariq *et al.*, 2011).

High internal  $K^+$  concentration can dampen extreme sudden environmental events like cold, frost, late season rains, high salt stresses and heat waves (Kant & Kafkafi, 2004; Iqbal *et al.*, 2011). Soluble Ca can improve crop production. Calcium affects the opening of K channels in leaves, especially guard cells by working as secondary messenger. Calcium increases ammonium, potassium and some other monovalents absorption through 'Viets Effect' (Fenn & Feagley, 1999; Jacobson *et al.*, 1960).

The objective of the present study, therefor, was to determine the effect of calcium and potassium on potato growth and tuber.

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## Materials and Methods

This work was carried out at a private farm in Delta Nile region, Menofia Governorate, Egypt, during 2013 and 2014 seasons. Chemical and physical properties of the soil and organic fertilizer analyses are presented in Tables 1 and 2.

**Table 1:** Chemical and physical analyses of soil site.

A- Chemical composition of the experimental soil.

pH	ECdm <sup>2</sup> /c m	CaCO <sub>3</sub> %	Cation meq/l				Anion meq/l			N Ppm	P ppm	K Ppm
			Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub>	Cl <sup>-</sup>	SO <sub>4</sub>			
8.1	0.65	2.30	1.05	0.40	2.15	0.36	1.11	2.07	1.13	50	25	370

B-Physical properties of the experimental area soil.

OM%	Sand%	Silt%	Clay%	Soil texture
1.14	43.2	10	36.88	Loamy

**Table 2:** Chemical analysis of the used organic fertilizer.

%			ppm				OM%	C/N	EC dm <sup>2</sup> /cm	pH
N	P	K	Fe	Mn	Zn	Cu				
0.96	0.79	1.00	165	220	100	90	61.5	1/20	4.3	6.8

Potato (*Solanum tuberosum*. L) cv. Spounta was planted on February 12<sup>th</sup> and 10<sup>th</sup> in the first and second growing seasons, respectively. Tuber yield was harvested in the following May. Potato tuber seeds were planted in rows 75cm apart and in pits spacing 30cm. Tubers seeds were imported from France under license of Egyptian Agricultural Ministry.

### Fertilizer treatments:

The calcium nutrient was added in two forms, one in gypsum form (CaSO<sub>4</sub>) at rate of 500 kg/feddan for all treatments. Other form was of calcium nitrate at rates of 0, 10, 20 kg as net calcium per feddan with the first irrigation time after planting date.

The potassium nutrient was added in the form of potassium sulfate (K<sub>2</sub>SO<sub>4</sub>) at rate of 0, 25, 50, 75 kg as net potassium per feddan. Potassium fertilizer was divided into two halves. One half was applied before the first irrigation time after planting date and the second half was applied before the following irrigation time. The organic fertilizer was added as farmers application, i.e. ten days before sowing at two levels, i.e. 15m<sup>2</sup> and 20 m<sup>2</sup> per feddan

### Experimental design and statistical analysis:

The experiment included twelve treatments which were the combination between 3 application rates of calcium fertilizer (0, 10, 20 kg/feddan of net Ca) and 4 rates of potassium fertilizer (0, 25, 50, 75 kg/feddan of net K). The treatments were arranged in complete block design. Each treatment was replicated 3 times in plots at 20 m<sup>2</sup> for each. The obtained data was subjected to analysis of variance as described by Snedecor and Cochran (1980) using MSTAT microcomputer statistical program. Least significant difference (LSD) at 5% level was used to differentiate between means.

### Data recorded on potato plants:

#### Vegetative growth data:

After 60 days from planting date five plants from each plot were randomly chosen and subjected to recording the following parameters.

#### Leaf chlorophyll content:

Ten leaves (3<sup>rd</sup> leaf) from plant apex which recently full expanded were subjected to chlorophyll content readings as SPAD via 501 MINOLTA device. SPAD readings were transformed to mg/m<sup>2</sup> according to the equation: Chl. = - 80.05 + 10.40 [SPAD – 502] (Monje and Bugbee, 1992).

#### Plant dry weight:

After recording leaf chlorophyll reading, the same plants were rooted out and individually placed in paper bags and immediately carried to the lab and dried at 70°C for 36hrs and weighed for recording dry weight.

#### Number of branches and average stem length:

In the same time of collection of leaf's chlorophyll content data, the same five plants were subjected to recording the parameters of average stem length and branch number per plant.

#### Plant chemical content:

After determination of plant dry weight, plants were ground to fine powder and 0.2g from its was digested by using H<sub>2</sub>SO<sub>4</sub>. The digestion solution was subjected to nitrogen phosphorus, potassium and calcium analyses. Nitrogen was analyzed using microkjeldahl apparatus as described by Black *et al.* (1965). Whereas potassium and calcium were analyzed by flame photometrically method according to Potassium concentration as mg/g dry weight, using absorption flame spectrophotometer to the method described by Brown and Lilliland, (1946).

Also phosphorus content of plant extract was analyzed colormetrically according to Taussky and Shorr (1952).

#### Data collected on tubers:

At harvest, after 110 days from planting, tubers were harvested from each plot separately and then the following data were recorded: tuber yield per feddan, average tuber weight, tuber specific gravity and dry weight for each treatment. The percent of infected tubers with internal brown spots (IBS) were determined.

### Results and Discussion

#### Plant growth:

Data in Table (1) showed that application level of calcium or potassium did not significantly affect plant stem number during the two experimental seasons. With regard to combination between Ca and K application, treatment at level of 75 kg net K/ feddan and zero Ca produced the highest stem number per plant. Also, the same results were obtained with treatments of 10, 20 kg Ca and 50, 75 kg K/ feddan. Data in the two experimental seasons followed the same trend. Calcium is a key component of cell walls, helping to build a strong structure and ensuring cell stability, also important for cell elongation. This result agree with Kelling and schulte, (2004) Mahmoud and Mahrous and (2010), Seny *et al.* (2011) and Shams *et al.* (2012).

**Table 1:** Effect of calcium and potassium fertilization level on average stem number per plant during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season( 2013)				2 <sup>nd</sup> season (2014)			
	Ca levels kg/feddan							
	Control(0)	10	20	Mean	Control(0)	10	20	Mean
K levels kg/*feddan								
Control (0)	3b	4ab	4ab	3.67A	3b	3a	4ab	3.33A
25	4ab	4ab	4ab	4.00A	3b	3a	4ab	3.33A
50	4ab	5a	5a	4.67A	4ab	4ab	5a	4.33A
75	5a	5a	5a	5.00A	4ab	5a	5a	4.67A
Mean	4.0A	4.5A	4.5A		3.5A	3.75A	4.5A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (2) showed that, 20 net kg Ca per feddan stimulated the stem length compared to control in the first season and the same trend were obtained in the second season. Meanwhile potassium application at 50or 75kg/feddan significantly improved stem length compered to control in the two experimental seasons. With regard to combination between Ca and K application, treatment at 75 kg net K/ feddan and 10 kg Ca gave the highest stem length . Also , the same results were obtained in the treatments of 50 kg K/feddan and 20 kg Ca. Data in the two experimental seasons followed the same trend. Calcium is important for cell division. This result agree with Kelling and schulte (2004), Mahmoud and Mahrous (2010), Seny *et al.* (2011) and Shams *et al.* (2012).

Data in Table (3) showed that 20 net Ca kg per feddan improved the plant dry weight compared to control. Meanwhile potassium application at 75 kg per significantly increased dry weight compared to control. With regard to combination between Ca and K application treatment at 75 kg net K/ feddan and 10 or 20 kg Ca gave

the highest value of plant dry weight. Data in the two experimental seasons followed the same trend. As fertilization with Ca and K increases, total dry weight increases, too. The obtained results are consistent with the findings of Haghighi *et al.* (2011). Torkaman *et al.* (2005) stated that fertilization could sustain photosynthetic tissues and thus total dry weight would increase. This result agree with Mahmoud and Mahrour (2010), Barghi *et al.* (2012) and Mahmoud and Tayeb, (2014).

**Table 2:** Effect of calcium and potassium fertilization level on average stem length during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	37.08j	40.43hi	43.62fg	40.38B	35.56f	38.00ef	40.31d	37.96B
25	39.95ij	42.02gh	45.55ef	42.51B	37.34f	40.45d	42.53cd	40.11B
50	46.13de	48.06bc	50.34ab	48.18A	40.78d	44.73bc	46.14ab	43.89A
75	45.97de	49.00b	51.46a	48.81A	41.58d	48.00a	46.00ab	45.19A
Mean		44.88B	47.74A		38.82B	42.79AB	43.75A	37.96B

\* Feddan = 4200 m<sup>2</sup>

**Table 3:** Effect of calcium and potassium fertilization level on average plant dry weight during Seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	30.65g	35.43f	36.00ef	34.03C	26.13g	31.87f	34.89d	30.96C
25	37.46e	37.32e	40.57d	38.45B	30.42f	34.61de	36.00d	33.68B
50	46.35c	47.85b	50.62a	48.27A	31.64f	35.95d	39.25bc	35.61B
75	47.68bc	49.36ab	51.09a	49.38A	37.75c	40.53ab	42.00a	40.09A
Mean	40.54B	42.49A	44.57A		32.18C	35.05B	38.04A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (4) showed that the Ca application level 20 net kg per feddan enhanced the chlorophyll content compared to control. Meanwhile potassium application at any level encouraged chlorophyll content compared. With regard to combination between Ca and K application treatment of 75 kg net K/ feddan and 20kg Ca showed the highest chlorophyll content. The same results, were obtained with the treatments of 50 kg K/feddan and 20 kg Ca. Potassium role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic. These results are in agreement with those Abd-ELatief *et al.* (2011), Dkhil *et al.* (2011) and Eleiwa *et al.* (2012).

**Table 4:** Effect of calcium and potassium fertilization level on average chlorophyll content mg/m<sup>2</sup> during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	294.6h	307.2g	341.5e	314.43C	287.1h	301.2g	327.5ce	305.27C
25	310.7g	330.9f	356.1ac	332.56B	304.4g	315.3f	339.2ab	319.63B
50	331.8f	350.6cd	360.4a	347.60A	316.6f	336.2bc	346.7ab	333.17A
75	346.4de	354.7bcd	363.8a	354.97A	320.9ef	339.4ab	347.8a	336.03A
Mean	320.88C	335.85B	355.45A		307.25C	323.03B	340.30A	

\* Feddan = 4200 m<sup>2</sup>

### Chemical composition:

Data in Table (5) showed that all tested Ca and K application levels increased significantly nitrogen concentration compared to control. As for the combination between Ca and K, addition of 50 or 75 kg K/feddan with 20 kg Ca/feddan resulted in the highest nitrogen concentration in potato plant. The increasing nitrogen percent due to increasing the levels of potassium fertilizer application may be due to the role of potassium on plant nutrition, i.e. promotion of enzyme activity and enhancing the translocation of assimilates and protein synthesis. In this connection, El-Said, (1999) and Awad, (2005) reported similar results. Recent findings show that calcium has a direct and positive effect on nitrogen assimilation, which increases content of nitrogen with activating the enzymes responsible for N assimilation (Lopez-Lefebvre *et al.*, 2000). This result is in agreement with that of Tan, (2005), Abong *et al.* (2011) and Ekin, (2011). Calcium also is required for stability of pectin in cell wall (Shams *et al.*, 2012).

Data in Table (6) showed that the phosphors concentration increased in potato plant, due to Ca and K application compared to control. With regard to combination between Ca and K application 50 or 75 kg

K/feddan with 20kg Ca/feddan gave the highest phosphors concentration in potato plant. In this connection, El-Said (1999) and Awad(2005) reported that highest content of P It is very important to the essential process of metabolism in the body. Phosphorus is a constituent of the nucleoproteins (Wiley, 2006). This result is in agreement with Tan (2005), Awad (2005) and Abd El-Latif *et al* (2011).

**Table 5:** Effect of calcium and potassium fertilization level on nitrogen (%) of plant during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	1.94g	2.09f	2.31d	2.11B	1.89e	2.30c	2.46c	2.23C
25	2.16ef	2.53c	2.74b	2.48A	2.11d	2.53b	2.85a	2.49C
50	2.28de	2.64bc	2.95a	2.62A	2.34c	2.81a	2.94a	2.69AB
75	2.31d	2.63bc	2.90a	2.61A	2.53b	2.89a	2.93a	2.78A
Mean	2.17C	2.47B	2.73A		2.23B	2.63A	2.79A	

\* Feddan = 4200 m<sup>2</sup>

**Table 6:** Effect of calcium and potassium fertilization level on phosphors (%) of plant during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	0.21d	0.27cd	0.31abd	0.26A	0.19f	0.24de	0.30c	0.24C
25	0.26d	0.29cd	0.35a	0.30A	0.23e	0.25d	0.32b	0.27B
50	0.27cd	0.34ab	0.36a	0.32A	0.29c	0.36a	0.36a	0.34A
75	0.27cd	0.33ab	0.36a	0.32A	0.30c	0.35b	0.35b	0.33A
Mean	0.25BC	0.31AB	0.35A		0.25B	0.30A	0.33A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (7) showed Ca or K application insignificantly increased potassium concentration in potato plant. With regard to combination between Ca and K application, all interaction treatments had slight effects on potassium concentration in potato plant. The extent in yield increase seemed considerable to a level which led to increase uptake of K-uptake. Increasing the levels of potassium fertilizer application may be due to the role of potassium on plant nutrition, i.e. promotion of enzymes activity and enhancing the translocation of assimilates and protein synthesis. In this connection similar results were reported by El-Said (1999), Awad (2005) and Noda *et al* (2005). Potassium plays a vital role in maintaining the turgidity of plant cells. Because of its very importance in turgor maintenance, potassium is essential to obtain maximum leaf extension and stem elongation. (Abd El-Latifa, *et al.*, 2011).

**Table 7:** Effect of calcium and potassium fertilization level on potassium (%) of plant during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	1.87c	1.90bc	1.96abc	1.91A	1.69a	1.96abc	1.79a	1.73A
25	1.98abc	2.00abc	2.30abc	2.09A	1.83a	2.30abc	1.99a	1.92A
50	2.40abc	2.50abc	2.64ab	2.51A	1.90a	2.64ab	2.20a	2.07A
75	2.50abc	2.60abc	2.70a	2.60A	2.11a	2.70a	2.39a	2.25A
Mean	2.19A	2.25A	2.40A		1.88A	2.40A	2.09A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (8) showed that Ca or K application level increased calcium concentration in potato plant. Application of 10 kg Ca/feddan combined with 75K/feddan gave the highest Ca concentration. Awad 2005, Noda *et al* (2005) and Abd El-Latif *et al* (2011) reported similar results. Calcium is transported in xylem from root to upper parts of plant by transpiration force. The calcium content in leaves was enhanced by the increase of calcium concentration within nutrition (Shams *et al.*, 2012).

**Table 8:** Effect of calcium and potassium fertilization level on calcium (%) of plant during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
	K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20
Control(0)	0.48f	0.51e	0.47cd	0.52b	0.41f	0.46de	0.47cd	0.45B
25	0.54d	0.55d	0.49c	0.57a	0.43ef	0.49c	0.49c	0.47B
50	0.60bc	0.61a	0.53b	0.61a	0.47cd	0.53b	0.53b	0.51A
75	0.59c	0.61a	0.52b	0.60a	0.48cd	0.57a	0.52b	0.52A
Mean	0.55B	0.57B	0.50A		0.45C	0.51A	0.50A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (9) showed that increased calcium level to 20kg Ca net /feddan increased average potato tuber yield. Increased potassium level to 75 kg K net /feddan increased the average potato tuber yield per. With regard to combination between Ca and K application, 75kg K net /feddan and 20kg Ca produced the highest potato tuber yield per feddan compared to control. Potassium plays a key role in increasing crop yield and improving the quality of produce (El-Gamal, 1985 ), This result is in agreement with that of Wada *et al.* (1996), Boliglowa, (2003) , Danilchenko *et al.* (2005) and Mahmoud and Mahrous, ( 2010). The satisfactory influence of Ca and K application might be due to their favorable effects on plant growth (Tables 1, 2 and 3), Chlorophyll (Table 4) and minerals (Table 5, 6, 7 and 8).

**Table 9:** Effect of calcium and potassium fertilization level on average potato tuber yield (ton per faddan) during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	10.7h	11.1h	11.2a	11.00C	9.9e	10.4e	11.3d	10.53C
25	11.9g	12.3ef	12.6ce	12.27B	10.4e	10.9de	12.00cd	11.10BC
50	12.0fg	12.9bce	13.5a	12.8AB	11.0d	11.6cd	12.7ab	11.77B
75	12.6ce	13.2abc	13.6a	13.13A	12.1bc	12.8a	13.2ab	12.70AB
Mean	11.80B	12.38AB	12.73A		10.85C	11.43B	12.30AB	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (10) showed that increased calcium level from zero to 20kg Ca net /feddan increased average tuber weight by 14% compared to control. Increased potassium level at 75 kg K net /feddan increased average tuber weight by 27% compared to control. With regard to combination between Ca and K application treatment at 75kg K net /feddan and 20kgCa increased significantly average tuber weight by 49% compared to control. Many researchers recorded an increase in potato tubers yield as a result of increasing the levels of potassium (K) fertilization. Such increases in yield of potato tubers was either due to the formation of large size tubers or increasing of the number of tubers per plant or both as reported by El-Gamal, (1985) and Humadi, (1986), This result agree with that of Clough(1994).

**Table 10:** Effect of calcium and potassium fertilization level on average tuber weight (g per tuber) during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season (2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	120.3h	130.7f	138.6c	130.43D	110.6e	125.4d	138.6c	124.87C
25	127.9g	136.9e	145.3bc	138.20C	127.4d	139.6c	145.3bc	137.43BC
50	136.4ef	150.3c	150.0b	151.57B	138.1c	148.2b	150.0b	145.63B
75	145.6cd	160.7b	165.3a	158.80A	149.8b	161.0a	165.3a	158.70A
Mean	132.55C	144.65B	149.95A		131.48B	143.55A	149.95A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (11) showed that increased calcium level did not significantly affect the specific gravity of potato tubers Potassium application increased the specific gravity, however such effect was insignificant in the second season. Increased Ca with K application significantly increased specific gravity. This result is in agreement with that of Herlihy and Carroll, (1969), Losascio *et al.* (1991) and Clough, (1994).

**Table 11:** Effect of calcium and potassium fertilization level on specific gravity during seasons of 2013 and 2014.

Treatments	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	1.053c	1.057c	1.059c	1.056B	1.057c	1.058bc	1.061bc	1.059A
25	1.060c	1.063bc	1.069bc	1.064B	1.060bc	1.063bc	1.066abc	1.063A
50	1.067bc	1.070bc	1.074ab	1.070A	1.064bc	1.068ab	1.069ab	1.067A
75	1.078ab	1.084a	1.086a	1.083A	1.066ab	1.069ab	1.077a	1.071A
Mean	1.064A	1.068A	1.072A		1.062A	1.065A	1.068A	

\* Feddan = 4200 m<sup>2</sup>

Data in Table (12) showed that increased calcium or potassium level significantly decreased the percent of infected tubers with internal brown spots (IBS). Calcium-enriched cell walls are more resistant to bacterial or fungal attack. Calcium also helps the plant adapt to stress by influencing the signal chain reaction when stress occurs. Increased combined Ca and K application level significantly decreased IBS. Potassium plays a key role

in increasing crop yield and improving the quality of produce (El-Gamal,1985 ), This result agree with Silva *et al* (1991), Clough, (1994), calcium also increases the tubers' resistance to soft rot during storage and may improve the performance of seed potatoes (Waterer, 2005).

**Table 12:** Effect of calcium and potassium fertilization level on average percent of infected tubers with internal brown spots (IBS%) during seasons of 2013 and 2014.

Treatments	(RDS%) during seasons of 2013 and 2014.							
	1 <sup>st</sup> season(2013)				2 <sup>nd</sup> season(2014)			
	Ca levels kg/feddan							
K levels kg/*feddan	Control(0)	10	20	Mean	Control(0)	10	20	Mean
Control(0)	20.32j	14.62g	8.47d	14.47D	27.46k	20.76i	9.32d	19.18D
25	18.46i	13.01f	7.36c	12.94C	21.53j	14.37f	10.56e	15.48C
50	16.00h	12.64f	6.72b	11.78B	18.78h	9.21d	7.48b	11.82B
75	15.84h	9.21e	5.24a	10.09A	17.41g	8.37c	4.29a	10.02A
Mean	17.65C	10.12B	6.94A		21.29C	13.17B	7.91A	

\* Feddan = 4200 m<sup>2</sup>

## Conclusion

The results of this study showed that calcium and potassium fertilization enhance potato growth and yield. The treatment 75 of potassium net kg/feddan and 20calcium net kg/feddan had significantly increased potato growth and yield. Our experimental results should provide useful information for the calcium and potassium fertilization to make better use of potato plant.

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