

## Effect of Different Rates of Potassium Fertilizer on the Growth, Productivity and Quality of Some Broccoli Cultivars under New Reclaimed Soil Conditions

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**Abstract:** Two field experiments were conducted at the agricultural experimental station of National Research Centre, at El-Nobaria region, Beheira Governorate, Egypt, during two successive winter seasons 2012/2013 and 2013/2014 to study the effect of different rates of potassium fertilizer (20, 40 and 60 kg K<sub>2</sub>O/fed.) on growth, production and quality of three broccoli cultivars, i.e., Calabrese American, Calabrese France and Southern Star Hybrid in sandy soil under drip irrigation system.

Results indicate that Southern Star Hybrid cultivar was superior in its vegetative growth; i.e., leaves number, fresh weight of spears and total plant; main spear yield; physical head quality, (mean head weight and head diameter); chemical head quality (vitamin C); N% in leaves and stems; P% in stems and spears as well as K% in stems and spears followed by Calabrese France and Calabrese American, respectively. On the other hand, Calabrese American were the tallest plants, heaviest leaves and stems fresh weight, highest leaves and spears dry weight and best TSS but Southern Star hybrid heads were the best vitamin C content and Calabrese France cultivar gave the highest values of branches number, stem dry weight and protein percentage.

Potassium levels differed statistically in their effect on the vegetative growth of broccoli plants (plant height, leaves numbers per plant, fresh weight of leaves, stems and spears; dry weight of leaves, stems and spears; main spear yield; physical heads quality (weight, height and diameter); chemical head quality (TSS, vitamin C and protein percentage); N, P and K% of leaves, stems and heads. The highest vegetative growth was obtained by adding 40 kg K<sub>2</sub>O/fed., followed by 60 kg K<sub>2</sub>O/fed., which came in the second order. The lowest values of vegetative growth; main head yield; physical heads quality and N, P and K of broccoli leaves, stems and heads were obtained by 20 kg K<sub>2</sub>O/fed. The results indicated that combined effect of cultivars and mineral potassium levels caused statistical increases in vegetative growth, yield, physical heads quality; N% in stems and K% leaves of broccoli. The highest vegetative growth, yield and chemical contents were obtained by the combined effect of Southern Star Hybrid cultivar with 40 units K<sub>2</sub>O/fed.

**Keywords:** Broccoli, Cultivars, K fertilizer, Yield, Quality, TSS, Vitamin C and Protein.

## Introduction

Broccoli is annual crop which grown to green maturity in about 75 to 95 days, depending on cultivar, season and nutrition. The whole immature inflorescence (head) is the edible portion, with the floret tissue most often being consumed. It could be an important vegetative crop for local consumption and exportation. The higher prices of its heads could be profitable for vegetable growers. The recent increase in broccoli consumption as well as in transportation introduce broccoli to cover more area in the vegetable rotation. Although, of broccoli known and used in the American and European countries for many decades has not gained the same attention in Egypt. One reason could be related to the lack of information about the nutritive value<sup>1</sup>.

Broccoli is a rich source of health promoting phytochemicals<sup>2, 3</sup>. Epidemiological studies have shown an inverse association between the consumption of Brassica vegetables and the risk of cancer<sup>4</sup>. Of the case-controlled studies, 56% demonstrate a strong association between increased broccoli consumption and the protection against cancer<sup>5</sup>. This protective effect has largely been attributed to the complement of phytochemicals, in broccoli which include the vitamins C and E, the flavones quercetin and kaempferol, the carotenoids  $\beta$ -carotene, lutein and the glucosinolates<sup>6</sup>. Broccoli is highly nutritious and has been deemed as anti-cancerous food by the American Cancer Society. It's a good source of vitamin A, calcium and vitamin B2<sup>7</sup>. Broccoli buds were found to be a rich source of most minerals especially of K, S, P, Mg and micro-elements<sup>1</sup>. More attention may be paid for studying its varieties, fertilization, irrigation and the other growing factors in Egypt.

Several investigators studied the role of potassium fertilization<sup>8, 9, 10, 11, 12</sup>. Other investigators dealt with broccoli cultivars under the different environmental conditions<sup>14, 15, 16, 8, 17, 18</sup>. Under the Egyptian conditions some investigators evaluated broccoli cultivars<sup>1, 10, 11, 12, 18, 19</sup>.

The aim of this investigation was studying the evaluation of three broccoli cultivars under new reclaimed soil conditions and studying the effect of three levels of mineral potassium fertilizer on the vegetative growth, total yield and quality of heads as well as nutrients contents.

## Materials and Methods

Two field experiments were conducted at the experimental station of National Research Centre, Nubaria, Beheira Governorate, Egypt during two successive winter seasons of 2012/2013 and 2013/2014 to study the effect of cultivars variation, potassium rates and their interactions on the vegetative growth, yield and quality of broccoli (*Brassica oleracea* var. *italica plenck*).

Seeds of three broccoli cultivars, i.e., Calabrese American, Calabrese France and Southern Star Hybrid were sown in foam trays. The recommended treatments of nursery growing transplants were followed till planting dates. Seedlings were transplanted after 45 days.

**Table (1): Physical and chemical properties of the experimental soil during the two successive seasons (2012/2013 and 2013/2014).**

A. Physical properties												
Season	Sand %		Clay %		Silt %		Soil texture					
1 <sup>st</sup>	55.85		3.45		40.70		Sandy clay loam					
2 <sup>nd</sup>	57.72		3.72		38.56		Sandy clay loam					
B. Chemical properties												
Season	E.C. (ds/m)	pH	OM (%)	CaCO <sub>3</sub> (%)	Cations ( Meq./L )				Anions ( Meq./L )			
					Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>
1 <sup>st</sup>	1.22	7.83	0.62	9.2	7.61	2.80	4.64	1.21	Nil	1.90	1.96	12.40
2 <sup>nd</sup>	1.26	7.78	0.57	9.8	7.53	2.70	3.84	1.13	Nil	1.40	1.60	12.20

The area of the experimental plot was 10.5 m<sup>2</sup> consisted of three rows, each row was 3.5 m length and 1m width and distance between plants 50 cm. Drip irrigation system was used. Agricultural practice, disease and pest control programs took place during growth period according to the recommendations of Egyptian Ministry of Agriculture. Physical and chemical analysis of soil samples was followed according to <sup>20</sup> and illustrated in Table (1).

### **Experimental treatments:**

**A) – Cultivars:** Three broccoli cultivars (Calabrese American, Calabrese France and Southern Star Hybrid) were used.

**B) – Potassium rates:** Potassium was applied at a rate of 20, 40 and 60 K units per fadden (4200m<sup>2</sup>).

### **Measurements:**

**I) - Vegetative growth parameters:** A random sample of five plants was taken from each experimental treatment at 70 days after transplanting and the following data were recorded during the two seasons, i.e., plant height, leaves number, branches number, fresh and dry weight of leaves, stems and spears.

**II) - Heads yield:** All broccoli heads of each plot were harvested at mature stage in order to record this data:-

- Main yield of the apical heads.

### **III) – Physical and chemical quality of main heads:**

**1) - Physical head quality:** Broccoli heads of each plot were harvested at mature stage to record these parameters, i.e., Mean head weight, head diameter and head height.

#### **2) - Chemical head quality:**

**A. Nutritional value:** The following determinations were done in the Primary heads at maturing stage.

- Total soluble solid (T.S.S.) was determined by a hand refract-meter, according to the method described by<sup>21</sup>.

- Ascorbic acid (vitamin C) was determined as mg/100g fresh weight by using 2, 4, 6-di-chlorophenol-indophenol method described in<sup>22</sup>.

- Protein Percentage.

**B. Chemical contents:** The percentages of nitrogen, phosphorus and potassium in the acid digested samples of dry leaves, stems and heads of broccoli at 90 days after transplanting were determined by<sup>20</sup>. Nitrogen was determined by the modified micro Kjeldahl method, phosphorous was determined colorimetrically by NH<sub>4</sub>-Metavanidate method. Potassium was estimated Flame-Photometrically.

**The experimental design:** Split-plot design with three replicates was followed. Cultivars were assigned in the main plots and potassium rates were arranged in the sub-plots.

**Statistical analysis:** Data of the experiment was arranged and statistically analyzed using Mstatic (M.S.) software<sup>23</sup>. The comparison among means of the different treatments was determined, as illustrated by<sup>24</sup>.

## Results and Discussion

### I. Vegetative growth parameters

**A. Effect of cultivars:** Data of Table (2) reveal that there were significant differences within cultivars vegetative growth. Plants of Calabrese American cultivar were the tallest plants, heaviest leaves and stems fresh weight, highest leaves and spears dry weight compared with Calabrese France or Southern Star Hybrid. On the other hand, Southern Star Hybrid was denser leaves followed by Calabrese France and Calabrese American without significant differences between two cultivars of Southern Star and Calabrese France. Similarly, branches number of Calabrese France and Calabrese American plants was significantly higher than Southern Star Hybrid branches without significant differences between the first two cultivars. Fresh weight of leaves, stems, spears and whole plant were significant differences between three cultivars. Calabrese American cultivar recorded higher and significant values for fresh weight of leaves and stems compared with the other two cultivars follow it Calabrese France but Southern Star cultivar is superior in fresh weight of spears and whole plants. Dry weight of leaves and spears of Calabrese American recorded higher and significant values compared with the other two cultivars. Stems dry weight of Calabrese France plants was significantly highest compared with other two cultivars. The lowest values of dry weight of leaves, stems and spears were recorded by Southern Star Hybrid plants. Results of the two seasons were similar in most cases. It could be concluded that Southern Star Hybrid recorded higher values of vegetative growth expressed as leaves number and fresh weight of spears and whole plants. Some investigators studied the differences among cultivars vegetative growth under Egyptian conditions. They recorded wide variations among vegetative growth of the different cultivars<sup>1, 10, 11, 18, 12</sup>. Similar results were recoded by<sup>15, 25, 9, 26, 27, 28</sup>.

**B. Effect of potassium levels:** Data in Table (3) indicated that potassium fertilization enhanced vegetative growth of broccoli plants. Vegetative growth of broccoli plants was activated by the increased potassium levels up to level, i.e. 40 K units/ fed. The highest vegetative growth of broccoli plants expressed as plant height and fresh weight of leaves, stems, spears and total plant were obtained by the application of 40 K unit/ fed followed by plants which received 20 K unit/ fed came in the second order (Table 3). In general, lower values of plant growth were obtained by 60 K unit/ fed. The same trend was observed over both growing seasons.

Many investigators reported generally that, mineral fertilizer increase vegetative growth<sup>28, 29</sup>. It is obvious to mention that Potassium is necessary in young growing tissues for cell elongation and possibly for cell division. Potassium is very mobile in plants and therefore circulates freely and has vital role in maintenance of turgor pressure. It also helps in several physiological processes and uptake of other nutrient elements<sup>30</sup>.

**Table (2): Effect of cultivars on vegetative growth and dry weight in leaves, stems and spears of broccoli during the two successive seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	Plant Height (cm)	Leaves No./ plant	Branches No./ plant	Fresh weight (g /100 g FW)				Dry weight (g /100 g FW)		
				Leaves	Stems	Spears	Total	Leaves	Stems	Spears
<b>First season (2012/2013)</b>										
Calabrese American	69.22	16.39	14.56	853.55	339.10	131.81	1324.46	16.21	11.99	14.73
Calabrese France	66.22	18.11	16.33	796.81	335.91	224.77	1357.49	15.41	12.65	14.64
Southern Star H.	54.44	18.78	7.33	652.06	275.61	475.14	1402.81	13.31	9.30	12.41
L.S.D at 0.05	2.66	0.97	2.41	21.12	10.95	35.67	44.83	1.12	0.38	0.40
<b>Second season (2013/2014)</b>										
Calabrese American	70.33	17.89	15.33	854.44	362.76	137.70	1354.90	16.71	12.29	14.71
Calabrese France	67.89	19.33	17.22	803.81	337.91	235.32	1377.05	15.72	12.91	14.84
Southern Star H.	55.44	19.78	8.44	657.95	277.61	480.14	1415.70	13.64	9.72	12.80
L.S.D at 0.05	1.32	0.53	0.53	16.47	4.68	33.94	32.92	0.20	0.19	0.29

**Table (3): Effect of potassium levels on vegetative growth and dry weight in leaves, stems and spears of broccoli during the two successive seasons (2012/2013 and 2013/2014).**

Potassium Levels (K <sub>2</sub> O unit/fed.)	Plant Height (cm)	Leaves No./ plant	Branches No./ plant	Fresh weight (g /100 g FW)				Dry weight (g /100 g FW)		
				Leaves	Stems	Spears	Total	Leaves	Stems	Spears
<b>First season (2012/2013)</b>										
20	63.22	18.50	15.56	763.91	301.91	236.64	1302.46	15.30	10.83	14.29
40	64.78	17.50	12.00	870.40	355.68	337.14	1563.21	14.54	11.29	13.52
60	61.89	17.28	10.67	668.12	293.03	257.94	1219.09	15.09	11.81	13.97
L.S.D at 0.05	1.37	0.52	2.19	25.42	8.72	41.26	55.18	N.S.	0.36	0.40
<b>Second season (2013/2014)</b>										
20	64.22	19.67	16.22	768.13	308.91	242.09	1319.13	15.57	11.03	14.27
40	66.44	18.89	13.11	872.40	367.12	343.69	1583.21	15.03	11.72	13.80
60	63.00	18.44	11.67	675.67	302.25	267.38	1245.31	15.47	12.18	14.28
L.S.D at 0.05	1.00	0.46	0.64	24.60	6.31	30.98	36.81	0.27	0.21	0.25

This can be explained based on K is an essential nutrient for plant growth and plays an important role in many metabolic processes<sup>31</sup> such as photosynthesis, use of water<sup>32</sup> and synthesis of amino acid and protein as well as translocation of sugars and assimilates within the plant and the accumulation of high molecular carbohydrates<sup>33, 34</sup> necessary for fruit formation and development<sup>35</sup> which leads to increase plant growth and yield. These results are in accordance with<sup>36</sup>.

Some investigators studied the differences among cultivars vegetative growth of broccoli under Egyptian conditions. They recorded wide variations among vegetative growth of the different broccoli cultivars<sup>1, 10, 11, 12</sup>. Similar results were recorded by<sup>15, 37, 38, 25, 9, 26, 27</sup>.

**C. Effect of the interaction:** Data tabulated in Table (4) indicated that vegetative growth characteristics of broccoli plants were widely and statistically affected by the combined effect of cultivars and potassium levels. Calabrese American plants fertilized with 60 Kg K<sub>2</sub>O/ feddan recorded the tallest broccoli plants follow by Calabrese France cultivar in the second order, respectively. On the contrary, the shortest plants were recorded by Southern Star Hybrid plants which received 60 Kg K<sub>2</sub>O/ feddan. Higher values of leaves number were recorded by Calabrese France cultivar when fertilized 20 Kg K<sub>2</sub>O/ feddan follow by Southern Star Hybrid when fertilized with 40 Kg K<sub>2</sub>O/ feddan without significantly difference. The highest values of branches number was recorded by Calabrese American plants which received 20 Kg K<sub>2</sub>O/ feddan. Fresh weight of leaves, stems, spears and whole plant were significant differences between three cultivars and potassium levels. Calabrese American cultivar which received 40 Kg K<sub>2</sub>O/ feddan recorded higher and significant values for fresh weight of leaves compared with the other two cultivars follow it Calabrese France. The highest values of stems fresh weight were recorded by Calabrese France cultivar which received 40 Kg K<sub>2</sub>O/ feddan but Southern Star plants which fertilized by 40 Kg K<sub>2</sub>O/ feddan is superior in fresh weight of spears and whole plants.

**Table (4): Effect of interaction between cultivars and potassium levels on vegetative growth and dry weight of broccoli during two seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	Potassium Levels (K <sub>2</sub> O unit/fed.)	Plant Height (cm)	Leaves No./ plant	Branches No./ plant	Fresh weight (g /100 g FW)				Dry weight (g /100 g FW)		
					Leaves	Stems	Spears	Total	Leaves	Stems	Spears
<b>First season (2012/2013)</b>											
Calabrese American	20	67.00	17.17	21.33	840.11	335.50	134.78	1310.39	16.85	11.74	15.04
	40	68.00	15.83	12.67	958.41	360.97	136.07	1455.45	15.18	11.38	13.29
	60	72.67	16.17	9.67	762.12	320.81	124.58	1207.52	16.59	12.86	15.87
Calabrese France	20	68.67	19.67	18.33	852.10	302.11	172.36	1326.57	14.13	11.61	14.66
	40	70.33	17.67	15.33	891.98	402.57	280.47	1575.01	16.55	12.58	15.65
	60	59.67	17.00	15.33	646.36	303.06	221.47	1170.90	15.56	13.74	13.60
Southern Star Hybrid	20	54.00	18.67	7.00	599.51	268.11	402.79	1270.41	14.92	9.13	13.16
	40	56.00	19.00	8.00	760.80	303.50	594.88	1659.18	11.89	9.92	11.63
	60	53.33	18.67	7.00	595.87	255.22	427.75	1278.84	13.13	8.84	12.44
<b>L.S.D at 0.05</b>		2.38	0.91	3.80	44.03	15.10	71.47	95.58	1.60	0.62	0.69
<b>Second season (2013/2014)</b>											
Calabrese American	20	68.00	18.67	21.67	842.11	352.50	141.12	1335.73	17.35	11.94	14.58
	40	69.00	17.33	13.67	957.07	391.31	142.40	1490.78	15.68	11.71	13.49
	60	74.00	17.67	10.67	764.12	344.48	129.58	1238.19	17.09	13.23	16.07
Calabrese France	20	69.67	20.67	19.00	859.10	304.11	177.36	1340.57	14.33	11.81	14.86
	40	73.33	19.33	16.33	892.31	404.57	288.80	1585.68	17.08	12.98	15.85
	60	60.67	18.00	16.33	660.03	305.06	239.81	1204.90	15.76	13.94	13.80
Southern Star Hybrid	20	55.00	19.67	8.00	603.18	270.11	407.79	1281.08	15.02	9.33	13.36
	40	57.00	20.00	9.33	767.80	305.50	599.88	1673.18	12.32	10.46	12.06
	60	54.33	19.67	8.00	602.87	257.22	432.75	1292.84	13.56	9.38	12.97
<b>L.S.D at 0.05</b>		1.73	0.79	1.10	42.60	10.93	53.67	63.75	0.47	0.36	0.44

Dry weight of leaves recorded its highest values with Calabrese American plants which received 20 Kg K<sub>2</sub>O/ feddan and the highest values of stems fresh weight was obtained by Calabrese France cultivar. Also, the highest values of spears fresh weight were obtained by Calabrese American cultivar but the lower values were obtained by Southern Star Hybrid plants which received 40 Kg K<sub>2</sub>O/feddan.

Results of vegetative growth and dry weight content as affected by the interaction were true and nearly similar in the two seasons of the experiment. Similar results were recorded by<sup>39, 40, and 41</sup>.

## II. Total main head yield

**A. Effect of cultivars:** Table (5) indicated that higher values of total main head yield were recorded by Southern Star Hybrid followed by Calabrese France and Calabrese American, respectively. Results were similar and significant in the two seasons.

Some investigators evaluated broccoli cultivars under the Egyptian environmental condition<sup>1, 10, 11</sup>. Similar results were recorded by<sup>42, 25, 37, 38, 43, 44</sup>.

**Table (5): Effect of cultivars on main spear yield and head quality of broccoli during the two seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	Main Spears yield (ton/fed.)	Physical head quality			Chemical head quality		
		Weight (g)	Dia. (cm)	Height (cm)	T.S.S. (%)	Vit. C (mg/100g FW)	Protein (%)
<b>First season (2012/2013)</b>							
Calabrese American	1.107	131.81	10.46	12.98	8.04	81.07	25.82
Calabrese France	1.888	224.77	11.72	16.13	7.10	102.85	26.50
Southern Star Hybrid	3.991	475.14	16.01	14.48	7.80	112.99	25.41
L.S.D at 0.05	0.300	35.67	0.17	0.36	0.33	8.69	N.S.
<b>Second season (2013/2014)</b>							
Calabrese American	1.157	137.70	10.49	13.20	8.14	85.62	24.88
Calabrese France	1.977	235.32	11.80	16.27	7.36	105.74	25.50
Southern Star Hybrid	4.033	480.14	15.84	14.53	8.00	116.99	24.69
L.S.D at 0.05	0.285	33.94	0.61	0.42	0.11	4.09	N.S.

**B. Effect of potassium levels:** Table (6) indicated that higher values of total main head yield were recorded by 40 K unit/ fed followed by plants which received 60 K unit/ fed came in the second order, respectively. In general, lower values of total main head yield were obtained by 20 K unit/ fed. Results were similar and significant in the two seasons. Potassium in plants is necessary to increase the efficiency of photosynthesis and use of water<sup>32</sup>. Moreover, K<sup>+</sup> plays an important role in the synthesis of amino acid and protein as well as translocation of sugars and assimilates within the plant and the accumulation of high molecular carbohydrates<sup>33,34</sup>. In addition, it has activate the enzymes involved in biosynthesis of organic acids<sup>45</sup>, as well as accelerating translocation of carbohydrate necessary for fruit formation and development<sup>35</sup> which leads to increase plant growth and yield.

Many investigators reported generally that, the high N + low K treatment resulted in the best plant growth, the highest photosynthetic accumulation and curd yield, and chlorophyll and nitrogen content in the leaves were also the highest, while the sugar content was in middle as compared with the other treatments<sup>46</sup>.

**Table (6): Effect of potassium levels on main spear yield and head quality of broccoli during the two seasons (2012/2013 and 2013/2014).**

Potassium Levels (K <sub>2</sub> O unit/fed.)	Main Spears yield (ton/fed.)	Physical head quality			Chemical head quality		
		Weight (g)	Dia. (cm)	Height (cm)	T.S.S. (%)	Vit. C (mg/100g FW)	Protein (%)
<b>First season (2012/2013)</b>							
20	1.988	236.64	12.93	13.71	7.33	93.23	27.31
40	2.832	337.14	12.83	16.19	7.61	99.81	25.13
60	2.167	257.94	12.43	13.69	8.00	103.87	25.29
L.S.D at 0.05	0.347	41.26	0.18	0.22	0.28	2.71	1.04
<b>Second season (2013/2014)</b>							
20	2.034	242.09	12.91	13.87	7.48	96.67	26.64
40	2.887	343.69	12.77	16.33	7.82	103.81	24.47
60	2.246	267.38	12.46	13.80	8.20	107.87	23.95
L.S.D at 0.05	0.260	30.98	N.S.	0.52	0.19	2.64	0.93

**C. Effect of interaction:** Data of Table (7) illustrate that the combined effect of cultivars and potassium levels affected significantly the total main head yield of broccoli crop. Combined affect of Southern Star Hybrid with 40 K unit/ fed recorded the highest and significant total main heads yield of broccoli.

On the contrary, the lowest total main heads yield was obtained by Calabrese American cultivar which received 60 K unit/ fed. Calabrese France cultivar recorded medium values of the total main heads yield. These results were true and similar in the two seasons of the experiments. Some investigators studied the interaction of cultivars of broccoli plants and potassium levels<sup>46, 47</sup>.

**Table (7): Effect of the interaction between cultivars and potassium levels on main spear yield and head quality of broccoli during the two seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	K Levels (K <sub>2</sub> O unit/fed.)	Main Spears yield (ton/fed.)	Physical head quality			Chemical head quality		
			Weight (g)	Dia. (cm)	Height (cm)	T.S.S. (%)	Vit. C (mg/100g FW)	Protein (%)
<b>First season (2012/2013)</b>								
Calabrese American	20	1.132	134.78	10.55	11.97	7.70	77.52	26.65
	40	1.143	136.07	11.20	13.57	8.00	82.08	25.32
	60	1.047	124.58	9.62	13.40	8.43	83.60	25.50
Calabrese France	20	1.448	172.36	11.80	15.67	6.67	97.28	29.25
	40	2.356	280.47	11.37	18.83	7.07	103.36	25.23
	60	1.860	221.47	12.00	13.90	7.57	107.92	25.00
Southern Star Hybrid	20	3.383	402.79	16.43	13.50	7.63	104.88	26.02
	40	4.997	594.88	15.93	16.17	7.77	114.00	24.86
	60	3.593	427.75	15.67	13.77	8.00	120.08	25.36
<b>L.S.D at 0.05</b>		0.600	71.47	0.32	0.38	N.S.	N.S.	N.S.
<b>Second season (2013/2014)</b>								
Calabrese American	20	1.185	141.12	10.63	12.30	7.73	83.19	26.15
	40	1.196	142.40	11.20	13.90	8.07	86.08	24.82
	60	1.089	129.58	9.63	13.40	8.63	87.60	23.67
Calabrese France	20	1.490	177.36	12.00	15.73	6.87	97.95	28.25
	40	2.426	288.80	11.33	18.83	7.43	107.36	24.23
	60	2.014	239.81	12.07	14.23	7.77	111.92	24.00
Southern Star Hybrid	20	3.425	407.79	16.10	13.57	7.83	108.88	25.52
	40	5.039	599.88	15.77	16.27	7.97	118.00	24.36
	60	3.635	432.75	15.67	13.77	8.20	124.08	24.19
<b>L.S.D at 0.05</b>		0.451	53.67	0.73	0.89	N.S.	N.S.	N.S.

## II. Nutrients content

**A. Effect of cultivars:** Results in Table (8) revealed that N, P and K content of the leaves, stems and spears were statistically affected within cultivars. Southern Star Hybrid leaves, stems and spears recorded the highest N, P and K content. Calabrese American spears are superior in N content compared with other two cultivars. P and K percentages in leaves, stems and spears were with higher values in Southern Star Hybrid and lower in Calabrese France. Many investigators studied effect cultivars on vegetative growth of broccoli plants<sup>10, 11</sup>.



**Table (8): Effect of cultivars on N, P and K in leaves, stems and spears of broccoli during the two seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	N (%)			P (%)			K (%)		
	Leaves	Stems	Spears	Leaves	Stems	Spears	Leaves	Stems	Spears
	<b>First season (2012/2013)</b>								
Calabrese American	2.02	2.00	4.16	0.61	0.50	0.71	3.22	3.61	3.24
Calabrese France	1.85	1.80	4.08	0.49	0.50	0.80	2.79	3.49	3.30
Southern Star H.	2.45	2.32	3.91	0.57	0.75	0.98	3.10	3.64	3.48
L.S.D at 0.05	0.08	0.15	0.04	0.04	0.10	0.09	0.21	0.03	0.05
	<b>Second season (2013/2014)</b>								
Calabrese American	2.09	1.88	4.23	0.63	0.46	0.73	3.05	3.31	3.02
Calabrese France	1.89	1.82	3.89	0.50	0.40	0.81	2.84	3.19	3.10
Southern Star H.	2.32	2.27	3.78	0.59	0.65	1.00	2.86	3.34	3.27
L.S.D at 0.05	0.07	0.14	0.09	0.02	0.05	0.07	0.07	N.S.	0.06

**B. Effect of potassium levels:** Data presented in Table (9) show that higher values of N, P and K content of the leaves, stems and spears were statistically affected within potassium. The highest values were recorded by 20 K unit/ fed. In general, lower values of N content in leaves and spears, P content in leaves and stems and K content in stems and spears were obtained by 60 K unit/ fed. Results were similar and significant in the two seasons.

**Table (9): Effect of potassium levels on N, P and K in leaves, stems and spears of broccoli during the two seasons (2012/2013 and 2013/2014).**

Potassium Levels (K <sub>2</sub> O unit/fed)	N (%)			P (%)			K (%)		
	Spears	Stems	Leaves	Spears	Stems	Leaves	Spears	Stems	Leaves
	<b>First season (2012/2013)</b>								
20	2.28	2.22	4.18	0.65	0.64	0.70	3.12	3.73	3.42
40	2.09	1.83	4.03	0.50	0.56	0.75	2.98	3.55	3.32
60	1.95	2.07	3.94	0.52	0.55	1.04	3.01	3.46	3.27
L.S.D at 0.05	0.06	0.13	0.10	0.07	0.04	0.10	N.S.	0.09	0.08
	<b>Second season (2013/2014)</b>								
20	2.21	2.10	4.11	0.67	0.58	0.72	3.00	3.43	3.20
40	2.15	1.80	3.78	0.51	0.48	0.77	2.86	3.25	3.10
60	1.94	2.07	3.81	0.54	0.45	1.05	2.89	3.16	3.09
L.S.D at 0.05	0.07	0.18	0.10	0.04	0.04	0.10	0.06	0.08	0.07

**C. Effect of interaction:** Data present in Table (10) revealed that higher N, P and K content of the leaves, stems and spears of broccoli was obtained by Southern Star Hybrid plants fertilized with 20 K unit/ fed., but the lower values of N, P and K percentage were obtained by Calabrese France and Calabrese American. These results were true and similar in two seasons of experiment.

**Table (10): Effect of cultivars on N, P and K in leaves, stems and spears of broccoli during the two seasons (2012/2013 and 2013/2014).**

Cultivars of broccoli	Potassium Levels (K <sub>2</sub> O unit/fed.)	N (%)			P (%)			K (%)		
		Leaves	Stems	Spears	Leaves	Stems	Spears	Leaves	Stems	Spears
<b>First season (2012/2013)</b>										
Calabrese American	20	2.21	2.18	4.18	0.74	0.53	0.52	3.21	3.90	3.41
	40	1.94	2.10	4.30	0.52	0.54	0.71	3.45	3.48	3.17
	60	1.91	1.72	4.00	0.57	0.44	0.89	3.00	3.44	3.14
Calabrese France	20	2.01	2.21	4.52	0.59	0.60	0.78	2.95	3.62	3.35
	40	1.91	1.24	3.88	0.42	0.37	0.75	2.67	3.56	3.30
	60	1.64	1.95	3.84	0.47	0.53	0.87	2.75	3.30	3.26
Southern Star H.	20	2.64	2.26	3.85	0.62	0.80	0.81	3.20	3.67	3.52
	40	2.43	2.16	3.90	0.55	0.76	0.78	2.83	3.62	3.49
	60	2.29	2.55	3.97	0.53	0.69	1.35	3.28	3.64	3.42
L.S.D at 0.05		N.S.	0.23	0.17	N.S.	0.08	0.18	0.28	0.16	N.S.
<b>Second season (2013/2014)</b>										
Calabrese American	20	2.21	1.81	4.32	0.76	0.53	0.54	3.04	3.60	3.19
	40	2.17	2.10	4.17	0.53	0.50	0.73	3.28	3.18	2.95
	60	1.88	1.72	4.19	0.59	0.34	0.91	2.83	3.14	2.92
Calabrese France	20	2.11	2.21	4.32	0.60	0.50	0.80	3.00	3.32	3.13
	40	1.91	1.31	3.68	0.43	0.27	0.77	2.72	3.26	3.11
	60	1.64	1.95	3.67	0.48	0.43	0.87	2.80	3.00	3.08
Southern Star H.	20	2.31	2.26	3.88	0.64	0.70	0.83	2.95	3.37	3.30
	40	2.36	1.99	3.70	0.57	0.66	0.80	2.59	3.32	3.25
	60	2.29	2.55	3.77	0.55	0.59	1.37	3.03	3.34	3.27
L.S.D at 0.05		0.12	0.32	0.16	N.S.	0.07	0.18	0.11	0.14	N.S.

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