**Effect of Cobalt on Cauliflower (*Brassica oleracea* L.**) **Production**

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**Key Words:** Cauliflower, Cobalt, Heads yield, Nutrients and chemical contents.

**ABSTRACT**

Three experiments, A pot preliminary greenhouse experiment was carried out to choose the most effective levels of cobalt on cauliflower growth and yield. Then Two, field experiments were conducted to evaluate the vegetative growth, heads quantity and quality as well as nutrients content of cauliflower (*Brassica oleracea* L.) as affected by using different levels of cobalt.

The obtained results showed that the addition of 9 ppm cobalt had a significant positive effect on cauliflower growth, head yield and quality whereas higher concentrations exerted hazards effect. The content of Mn, Zn and Cu in heads increased with increasing the level of cobalt application. On the other hand, the opposite trend was observed with Fe. Cobalt rate at 9 ppm resulted the greatest values of the vegetative growth, heads yield quantity and quality. Increasing cobalt level more than 9 ppm , the promotive effect reduced.

**INTRODUCTION**

Cauliflower belongs to family *Brassicaceae* and considers a member of cole vegetable crops; which includes cabbage, cauliflower, and Chinese cabbage, Brussels sprouts and kohlrabi. It well known that, cauliflower has enormous nutritional and medicinal values due to its high contents of vitamins (A, B1, B2, B5, B6 and E), minerals (Ca, Mg, Zn, and Fe) and antioxidant substances which prevent the formation of cancer causing agents (**Beecher, 1994**).

Cauliflower, also known as calabrese in England and much of Europe. In Egypt, Cauliflower still a grown in a very limited scattered areas and the total cultivated area is not exactly known. Eating larger portions may also have additional benefits, since cauliflower is a rich source of many vitamins and minerals such as vitamin A and C, carotenoids, fiber, calcium and folic acid (**Michaud *et al*., 2002**). Eating more than one serving of cauliflower a week reduces the risk of prostate cancer by up to 45%.

Recently, slight increased attentions towards extending the devoted cultivated areas and increasing the production of some untraditional vegetable crops including cauliflower, through nutrition, for local consumption and early exportation, have been directed.

Cobalt is a beneficial element for plant growth. In higher plants, cobalt also promoted many developmental processes including stem and coleoptile elongation opening of hypocotyl, leaf expansion and bud development (**Howell and Skoog, 1975**). It is also required for maintaining cucumber (**Nadia Gad, 2009**), ground nut (**Besu *et al*, 2006**) and squash (**Atta Aly, 1998**) plant growth with low levels of its supply. Excess cobalt induces yield reduction, photoassimilates to roots and other sinks (**Rauser and Samarakoon 1980**). **Walser *et al*. (1996)** added, that cobalt application at the rate of (2.7 kg Co/ha soil) increased tomato leaf number as well as surface of chloroplasts per unit leaf area , leaf chlorophyll content, leaf area and rate of photosynthesis.

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The aim of the present experiment is to investigate the response of growth, heads yield, chemical constituents as well as nutrients status of cauliflower to different cobalt concentrations.

**MATERIALS AND METHODS**

***Soil analysis:***

Particle size distribution and moisture of the soil sample were determined as described by **Black *et al.* (1982).** Soil pH, EC, cations and anions as well as organic matter, CaCO3 %, soluble, available micronutrients along with soluble, available and total cobalt were determined according to **Cottenie *et al*.(1982).**

Some physical and chemical properties of El-Nubaria soil, Research and Production Station, of National Research Centre, are shown in Table (1).

**Table (1): Some physical and chemical properties of the used soil at El-Nubaria farm.**

|  |  |  |
| --- | --- | --- |
| **Soil properties** | **Particle size distribution %** | **Soil moisture constant %** |
| **Physical** | **Sand** | **Silt** | **Clay** | **Texture** | **Saturation**  | **FC** | **WP** | **AW** |
| **68.7** | **24.5** | **6.8** | **S L** | **32.0** | **19.2** | **6.1** | **13.1** |
| **pHa** | **ECb****dS/m** | **CaCO3%** | **OM c%** |
| **7.8** | **0.18** | **7.07** | **0.16** |
| **Chemical** | **Soluble cations (meq/l)** | **Soluble anions (meq/l)** |
| **Ca++** | **Mg++** | **K+** | **Na+** | **CO3=** | **HCO3-** | **Cl-** | **SO4** |
| **3.00** | **2.00** | **0.32** | **2.09** | **0.00** | **1.41** | **0.70** | **5.30** |
| **Total (mg/100 g soil)** | **Available (mg/100 g soil)** | **Available micronutrients ( ppm)** |
| **N** | **P** | **K** | **Fe** | **Mn** | **Zn** | **Cu** |
| **15.0** | **9.4** | **16.0** | **7.8** | **3.3** | **1.86** | **4.0** |
| **Cobalt (ppm)** | **Soluble** | **Available** | **Total** |
| **0.49** | **4.43** | **15.00** |

**a: Soil pH was measured in 1:2.5 soil-water suspension, b: EC was measured as dSm-1 in soil paste,**

**S L: sandy loam.**

**FC, WP; AW= Field capacity, Wilting point and Available water.**

**Experimental work**

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***Experiment (1): preliminary experiment***

 A pot greenhouse experiment was conducted during season 2017 at National Research Centre, Egypt to choose the most effective concentrations of cobalt on cauliflower growth and yield. Seeds of cauliflower (*Brassica oleraceae* var. Italica), family crucifer were sown in the nursery in foam trays filled with a mixture of peatmoss and sand (1:1) on the 1st of September 2017. Trays being kept under greenhouse conditions with practicing all agricultural management required for production of cauliflower seedlings. Plastic pots of diameter 40 cm were filled with sandy loam soil samples taken from Research and Production Station, of National Research Center El-Nubaria area. Seedling of five weeks-old with almost stem thickness were transplanted to each pot. Cobalt sulphate salt was used to enrich the soil with cobalt. The concentrations used were: 0, 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 ppm. All treatments were triplicated and arranged in a randomized complete block design. Irrigation with tap water was practiced to keep the soil almost at field capacity for 110- 120 days. After 60 days from transplanting, growth parameters were recorded according to **Gabal *et al*. (1984).** After 90 days from transplanting, heads of cauliflower were harvested, and head yield parameters were recorded according to **Gabal *et al*. (1984).**

***Experiments (2 and 3):***

 According to the results obtained from the preliminary experiment, it was found that cobalt concentrations at rate of 6,9,12 and 15 ppm were more effective than the higher concentrations, therefore, two field experiments were conducted during two successive seasons, 12th October and 15th October 2018 & 2019 at El-Nubaria soil, Research and Production Station of National Research Center, El-Beheara Governorate, Egypt, to evaluate the vegetative growth, heads yield, heads chemical constituents and minerals composition of cauliflower as affected by different concentration of cobalt i.e.6,9,12 and 15 ppm.

 Seeds of cauliflower were sown in the nursery in foam trays filled with mixture of peat moss and sand (1:1 by volume) on the 1st September. Seedlings were transplanting in the field when reached 45 days age during season of 2017. The experiment contains 5 plots. Each plot area was 5 X 3 m2, consisting of three rows. Ten plants in each row (50 cm a part) were planted under drip irrigation system. Farmyard manure (OM = 32.6%, total N =1.3, C/N ratio =1:6, pH = 6.3, EC= 3.5 dS.m-1, K= 0.69%, P = 0.82% Fe = 420ppm, Mn = 27.2ppm, Zn = 15.5ppm, Cu = 12.6ppm) at a rate of 10 m3/fed was added during soil preparation. Ammonium nitrate (33.5 %N) at a rate 100 N unit/fed; superphosphate calcium (15.5 P2O5 %) at a rate of 60 unit P2O5/fed and potassium sulphate (48 %K2O) at a rate of 50 unit K2O/fed were split into three equal doses and applied at 6,9,12 and 15 ppm weeks after transplanting.

*Measurement of plant growth parameters:-*

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 After 60 days from transplanting date and at the end of vegetative growth, growth parameters i.e. plant height, branches and leaves number per plant, leaves area as well as fresh and dry weight of both shoots and roots (3 plants from each treatment) were recorded according to **Gabal *et al.* (1984).** At mature stage, after 90 days from transplanting date, cauliflower heads were harvested (three harvests) to record heads number/plant, heads weight, heads diameter , yield of the 1st 2nd and 3rd harvests and total yield according to **Gabal *et al.* (1984).**

***Measurement of head quality:-***

 Chemical constituents i.e. TSS, protein, sugars, phenols, titrtable acidity as well as vitamins A and C were determined according to the methods described by **A.O.A.C. (1990).** Nutrients content were determined according to **Cottenie *et al*. (1982).**

 Statistical analysis of the obtained data was subjected to standard analysis of variance procedure. The values of LSD were calculated at 5% level according to **Snedecor and Cochran (1984).**

**RESULTS AND DISCUSSIONS**

***Vegetative growth***

Data presented in Table (2) showed that addition of different cobalt levels (3, 6, 9, and 12 ppm) to the growth media significantly increased plant height, number of branches and leaves per plant and leaves area of cauliflower plants when compared with control treatment.

Data also revealed that all cobalt levels used significantly promoted both fresh and dry weights compared with untreated plants. The superior recorded results of the previously mentioned parameters were obtained under treatment of 6 ppm. Higher cobalt concentrations, 9 and 12 ppm, resulted in slight significant reduction in all growth parameters of cauliflower compared with the treatment of 6 ppm but it still higher than control. These observations are consistent with previous report obtained by **Nadia Gad (1989**), who stated that low cobalt levels had a significant synergestic effect on induces some endogenous hormones Auxins and Gibberellins and decrease the activity of some enzymes (peroxidase and catalase) in plants. Moreover increasing the anabolism rather than catabolism while the higher cobalt levels increased the catabolism rather than anabolism.

**Table (2): Vegetative growth parameters of cauliflower as affected by different cobalt concentrations(data in this table is the mean of the two seasons of the study).**

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|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Cobalt treatment (ppm)** | **Plant height (cm)** | **No. of Branches/ plant**  | **No. of Leaves/plant** | **Leaves area (cm2)** | **Fresh weight (g)** | **Dry weight (g)** |
| **Shoot** | **Root** | **Shoot** | **Root** |
| **control** | **54.7** | **8** | **20** | **336** | **439** | **36.9** | **46.6** | **9.55** |
| **6** | **56.6** | **9** | **24** | **404** | **486** | **41.0** | **51.7** | **10.60** |
| **9** | **60.3** | **11** | **29** | **488** | **548** | **46.2** | **58.0** | **15.30** |
| **12** | **58.0** | **10** | **25** | **420** | **512** | **43.0** | **54.8** | **12.80** |
| **15** | **55.5** | **9** | **23** | **387** | **506** | **42.3** | **53.7** | **10.90** |
| **LSD 5%** | **2.1** | **2** | **2** | **24** | **32** | **1.1** | **1.3** | **0.82** |

***Heads yield of cauliflower***

 The present data in Table (3) concerning the yield parameters of cauliflower as affected by different levels of cobalt indicated that all cobalt doses gave a significant positive effect for the yield parameters i.e. heads number per plant, heads diameter and heads weight compared to the control.

**Table (3): Cauliflower head parameters as affected by different cobalt concentrations (data in this table is the mean of the two seasons of the study)..**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cobalt treatments (ppm)** | **Heads No./plant** | **Heads diameter (cm)** | **Heads weight g/plant** | **Heads weight at different harvests (ton /fed)** |
| **First** | **Second** | **Third** | **Total** |
| **control** | **4** | **13.2** | **204** | **1.84** | **1.78** | **1.63** | **5.25** |
| **6** | **5** | **14.6** | **262** | **2.23** | **2.38** | **1.96** | **6.57** |
| **9** | **6** | **16.5** | **306** | **3.06** | **2.97** | **2.75** | **8.78** |
| **12** | **5** | **15.3** | **286** | **2.69** | **2.59** | **2.37** | **7.65** |
| **15** | **5** | **14.1** | **253** | **2.28** | **2.20** | **2.03** | **6.51** |
| **LSD 5%** | **1** | **1.1** | **26** | **0.23** | **0.16** | **0.27** | **0.34** |

Cobalt at 9 ppm gave the superior heads yield at different harvests. Increasing cobalt addition in plant media more than 9 ppm (12 and 15 ppm) reduced the positive effect on yield of cauliflower. These observations are consistent with the previous reports obtained by **Nadia Gad *et al.* (2008)** who stated that the lower doses of cobalt resulted in maximum growth and yield of cucumber plants as compared with the higher ones. It is evident that cobalt at rate of 9 ppm increased the heads yield of cauliflower by 66.3, 66.9 and 68.7% in the first, second and third harvests, respectively.

***Chemical constituents***

Data presented in Table (4) reveled that all cobalt levels showed favorable effect on some chemical parameters such as TSS, protein, sugars, titrable acidity and phenols as well as vitamins "A" and "C" in cauliflower heads. The obtained results indicated that all the above mentioned parameters significantly increased by the addition of different cobalt levels (6,9,12 and 15 ppm) when compared with control treatment. The highest values for all chemical parameters are recorded when using cobalt at level of 9 ppm (Table 4).

**Table (4): Chemical constituents of cauliflower heads as affected by different cobalt concentrations (data in this table is the mean of the two seasons of the study)..**

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|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Cobalt treatments (ppm)** | **TSS %** | **Protein %** | **Sugar %** | **Phenols %** | **Titrable acidity%** | **Vitamin (A)** | **Vitamin (C)** |
| **mg/100 gm fresh tissue** |
| **control** | **5.13** | **9.85** | **4.61** | **6.44** | **0.49** | **16.5** | **78.2** |
| **6** | **5.82** | **11.91** | **4.88** | **6.92** | **0.44** | **16.9** | **78.9** |
| **9** | **6.70** | **19.41** | **5.13** | **7.45** | **0.40** | **17.4** | **80.6** |
| **12** | **6.33** | **18.09** | **4.85** | **7.02** | **0.37** | **17.0** | **78.2** |
| **15** | **5.75** | **11.79** | **4.56** | **6.87** | **0.33** | **16.8** | **77.6** |
| **LSD 5%** | **0.14** | **0.17** | **0.21** | **0.37** | **0.06** | **0.3** | **0.6** |

It is evident that cobalt at rate of 6 ppm increased the contents of TSS by 30.6 %, protein by 97%, sugars by 11.3 %, phenols by 15.7 %, Vitamin "A" by 5.5 % and vitamin "C" as L-Ascorbic acid by 3.07 %. These components are essential for human growth, normal physiological functions. Moreover, vitamin "C" is an antioxidant and its necessary to several metabolic processes **(Grifithus and Lunec, 2001).** Data also showed that, increasing the levels of cobalt above 9 ppm (12 and 15 ppm) led to significant reduction in all mentioned parameters. However, these values were higher than those obtained by control treatment. The obtained results revealed that cobalt had a positive effect on all studied chemical constituents of cauliflower heads and came in harmony with those obtained by **Nadia Gad and Hala Kandil (2008**) who found that cobalt had a positive effect on TSS, protein, sugars, phenols as well as vitamin "A" and "C" of sweet potato roots while increasing cobalt levels resulted in significant adverse effect. On the other hand, titrable acidity as citric acid showed negative response to all levels of cobalt which mean increasing the heads quality of cauliflower.

**Mineral composition of heads**

***N, P and K contents***

Data in Table (5) showed that, all cobalt doses significantly increased the content of N, P and K as compared with the control. Cobalt at rate of 9 ppm gave the highest values of N, P and K, while increasing cobalt levels more than 9 ppm (12 and 15 ppm) in plant media gave an adverse effect. **Besu *et al.* (2006)** stated that the application of low levels of cobalt significantly increased the status of macronutrients (N, P and K) in ground nut plants as compared with the higher levels.

**Table (5): Minerals composition of cauliflower heads as affected by different cobalt concentrations (data in this table is the mean of the two seasons of the study)..**

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|  |  |  |  |
| --- | --- | --- | --- |
| **Cobalt treatments (ppm)** | **Macronutrients (%)** | **Micronutrients (ppm)** | **Cobalt (ppm)** |
| **N** | **P** | **K** | **S** | **Mn** | **Zn** | **Cu** | **Fe** | **Shoots** | **Heads** |
| **control** | **1.58** | **0.256** | **1.63** | **0.791** | **59.6** | **34.5** | **29.4** | **163** | **2.80** | **1.00** |
| **6** | **1.83** | **0.288** | **1.95** | **0.821** | **61.6** | **37.8** | **32.0** | **156** | **5.01** | **1.87** |
| **9** | **3.19** | **0.311** | **2.41** | **1.102** | **65.7** | **41.5** | **35.4** | **150** | **8.24** | **3.05** |
| **12** | **2.90** | **0.290** | **2.02** | **0.956** | **67.2** | **43.3** | **36.6** | **143** | **11.30** | **4.90** |
| **15** | **1.89** | **0.276** | **1.89** | **0.883** | **68.7** | **45.7** | **38.4** | **137** | **14.60** | **6.98** |
| **LSD 5%** | **0.22** | **0.027** | **0.20** | **0.126** | **1.13** | **2.6** | **2.8** | **4** | **3.2** | **0.62** |

***Mn, Zn and Cu contents***

Presented data in Table (5) revealed that, all cobalt levels had a significant effect on status of Mn, Zn and Cu in heads of cauliflower compared with the control. Higher cobalt doses (12 and 15 ppm) also increased the content of Mn, Zn and Cu. These elements play a vital role as catalyst elements. These results are in good agreement with those obtained by **Nadia Gad (2009)** who stated that cobalt level of 12.5 ppm gave the highest values of the Mn, Zn and Cu in canola seeds. In the same regard S had the same trend as the other elements.

**Cobalt and iron contents**

Results in Table (5) clearly indicated that, increasing cobalt concentrations increased cobalt content in cauliflower heads where cobalt concentrations are still in the safety limits for human consumption. Cobalt content in cauliflower shoots were generally increased approximately 2-3 folds than heads. These data are in harmony with those obtained by **Nadia Gad (2005)** who reported that cobalt content of tomato shoots were generally increased 2 – 3 folds than fruits. Data in Table (5) also clearly indicated that, increasing cobalt doses in plant media from 6 to 15 ppm resulted in a progressive depression effect on iron content in cauliflower heads. This may be explained on the basis obtained by **Bisht (1991) and Nadia Gad *et al.* (2008)** who stated that there is an antagonistic relationships between (Co and Fe), Also they added that the relative response of iron to the control indicated continuous of this elements. Moreover they proposed that the hazardous effect of cobalt being severely involved in wilting appearance and reduction for net photosynthesis processes.

**CONCLUSION**

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Cobalt content of cauliflower shoots were increased approximately 2 – 3 folds than heads at level of 15 ppm cobalt treatment (6.98 ppm.) which is below the dangerous level, since the daily consumption of cauliflower heads does not exceed a few grams.

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**تأثير الكوبلت على إنتاجية القرنبيط**

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أجريت ثلاثة تجارب ، تم إجراء تجربة أولية تشمل مدى واسع من تركيزات الكوبلت لإختيار التركيزات التى أعطت إستجابة فى نمو ومحصول نباتات القرنبيط وشملت التركيزات التالية: صفر ، 6، 9، 12، 15 جزء فى المليون كوبلت (فى صورة سلفات الكوبلت).

ثم تم إجراء تجربتان حقليتان فى الموسمين 2018 و 2019 فى مزرعة المركز القومى للبحوث بالنوبارية - محافظة البحيرة - دلتا مصر حيث تم نقل الشتلات (ذات ثلاثة أوراق حقيقية) إلى الأرض وتم معاملتها مرة واحدة بالكوبلت بالتركيزات : صفر ، 6، 9، 12، 15 جزء فى المليون.

**أظهرت النتائج التي تم الحصول عليها مايلى:**

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\* الكوبلت بكل تركيزاته أعطى تأثير إيجابى على نمو النباتات ومحصول الرؤوس وجودتها بالمقارنة بالكنترول.

\* الكوبلت بتركيز 9 جزء فى المليون أدى إلى زيادة نمو النباتات ومحصول الرؤوس وجودتها متمثلة فى محتواها من العناصر الغذائية وأيضاً المحتوى الكيميائى لها.

\* بزيادة تركيز الكوبلت فى بيئة نمو النباتات قل التأثير الايجابى له لكنه ظل أعلى من الكنترول.

**الكلمات الداله:**

 القرنبيط ، الكوبلت ، محصول الرؤوس ، المحتوى المعدنى والكيميائى