GROWTH, YIELD, AND ANTIOXIDANT TRAITS OF DIFFERENT PARTS OF BEETROOT AS AFFECTED BY VERMICOMPOST AND GLUTATHIONE

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ABSTRACT

This study was aimed to assess the impact of vermicompost, glutathione, and their interaction on beetroot (*Beta vulgaris* L.) growth, yield, and antioxidant traits. The experiment carried out at vegetable field of the College of Agricultural Engineering Sciences - University of Baghdad during fall season 2019. The experiment was conducted using factorial arrangement within Randomized Complete Block Design with two factors and three replicates (3X3X3). Applying vermicompost before cultivation represented the first factor (0, 15, 30 ton.ha^{-1}), which symbolized (V_0, V_1, V_2). Glutathione (0, 75, 150 mg.L^{-1}) which symbolized (G_0, G_1, G_2) represented the second factor. Results showed the superiority of secondary interaction treatment V_2G_2 in producing significant increases in dry weight of vegetative growth (50 g.) chlorophyll concentration in leaves (244.6mg.100^{-1}g FW), Betacyanins in leaves and tuber roots (52.67, 89.33 mg.100ml^{-1}) respectively scavenging activity for DPPH in leaves and root tubers (97.33, 91.66 %) respectively, and tuber root weight (200 g).

Keywords: sugar beet; scavenging activity; betanin; γ-glutamyl-cysteinyl-glycine; worm manure

تأثر مؤشرات نمو وحاصل ومضادات الاكسدة في اجزاء مختلفة من نبات الشوندر عند المعاملة بسماد الدود والجلوتاثيون

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المستخلص

هدفت التجربة الى اختبار تأثير سماد الدود والجلوتاثيون وتداخلاتهما في نمو وحاصل وتراكم مضادات الأكسدة والصبغات لنبات الشوندر (.*Beta vulgaris* L)، نفذت تجربة حقلية في حقول كلية علوم الهندسة الزراعية/جامعة بغداد للموسم الخريفي 2019. طُبّقت التجربة باستعمال تصميم القطاعات الكاملة المعشاة حسب ترتيب التجارب العاملية بعاملين وثلاث مكررات (3X3X3)، فيما يخص العامل الاول فتم اضافة سماد الدود الى التربة خلطا قبل الزراعة بمستويات (0، 15، 30 طن.هـ$^{-1}$) والذي رُمز له (V_0 وV_1 و V_2)، اما العامل الثاني فتضمن الرش بالجلوتاثيون (0، 75 ، 150 ملغم.لتر$^{-1}$) والذي رمز له (G_0 وG_1 وG_2). اظهرت النتائج التفوق المعنوي لمعاملة التداخل الثنائي V_2G_2 في زيادة الوزن الجاف للمجموع الخضري (50 غم) و تركيز الكلوروفيل في الاوراق (244.6 ملغم . 100غم$^{-1}$) والبيتاسيانين في الاوراق والجذور الدرنية (52.67، 89.33 ملغم . 100مل$^{-1}$) على التتابع والنسبة المئوية لكسح جذر DPPH في الاوراق والجذور الدرنية (97.33، 91.66%) على التتابع ووزن الجذر الدرني (200 غم).

الكلمات المفتاحية: الشمندر الحلو، قابلية الكسح, بيتانين, γ–glutamyl-cysteinyl-glycine، دمان دودة الارض

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INTRODUCTION

Beetroot *Beta vulgaris* L. that belongs to Chenopodaceae considered one of the most important crops that has tremendous amount of antioxidants in all of its edible parts (28). In fact; increasing antioxidant potency supports a lot of additional factors in plant and human fitness that go beyond just neutralizing free radicals, such as affecting gene expression (23), biosynthesis of important molecules (24), and strengthening plant sensation (32). As a result there is an emphasis on regular intake of vegetables that loaded with antioxidants (2). Betacyanin is the most important antioxidant pigment in beetroot plant and it's responsible of sugar beet vibrant color (6). mainly; sugar beet is grown for its taproot, but recently the researches proved the huge health importance of the edible vegetative parts of the plant (10; 16).In a comparative study based on nutrients content done by preventing chronic disease center (9); beet greens ranked fourth place among 41 different vegetables and fruits, based on its unique nutritive profile such as its antioxidant power and its good amounts of minerals like Potassium, Magnesium, Iron, and Zinc, beetroot also has many vitamins such as B-vitamins (B_1, B_2, B_3, B_6 and B_{12}) (8). However, we lack of information about how unique certain compounds directly or indirectly influence the amount of Betacyanin and the overall plant scavenging potency. Conventional farm systems that depend on just mineral fertilizers have proved their negative impacts on soil and plant (19, 27). As a result; planning a smart fertilizing program that meets plants physiological demands and ecofriendly has a strong impact on plant wellness and environment. In fact; using fertilizers from organic sources and spraying clean materials such as vitamins (14), sugars (3, 4) and amino acids (5, 25), within minimum recommended doses of essential minerals Proven to be effective in plant fitness. Vermicompost is a microbial organic fertilizer that used as a clean soil amendment and plant fertilizer since it has biological properties and water-soluble nutrients. Wang et al (30) revealed that fertilizing with vermicompost in 4:7 (w/w) percentage increased scavenging activity (antioxidant activity), vitamin C, and total flavonoids of Chinese cabbage. Gholami et al (11) results showed a significant increases in phenolics and flavonoids in chicory plant when they applied vermicompost at 7.5 ton.ha^{-1}. Glutathione is a tripeptide of glutamic acid, cysteine, and glycine with a peptide linkage. It considered the strongest antioxidant in plants (31). Moreover; it utilized in sulphur metabolism, metabolism regulation, cell protection, redox signaling, and regulation of gene expression (12). Semida et al (26) noticed that spraying glutathione mitigated salinity harmful effect and increased enzymatic and non-enzymatic antioxidants compared to control in *Vicia faba* L. Jung et al (15) observed significant increase in scavenging activity and significant reduction of cadmium levels when applying exogenous glutathione on *Brassica napus* plant. Thus, this study was aimed to the impact of vermicompost and glutathione on pigments accumulation and antioxidant potency in beetroot plant.

MATERIALS AND METHODS

This experiment was conducted during fall season 2019 at researches station (A) College of Agricultural Engineering Sciences, University of Baghdad (Al-Jadiryah). Table 1 shows the chemical and physical characteristics of the soil. The seeds of beetroot Detroit dark red selection were sowed in four lines on terraces in 15/September, 2019.

Table 1. Physical and chemical Characteristics of the soil

Character	Values Fall 2019
pH	7.43
$EC_{1:1}$ ($ds.m^{-1}$)	2.35
Total N (mg kg^{-1})	45.5
P (mg kg^{-1})	12.2
K (mg kg^{-1})	167
Ca (mg kg^{-1})	179
Mg (mg kg^{-1})	131
Fe (mg kg^{-1})	2.11
Na (Meq L^{-1})	63.1
Cl^- (Meq L^{-1})	55.2
SO_4^{-2} (Meq L^{-1})	210
HCO_3^- (Meq L^{-1})	455
O.M. (%)	9.11
Gypsum (%)	329
Sand (%)	15.0
Silt (%)	46.1
Clay (%)	38.9
Texture	Clay Loam

The field was under drip irrigation system. Mineral fertilizer was added as recommended for beetroot plants to all plots before planting (1). The spacing between one plant and another was 0.25 m. all plots harvested after 110 days of the seeds sowing.The experiment was implemented by using factorial arrangement within Randomized Complete Block Design with two factors and three replicates (3X3X3). The first factor is fertilizer with three levels of vermicompost (0, 15, 30 ton.ha^{-1}), which symbolized (V_0, V_1, V_2) added to the soil before sowing the seeds. Table 2 shows the properties of the mentioned fertilizer. The second factor is spraying with three levels of glutathione (0, 75, 150 mg.L^{-1}) which symbolized (G_0, G_1, G_2). The first spraying was after 1 month from sowing. The second spraying was after 15 days from the first spraying. The third spraying was after 15 days from the second spraying. The studied traits were determinated; leaves number, chlorophyll concentration in leaves (mg.100^{-1}g FW) (13), vegetative growth dry weight (g.), Betacyanins (mg/100 ml) in leaves, stems, tuber roots (21), DPPH radical assay (%) in leaves, stems, tuber roots (17) (%).foliage yield (g.), tuber root weight (g), and tuber root diameter (cm). The collected data were analyzed using analyses of variance and the means were compared according to L.S.D. test under 5%probability.

Table 2. Physical and chemical characteristics of vermicompost Fertilizer

Character	Values
pH	7.66
$EC_{1:1}$ (ds.m^{-1})	1.1
Total N (%)	1.69
P_2O_5 (%)	0.0103
K_2O (%)	0.394
Fe (mg kg^{-1})	50
Cu (mg kg^{-1})	45
Mn (mg kg^{-1})	25
Zn (mg kg^{-1})	40
Cl^- (mg. L^{-1})	15.5
Moisture (%)	25
O.M. (%)	32.77

RESULTS AND DISCUSSION

Leaves number Chlorophyll conc.leaves^{-1}, fresh and dry weight of vegetative growth

It is obvious from Table 3 that there is a significant effect of interaction treatments in chlorophyll conc.leaves^{-1} and dry weight of vegetative growth of beetroot plant. V_2G_2 treatment produced the highest chlorophyll conc.leaves^{-1} and dry weight of vegetative growth (244.6 mg.100^{-1}g FW) (50.00 g.) respectively, compared to the lowest numbers in V_0G_0 (157.3 mg.100^{-1}g FW) (21.67 g.) respectively. The results of Table 3 also show that there were significant differences in individual factors. (V_2) produced the highest leaves number, chlorophyll conc.leaves^{-1}, and dry weight of vegetative growth. (10.56) (212 mg.100^{-1}g FW) (41.89 g.) respectively compared to the lowest percentages in V_0 (8.44) (165.6 mg.100^{-1}g FW) (25.67 g.) respectively. G_2 treatment increased the mentioned traits (10.44) (206.3 mg.100^{-1}g FW) (39.33 g.) respectively compared to the lowest percentages in G_0 (8.56) (172.8 mg.100^{-1}g FW) (30 g) respectively.

Betacyanins (mg.100 mL^{-1}) in leaves, stems, tuber roots of beetroot plant Secondary interaction between vermicompost and glutathione tended to consistently promoting betacyanins increase in leaves and tuber roots. In fact; all interaction treatments had a significant impact over the control. However; V_2G_2 produced the highest concentration of betacyanins in leaves and root tubers (52.67, 89.33 mg.100ml^{-1}) respectively over control V_0G_0 (38.5, 69 mg.100ml^{-1}) respectively (Table 4).Statistical analysis of the individual factors (Table 4) reveals significant results of V_2 treated plants by producing the highest concentration of Betacyanins in all edible parts (50.28, 14.79, 73 mg. 100ml^{-1}) respectively over V_0 (41.39, 19.75, 84.56 mg. 100ml^{-1}) respectively. Application of (G_2) had a significant effect of Betacyanins in leaves, stems, and tuber roots (48.5, 18.5, 81.89 mg. 100ml^{-1}) respectively over G_0 (44.11, 16.59, 74.89 mg. 100ml^{-1}) respectively (Table 4).

Table 3. Effect of vermicompost and glutathione on vegetative growth parameters of beetroot plant

traits / treatments	Leaves number	Chlorophyll conc. in leaves ($mg.100^{-1}g$ fw)	Vegetative growth (dw.g.)
V0	8.44	165.6	25.67
V1	10.11	185.2	36.00
V2	10.56	212.0	41.89
L.S.D.(0.05)	0.73	4.487	1.912
G0	8.56	172.8	30.00
G1	10.11	183.7	34.22
G2	10.44	206.3	39.33
L.S.D. (0.05)	0.73	4.487	1.912
C0G0	7.67	157.3	21.67
V0G1	9.00	162.0	26.00
V0G2	8.66	177.6	29.33
V1G0	9.00	172.0	33.00
V1G1	10.33	187.0	36.33
V1G2	11.00	196.6	38.67
V2G0	9.00	189.0	35.34
V2G1	11.00	202.3	40.33
V2G2	11.67	244.6	50.00
L.S.D. (0.05)	N.S.	7.772	3.312

Table 4. Effect of vermicompost and glutathione on Betacyanins content (mg/100 mL) in edible parts of beetroot plant

traits / treatments	Betacyanins (leaves)	Betacyanins (stems)	Betacyanins (root tubers)
V0	41.39	14.79	73.00
V1	47.61	18.42	79.22
V2	50.28	19.75	84.56
L.S.D.(0.05)	1.11	0.51	1.87
G0	44.11	16.59	74.89
G1	46.67	17.88	80.00
G2	48.50	18.50	81.89
L.S.D. (0.05)	1.11	0.51	1.87
V0G0	38.50	13.83	69.00
V0G1	41.00	14.66	74.00
V0G2	44.67	15.88	76.00
V1G0	46.67	17.22	77.33
V1G1	48.00	19.00	80.00
V1G2	48.17	19.05	80.33
V2G0	47.17	18.72	78.33
V2G1	51.00	20.00	86.00
V2G2	52.67	20.55	89.33
L.S.D. (0.05)	1.93	N.S.	3.25

DPPH radical assay (%) in leaves, stems, tuber roots: the results in table 5 show the most significant increases in scavenging activity in leaves and root tubers of beet root plant were observed in V_2G_2 treatment (97.33, 91.66%) respectively when compare with the lowest scavenging activity in V_0G_0 treatment (82, 74.33%) respectively. However scavenging activity did not show any significant differences in beetroot stems (Table 5). Statistical analysis of the individual factors (Table 5) showed the significant impact of V_2 in increasing scavenging activity in leaves, stems, root tubers (94.78, 88.22, 86.78 %) respectively over V_0 (85, 77, 79 %) respectively.Results also reveal that DPPH radical assay (%) in leaves, stems, and tuber roots significantly affected by elevated concentration of glutathione. In fact, it was observed from individual factors that G_2 treated plants had high scavenging activity in all edible parts (91.56, 85.44, 89.22 %) respectively over G_0 (86.89, 80.11, 79 %) (Table 5).

Table 5. Effect of vermicompost and glutathione on DPPH radical assay (%) in edible parts of beetroot plant

traits treatments	scavenging activity (leaves)	scavenging activity (stems)	scavenging activity (root tubers)
V0	85.00	77.00	79.00
V1	89.33	84.00	85.33
V2	94.78	88.22	86.78
L.S.D.(0.05)	1.55	1.93	1.90
G0	86.89	80.11	79.00
G1	90.67	83.67	85.33
G2	91.56	85.44	89.22
L.S.D. (0.05)	1.55	1.93	1.90
C0G0	82.00	72.33	74.33
V0G1	86.00	78.32	80.33
V0G2	87.00	80.30	82.33
V1G0	88.67	82.67	84.67
V1G1	89.00	84.00	85.00
V1G2	90.33	85.33	86.33
V2G0	90.00	85.30	86.30
V2G1	97.00	88.67	89.67
V2G2	97.33	90.60	91.66
L.S.D. (0.05)	2.69	N.S.	3.35

Foliage yield, tuber root yield (g), tuber root diameter (cm) of beetroot plant

Interaction between vermicompost and glutathione was likely to increases in tuber root weight. V_2G_2 produced the highest (200 g) over control V_0G_0 (94 g) (Table 6). Statistical analysis of the individual factors (Table 6) reveals the significant results of V_2 treated plants by producing the highest foliage, tuber root yield, tuber root diameter of beetroot plant (129.1 g, 170 g, 7.25 cm) respectively over V_0 (92.11 g, 108 g, 5.73 cm) respectively. Application of (G_2) had a significant effect on the mentioned traits (124.4 g, 156 g, 6.93 cm) respectively over G_0 (101.3 g, 117 g, 5.95 cm) respectively (Table 6).

Table 6. Effect of vermicompost and glutathione on foliage yield, tuber root yield (g), tuber root diameter (cm) of beetroot plant

traits treatments	Foliage yield (fw.g.)	Tuber root weight (g)	Tuber root diameter (cm)
V0	92.11	108	5.73
V1	117.7	131	6.53
V2	129.1	170	7.25
L.S.D.(0.05)	3.375	6.45	0.26
G0	101.3	117	5.90
G1	113.2	136	6.68
G2	124.4	156	6.93
L.S.D. (0.05)	3.375	6.45	0.26
C0G0	83.00	94	5.20
V0G1	91.33	113	5.93
V0G2	102.0	118	6.06
V1G0	106.0	116	6.03
V1G1	117.3	126	6.70
V1G2	130.0	150	6.86
V2G0	115.0	141	6.46
V2G1	131.3	169	7.43
V2G2	141.0	200	7.86
L.S.D. (0.05)	N.S	11.17	N.S

Fertilization with vermicompost, was efficiently utilized by increasing vegetative growth traits of beetroot plant. The reason behind this could be due to the effect of minerals (Table 2); which play a vital role in plant growth such as nitrogen, zinc, iron, and manganese (29). Moreover; plant growth regulators and humic acids that vermicompost has, which provided a proper environment for root nutrients absorption of minerals that enhanced plant growth and development (7). Even more; the increases in total Betacyanins and scavenging activity in this study may be due to the humic acid in vermicompost. In fact; many researches are associated the abundance of humic acid in soils with increasing plant anti-oxidant capacity (20, 22). On the hand; vermicompost enhances the chlorophyll concentration and leaves number (Table 3); which in turn increasing the level of photosynthesis then building up new materials and metabolites such as Betacyanins. That's come in consistent with some researchers which also stated the significant influence of vermicompost in enhancing the synthesis of antioxidant compounds in plants (18, 22). The significant influence of glutathione on vegetative and yield traits is due to its impact on plant metabolism, which improved plant fitness, growth, homeostasis and responses to external signals (12). The significant impact of glutathione on promoting antioxidant potency of beetroot plant could be due to upregulating the AsA-GSH-NADPH cycle and maintaining balance in hormones; and that's all reflect on improving plant redox status (15) Moreover; Increasing total Betacyanins could be the cause of scavenging activity due to the strong antioxidant effect of Betacyanins (Table 4). In conclusion; there is a strong effect of vermicompost and glutathione and their interaction on beetroot growth, development and accumulation of antioxidant materials and that's all reflected on the overall scavenging activity of the plant. The most scavenging activity was found in leaves and that means they are the most accumulative part of antioxidant compounds. As a result we recommend a daily consumption of them because their huge ability of neutralizing free radical in our bodies.

REFERENCES

1. Ali, N. S., H. S. Rahi, and A. A. Shackir, 2014. Soil Fertitity. Arabic Community publisher for Publication and Distribution 1st ed , pp: 307

2. Al-Khafaji, A. M. H. H. 2019. Stimulation growth, yield, and accumulation of antioxidant compounds of onion hybrids by colored shades of poly ethylene covers . Iraqi Journal of Agricultural Sciences, 50(6): 1580-1587

3. Al-Khafaji, Aseel. M. H. H. and Kadhim D. H. Al-jubouri. 2022. Influence of aqueous extract of barley sprouts, trehalose, and calcium on growth, quality and yield of carrot. Iraqi Journal of Agricultural Sciences, 53(1): 133-140

4. Al-Khafaji, Aseel. M. H. H. and Kadhim D. H. Al-jubouri. 2022. Maximization carrot minerals preserve and antioxidant capacity by foliar application of aqueous barley sprouts extract, trehalose, and calcium. Iraqi Journal of Agricultural Sciences, 53(1):122-132

5. AL-Zaidy, A. K. N. and R. M. AL-Ubaidy,2017. Effect of adding wheat peat and spraying with its extract and organic nutrient vegaamino on growth and yield of red cabbage. Iraqi Journal of Agricultural Sciences, 48(2): 429-438

6. Azeredo, H. M. C., A. C. Pereira, A.C. R. de Souza, S.T. Gouveia and K. C.B. Mendes. 2009. Study on efficiency of betacyanin extraction from red beetroots. International Journal of Food Science and Technology , 44, 2464–2469

7. Canellas LP, F.L.Olivares, F. A. L. Okorokova, and A. R. Façanha. 2002. Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H^+-ATPase activity in maize roots. Plant Physiol, 130:1951–1957

8. Ceclu, L., and O. Nistor. 2020. "Red Beetroot: Composition and Health Effects—A Review." J. Nutr. Med. Diet Care, 6(1): 1-9

9. Di Noia, J. 2014. Defining powerhouse fruits and vegetables: a nutrient density approach. Preventing Chronic Disease, Centers for Diseases Control and Prevention, 11:1-15.

10. Fernández, M. V., R. J. Jagus and M. V. Agüero. 2017. Evaluation and characterization of nutritional, microbiological and sensory

properties of beet greens. Acta Scientific Nutritional Health 1(3): 37-45

11. Gholami, H., M. J. Saharkhiz, F. R. Fard, A. Ghani, and F. Nadaf. 2018. Humic acid and vermicompost increased bioactive components, antioxidant activity and herb yield of Chicory (*Cichorium intybus* L.). Biocatalysis and Agricultural Biotechnology,14: 286-292

12. Gomez , L. D., G. Noctor, M. R. Knight, and C. H. Foyer. 2004. Regulation of calcium signalling and gene expression by glutathione, Journal of Experimental Botany, 55(404): 1851–1859

13. Goodwin, T. W. 1976. Chemistry and Biochemistry of Plant Pigment. 2nd Academic. Press. London. NewYork. San Francisco, pp:373

14. Hamed, K.S. and M.A.M. Sanavy, 2015. Biochemical and morphological response of common bean (*Phaseolus vulgaris* L.) to salinity stress and vitamin B12. Intl. J. Farm and Alli. Sci.., 4(7):585-593

15. Jung, H., T.Lee1, J. Lee, M. Chae, E Lee, M Kim,G. Jung, A. Emmanuel, S. Jeon, and B. Lee. 2021. Foliar-applied glutathione mitigates cadmium-induced oxidative stress by modulating antioxidant-scavenging, redox-regulating, and hormone-balancing Systems in *Brassica napus*. Frontiers in Plant Science,12:1-17

16. Kaushik, A., and Kavita. 2020. Development of product through supplementation using beet greens and its sensory evaluation. Journal of Pharmacognosy and Phytochemistry: 9(6):83-85

17. Kedare, S. B., and R. P. Singh. 2012. Genesis and development of DPPH method of antioxidant assay. J Food Sci Technol, 48(4):412–422

18. Kheiry, A., M. Arghavani, and M. Khastoo. 2016. Effects of organic fertilizers application on morphophysiological characteristics of Calendula (*Calendula officinalis* L.). Iranian Journal of Medicinal and Aromatic Plants, 31 (6): 1047-1057

19. Liu, M, F. Hu, X. Chen, Q. Huang, J. Jiao, B. Zhang, and H.Li. 2009. Organic amendments with reduced chemical fertilizer promote soil microbial development and nutrient availability in a subtropical paddy field: the influence of quantity, type and application time of organic amendments. Appl Soil Ecol, 42:166–175

20. Oliveira C, A. C. S.Ferreira, M. M. Pinto, T. Hogg, F. Alves, P. G. de Pinho.2003. Carotenoid compounds in grapes and their relationship to plant water status. J Agric Food Chem., 51:5967–5971

21. Ranganna, S. 1977. Manual of Analysis of Fruit and Vegetable Product. TATA MC Graw Hill pub. Co. ltd. Newdelhi. pp:634

22. Rimmer D.L. 2006. Free radicals, antioxidants, and soil organic matter recalcitrance. Eur J Soil Sci, 57:91–94

23. Romero, I, M. T. S.-Ballesta, R. Maldonado, M. I. Escribano, and C. Merodi. 2008. Anthocyanin, antioxidant activity and stress-induced gene expression in high CO_2-treated table grapes stored at low temperature. Journal of Plant Physiology,165 (5):522-530

24. Rutkowska, M., E. Balcerczak, R. Świechowski, M. Dubicka, and M. A. Olszewska.2020 . Seasonal variation in phenylpropanoid biosynthesis and in vitro antioxidant activity of *Sorbus domestica* leaves: Harvesting time optimisation for medicinal application. Industrial Crops and Products, 156,112858

25. R. A. A. Al-asadi, and K. D. Al-jebory. 2020. Effect of spraying amino acids on growth and yield of bitter guard plant genotypes *Momordica charantia* L. and its charantin content. Iraqi Journal of Agricultural Sciences, 51(4):991-1000

26. Semida, W. M., T. A. Abd El-Mageed, R. M. Abdalla, K. A. Hemida,S. M. Howladar, A. A. A. Leilah and Mohamed O. A. Rady. 2021. Sequential antioxidants foliar application can alleviate negative consequences of salinity stress in *Vicia faba* L. Plants,10(914):1-17

27. Singh K. P., A. Snman, P. N. Singh, and T. K. Srivastava. 2007. Improving quality of sugarcane-growing soils by organic amendments under subtropical climatic conditions of India. Biol Fertil Soils, 44: 367–376

28. Skalicky, M. S., J. Kubes, , H. Shokoofeh , M.. T. Ul-Arif ,P. Vachova and V. Hejnak. 2020. Betacyanins and Betaxanthins in Cultivated Varieties of *Beta vulgaris* L. Compared to Weed Beets. Molecules,25,5395. doi:10.3390/molecules25225395

29. Taiz, L. , E. Zeiger, I. M. Moller, and A. Murphy. 2014. Plant Physiology and Development. 6th ed, Sinauer Assotiates, Inc., Publishers Sunderland, Massachusetts. pp, 761

30. Wang, D., Q. Shi, X. Wang, M. Wei, J. Hu, J. Liu, and F. Yang. 2010. Influence of cow manure vermicompost on the growth, metabolite contents, and antioxidant activities of Chinese cabbage (*Brassica campestris ssp. chinensis*). Biol Fertil Soils, 46:689–696.

31. Wexler, P. 2014. Encyclopedia of Toxicology. 3rd ed. vol 2. Elsevier Inc., Academic Press, pp: 352

32. Xia, X.-J.; P.P. Fang, X. Guo, X. J. Qian, J. Z., K. Shi, Y. H. Zhou, and J. Q. Yu. 2018. Brassinosteroid-mediated apoplastic H_2O_2-glutaredoxin 12/14 cascade regulates antioxidant capacity in response to chilling intomato. Plant Cell Environ;41:1052–1064.