RESPONSE OF SOME HERBACEAUS PLANTS TO DIFFERENT GROWING MEDIA AND POTASSIUM SILICATE FOLIAR SPRAYING IN (LWS)

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ABSTRACT

This study was aimed to conduct one of the vertical garden systems , selecting suitable plant species that with stand the climate conditions of Baghdad city in outer space to determine the appropriate growing medium for the (LWS), and to assess the impact of spraying with potassium silicate on the resistance of the cultivated plants to heat stresses . The study carried out at at Al-Batool Park of (Al-Kadhimiya Holy City). Two experiments were carried out, each one with a different plant species, including *Wedelia trilobata* and *Tradescantia pallida*, during the winter season of 2021 and summer season of 2022. The experiments were designed using a split block design. The experiments included two factors, the first being the growing medium, peatmoss + Perlite (50:50%) (M1), Vermicompost + Perlite (50:50%) (M2), Water hyacinth Compost + Perlite (50:50%) (M3), and Wheat Straw Compost + Perlite (50:50%) (M4). The second factor included spraying shoots with three levels of potassium silicate, (S), which were 0 ml/L (S0), 1.5 ml/L (S1), and 3 ml/L (S2). The results showed that using media M2, M3, and S2, as well as the interaction between them, was superior effect on the vegetative characteristics of the two plants. These treatments were successful in cultivating plants in (LWS) and covering the panels planted in it.

Key words: vertical gardens; felt layer; k2sio3; heat stress; cold stress; substrates
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استجابة بعض النباتات العشبية لأوساط النمو المختلفة والرش الورقي بسيليكات البوتاسيوم في نظام الجدران الحية (LWS)

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المستخلص

هدفت الدراسة إلى تطبيق أحد نظم الحدائق العمودية، و اختيار الأنواع النباتية الملائمة لتحمل ظروف المناخ في مدينة بغداد في الفضاء الخارجي وزراعتها في الحديقة العمودية، و اختيار وسط النمو الزراعي الملائم وتأثيرها في نمو النباتات المختارة، و تأثير الرش بسيليكات البوتاسيوم وأثره في مقاومة النباتات المزروعة للإجهادات الحرارية. ضمت الدراسة تجربتين، زُرِعَ في كل تجربة نوع نباتي مختلف عن الآخر وهي *Wedelia trilobata* و *Tradescantia pallida* اثناء الموسم الشتوي 2021 والموسم الصيفي 2022 ، تم تنفيذ هذه الدراسة في منتزه البتول (مدينة الكاظمية المقدسة)، نفذت التجربتين حسب تصميم القطاعات المنشقة، تضمنت الدراسة عاملين، العامل الأول شَمِلَ أربعة أنواع من الأوساط الزراعية و رُمز لها (M): البيتموس + البيرلايت (50:50%) (M1)، الفيرمي كومبوست + البيرلايت (50:50%)(M2)، كومبوست زهرة النيل + البيرلايت (50:50%) (M3)، كومبوست تبن الحنطة + البيرلايت (50:50%) (M4)، أما العامل الثاني فشَمِلَ رش المجموع الخضري بثلاثة مستويات من سيليكات البوتاسيوم و رُمز لها (S) وكما يأتي: (0 مل.لتر-¹) (S0) ، (1.5 مل.لتر-¹) (S1) ، (3 مل.لتر-¹) (S2) ، بينت النتائج تفوق معاملة الوسطين M2 و M3 والـ S2 والرش بسيليكات البوتاسيوم وتداخلاتها في تأثيرها في صفات المجموع الخضري للنباتات الثلاث المذكورة لنجاحها في للزراعة في الحدائق العمودية (الجدران الحية) وتغطية النمو الخضري للألواح المزروعة فيها.

الكلمات المفتاحية: الحدائق العمودية؛ اللباد؛ K2SiO3 ؛ إجهاد الحرارة؛ إجهاد البرودة؛ الركائز
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INTRODUCTION

With the urban expansion that many cities are experiencing at the expense of green areas; and the conversion of numerous agricultural regions into residential areas after the clearing of trees and shrubs; turning them into concrete jungles, in addition to the increase in population density and numbers in Iraq. As a result, the area of dense plantings has decreased from 0.025 km² to 0.013 km² during the period from 2001-2020, which has had a negative impact on the climate, with temperature rates increasing from 26-47°C in 2001 to 32-56°C in 2020, The highest temperatures were recorded in urban growth areas and areas devoid of vegetation cover (40). Employing plants to serve architecture in the past was through the concept of the garden, where public parks and private gardens are considered among the main and essential components and an important tool in order to improve the level of urban life (8, 49), and they must also have Environmental characteristics through which human comfort is achieved as well as renewal of vitality and promotion of social interaction (35). Vertical gardens, also known as green walls, gardens that cover building facades using different types of plants, depending on the systems and methods of cultivation. The concept of green walls has been used in conjunction with hydroponic technology. However, there is a lack of knowledge about the mechanisms of implementing green walls in urban buildings in Iraq, which has a hot and dry climate. These gardens can play an active role in achieving energy efficiency. Living walls have numerous corrective applications that vary between designs within or outside the buildings (11,45). These gardens support various types of plants with varying densities, such as a mixture of grasses, bamboo, different shrubs, perennial flowers, and other plants (30). The agricultural medium used in these gardens is the most important element that determines the success of the vertical garden system. The high cost of medium components and the scarcity of these mediums, are reasons to find suitable alternative components, as well as organic fertilizers and hydrogel compounds as mediums for plant cultivation. Moreover, the limited size of the mediums and competition by plant roots due to high planting density can restrict the growth of the root system. Therefore, the vertical system requires intensive applications of fertilizers and water to maintain plant growth (46).The selection of plant species, growth medium, and planting location is crucial for the living wall as it affects the spatial root growth of the plants (36). Finding alternative agricultural media to peat moss and rockwool in soilless growing systems has become an urgent need due to the high consumption of peatlands, which are of high environmental importance. Biological sources such as renewable raw materials, as well as treated and untreated waste, can be used as components of growing media, which are renewable and self-sustaining growth media (14,27). Recycling agricultural waste and converting it into growing media is one of the solutions adopted to reduce environmental pollution resulting from the burning of plant residues (9). The sources of organic waste have a high water retention capacity and a high concentration of microorganisms that contribute to their biologically active nature, They can promote plant growth and enhance stress tolerance mechanisms, thereby reducing or improving the supply of chemical inputs typically used to feed plants (24,42). Vermicompost is a type of fertilizer made from the organic waste produced by earthworms during their digestion process, it has a high water retention capacity, cation exchange capacity, and positive effects on soil aeration, allowing plants to more efficiently utilize the soil's nutrients and plays a vital role in enriching the physical, chemical, and biological properties of soil (15,34). As a result, Vermicompost from Water hyacinth showed a remarkable effect on growth indicators for many plants , as well as crop yield treats (12). Straw is a secondary agricultural product composed of dry stems of cereal crops after removing the grains and seeds. Chemical additives are usually added to create wheat compost in order to improve the physical, chemical, and biological properties of the soil. which increases the presence of humic and fulvic acids, natural elements that help release essential nutrients for plant growth in the vicinity of the root zone (43). In recent times, there has been a growing interest in using natural or biological materials that can increase plant tolerance to biotic or abiotic stressors. One such material is potassium silicate, which is a major source of potassium and silicon and is primarily used in agriculture to provide plants with these nutrients and reduce various stress factors, including oxidative damage, nutrient deficiency, and heat stress. Additionally, potassium silicate does not contain any volatile organic compounds or hazardous secondary products, making it an environmentally safe option. spraying white eggplant plants with potassium silicate (25% $SiO2$ and 10% $K2O$) at three concentrations (0.75, 1.00, 1.50 mg/L-1) resulted in increased growth and yield indicators for white eggplant plants (31). Due to a lack of knowledge on the mechanisms of applying green walls in urban environments in Iraq (such as Baghdad), and their effective role in achieving the city's aesthetics, improving air quality, and other benefits, This study was aimed to apply a vertical garden system (Hydroponic cultivation) and choose suitable plant species to withstand the climate conditions in outdoor space. The study also was aimed to select a suitable growth medium and study its effect on the growth of selected plants, as well as investigate the impact of spraying potassium silicate and its effect on enhancing plant resistance to heat stress.

MATERIALS AND METHODS

The study included two experiments, in each experiment a different type of plant species: *Wedelia trilobata* and *Tradescantia pallida*, during the winter season of 2021 and the summer season of 2022. This study was carried out at Al-Batool Park (Baghdad), located on Street 60, The plants were grown using a system composed of panels made of textile waste (called 'labbad') and PVC foam panels fixed to iron frames. Two layers of these fabrics were sewn together with dimensions of 70*100 cm, leaving a 3 cm gap for vertical ribs and a 1.5 cm gap for horizontal ribs for fixation purposes. The fabric had pockets with dimensions of 16* 27 cm, which were made by cutting an opening in the upper rib of each pocket. There was an 8 cm gap between each pocket in the longitudinal lines for cultivation. Iron frames with dimensions of 100*310 cm were prepared and the cultivation bags, which were 70*100 cm, were fixed with a 10 cm gap between each bag. The panels were then fixed to the park's fence. An open-source irrigation system was installed using a series of Xeri bug emitters (made by American company Rain Bird) with a discharge rate of 1.89 liters per hour. The emitters were mounted on top of the canvas and placed at the same intervals as the crops (intra-row spacing). Water was supplied to the emitters through a drip irrigation tube (made by Jordanian company Al-Alamiya) with a diameter of 16 mm and a thickness of 0.9 mm. The tube was connected to a drip timer (best Flora made in Germany) and then connected to a water source. The study involved two factors. The first factor included four types of growing media , denoted by (M), as follows: peat moss + perlite (50:50%) (M1), vermicompost + perlite (50:50%) (M2), Water hyacinth compost + perlite (50:50%) (M3), and wheat straw compost + perlite (50:50%) (M4) .Table 1. Was shows some chemical properties of the substrate. The second factor included spraying the shoots with three levels of potassium silicate, denoted by (S), as follows: (0 mL^{-1}) (S0), (1.5 mL^{-1}) (S1), and (3 mL^{-1}) (S2). The potassium silicate used in the experiment was prepared by AGRI Sciences and was sprayed per season. The first season included three sprays, with the first on 10/15/2021, the second on 11/1/2021, and the third on 11-15-2021. In the second season, potassium silicate was sprayed on 2/1/2022, followed by the second spray on 3/1/2022 and then the third on 1/4/2022. The study consisted of three experiments, each with a different plant species. Each experiment included treatments of four growing media and three concentrations of potassium silicates The plants were distributed after their lengths were standardized to (18 cm) . *Wedelia trilobata* and were sprayed during the day, while *Tradescantia pallida* was sprayed at night due to its CAM plant nature (17). All plants were fertilized with NPK fertilizer (20-20-20 + TE) once a month during the growing season . Each experiment of the three included 12 treatments according to The Split-Block Design (Strip-Block Design) (7) with three replicates. The levels of the potassium silicate spray treatment (S) were randomly distributed among the sectors, with each sector containing all levels of the treatment (S). Characteristics of vegetative growth that were investigated; plant length (cm),total leaf area (dm² per plant⁻¹) (1), Leaves Dry Matter Percentage(%),and Chemical Characteristics that were investigated; Leaf chlorophyll content (mg 100g-¹ f. w.) (26),determine the total anthocyanin concentration (mg. 100 g - ¹ f. w.) (47), the effect of 40°C and 2°C on leaves (%) (22).

Table 1. Chemical properties of the growing media used in the living wall

Trait measure	The unit	M1	M2	M3	M4
EC 1:5	Dm M-1	0.48	2.08	21.8	6.30
pH 1:5	———	7.94	8.04	7.91	7.50
C/N ratio	———	18.65	25.45	25,64	28.14
organic carbon	mg kg-1 soil	19.023	70.242	53.844	81.8874
total nitrogen N	%	1.02	2.76	2.10	2.91
total phosphorus P	%	1.18	2.01	0.40	0.68
total potassium K	%	1.98	2.59	1.69	2.31
total magnesium Mg	%	0.23	0.4135	0.3521	0.4212
CEC	centimole-charge/kg-1	2.69	1.95	1.65	1.02

RESULTS AND DISCUSSION

The first experiment: winter season: vegetative growth traits : Plant height (cm): Table 2 shows significant effect of different growing media and potassium silicate spray on the length of *Wedelia trilobata* plants during both winter and summer seasons. The growing media treatments differed significantly from each other in both seasons. In the winter season, (M3) showed the highest significant effect with a length of (80.87) cm, followed by the (M2) medium (60.96) cm with an increase of (94.45% and 46.57%) respectively, compared to the lowest significant mean represented by the (M1) (41.59)cm. Potassium silicate spray also showed a significant effect, where treatment S2 recorded (68.69) cm and there was no significantly difference of treatment S1 which recorded (59.63) cm, while treatment S0 recorded (47.42) cm. for the interaction between the two factors, the treatment M3S2 surpassed all other treatments, recording (89.58) cm. On the other hand, treatments M4S0 and M1S0 recorded the lowest values of (39.63 and 34.58) cm, respectively.

Table 2. Effect of different media (M) and spraying with potassium silicate (S) and the interaction between them on *Wedelia trilobata* during winter season

Treatments			Plant height (cm)	total leaf area (dm² plant⁻¹)	Leaf chlorophyll content (mg.100g-¹)	leaf dry matter Percentage (%)	impact of a 2°C (%)
Growing Media (M)	M1		41.59	5.40	97.78	21.32	11.17
	M2		60.96	11.25	106.39	22.44	6.06
	M3		80.87	21.50	107.40	22.02	5.98
	M4		50.89	9.73	88.94	19.14	7.57
L.S.D (0.05)			13.21	4.48	11.45	2.34	4.19
Potassium silicate spray levels	S0		47.42	9.57	89.69	19.48	10.29
	S1		59.63	12.29	98.26	21.66	7.75
	S2		68.69	14.04	112.44	22.54	5.04
L.S.D (0.05)			20.35	3.33	12.21	0.69	4.13
interaction M*S	M1	S0	34.58	4.81	88.79	19.56	15.99
		S1	44.50	5.16	93.90	21.63	9.75
		S2	45.70	6.22	110.64	22.77	7.78
	M2	S0	45.77	10.11	95.64	20.26	8.20
		S1	58.78	11.33	102.38	22.66	5.77
		S2	78.33	12.32	121.16	24.40	4.20
	M3	S0	69.68	14.76	92.39	20.58	8.32
		S1	83.33	23.82	105.61	22.03	7.10
		S2	89.58	25.93	124.22	23.44	2.53
	M4	S0	39.63	8.61	81.92	17.54	8.66
		S1	51.90	8.87	91.14	20.32	8.39
		S2	61.12	11.70	93.74	19.57	5.66
L.S.D (0.05)			28.03	6.46	14.89	2.42	4.06

Total leaf area (dm² plant⁻¹): Table 2 shows the significant effect of M2 on the total leaf area of *Wedelia trilobata* in the winter season and potassium silicate spray, During the winter season, the highest leaf area was recorded in the treatment with M2, reaching 21.50 dm² plant⁻¹, which was significantly higher than the values recorded for the control treatment M1 (5.40 dm² plant⁻¹). Among the potassium silicate treatments, the treatment (S2) was significantly superior to the control treatment S0, with a leaf area of 14.04 dm² plant⁻¹. Treatment S1, did not differ significantly from S2, and had a leaf area of 12.29 dm² plant⁻¹. The lowest rate of leaf area was recorded in S0, with a value of 9.57 dm² plant⁻¹. the interaction between the two factors, the treatments M3S2 and M3S1 had significantly higher leaf area than the other treatments, reaching 25.93 dm² plant⁻¹ and 23.82 dm² plant⁻¹, respectively. The lowest rate was recorded in the treatment M1S0, with a leaf area of 4.81 dm² plant⁻¹.

Chemical characteristics: Leaf chlorophyll content (mg.100g⁻¹ f. w.): Table 2 shows the effect of different growing media and potassium silicate foliar spray on the total chlorophyll concentration in *Wedelia trilobata* leaves for both winter and summer seasons. The results showed that the average of M3 and (M2) significantly outperformed the other agricultural media, with no significant difference between them, recording 107.40 and 106.39 mg 100g-1, respectively. The lowest value of total chlorophyll percentage was recorded in (M4) with 88.94 mg 100g-1. Moreover, the potassium silicate foliar spray treatment (S2) significantly effect on control treatment, recording 112.44 mg 100g-1, while the control treatment gave the lowest value with 89.69 mg 100g-1. Regarding the interaction between the experimental treatments, the M3S2 treatment, which did not differed significantly from the M2S2 treatment, outperformed the other treatments, recording 124.22 and 121.16 mg 100g-1, respectively. Meanwhile, the M4S0 treatment gave the lowest value with 81.92 mg 100g-1.

Leaf dry Matter percentage (%): Table 2 shows the significant effect of growing media and potassium silicate spraying on dry matter percentage of *Wedelia trilobata* leaves for both winter and summer seasons. Treatment combinations M2 and M3 significantly superiored to other treatments, with rate (22.44% and 22.02%), while treatment M4 had the lowest percent (19.14%). In addition, spraying with treatment (S2) resulted in the highest dry matter percentage (22.54%), surpassing treatments S1 and S0, while treatment S0 had (19.48%). Regarding the interaction between the two factors, treatment combination M2S2 showed the highest rate (24.40%), significantly outperforming the other treatment combinations, while treatment M4S0 had the lowest significant rate (17.54%).

Evaluation the impact of a 2°C temperature on the leaves: The treatments in Table 2 varied according to growing media and their impact of temperature percentage decreases on the leaves in the winter season. Treatments M3 and M2 exhibited statistically significant superiority over the other treatments, with a lower percentage of sensitivity to temperature (2°C) at 5.98% and 6.06%, respectively. These two treatments did not differed significantly from each other. However, treatment M1 showed the highest percentage of sensitivity to temperature (2°C) at 11.17%. Treatment M4 was intermediate, recorded rate of 7.57%. As for the application of potassium silicate, treatment S2 had the lowest percentage of sensitivity to temperature (2°C) in the leaves, with a significant difference compared to the control treatment S0, which had the highest percentage of sensitivity at 10.29%. Treatment S1 was intermediate with rate 7.75%. Regarding the two-way interaction between the experimental treatments, the combination of M3S1 recorded the lowest statistically significant rate of sensitivity to temperature (2°C) at 2.53%, while the combination of M1S0 had the highest statistically significant rate of sensitivity to temperature at 15.99%.

Summer season: Vegetative growth treat: Plant height (cm): The statistical analysis conducted during the summer season shows that M2 and M3 treatment significantly affect all other treatments (Table3) These treatments recorded an average plant height of (170.30 and 164.06) cm, respectively, which represents a significant increases of (44.91 and 39.60)% compared to the lowest significant rate recorded in the control treatment M1 (117.52) cm. The treatment M4 had an intermediate plant height of (138.23) cm, which did not differed significantly from M3 and M1. Regarding the potassium silicate spray treatments, the treatment with a concentration of (3 ml/L) S2 yielded the highest plant height of (163.22) cm, while the comparison treatment had an rate of (143.51) cm. The combination treatment M2S2 achieved a significant improvement over all other treatments when the two factors were analyzed together. It recorded a plant height of (182.25) cm, representing a significant increases of (66.70 and 66.85)% compared to the lowest significant treatments M1S0 and M1S1 (109.33 and 109.23) cm, respectively, which did not differed significantly from each other.

Total leaf area (dm² plant⁻¹): The statistical analysis results during the summer season show that M2 treatment outperformed the other treatments, on leaf area of (52.93) dm², followed by the M3 treatment with (46.22)dm². Both treatments showed an increase of (124.38% and 95.93%), respectively, compared to the lowest performing treatment, M1, which recorded (23.59) dm². Additionally, the two potassium silicate spray treatments (S2 and S1) showed significant superiority over the control treatment, recording (42.92 and 38.05) dm², respectively. These two treatments were not significantly differed from each other and achieved an increases of (44.37 and 27.99%), respectively, compared to the control treatment which recorded the lowest significant rate of (29.73) dm². Regarding the interaction between the experimental treatments, the M2S2 treatment outperformed the other treatments by a significant margin, with an increases of (198.21%) compared to the lowest rate, recording (58.15) dm². The M2S1 and M3S2 treatments did not show significant differences from each other, recording (56.85 and 53.48) dm², respectively. Meanwhile, the M4S0 and M1S0 treatments did not differed significantly from each other, recording the lowest rate of (20.97 and 19.50) dm², respectively.

Table3. Effect of different media (M) and spraying with potassium silicate (S) and the interaction between them on *Wedelia trilobata* during summer season

Treatments			Plant height (cm)	Total leaf area (dm² plant⁻¹)	Leaf chlorophyll content (mg.100g⁻¹)	Leaf Dry Matter Percentage (%)	Impact of a 40°C (%)
Growing Media (M)	M1		117.52	23.59	103.28	19.77	25.36
	M2		170.30	52.93	124.04	23.27	10.84
	M3		164.06	46.22	119.84	20.33	18.02
	M4		138.23	24.87	110.42	18.71	17.25
L.S.D (0.05)			44.16	3.00	7.44	2.41	4.16
Potassium silicate spray levels	S0		134.51	29.73	100.65	18.67	28.97
	S1		144.85	38.05	120.11	21.62	14.96
	S2		163.22	42.92	122.43	21.26	9.68
L.S.D (0.05)			49.88(N.S.)	7.97	10.78	1.22	12.04
Interaction M*S	M1	S0	109.33	19.50	89.59	17.46	39.67
		S1	109.23	22.57	106.63	19.90	23.41
		S2	134.00	28.70	113.6267	21.93	12.99
	M2	S0	155.22	43.78	101.53	21.20	15.41
		S1	173.43	56.85	132.7	24.76	8.70
		S2	182.25	58.15	137.88	23.84	8.40
	M3	S0	152.82	34.68	109.9333	19.07	27.89
		S1	164.13	50.51	125.43	22.43	17.48
		S2	175.22	53.48	124.1533	19.47	8.69
	M4	S0	120.67	20.97	101.5333	16.95	32.89
		S1	132.62	22.27	115.68	19.38	10.25
		S2	161.42	31.36	114.04	19.79	8.61
L.S.D (0.05)			45.25	6.45	14.01	3.27	5.75

Chemical Characteristics: Leaf chlorophyll content (mg.100g⁻¹ fresh weight): The same Table in the summer season shows that the average superiority of M2 and M3 treatments was statistically significant compared to the other growing media, which did not differ significantly between them, reaching (124.04 and 119.84) mg 100g-1, respectively. Meanwhile, the two media, M4 and M1, showed the lowest values for total chlorophyll content, giving (110.42 and 103.28) mg 100g-¹, respectively. In addition, the concentrations of potassium silicates spray (S2 and S1) were statistically superior to the control treatment, which did not differed significantly between them, reaching (122.43 and 120.11) mg 100g-1, respectively, while the control treatment recorded (100.65) mg 100g-¹. Regarding the interaction between the experiment treatments, the M2S2 treatment was statistically superior to the other treatments, which did not differed significantly between them, reaching (137.88 and 132.70) mg 100g-1, respectively. It was followed by M3S1 and M3S2 treatments, which did not differed significantly between them, and did not differed significantly from M2S2 and M2S1 treatments, recording (125.43 and 124.15) mg 100g-1, respectively. Meanwhile, the M1S0 treatment recorded the lowest value, reaching (89.59) mg 100g-¹.

Leaf Dry Matter Percentage (%): the same table shows the significant superiority over the other treatments of growing media (M2) During the summer season, on dry matter percentage of 23.27%. The treatments M3, M1, and M4 showed the lowest values, which did not differed significantly from each other, with 20.33%, 19.77%, and 18.71%, respectively. The treatments using potassium silicate spray, with concentrations of S1 and S2, showed a significant improvement over the control treatment, with significantly difference between them, 21.62% and 21.26%, respectively. The control treatment had the lowest value with 18.67%. The interaction between the two factors showed that the treatment M2S1 significantly outperformed the other treatments, with a recorded percentage of 24.76%, while the treatment M4S0 had the lowest rate , with a significant percentage of 16.95%.

Evaluation the impact of a 40°C temperature on the leaves: As shows in Table, the M2 treatment recorded the lowest percentage of temperature impact (40°C), superior to M1 treatment with rate (10.84)%. the M4 and M3 treatments which gave (17.25 and 18.02)%, respectively. The highest values were recorded in the M1 treatment with (25.36)%. Statistical analysis of the results showed that when treated with potassium silicate, the S2 and S1 treatments recorded the lowest percentage of impact , with (9.68 and 14.96)%, respectively, and did not significantly differed from each other. These treatments outperformed the comparison treatment, which recorded the highest percentage of impact with (28.97)%. The interaction between the M2S2, M4S2, M3S2, and M2S1 treatments showed a significant reduction in their temperature impact (40°C) compared to the other treatments, which were not significantly different from each other. The percentage of temperature impact (40°C) in the leaves reached (8.40, 8.61, 8.69, and 8.70)% for the M2S2, M4S2, M3S2, and M2S1 treatments, respectively. The highest value was recorded in the M1S0 treatment with (39.67)%.

The second experiment: winter season: vegetative growth treats :Plant height (cm): Table 4 shows significant effect of growing media and potassium silicate spray treatments on plant height of *Tradescantia Pallida* plant during the winter season. growing media treatments showed significant differences among them, M3 and M2 treatments significantly outperforming other treatments, recording (41.68 and 39.63) cm, respectively. The M4 treatment with (35.60) cm, while the lowest significant was recorded from the M1 treatment, with (28.08) cm. Potassium silicate spray treatments showed a significant improvement over the control treatment, with treatments S2 and S1 recording (39.42 and 36.93) cm, respectively, while treatment S0 recorded (32.55) cm. The interaction between the two study factors showed that treatments M2S2, M3S2, and M3S1 outperformed the other treatments significantly, with (44.00, 43.22, and 42.46) cm, respectively, while treatment M1S0 recorded the lowest rate (24.14) cm.

The total leaf area (dm² plant⁻¹): Table 4 shows significant effect of two compost types , M3 and M2 , on the leaf area of *Tradescantia pallida* plants during the winter season. These compost types outperformed significantly the other two compost types, M4 and M1 , which did not differed significantly from each other, with recorded rates of 17.50 and 16.84 dm², respectively, compared to 9.94 and 7.85 dm². respectively, the potassium silicate S2 with concentration of 3 ml/L of surpassed significantly the control treatment S0, with rate of 14.76 dm², while treatment S1, which had an intermediate concentration of potassium silicate, did not differed significantly from treatment S2, with rate 13.71 dm². The control treatment S0 recorded the lowest rate of leaf area, with 10.63 dm². The interaction between the two factors of the study, treatments M2S2, M3S2, and M2S1 significantly outperformed the other treatments with recorded rates of 20.00, 19.87, and 19.76 dm², respectively. The lowest rate was recorded by treatment M1S0, with 6.65 dm².

Chemical Characteristics: Leaf anthocyanin content ($mg.100g^{-1}$ f. w.): Table 4 shows the effect of different agricultural media and potassium silicate spraying on Leaf anthocyanin content of *Tradescantia pallida* plant during the winter season. the growing media did not showed a significant effect on this trait, although the M2 recorded the highest rate of 92.65 mg/100 g f. w. . In potassium silicate spraying, treatment S2 had a significant effect and recorded the highest rate 94.25 mg/100 g f. w. , followed by treatment S1, which did not differed significantly and recorded a rate of 88.51 mg/100 g f. w. . However, treatment S0 had the lowest rate, recording 81.64 mg/100 g f. w. . The interaction between the two factors, the M3S2 treatment outperformed the other treatments and recorded a rate of 100.00 mg/100 g f. w. , followed by treatment M2S2, which did not differed significantly and recorded a rate of 98.64 mg/100 g f. w. . The lowest average was recorded by treatments M4S0 and M1S0, which recorded rates of 78.69 and 77.31 mg/100 g f. w. , respectively.

Table 4. Effect of different media (M) and spraying with potassium silicate (S) and the interaction between them on *Tradescantia pallida* during winter

Treatments			Plant height (cm)	Total leaf area (dm^2 $plant^{-1}$)	Leaf Anthocyanin content ($mg.100g^{-1}$)	Leaf dry matter Percentage (%)	impact of 2°C (%)
Growing Media (M)	M1		28.08	7.85	83.21	5.59	9.59
	M2		39.63	16.84	92.65	6.89	6.83
	M3		41.86	17.50	92.48	6.86	5.87
	M4		35.62	9.94	84.20	5.25	12.25
L.S.D (0.05)			3.86	2.47	10.08 (N.S.)	0.58	4.55
Potassium silicate spray levels	S0		32.55	10.63	81.64	5.60	12.98
	S1		36.93	13.71	88.51	6.18	5.91
	S2		39.42	14.76	94.25	6.67	7.02
L.S.D (0.05)			3.19	3.13	7.51	0.55	4.52
Interaction M*S	M1	S0	24.14	6.65	77.31	5.39	16.21
		S1	30.28	7.61	83.58	5.50	4.65
		S2	29.80	9.29	88.75	5.88	7.92
	M2	S0	35.25	10.77	86.22	6.14	8.70
		S1	39.65	19.76	93.08	6.75	4.88
		S2	44.00	20.00	98.64	7.78	6.90
	M3	S0	39.92	14.71	84.34	6.00	8.55
		S1	42.46	17.93	93.10	6.99	5.08
		S2	43.22	19.87	100.00	7.60	3.97
	M4	S0	30.90	10.41	78.69	4.88	18.45
		S1	35.31	9.53	84.29	5.47	9.04
		S2	40.65	9.89	89.61	5.41	9.27
L.S.D (0.05)			6.59	7.58	13.04	1.22	4.02

Leaf Dry Matter Percentage (%): Table 4 showed significant effect of growing media M2 and M3, as they showed a significant advantage over the other media on leaf dry matter percentage in *Tradescantia pallida* during the winter season. These treatments achieved (6.89% and 6.86%, respectively), and there was no significant difference between them. On the other hand, the agricultural media M1 and M4 producd the lowest average percentage of dry matter, and there was no significant difference between them, with (5.59% and 5.25%, respectively). The concentration of potassium silicate spray treatments (S2 and S1) had a significant effect and outperformed the control treatment, recorded (6.67% and 6.18%, respectively), while the control treatment had the lowest rate of (5.60%). The interaction between the study's factors had a significant effect on the different treatments, and treatments M2S2 and M3S2 outperformed the other treatments significantly, recorded (7.78% and 7.60%, respectively), while the treatment M4S0 had the lowest percentage of dry matter, which was significant (4.88%).

Evaluation the impact of a 2°C temperature on the leaves: The results in Table 4 show significant effect among different treatments during the winter season. The treatments M3 and M2 had significantly lower percentage of temperature effect (2°C) compared to other treatments, with rates of 5.87% and 6.83%, respectively. Treatment M4 recorded the highest percentage of temperature effect (2°C), reaching 12.25%. Treatment M1 had an intermediate rate of 9.59%. When potassium silicate treatments S1 and S2 had the lowest percentage of temperature effect (2°C) in the leaves, with rates of 5.91% and 7.02%, respectively, which were significantly lower than the control treatment S0, which had the highest value (12.98%). The interaction between the two experiment treatments showed that treatment M3S2 had the significantly lowest rate, with only 3.97% of temperature effect, outperforming all other treatments. On the other hand, treatments M1S0 and M4S0 had the highest percentage of temperature effect (2°C) in the leaves, with rates of 16.21% and 18.45%, respectively, which were significantly higher than the other treatments.

Summer season: Vegetative growth characters: Plant height (cm): Statistical analysis in the summer season (Table 5) had significant superiority on plant height the M3 treatment recorded the highest rate 69.44 cm over all other treatments . the treatments M2 and M4 mediated between the highest and lowest rates, recording 63.38 cm and 61.30 cm, respectively. These two treatments did not differed significantly from each other. However, treatment M1 recorded the lowest rate 45.81 cm. treatments S2 and S1, which involved the application of potassium silicate, significantly outperformed to control treatment, with 65.07 cm and 61.37 cm, respectively. The control treatment recorded the lowest rate for plant height at 53.52 cm. treatments M3S2, M3S1, and M2S2 had significant superiority over the other treatments when considering the two factors studied together. These treatments recorded 73.17 cm, 72.80 cm, and 72.73 cm, respectively. The treatment M1S0 had the lowest rate, recording only 40.10 cm.

Total leaf area (dm^2 $plant^{-1}$): The results of the statistical analysis in the summer season showed that the treatment of the (M3) and (M2) outperformed all other treatments and did not differed significantly from each other, on leaf area with rate (72.64 and 68.92) dm^2, respectively. They were followed by the M4 treatment, which produced (39.66) dm. the (M1) treatment recorded the lowest significant rate with (26.86) dm^2. Potassium silicate spraying outperformed the comparison treatment, as treatments S2 and S1 recorded (60.34 and 55.85) dm^2, respectively, while treatment S0 recorded (39.87) dm^2. treatments M3S2 and M2S2 showed significant superiority over the other treatments in the two-factor study interaction, with (81.17 and 80.74) cm^2, respectively. The treatment of M1S0 had the lowest significant mean, recording (21.14) cm^2.

Chemical Characteristics: Leaf anthocyanin content ($mg.100g^{-1}$ f. w.): The Table (5) shows the superiority of (M2) treatment on anthocyanin content, reaching a significant rate of (145.14) mg 100 g-1. This was followed by the M3 treatment, which did not differed significantly from M2 treatment, recording (144.43) mg 100 g-1. The M4 treatment was found to be among the superior treatments, with an average rate of (133.24) mg 100 g-1 fresh weight, while the M1 treatment had the lowest mean concentration of anthocyanins, recording (123.40) mg 100g-¹. The concentrations of potassium silicate sprays (S2 and S1) significantly outperformed the control treatment, reaching (146.49 and 141.88) mg.100g-¹, respectively, while the control treatment recorded (121.29) mg.100g-¹ f. w. . Regarding the interaction between the two factors, the M2S2 treatment outperformed the other treatments with a rate of (158.54) mg. 100g-¹ f. w., followed by the treatments of M3S2, M3S1, and M2S1, which did not differed significantly from M2S2 also did not differed significantly from each other, recording (153.58, 153.55, and 148.71) mg 100 g-1, respectively. These treatments outperformed the M1S0 and M4S0 treatments, which recorded the lowest rates of (115.79 and 115.04) mg 100 g-1, respectively.

Table 5. Effect of different media(M) and spraying with potassium silicate (S)and the interaction between them on *Tradescantia pallida* during summer season

Treatments			Plant height (cm)	Total leaf area (dm² plant⁻¹)	Leaf Anthocyanin content (mg.100g-¹)	Leaf dry matter Percentage (%)	impact of 40°C (%)
Growing Media (M)	M1		45.81	26.86	123.40	5.98	14.74
	M2		63.38	68.92	145.14	9.23	9.28
	M3		69.44	72.64	144.43	8.12	9.74
	M4		61.30	39.66	133.24	7.57	17.39
L.S.D (0.05)			5.80	9.93	11.34	0.46	3.88
Potassium silicate spray levels	S0		53.52	39.87	121.29	6.78	18.84
	S1		61.37	55.85	141.88	7.79	10.63
	S2		65.07	60.34	146.49	8.61	8.89
L.S.D (0.05)			4.19	7.09	8.28	0.35	1.95
Interaction M*S	M1	S0	40.10	21.14	115.79	5.32	23.13
		S1	46.80	28.87	122.64	6.10	11.80
		S2	50.53	30.57	131.77	6.52	9.29
	M2	S0	54.27	50.59	128.18	8.40	12.69
		S1	63.13	75.44	148.71	9.45	7.73
		S2	72.73	80.74	158.54	9.83	7.43
	M3	S0	62.37	60.24	126.16	6.75	13.92
		S1	72.80	76.53	153.55	8.17	7.83
		S2	73.17	81.17	153.58	9.44	7.46
	M4	S0	57.33	27.53	115.04	6.65	25.62
		S1	62.73	42.58	142.62	7.43	15.15
		S2	63.83	48.86	142.06	8.65	11.39
L.S.D (0.05)			8.65	18.92	14.33	0.65	7.22

Leaf Dry Matter Percentage (%): During the summer season, the results showed that the M2 medium had the highest dry matter percentage of *Tradescantia pallida* leaves, recording 9.23%. M3 medium had the second-highest dry matter percentage (8.12%), followed by M4 medium (7.57%). The lowest value was recorded for M1, with a dry matter percentage of 5.98%. Regarding the potassium silicate concentrations, the highest significant mean was recorded for S2 (3 ml/L), with 8.61%, followed by S1 (1.5 ml/L) with 7.79%. The control treatment (S0) had the lowest dry matter percentage with 6.78%. Regarding the interaction between compost media and potassium silicate concentrations, M2S2, M2S1, and M3S2 treatments significantly outperformed the other treatments, with dry matter percentages of 9.83%, 9.45%, and 9.44%, respectively. The lowest dry matter percentage was recorded for M1S0 treatment, with 5.32%.

Evaluation the impact of a 40°C temperature on the leaves: The effect of temperature (40°C) on leaves in this study had significant superiority. The results showed that treatments M2 and M3 had the least percentage of temperature impact, recording 9.28% and 9.74%, respectively. On the other hand, treatments M1 and M4 had the highest rates with 14.74% and 17.39%, respectively. Statistical analysis revealed that treatments S2 and S1, which were treated with potassium silicates, had the least temperature impact with 8.89% and 10.63%, respectively. These treatments did not significantly differed from each other and were superior to the control treatment, which recorded the highest temperature impact with 18.84%. the interaction between the two study factors showed that treatments M2S2, M3S2, M2S1, and M3S1 had a significant temperature impact compared to other treatments, with percentage rates of 7.43%, 7.46%, 7.73%, and 7.83%, respectively. The highest rates were recorded in treatments M1S0 and M4S0, which showed a temperature impact of 23.13% and 25.62%, respectively.

Figure 1. Living wall plants from the experiment implemented in Baghdad

The results of the vegetative growth of *Wedelia trilobata* (Table 2-3), *Tradescantia pallida* (Table 4-5) demonstrate that the growing media used in the vertical garden system (vermi-compost and Water hyacinth compost) achieved the highest averages for the mentioned traits compared to the media of wheat and peatmoss. Although vermi-compost and Water hyacinth compost possess good growing media properties (supporting the plant, providing water and nutrients, and having gas exchange capacity in the root zone with sufficient oxygen and space between solid media particles), the choice of suitable media is one of the crucial factors that affect the cultivation of ornamental plants. Vermi-compost may have provided the plants with their necessary micro and macro elements essential for plant growth and development (Table 1), along with various hormones, enzymes, organic, and amino acids that were absorbed from the roots (15). vermi-compost supplies the media and plants with a wide range of bacteria that have multiple functions, such as supplying growth regulators, nutrients, growth hormones, and soil pest-resistant materials, which restore the vitality of the media. All of these factors had an impact on the vegetative grozwth of *Wedelia trilobata* (Table 2-3) and *Tradescantia pallida* (Table 4-5). The process of vermicomposting, in which organic waste is broken down through the symbiotic relationship of earthworms and microbial communities, results in the secretion of hormones necessary for plant growth, such as gibberellins, auxins, and cytokinins. In addition, it leads to the synthesis of streptomycin (which controls pathogenic bacteria), salicylic acid (a growth regulator), and nitrates. Indirectly, earthworms stimulate the microbial biomass and activity through soil aeration and fragmentation of solid materials, thereby increasing the available surface area of organic materials that beneficial microorganisms can utilize. This, in turn, affects the formation of microbial communities, including those that fix nitrogen and provide plants with protection against diseases by promoting their growth and providing them with antibiotics produced by bacteria belonging to the Proteobacteria, Chlorobi, Achromobacter, and Rhizobiales genera (20); (32). Compost may slowly but steadily provide the necessary nutrients and improve the physical properties of the soil over time, resulting in better nutrient absorption by cultivated plants. This compost could be also lower soil acidity, allowing microorganisms to release nutrients into the soil, resulting in better root growth and increased growth of plants (6, 19, 30). The Water hyacinth compost stands out for its richness in nutrients (Table 1), containing nitrogen, phosphorus, potassium, micronutrients, calcium, and sodium (37). These nutrients can influence the plant's metabolic process (44), resulting in increased green growth. The compost is also rich in vitamins, nutrients especially nitrogen and phosphorus, which are essential for chlorophyll formation and plant growth (50), It also increases the formation rate of Carbohydrates in the leaves and increase them is a good Indicator of increasing leaves fresh and dry weight (3). Furthermore, Water hyacinth compost contains high levels of organic matter and high porosity, which can enhance soil moisture retention (25). Moreover, Water hyacinth compost is rich in nutrients (Table 1), including nitrogen, phosphorus, potassium, micronutrients, calcium, and sodium (37). These nutrients can enhance plant metabolism (44), leading to improve vegetative growth. The compost is also rich in vitamins, especially nitrogen and phosphorus, which are essential for chlorophyll formation and plant growth (50). Additionally, Water hyacinth compost contains high levels of organic matter and is highly porous, which can increase soil moisture retention (25). Furthermore, compost may contain a diverse microbial community (41) that can improve soil aeration, root growth, and nutrient availability. In fact, according to Ben (13), Water hyacinth has wide-ranging applications, including production of biofertilizers and beneficial growth hormones and facilitating the availability of macro- and micronutrients to plants. wheat waste compost showed lower growth performance compared to two other compost types, Vermi-compost and Water hyacinth compost, even though its nutrient analysis was satisfactory (Table 1). While the initial growth after planting was similar among the three composts, vermi-compost and Water hyacinth compost outperformed wheat residue compost afterwards. This may be due to the release of allelopathic compounds from wheat residues, as several phenolic compounds, including Hydroquinone, Quercetic, Rutin, P-Hydroxy benzoic acid, and salicylic acid, were identified in the wheat residue compost using HPLC analysis (29). Hydroquinone, in particular, is known for its inhibitory effect on guard cell movement and cell division, which may have led to reduce growth in the plants (51) ; (52). These phenolic compounds are soluble in water and may have been absorbed by the plants during watering, resulting in reduced leaf area, length, and other growth parameters for plants such as *Wedelia trilobata* (Tables 2-3) and *Tradescantia pallida* (Tables 4-5). The application of potassium silicates at concentrations of S1 (1.5 ml/L) and S2 (3 ml/L) improved the vegetative growth characteristics, as observed in the tables for *Wedelia trilobata* (Table 2-3) and *Tradescantia pallida* (Table 4-5) when sprayed on the leaves. Plants that were not treated with this substance showed a decrease in the mentioned characteristics, which may be attributed to a decrease in photosynthesis, an increase in growth inhibitors, a decrease in internal hormones, and a decrease in leaf area (38), especially when exposed to low winter temperatures and high summer temperatures. The application of potassium silicates at concentrations of S1 (1.5 ml/L) and S2 (3 ml/L) has been shown to improve the growth characteristics of various plant species, as demonstrated in Table 2-5 for *Wedelia trilobata* and *Tradescantia pallida*. Plants treated with potassium silicates may have higher levels of gibberellins, which promote cell elongation and growth (33). Additionally, silicon has been shown to increase photosynthesis, nutrient and water uptake, cell division, and pigment content in plants (Tables 2-5). Silicon is also necessary for cell differentiation and healthy plant growth (2); (21); (23). The results also demonstrate an increase in chlorophyll content (Tables 2-5), which may be attributed to the role of potassium silicates in the photosynthetic pathway and protection against chlorophyll degradation (4). Furthermore, plants treated with potassium silicates maintained higher relative water content (RWC) compared to untreated plants. In summary, the application of potassium silicates has significant potential to enhance the growth and development of various plant species, likely through the promotion of cell elongation, increased photosynthesis, and protection against stress factors such as heat and low temperatures. As observed, there was an increase in the number of leaves, leaf area, and pigments related to photomorphogenesis (Table 2, 3, 4, 5), which may be attributed to the role of potassium in regulating stomatal opening and closure, osmotic adjustment within cells, and transportation of nutrients from leaves to all parts of the plant. It also affects cell expansion by regulating water uptake and maintaining water balance, through its control over stomatal aperture, encourages CO_2 fixation, contributes to the movement of metabolites to plant parts, stimulates cell division and meristematic tissue growth, and has a significant role in photosynthesis, respiration, and synthesis of chlorophyll. Additionally, it plays a crucial role in activating enzymes involved in protein and carbohydrate metabolism, as it activates over 80 enzymes that aid in various essential plant activities, and the plant requires it to produce the important ATP compound for plant metabolism. Potassium is an essential nutrient that affects photosynthesis, respiration, and contributes to numerous vital plant functions. It activates over 80 enzymes involved in many essential plant activities, and it is vital for maintaining water balance, turgor pressure, and regulating stomatal aperture to facilitate carbohydrate accumulation and transport. Thus, it contributes to the plant's tolerance to stress conditions, such as high or low temperature (53). The decrease in water loss observed in plants sprayed with potassium silicate may be attributed to the reduction in transpiration rates, as it decreases the accumulation of silicates in the lower epidermal cells, leading to reduced water loss from the epidermal cells (28), 2005, and (16). This could explain the increase in relative water content and turgor weight in the plant (Table 2, 3, 4, 5).The application of potassium silicates may enhance the activity of antioxidant enzymes, such as peroxidase (POD), catalase (CAT), and superoxide dismutase (SOD) under thermal stress conditions, both in summer and winter. This finding is consistent with (10), who reported that foliar silicon application can promote plant growth and improve plants' ability to withstand various abiotic stresses, including heat waves. Furthermore, the use of potassium silicates increased the total chlorophyll content and anthocyanin pigment in leaves, resulting in improved photosynthesis during the summer season (10). The effect of thermal stress on plants depends on the intensity and duration of stress, plant species, and growth stage (18). Plants possess strategies to mitigate stresses and stimulate physiological and molecular mechanisms to adapt to the changing environment. Stressors alter many physiological, biochemical, and molecular equilibria, including cell membrane integrity, enzyme activity, photosynthetic efficiency, nutrient uptake, water relations, stomatal regulation, and hormonal balance (39). Under non-biological stress conditions, silicon regulates plant growth and development by modulating the self-levels of Indole-3-Acetic Acid (IAA). Additionally, experiments have demonstrated that increased root biomass occurs when lateral root formation is stimulated by IAA and plant growth-promoting rhizobacteria (PGPR), thus protecting roots from inhibitory effects. Potassium silicates play a role in alleviating various stress factors, including oxidative damage caused by temperature fluctuations. In heat stress, silicon enhances the antioxidant defense system by suppressing reactive oxygen species (ROS) and improving photosynthetic activity and relative water content to mitigate the effects of high temperature stress. Moreover, the concentration of abscisic acid (ABA) decreases in plants with increased silicon concentration during non-biological stress conditions. Silicon regulates the self-levels of plant hormones, improving plant growth, photosynthesis, and increasing plant length and leaf area, as well as enhancing the plant's resistance to temperature stress (Table 2,3,4,5) over two seasons. Silicon may also aid in plant tolerance to osmotic stress by reducing H2O2, ion leakage, and lipid peroxidation in cell membranes, while enhancing antioxidant activities, phenolic compounds, flavonoids, anthocyanin content, and improving physiological traits such as photosynthetic efficiency, water use efficiency, and conductance. This, in turn, enhances plant growth, development, and productivity (5). Despite the success of plants wheat straw and peat moss, the vegetative and root plants were lower (47). All plants have succeeded in this type of vertical gardens (living walls). The selected of plant leaves had a beautiful contrasting color combination, with the vibrant green of *Wedelia trilobata*, the dark red of *Tradescantia pallida*. This encourages creating living wall murals with various arrangements of these plants. It can be said that the *Tradescantia pallida* plant has covered the living wall panel successfully. Overall, the study suggests that the (LWS) with felt cultivation is a promising method for growing plants in urban areas, and the using of suitable growth media and potassium silicate can further enhance plant growth and resistance to thermal stress.

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