EFFECT OF ORGANIC FERTILIZERS AND NUTRIENTS ON ANATOMICAL TRAITS OF RED BEETROOTS

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ABSTRACT

A field experiment was conducted during fall season 2021-2022 In order to study the effect of soil as an agricultural medium, organic fertilizers (Vermecompost, cow manure) and foliar spraying of silicon and calcium on skin, bark and cambium ring thickness of three beetroot varieties (Red, Dark Red, and Cylindra). Seeds directly sown in the fields of Station A College of Agricultural Engineering Sciences - University of Baghdad - Al-Jadriya campus- Within RCBD a split-plot experiment, where the cultivars were the main unites, organic fertilizer, and foliar spray as the subunits, with three replicates, the number of treatments was 27. The results revealed that the triple interaction treatment of Dark Red, Vermicompost, and silicon spray $V_2S_2F_1$ was superior in epidermis thickness, cortex thickness, and cambium ring thickness (55.00 µm, 78.90 µm, and 182.07µm) respectively, compared with Cylindra cultivar, soil medium, and spraying with distilled water $V_3S_1F_0$, which produced the lowest averages (21.77 µm, 31.23 µm, 64.57 µm) respectively. The interaction treatment between Red cultivar, cow manure and spraying with distilled water $V_1S_3F_0$ excelled in the thickness of the middle xylem ring (261.33 µm). Compared with the thinnest middle xylem (143.8 µm) in red cultivar roots treated with soil medium and distilled water.

Keywords: Cultivars, volumetric fertilization, vermicompost, silicon, calcium
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تأثير الأسمدة والمغذيات العضوية في الصفات التشريحية لجذور الشوندر

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المستخلص

نفذت تجربة حقلية للموسم الخريفي 2021−2022 بهدف دراسة تاثيرالتربة كوسط زراعي والأسمدة العضوية (سماد دودة الأرض وسماد الابقار) والرش الورقي للماء المقطر فضلا عن عنصري (السليكون والكالسيوم) في سمك البشرة والقشرة وحلقة الكامبيوم لثلاثة أصناف من الشوندر (Red، Dark Red وCylindra) زرعت البذور في الحقول التابعة لقسم البستنة وهندسة الحدائق – كلية علوم الهندسة الزراعية – جامعة بغداد– مجمع الجادرية – محطة A –، ضمن تصميم القطاعات التامة التعشية كتجربة قطع منشقة اذ عدت الأصناف العامل الرئيس والاوساط العضوية والرش الورقي العامل الثانوي وبثلاث مكررات، بلغ عدد المعاملات 27 . اظهرت النتائج تفوق معاملة التداخل الثلاثي بين الصنف Dark Red والسماد العضوي Vermicompost والرش بالسليكون $V_2S_2F_1$ تفوقا معنويا على باقي المعاملات في سمك البشرة وسمك القشرة وسمك حلقة الكامبيوم باعطائها (55.00 µm، 78.90 µm و µm182.07) على التتابع مقارنة مع الصنف Cylindra ووسط التربة والرش بالماء المقطر $V_3S_1F_0$ التي أعطت اقل المعدلات اذ بلغت (21.77 µm ، 31.23 µm ، 64.57 µm) على التتابع ، في حين تفوقت معاملة التداخل بين الصنف Red وسماد الابقاروالرش بالماء المقطر $V_1S_3F_0$ في سمك حلقة الخشب الوسطى باعطائها 261.33 µm مقارنة مع اقل قيمة للتداخل بين الصنف Red ووسط التربة والرش بالماء المقطر F0×S1×V1 بلغت 143.80 µm .

الكلمات المفتاحية: أصناف ،التسميد الحجمي، السماد الدودي، سليكون، كالسيوم
مستل من اطروحة دكتوراه للباحث الأول

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INTRODUCTION

The agricultural side faces many challenges, the foremost of which is the need to increase production to match the steady population increase. Plant nutrition is the most important aspect in achieving high agricultural production, which prompts the excessive use of chemical fertilizers. As a result, the amount of emitted pollutants increased (1), so it worthy to use everything organic to prevent any defect of the environmental balance and protect natural resources (5, 11, 14, 27, 28, 29).Therefore, it is necessary to search for innovative technologies to reduce this, but the disadvantage of traditional agents used in agriculture is poor improvement efficiency and fertilizer efficiency. This is due to the fact that most of the compounds are exist in unavailable forms, In addition to the fact that most organic fertilizers contain harmful seeds come from the animal food, and that weed seeds reduce crop productivity, in addition to the existence of many types of pathogenic microorganisms. Therefore, the trend has increased towards the most promising methods, which is the use of formulations that have both of nutrient supplying and soil amendment potential, which represent a special perspective for the progress of agricultural production. At the forefront of these compositions is earthworm compost, which has a significant impact on the formation of the physical, chemical and biological properties of the soil (6) and the plant (9). In fact; it has found that it protects the plant due to the availability of oxidative enzymes in the fertilizer, which facilitate the formation of lignin through the enzyme phenylalanine ammonia-lyase (PAL), which strengthens plant cells (22). In addition to cow manure, which contains nutrients in an available forms, as the animal uses only half of the organic matter (18), and the rest is used as fertilizers to strengthen plant tissues (30) Silicon is one of the most important nutrients that improves anatomical and physiological traits of plant tissue because it is deposited under the epidermis layer (2, 21), forming a double layer of epidermis - silicon, which works to increase leaf thickness and dry weight of the plant. Also, SiO interacts with a number of components of plant cell walls in the form of silica, which leads to a change in the bonds of non-cellulosic polymers and lignin in them and thus strengthening them (16). As for the effect of calcium, it is one of the main nutrients that synthesizes cells membranes and walls, especially the middle plate that connects plant cells, as calcium binds to lactic acid that exist in the cell wall to form calcium pectate, which forms the structural structure of the cell wall, giving it strength and rigidity (25). Admittedly; many researches approved the action of calcium in improving plant status and fitness (3, 7, 8, 10 25, 26). this study was aimed to strengthen the cell walls of red beet plants using organic fertilizers and foliar nutrients, and their effect on the anatomical characteristics of red beet roots.

MATERIALS AND METHODS

The research was conducted in the fields of Department of Horticulture and Landscape Gardening - College of Agricultural Engineering Sciences - University of Baghdad - Al-Jadriya campus _ Station A - for fall season 2021-2022. The field was divided into terraces with a length of 1.25 m and a width of 2 m. Seeds were sown on 4 lines, the distance between one line and another was 20 cm, and a distance of 15 cm between one plant and another, and the fertilizer recommendation for red beet was added (150 kg N / ha in the form of urea, 120 kg P / ha in the form of superphosphate and 120 kg K / ha in the form of potassium sulfate) (13). the experiment had three factors (3 × 3 × 3) within split plot with factorial RCBD, as the first factor represented three cultivars distributed on the main plots, and the combinations between the second factor coefficients and the third factor coefficients (3×3) were distributed randomly on the secondary plots, bringing the number of treatments to 27, with three replicates, and the total number of experimental units is 81 experimental units (27 treatments × 3 replicates). The seeds were sown directly on 10/1/2021. The research included two factors.

The first factor: cultivars

V1- Red (a product of Delta seeds company)

V2 - Variety Dark Red (variety produced by Golden land seedcompany)

V3- Cylindra (a variety produced by the Mountain valley seed company)

The second factor: organic fertilizer

S1- soil only.
S2- Vermicompost (added by 1% of the soil weight at a depth of 30 cm before planting, mixing with the soil of the plot)
S3 - Cow manure (added by 1% of soil weight a depth of 30 cm before planting, mixing with the soil of the plot)
The third factor: foliar spray with the follows
F0 - without spraying (spraying with distilled water only).
F1- Silicon Si (1.25 mg/L) Source: Growsil Fertilizer.
F2- Calcium Ca (2 g / liter) Source: Tecnokel calcium fertilizer.
After completing the indicators of the field study, the averages were compared according to the least significant difference, L.S.D, at a probability level of 5%.=

Preparing cross-sections of the plant samples: Roots of red beet represented the plant sample, were collected at the stage of maturity and cut from the middle to prepare them for manual cutting. Hand Sectioning was prepared by following the following steps, according to (18), modified by (4), my agency:
1. The selected roots were cut into small pieces, with a length ranging between (5-7) cm, from an area located approximately in the middle, and when cutting. The sample was held in a vertical position between the thumb and forefinger and was cut using a sharp slicing blade into thin pieces in a flat, non-inclined position until the thinnest cross section and the clearest features were obtained. Some plant sections were also cut under a dissecting microscope.
2- The sections were transferred to a solution of industrial bleach diluted with distilled water at a concentration of 5% to get rid of the dye, for a period of 5-10 minutes.
3- The sections were stained with safranin (prepared by dissolving 1 gram of the dye in 99 ml of ethyl alcohol at a concentration of 50%) for 1-2 hours, then the sections were washed with 70% ethyl alcohol to get rid of the excess dye.=
4- The sections were transferred to 90% ethyl alcohol for 5 minutes.
5- After that, the sections were transferred to alcohol with a concentration of 95% and absolute alcohol, respectively, for two minutes for each concentration.
6- The sections were then transferred to a mixture of absolute alcohol and xylene in a 1:1 volume ratio for two minutes.
7- Then the sections were transferred to pure xylene for two minutes.
8- The sections were then transferred to a slide of a bottle in which a drop of water + a drop of xylene was placed, then the cover of the slide was gently placed on it, avoiding the formation of bubbles in the section.
9- The tests was conducted with a KRÜSS compound microscope, and the imaging was done with The anatomical traits consisted of epidermis thickness (μm), cortex thickness (μm), number of cambium rings, cambium thickness (μm), and middle xylem ring thickness (μm).

RESULTS AND DISCUSSION

Results in Table (1) show that the triple interaction treatment between cultivar, medium and foliar spray Significant effect in epidermal thickness, cortex thickness, cambium thickness, and middle ring thickness of wood, and a non-significant effect in the number of cambium rings, as the treatment was given $V_2S_2F_1$ is significantly excelled the rest of the treatments in epidermal thickness, cortex thickness and cambium ring thickness (55.00 μm, 78.90 μm and 182.07 μm) respectively, comparing with treatment $V_3S_1F_0$, which produced the lowest (21.77 μm, 31.23 μm, 64.57 μm) respectively. The treatment $V_1S_3F_0$ excelled in middle xylem ring thickness by producing 261.33 μm compared with the lowest thickness which found in $V_1S_1F_0$ (143.80 μm). The results of Table (2) show the effect of the bilateral interaction between the cultivar and the cultural medium, where it was noticed that the V_2S_2 treatment was significantly superior by producing the highest epidermal thickness, cortex thickness, and cambium ring thickness (44.14 μm, 72.06 μm, and 144.88 μm) followed by treatment. V_1S_2 and without a significant difference in the epidermal thickness, while the treatment V_3S_3 was superior in the middle xylem ring thickness (220.43 μm) compared to the lowest thickness that found in V_2S_1 (169.31) μm.

Table 1. Effect of triple interactions of cultivars, medium and organic fertilizers on the anatomical yield indicators of red beet for fall season 2021

traits Treatments	epidermis thickness µm	Cortex thickness Mm	number of cambium rings rings. Plant^{-1}	cambium ring thickness µm	The thickness of the middle Xylem ring µm
			V×S×F		
$V_1S_1F_0$	24.63	34.83	3.00	88.97	143.80
$V_1S_1F_1$	30.37	42.43	4.00	100.07	197.43
$V_1S_1F_2$	26.63	49.93	3.00	99.83	166.70
$V_1S_2F_0$	37.93	54.20	4.00	108.67	211.47
$V_1S_2F_1$	49.40	73.07	5.00	175.77	190.53
$V_1S_2F_2$	42.17	55.03	4.00	110.47	175.17
$V_1S_3F_0$	33.97	47.97	4.00	102.10	261.33
$V_1S_3F_1$	34.60	58.20	4.00	126.47	202.83
$V_1S_3F_2$	31.07	50.03	4.00	131.10	163.43
$V_2S_1F_0$	26.57	42.33	3.00	105.57	195.40
$V_2S_1F_1$	31.97	48.17	4.00	122.30	165.30
$V_2S_1F_2$	30.73	45.07	3.00	106.33	162.10
$V_2S_2F_0$	38.50	67.43	4.00	127.67	207.83
$V_2S_2F_1$	55.00	78.90	5.00	182.07	201.17
$V_2S_2F_2$	39.73	69.83	4.00	131.20	184.80
$V_2S_3F_0$	33.93	42.63	4.00	116.63	209.10
$V_2S_3F_1$	38.27	62.63	4.00	146.33	195.30
$V_2S_3F_2$	34.53	56.63	4.00	130.30	228.40
$V_3S_1F_0$	21.77	31.23	3.00	64.57	210.03
$V_3S_1F_1$	28.73	38.70	4.00	94.10	163.33
$V_3S_1F_2$	26.23	34.63	3.00	98.87	218.90
$V_3S_2F_0$	31.73	42.57	4.00	102.13	173.70
$V_3S_2F_1$	50.90	68.70	4.00	160.60	229.20
$V_3S_2F_2$	43.23	49.00	4.00	108.40	205.27
$V_3S_3F_0$	29.03	40.63	4.00	101.83	213.97
$V_3S_3F_1$	36.50	52.17	4.00	125.47	223.80
$V_3S_3F_2$	30.40	40.10	4.00	105.63	223.53
LSD 0.05	2.569	3.158	N.S	3.094	3.30

V_1 Red cultivar, V_2 Dark Red cultivar, V_3 Cylindra cultivar
S_1 Soil only, S_2 Vermicompost at 1%, S_3 Cow manure at 1%
F_0 spray distilled water, F_1 spray silicon (1.25 mg L-1), F_2 spray calcium (2 g L-1)

As for the lowest epidermis thickness, cortex thickness, and cambium ring thickness, it was observed that they found in V_3S_1 treatment (25.58 µm, 34.86 µm, and 88.16 µm) respectively.n The cortex and the thickness of the cambium ring were (41.74 µm, 63.23 µm, and 148.13 µm) respectively, while the treatments V_3F_0 produced the lowest rates (27.51 µm, 38.14 µm, and 89.51 µm) respectively. While the treatment V_3F_2 prodeced the highest rate The thickness of the middle Xylem ring was 215.90 µm, while the treatment V_1F_2 produced the lowest rates of 168.43 µm The results of table (2) also show that the S_2F_1 treatment was significantly excelled on the rest of the treatments in epidermis thickness, cortex thickness, and cambium ring thickness (51.77 µm, 73.56 µm, 172.81 µm) respectively compared to the treatment S_1F_0, which produced the lowest (24.32 µm, 36.13 µm, 86.37µm) respectively, While the treatment S_3F_0 produced the thickest middle xylem ring (228.13 µm), while the lowest rate was 175.36 µm, while there were no significant differences in the number of cambium rings for all bilateral interactions. As for the effect of the individual factors, it is clear from the results of table (3) that the V_2 variety was excelled in epidermis thickness, cortex thickness, and cambium ring thickness, as it produced (36.58 µm, 57.07 µm, 129.12 µm) respectively, compared to the lowest thickness in the V_3 variety (33.17 µm , 44.19 µm, 110.23 µm) respectively, as for the thickness of the middle xylem ring; V_3 variety produced the thickest xylem ring (206.86 µm), compared to V_1 variety (190.30 µm). The results of Table (3) also show a significant superiority of the medium S_2, by producing the highest epidermal thickness, cortex thickness, and cambium ring thickness (43.18 µm, 62.08 µm, 134.11 µm) respectively. compared to medium S_1, which produced the lowest (27.51 µm, 40.81 µm, 97.84 µm) While the medium S_3 excelled in the thickness of the middle xylem ring, as it produced 213.52 µm, compared to the medium S_1, which produced the lowest (180.33 µm). While the F_1 spray treatment significantly excell on the highest epidermis thickness, cortex thickness, and cambium ring thickness (39.53 µm, 58.11 µm, 137.55 µm) respectively, compared to the lowest rates of control F_0, which produced (30.90 µm, 44.87 µm, 102.01 µm) respectively. However; the F_0 treatment spraying with distilled water excelled in the thickness of the middle xylem layer as it produced 202.96 µm compared to the lowest value of the F_2 treatment, which amounted to 192.03 µm, while there were no significant differences in the number of cambium rings for all individual factors.

Table 2. Effect of bi-interactions of cultivars, medium and organic fertilizers on the anatomical yield indicators of red beet for fall season 2021

Traits / Treatments	epidermis thickness µm	Cortex thickness Mm	number of cambium rings rings. Plant^{-1}	cambium ring thickness µm	The thickness of the middle Xylem ring µm
			V×S		
V_1S_1	27.21	42.40	3.33	93.98	169.31
V_1S_2	43.17	60.77	4.33	125.89	192.39
V_1S_3	33.21	52.07	4.00	119.89	209.20
V_2S_1	29.76	45.19	3.33	111.40	174.27
V_2S_2	44.41	72.06	4.33	144.88	197.93
V_2S_3	35.58	53.97	4.00	131.09	210.93
V_3S_1	25.58	34.86	3.33	88.16	197.42
V_3S_2	41.96	53.42	4.00	131.56	202.72
V_3S_3	31.98	44.30	4.00	110.98	220.43
LSD 0.05	1.44	1.73	N.S	1.88	1.79
			V×F		
V_1F_0	32.18	45.67	3.67	99.91	205.53
V_1F_1	38.12	57.90	4.33	128.64	196.93
V_1F_2	33.29	51.67	3.67	111.20	168.43
V_2F_0	33.00	50.80	3.67	116.62	204.11
V_2F_1	41.74	63.23	4.33	148.13	187.26
V_2F_2	35.00	57.18	3.67	122.61	191.77
V_3F_0	27.51	38.14	3.67	89.51	199.23
V_3F_1	38.71	53.19	4.00	135.87	205.44
V_3F_2	33.29	41.24	3.67	105.31	215.90
LSD 0.05	1.44	1.73	N.S	1.88	1.79
			S×F		
S_1F_0	24.32	36.13	3.00	86.37	183.08
S_1F_1	30.36	43.10	4.00	107.08	175.36
S_1F_2	27.87	43.21	3.00	100.09	182.57
S_2F_0	36.06	54.73	4.00	112.82	197.67
S_2F_1	51.77	73.56	4.67	172.81	206.97
S_2F_2	41.71	57.96	4.00	116.69	188.41
S_3F_0	32.31	43.74	4.00	106.86	228.13
S_3F_1	36.46	57.67	4.00	132.76	207.31
S_3F_2	32.00	48.92	4.00	122.34	205.12
LSD 0.05	1.512	1.874	N.S	1.765	1.96

V_1 Red cultivar, V_2 Dark Red cultivar, V_3 Cylindra cultivar
S_1 Soil only, S_2 Vermicompost at 1%, S_3 Cow manure at 1%
F_0 spray distilled water, F_1 spray silicon (1.25 mg L-1), F_2 spray calcium (2 g L-1)

Table 3. Effect of individual factors for cultivars, medium and organic fertilizers on the anatomical yield indicators of red beet for fall season 2021

Traits / Treatments	epidermis thickness µm	Cortex thickness Mm	number of cambium rings rings. Plant^{-1}	cambium ring thickness µm	The thickness of the middle xylem ring µm
			V		
V_1	34.53	51.74	3.89	113.25	190.30
V_2	36.58	57.07	3.89	129.12	194.38
V_3	33.17	44.19	3.78	110.23	206.86
LSD 0.05	1.003	1.110	N.S	1.561	1.10
			S		
S_1	27.51	40.81	3.33	97.84	180.33
S_2	43.18	62.08	4.22	134.11	197.68
S_3	33.59	50.11	4.00	120.65	213.52
LSD 0.05	0.87	1.08	N.S	1.01	1.13
			F		
F_0	30.90	44.87	3.67	102.01	202.96
F_1	39.53	58.11	4.22	137.55	196.54
F_2	33.86	50.03	3.67	113.04	192.03
LSD 0.05	0.87	1.08	N.S	1.01	1.13

V_1 Red cultivar, V_2 Dark Red cultivar, V_3 Cylindra cultivar
S_1 Soil only, S_2 Vermicompost at 1%, S_3 Cow manure at 1%
F_0 spray distilled water, F_1 spray silicon (1.25 mg L-1), F_2 spray calcium (2 g L-1)

It should be noticed that the root of red beet at the beginning of growth consists of the central cylinder only and is surrounded by the cortex and the epidermis (19, 20). The increase in stored sugars requires Then the existence of wide rings (15) for the purpose of transporting carbon metabolites that transported with the phloem pathway in the form of sucrose from the leaves to the root، Vermicompost fertilizer contributes to the processing of plant hormones that work on the division and expansion of cells, as well as the formation of additional rings in the roots of beetroot through the division and expansion of cells, as well as the formation of additional rings in the roots of beetroot. (12, 23). Through cell division and expansion, as well as the formation of additional rings in beetroot (figure 1) (1), (figure 2) (2), (figure 3) (2) .As for the role of silicon, it may be due to its association with polysaccharides, which works to strengthen the cell wall and preserve it from rupture. As silicon is deposited in the form of double layers of amorphous silica in the epidermis (26), it was also found that silicon associated with hemicellulose produces thicker cell walls with a larger diameter, which may be attributed to the association of primary cellulosic fibers with polysaccharides, which provides a mechanical barrier to protect the cell (24). It could be concluded from the study that the genetic composition of the cultivar has a clear effect on the anatomical traits of the roots of the red beet plant, and the use of vermicompost fertilizer led to improve of physical, chemical and biological properties of the soil, which was reflected on the availability of the nutrients by the plant, and this is the reason for the improvement in the structure of the cell walls of the roots As for the effect of foliar silicon on the anatomical indicators, it had clear indications in increasing the thickness of the epidermis, cortex, and the thickness of the bark ring, because of its role in increasing the sugars plant content and its reflection on the structures of the cell walls, so the effect was synergistic for the study factors in improving the anatomical traits of the plant.

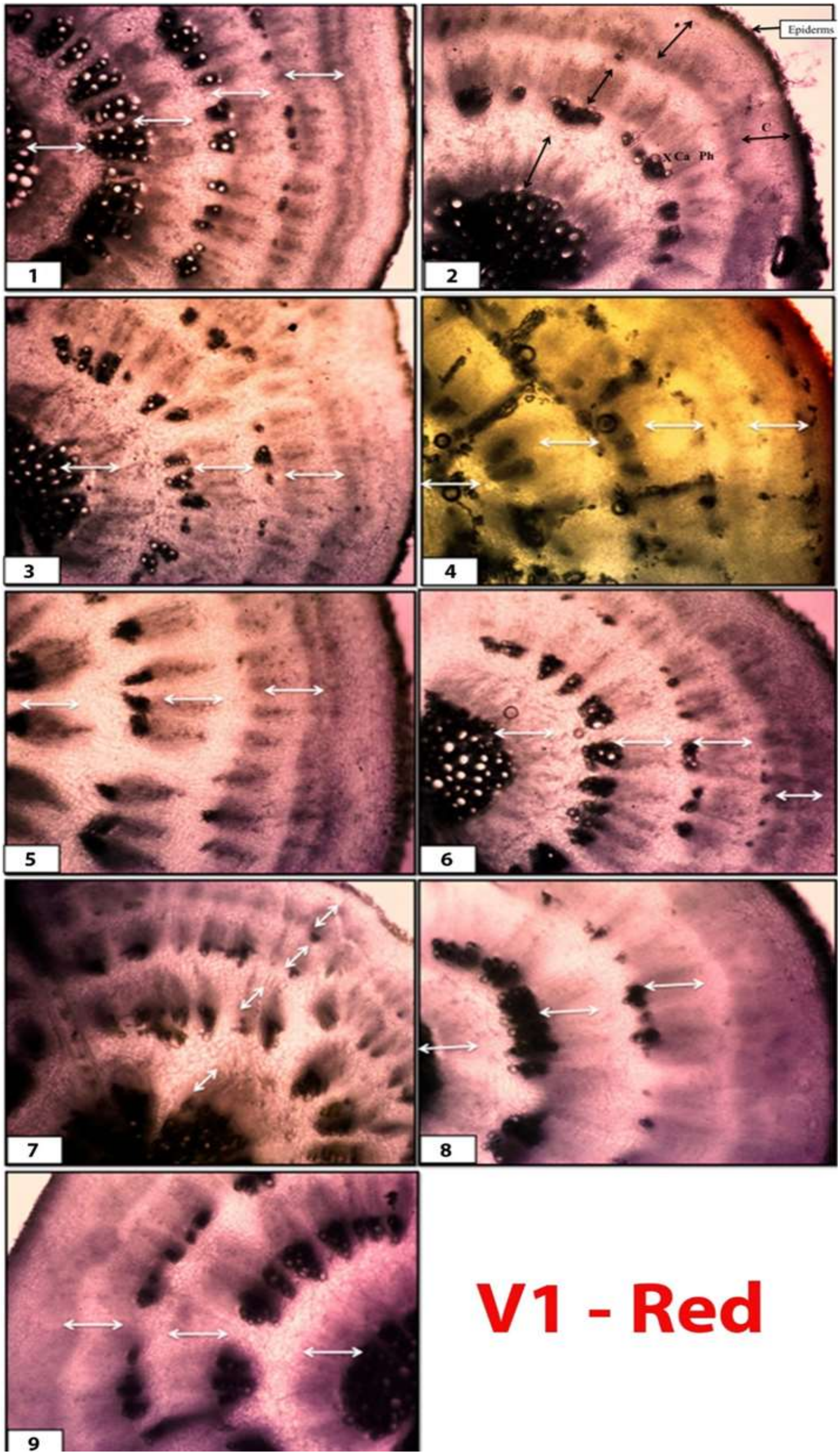

Figure 1. Anatomical sections of the roots of Red beets

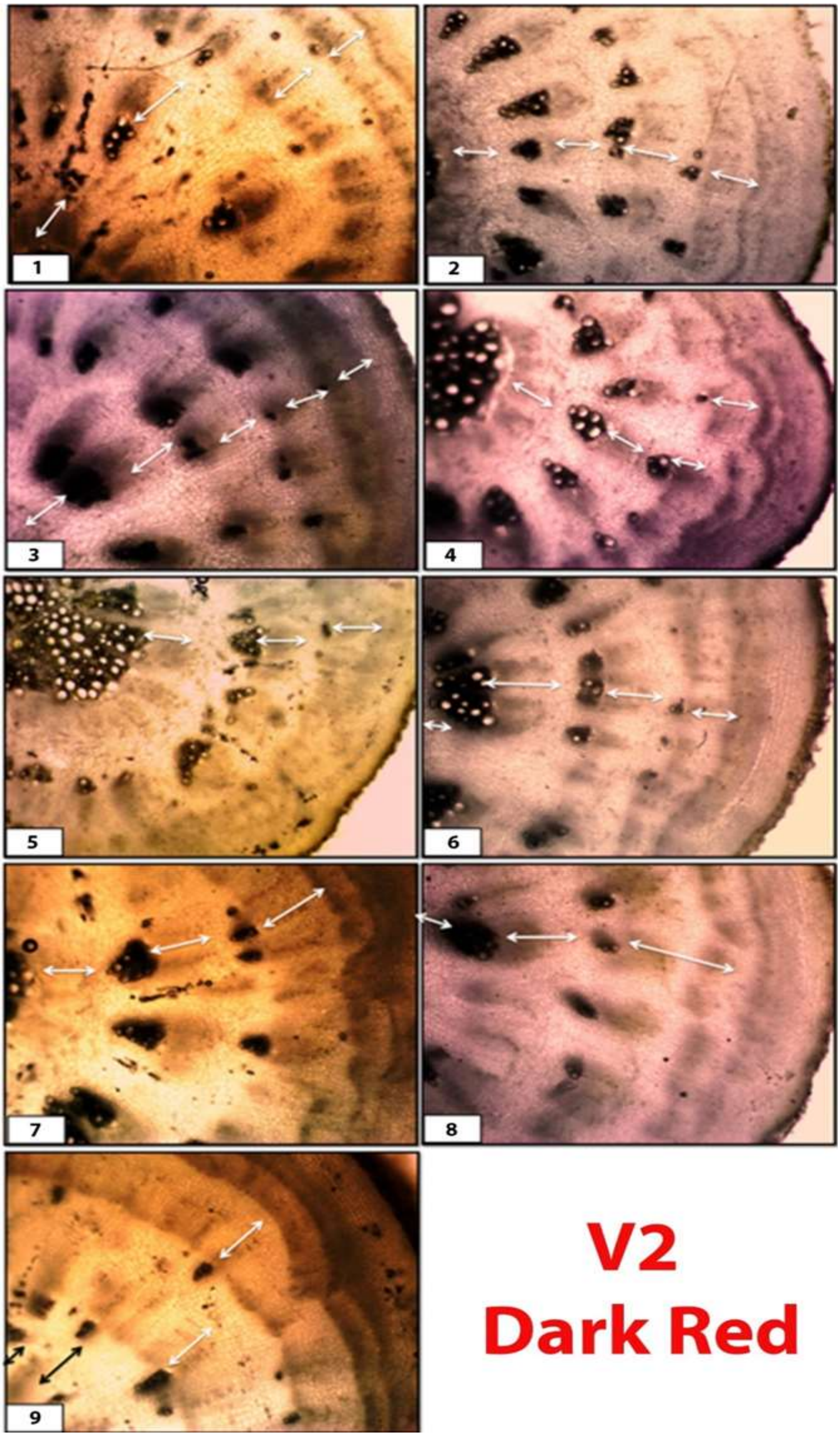

Figure 2. Anatomical sections of the roots of Dark Red beets

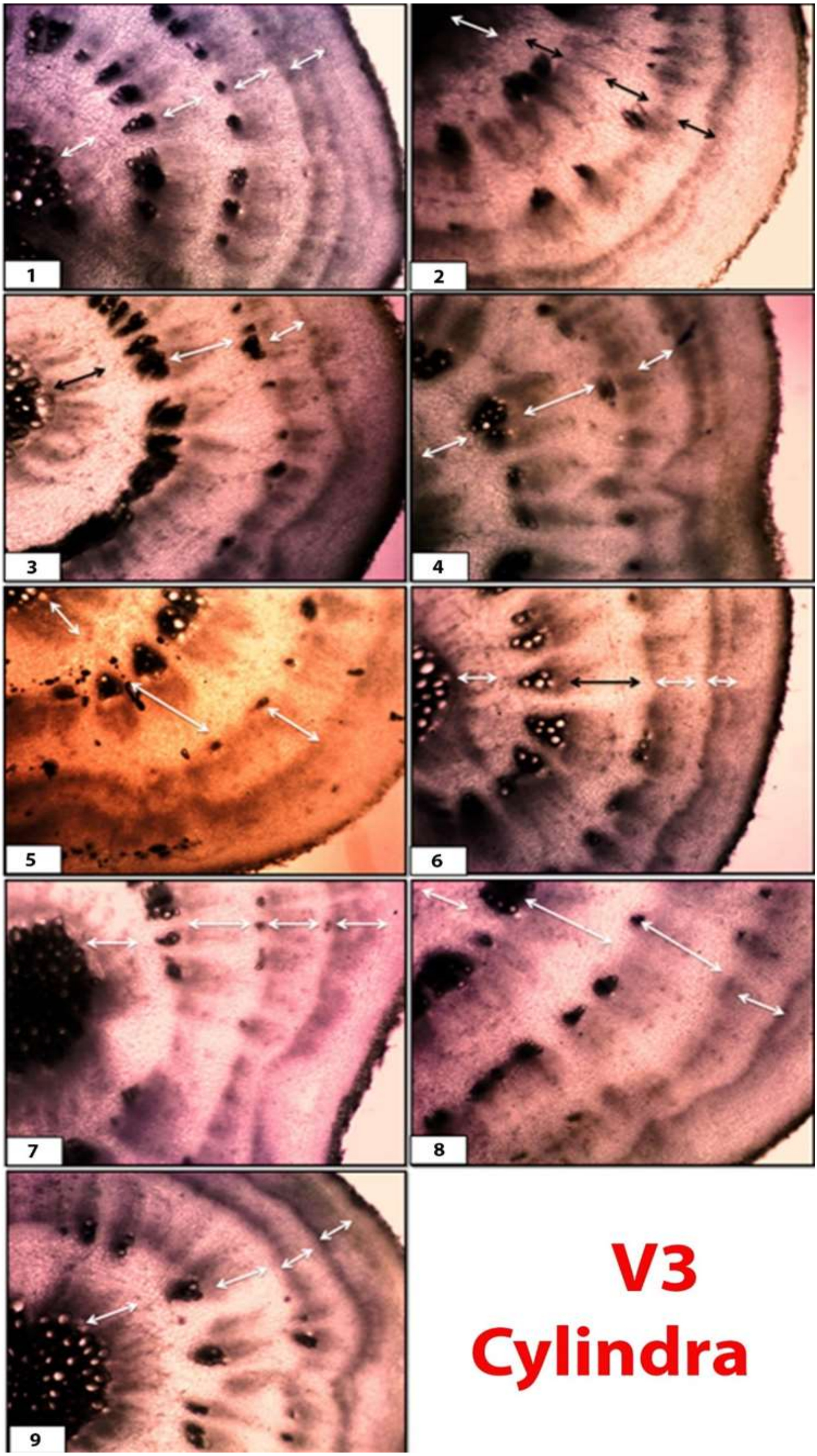

Figure 3: Anatomical sections of the roots of Cylindra beets

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