

ANATOMICAL STUDIES ON SOME SPECIES OF THE GENUS *Vicia*

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ABSTRACT

This investigation was carried out at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt, during the season of 1997/98 to study the anatomical features of seven species of the genus *Vicia*. Transverse sections of primary root at the age of two weeks revealed that the stele was tetrarch in *V. faba* and triarch in the other studied species. The primary xylem strand was solid in *V. hybrida* root, while in the other species the vascular cylinder exhibited pith with different areas in root center.

Transections of the first internode of the main stem showed that in *V. faba* most of transitional steps towards the stem structure took place in this internode. In the other six species, this transitional internode exhibited intermixture of root-like and stem-like orientations of the vascular tissues. The second internode of the main stem revealed structure of true stem in *V. faba* and *V. narbonensis*. In the other five species this internode appeared wide cortex and the center of section was occupied by xylem vessels of nearly collateral fused vascular bundles. Some of the epidermal cells of fifth internode contained dark-yellow and brown contents, differentiated as idioblasts in *V. sativa*. Prismatic or rhomboid crystals were noticed in primary phloem and cortical bundle regions in *V. ervilia* and *V. narbonensis*.

Transections of median internode of the tallest basal branch, at the age of 12 weeks, revealed that *V. faba* showed the highest cross sectional area and *V. palaestina* or *V. hybrida* appeared the lowest cross sectional area. This internode was hollow in the species of *V. faba*, *V. narbonensis* and *V. sativa* and solid in the species of *V. villosa*, *V. palaestina*, *V. hybrida* and *V. ervilia*. Stems and leaf blades of *V. palaestina* and *V. villosa* were characterized by the presence of fan-like bodies in some epidermal cells, and outer layers of stem cortex.

Transverse sections of the leaflet blades of the tallest branch leaf showed that *V. faba* had thicker midrib and midvein, while *V. palaestina*, *V. hybrida*, and *V. ervilia* species appeared lower midvein size.

INTRODUCTION

The genus *Vicia* comprises approximately 200 annual and perennial species. The most economically important species is *Vicia faba*, the only species of the genus used for human food. However, other several species have been used in the same purpose but to a limited extent, usually in times of famine. These include *Vicia ervilia*, which was used in Spain and Morocco and *Vicia articulata* (black lentil) which previously used in Spain and Latin America for human consumption. Recently *Vicia sativa* subsp. *sativa* has been used as a lentil substitute in the Indian sub continent. Several other species of the genus *Vicia* are recorded as forage crops. Chief among these are common vetch (*V. sativa* sub sp. *sativa*) narbon bean (*V. narbonensis*), woolly pod vetch (*V. villosa*) and bitter vetch (*V. ervilia*). Faba bean seeds are

also used for animal feeding, especially in North Africa and Europe (Robertson *et al.*, 1997).

Kupicha (1976) believed that correlated characters divided the species into two natural subgenera; *Vicia* and *Vicilla*. She listed each of *V.faba*, *V.sativa*, *V.narbonensis* and *V.hybrida* among species belonging to the subgenus *Vicia* and each of *V.villosa*, *V.ervilia* and *V.palaestina* among those belonging to the subgenus *Vicilla*.

Streicher (1902) described the shape of the epidermal cells, distribution of stomata, hairs, sclerenchyma and cell inclusions in several species of each genus of Viciae and decided that these characters have little importance in the taxonomy of the group. He reported also the presence of pericyclic fibers around the main vascular strand and finally the presence of cortical vascular bundles especially in winged or grooved stems in some species including *Vicia*. Hector (1936) studied the anatomy of *Vicia faba* root and reported that the cortex is narrow and bounded by the endodermis. The pericycle consists of a single or a double layer. Xylem exhibited triarch or tetrarch arrangement.

Hayward (1938) reported that the root-stem transition zone in pea is not completed in the short hypocotyl, but involves the three basal internodes of the stem. Hence, the stele is not an endarch dictyostele until the fourth internode. Kawatake (1955) reported that the transition zone between root and stem in *Vicia faba* L. was found to extend to the first, third or fourth internode of the stem. El-Sahhar (1967) decided that the tetrarch stele characterized Giza 2 cultivar root whereas the pentarch was prevalent in Cyprian and Sakis varieties of *Vicia faba*. He reported that most of the transitional steps towards the appearance of true stem structure took place in the first basal internode.

The present study was carried out to throw some light on the anatomical features characterize some species of the genus *Vicia*.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The following seven species belonging to the genus *Vicia* were used in this study, *Vicia faba* cv. Giza 674, *Vicia villosa* ssp. *dasycarpa* (woolly - pod vetch), *Vicia narbonensis* (narbon vetch), *Vicia sativa* (common vetch), *Vicia ervilia* (bitter vetch), *Vicia hybrida* (broad - podded vetch) and *Vicia palaestina* (Palestine vetch)

Seeds of *Vicia faba* cv. Giza 674 was obtained from the Food Legume Section, Field Crop Research Institute, Agricultural Research Center, Giza Egypt. The seeds of the other six species were kindly supplied by ICARDA (International Center of Agricultural Research in the Dry Areas), Aleppo, Syria.

Seeds of the seven species were sown on October 12, 1997. The layout of the experiment was the completely randomized design (CRD) with three replications. Pots 20 cm. in diameter were completely filled with sandy loam mixture. Six seeds were sown per pot. Specimens of the main root,

main stem, tallest basal branch, and leaflet were taken at different stages of growth.

Specimens were killed and fixed for at least 48 hr. in F.A.A. (10ml. formalin, 5 ml. glacial acetic acid and 85 ml. ethyl alcohol 70 %). Fixed materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series and embedded in paraffin wax, melting point 52-54 C. Sections of 15 to 20 μ thick were cut. Crystal violet - erythrosin combination method (Jackson, 1926) was used for staining, stained section were cleared in xylene and mounted in Canada balsam (Willey, 1971).

RESULTS AND DISCUSSION

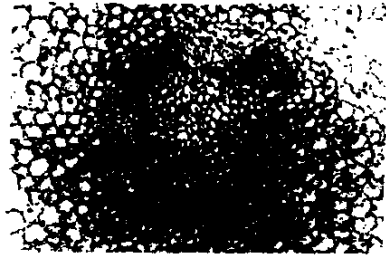
Anatomy of the Root:

Transverse sections of the primary root, at the age of 2 weeks, revealed some differences between the studied species with respect to the primary structure of root (Fig. 1). The stele was tetrarch in *V. faba* and triarch in the other studied species. The number of primary xylem vessels at this stage of growth ranged between 13 and 40. The highest number was recorded for *V. hybrida* and the lowest one for *V. sativa*. In *V. hybrida* root, the centripetal differentiation of the metaxylem resulted in the formation of a solid primary strand, i.e. the root center was occupied by metaxylem vessels. In all other studied species the vascular cylinder exhibited pith in the root center. The diameter of pith ranged between 20 and 165 μ . *V. faba* showed the widest pith, while *V. villosa* pith was the narrowest one (Table 1).

Primary phloem groups developed between the xylem arms, and the peripheral phloem cells in *V. palaestina*, *V. hybrida* and *V. ervilia* differentiated as fibers adjacent to the pericycle. No phloem fibers appeared in the roots of the other studied species at this early stage of growth. In most studied species the pericyclic region appeared multiseriate, especially outside the protoxylem points. This might be due to the tangential divisions of the pericyclic cells. This observation agrees with that found by Hayward (1938), on pea and El-Sahhar (1967), on *V. faba*. Diameter of the vascular cylinder ranged between 185 and 585 μ . *V. faba* showed the largest vascular cylinder and *V. sativa* revealed the smallest one (Table 1).

Table (1): Average of anatomical measurements of the primary root of studied species at the age of two weeks.

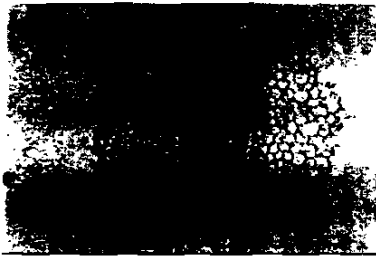
Species	Thickness of cortex μ	Diameter of vascular cylinder μ	Diameter of pith μ	Number of xylem poles	Number of xylem vessels	Diameter of the cross section μ
<i>V. faba</i>	790	585	165	4	33	2155
<i>V. narbonensis</i>	400	300	50	3	33	1095
<i>V. sativa</i>	210	185	30	3	13	640
<i>V. palaestina</i>	365	190	30	3	14	930
<i>V. villosa</i>	268	195	20	3	16	755
<i>V. hybrida</i>	420	320	--	3	40	1075
<i>V. ervilia</i>	358	250	35	3	26	935



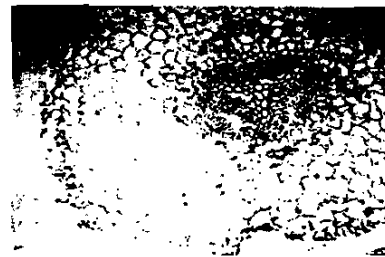
V. faba



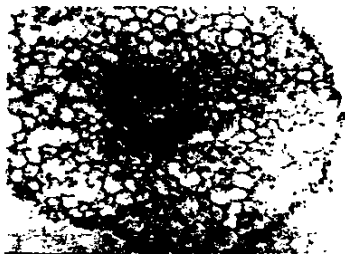
V. villosa



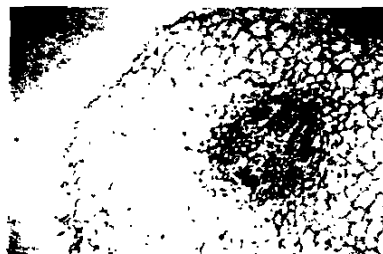
V. sativa



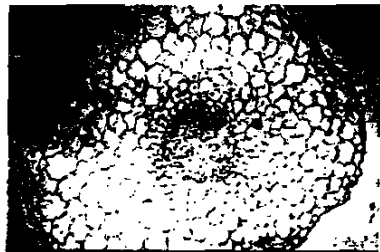
V. hybrida



V. ervila



V. narbonensis



V. palaestina

Fig (1): Transections of primary root, for different studied species of *Vicia*, at the age of two weeks. (x. 60)

The cortex consisted of an endodermis and 8-14 layers of large parenchymatous cells, which are limited outwardly by the epidermis. The thickness of cortex ranged between 210-790 μ . The most wide cortex observed for *V. faba*, in disagreement with the findings of Hector (1936) and El-Sahhar (1967) who mentioned that the cortex of *V. faba* root was narrow.

There was considerable difference in the cross sectional area between the various studied species. Measurements of the cross section diameter show that the highest value was recorded for *V. faba* root and the lowest one for *V. sativa* (Table 1).

Anatomy of the main stem:

1. The first basal internode:

Transverse sections of the first internode of the main stem at the age of two weeks (Fig. 2), revealed that outline of the internode was nearly cylindrical in the different studied species. This internode consisted of uniseriate epidermis, with cells nearly square in shape and some of them elongated in the radial direction. The epidermal cells covered with thin layer of cuticle. Stomata were rarely observed. The cortex was wide, consisting of 14-20 layers of cells. The two layers underlying the epidermis were collenchymatous and the rest of layers were parenchymatous. Large schizogenous lacunae developed in the cortical parenchyma of *V. ervillia* stem. Four large cavities were observed between the cortical bundles in this species (Fig. 2). The cortical bundles consisted of two fibrous strands on two opposite sides, and two fibrovascular bundles on the other two opposite sides. These bundles showed differences in size between the different species.

The stele of the first internode showed great differences, specially between *V. faba* and the other studied species. It is obvious that in *V. faba* the peripheral zone of the stele appeared meristematic tissue, which is probably of pericyclic origin. It is apparent also that in this species

most of the transitional steps towards the stem structure took place in this internode (Fig. 2). The stele consisted of 10-12 collateral bundles. A fibrous cap with thin walled cells was abutting the outside of each bundle. The pith across its diameter consisted of eleven large cells, with small triangular intercellular spaces. The pith was in continuity with the cortex through medullary rays. This observation agrees with that found by El-Sahhar (1967) on the same species. On the other hand Kawatake (1955) mentioned that the transition zone in *V. faba* was found to be extend to the first, third or fourth internode of the stem.

In the other six species, the stellar region appeared groups of exarch xylem alternated with endarch collateral bundles. The primary phloem was in a collateral position with respect to the endarch primary xylem, and in an alternate, radial position in relation to the exarch xylem groups. Thus, the transitional region exhibited an intermixture of root-like and stem-like orientations of the vascular tissues (Figs. 2). In this connection Hayward (1938) mentioned that in pea the root-stem transition zone is not completed in the short hypocotyl, but involves the three internodes of the stem. Hence, the stele is not an endarch dictyostele until the fourth internode.

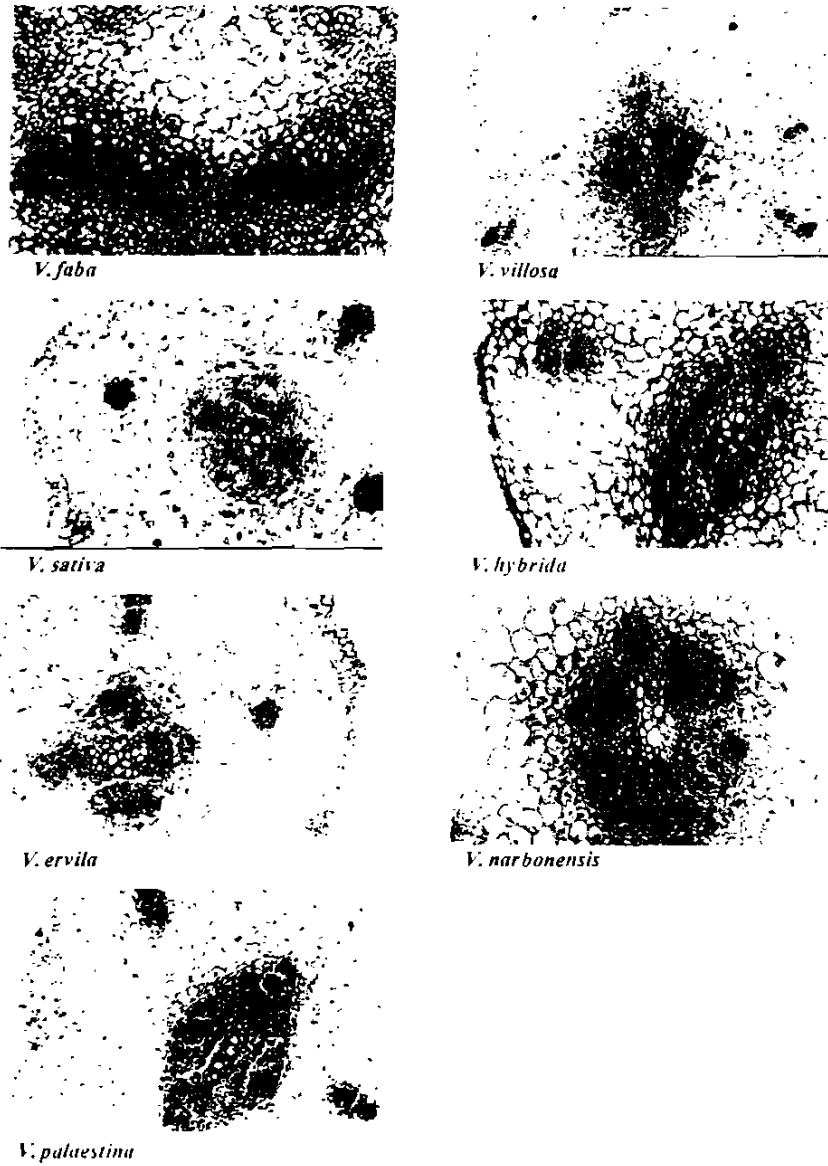


Fig (2): Transections of the first basal internode of the main stem, two weeks old, for different studied species of *Vicia*. (x. 60)

2. The second internode:

Transections of the second internode, 3 weeks old showed that the outline of this internode was nearly circular in different studied species except in *V.narbonensis* where it was quadrangular. The studied species showed differences in the cross sectional area, the amount of different tissues and arrangement and position of vascular bundles (Fig. 3). *V.faba* and *V.narbonensis* appeared structure of the true stem at this level of main stem and had thicker stems as compared to the other studied species. The second internode in both species consisted of uniseriate epidermis, with cells different in size and shape. Four cortical bundles were observed similar to those recorded for the first internode. Twelve collateral vascular bundles in *V.faba* and five in *V.narbonensis* were detected, with 2-7 and 2-5 rows of vessels in each bundle for the two species respectively. Pith, of thin-walled parenchyma, with thickness nearly equal to that of cortex was observed in both species. Fibers of cortical bundles or those accompanied the collateral vascular bundles showed thin walled- cells. Some prismatic crystals were observed near the cortical bundles.

Transverse sections of the second internode of the other five species appeared wide cortex, similar to that of the first transitional internode. The center of section was occupied by xylem vessels. Fine examination exhibited that there was number of collateral bundles occupied the central region of the internode and their primary xylem poles might be fused. Some cambial activity within collateral vascular bundles and differentiation of few secondary xylem vessels was noticed in *V.sativa* and *V.ervilia* (Fig. 3).

The beginning of pith development was detected in *V.sativa*, *V.hybrida* and *V.ervilia*, but not in *V.palaestina* and *V.villosa* (Figs. 3). The appearance of pith might be occurred by divergence of the vascular bundles. Thus it could be concluded that in these five species reorientation of vascular tissues or transition was nearly completed in the second internode though it appeared wide cortex and no pith. These observations are in agreement with the findings of Hayward (1938) for pea root-stem transition zone and with those of Kawatake (1955) for *V.faba* species.

Outward the central vascular region there was a wide cortex mostly consisted of parenchyma cells except the outer two or three layers, which were chlorenchyma. The cortex showed schizogenous lacunae, which were large in *V.ervilia*. Four cortical bundles were observed. The epidermis was uniseriate and covered with thin layer of cuticle. Some epidermal cells were differentiated as idioblasts in *V.sativa*.

3. The fifth internode

Transverse sections of the fifth internode of the main stem, 5 weeks old (Fig. 4) revealed that the outline of this internode was nearly rhomboid in *V.palaestina* and *V.sativa* and quadrangular in *V.faba*, *V.narbonensis*, *V.villosa*, *V.hybrida* and *V.ervilia*.

Although the transition to the stem structure might be completed in the second internode, the fifth internode of some species showed narrow pith (*V.sativa* and *V.hybrida*) and that of others with no differentiated pith (*V.villosa* and *V.palaestina*).

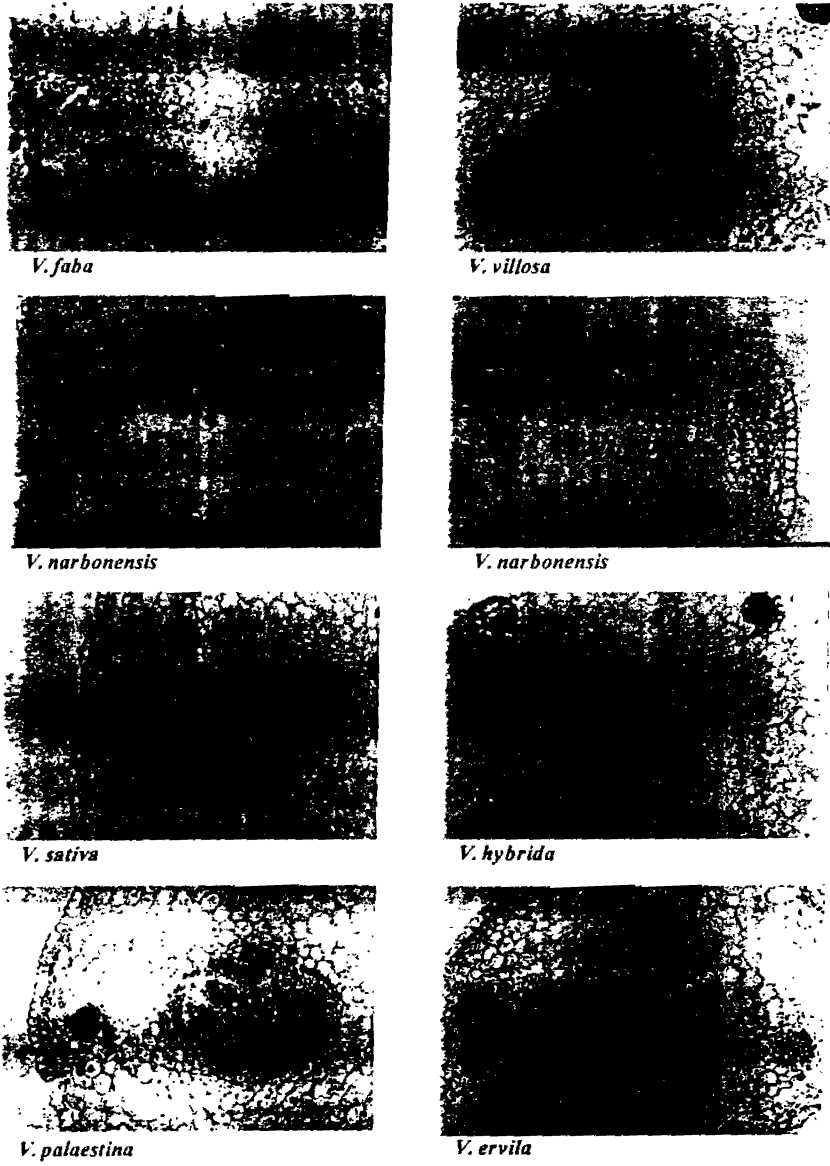


Fig (3): Transsections of the second basal internode of the main stem three weeks old, for different studied species of *Vicia* (x. 60)

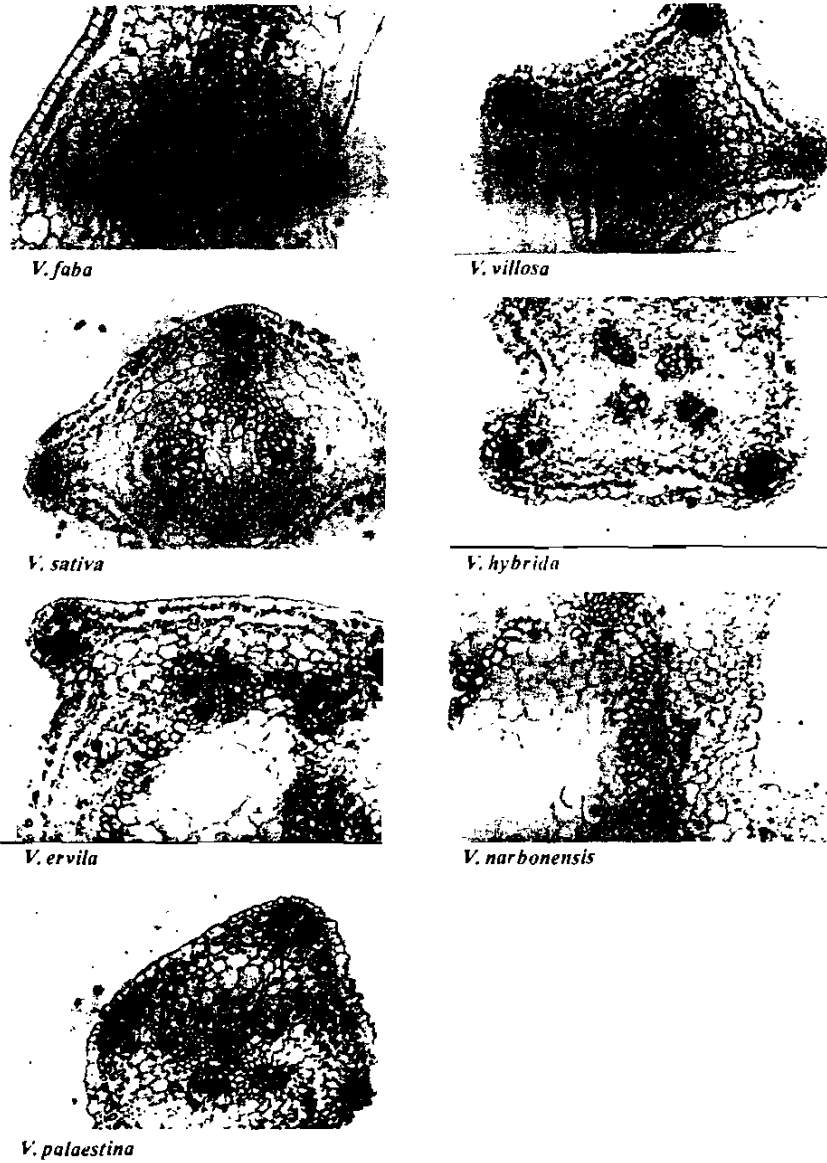


Fig (4): Transections of the fifth internode of the main stem five weeks old, for different studied species of *Vicia*. (x. 60)

In the latter two species, two opposite vascular bundles were diverged, while the other two opposite ones still in adnation. Consequently the center of the internode was occupied by xylem vessels (Fig. 4). In the above mentioned four species, four collateral vascular bundles in addition to four cortical bundles were recognized. In *V.sativa* the collateral vascular bundles interconnected tangentially by thick walled - cells. Some of the epidermal cells in this species were differentiated as idioblasts (Fig.4). The outer region of the wide cortex consisted of 2-3 layers of chlorenchyma. Chlorenchymatous cells in *V. palaestina* appeared with high density of chloroplasts. The rest of cortex layers were parenchymatous (Fig.4).

The other three species, *V.faba*, *V.ervilia* and *V.narbonensis* showed wide pith (Figs. 4). Moreover hollow pith cavity was developed in *V.faba* and *V.narbonensis*. Four major collateral vascular bundles and 20 minor ones were detected in *V.faba*. In *V.narbonensis* four major collateral vascular bundles and six minor ones were observed. Whereas in *V.ervilia* six collateral vascular bundles nearly equal in size encircled wide pith of large parenchymatous cells, were recorded. In each of the three species four cortical bundles were observed. Prismatic or rhomboid crystals were noticed in primary phloem and cortical bundle regions in *V.ervilia* and *V.narbonensis*. Metcalf and Chalk (1950) reported in their study on Papilionaceae, the presence of solitary (styloid) crystals very variable in size and shape and so the crystalliferous cells frequently form a sheath along the outer boundary of the pericyclic sclerenchyma.

Anatomy of the median interenode of the tallest basal branch:

Transections were made in the internode located at the middle of the tallest basal branch at the age of 12 weeks. This internode showed the complete primary structure of the stem in addition to the beginning of secondary growth. Some differences in the structure of this internode were recorded for the different studied species (Fig. 5). *V.faba* surpassed all the other studied species with respect to the thickness of this internode. On the other hand *V. palaestina* and *V.hybrida* showed the thinner internode in comparison with the other studied species (Fig. 5).

The difference in internode thickness was due to the difference in thickness of cortex, radial length of the vascular bundles and diameter of pith or pith cavity (Table 2). Most of pith cells was disintegrated in the species of *V. faba*, *V.narbonensis* and *V.sativa*, thus the internode was hollow. Pith of intact cells was observed in *V.villosa*, *V.palaestina*, *V.hybrida* and *V.ervilia* (Figs. 5).

Vascular bundles showed differences in size and number among the different species. The highest values in this respect were recorded for *V.faba* and the lowest ones for *V.hybrida* (Table 2). Some epidermal cells in *V.sativa* were differentiated as idioblasts. *V.palaestina* and *V.villosa* were characterized by the presence of fan-like structures in some cells of the epidermis and outer layers of the cortex (Fig. 6). *V.villosa* possessed wider secondary xylem vessels and pith cells when compared with those of the other studied species. *V.palaestina* showed high density of chloroplasts in the chlorenchymatous layers.

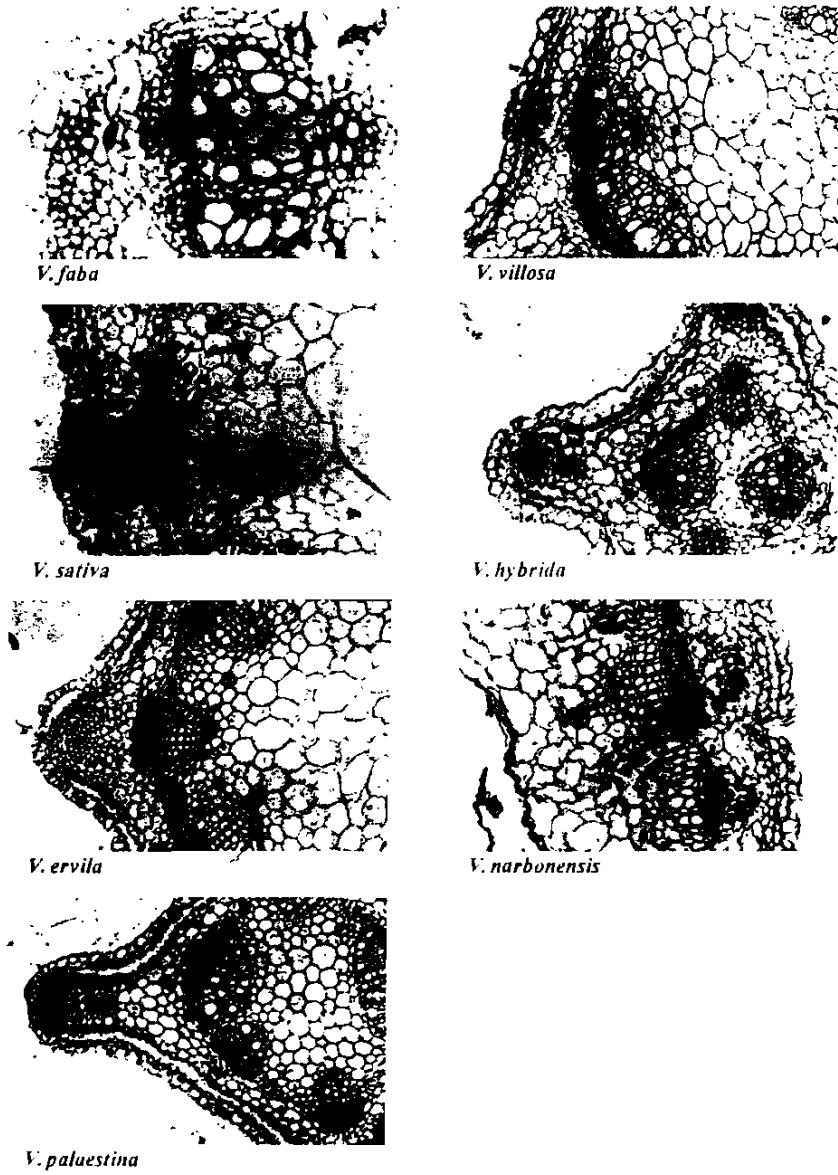


Fig (5): Transections in the median internode of the tallest basal branch 12 weeks old.
for different studied species of *Vicia* (x. 60)

Table (2): Average anatomical measurements of the median internode of the tallest basal branch of seven species of genus *Vicia* at the age of 12 weeks.

Species	Diameter of cross section μ	Diameter of cavity μ	Pith diameter μ	Major bundles μ		Minor bundles μ	
				length	width	length	width
<i>V. faba</i>	9075	5212	--	756.0	× 956.0	668.8	× 468.8
<i>V. narbonensis</i>	2675	1412	--	256.3	× 287.5	181.3	× 193.8
<i>V. sativa</i>	2100	587	--	218.8	× 212.5	243.8	× 243.8
<i>V. palaestina</i>	1375	--	675	125.0	× 93.8	187.5	× 275.0
<i>V. villosa</i>	750	--	337	156.3	× 162.5	208.3	× 375.0
<i>V. hybrida</i>	1725	--	662	118.8	× 68.8	117.0	× 104.0
<i>V. ervilia</i>	775	--	150	156.3	× 118.8	193.8	× 181.3

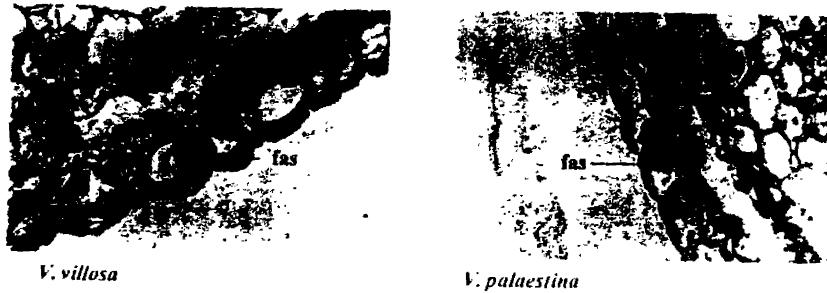


Fig (6): Transsections in the median internode of the tallest basal branch 12 weeks old, for *V. villosa* and *V. palaestina*. (x. 240)

fas: fan-like structures

Anatomy of leaflet blade

Transections of the leaflet blades of the tallest basal branch revealed that there were some differences in the structure of leaflets between the different studied species. *V.faba* surpassed all the other species with respect to the thickness of blade, midrib, midvein and number of xylem vessels. The higher thickness of blade in *V.faba* might be due to the increase in number and size of mesophyll cells. The lowest thickness of blade was recorded for *V.villosa* species (Fig. 7 and Table 3). *V.palaestina*, *V.hybrida* and *V.ervilia* species showed lower midvein size as compared to the other studied species. The difference in midvein size was due mainly to the difference in size and number of xylem vessels. The amount of phloem tissue shared also in this respect.

It is of interest to notice that as mentioned in the structure of stem, fan-like structures were noticed in some leaflet epidermal cells of *V.palaestina* and *V.villosa*. In *V.sativa* dark-yellow and brown contents were also detected in epidermal cells, which differentiated as idioblasts (Fig. 7).

Table (3): Average of anatomical measurements of leaflet corresponding to the median internode of the tallest basal branch of studied species at the age of 12 weeks.

Species	Thickness of blade μ	Dimensions of midrib μ	Dimensions of the vascular bundle μ	Dimensions of xylem μ	No. of xylem vessels
<i>V.faba</i>	500	980 × 880	290 × 220	200 × 200	55
<i>V.carbonensis</i>	250	500 × 490	140 × 130	100 × 110	31
<i>V.sativa</i>	200	280 × 300	90 × 70	40 × 50	18
<i>V.palaestina</i>	140	190 × 200	50 × 40	20 × 30	7
<i>V.villosa</i>	120	240 × 260	70 × 60	50 × 50	15
<i>V.hybrida</i>	180	240 × 200	50 × 50	20 × 30	7
<i>V.ervilia</i>	190	230 × 230	50 × 50	30 × 20	6

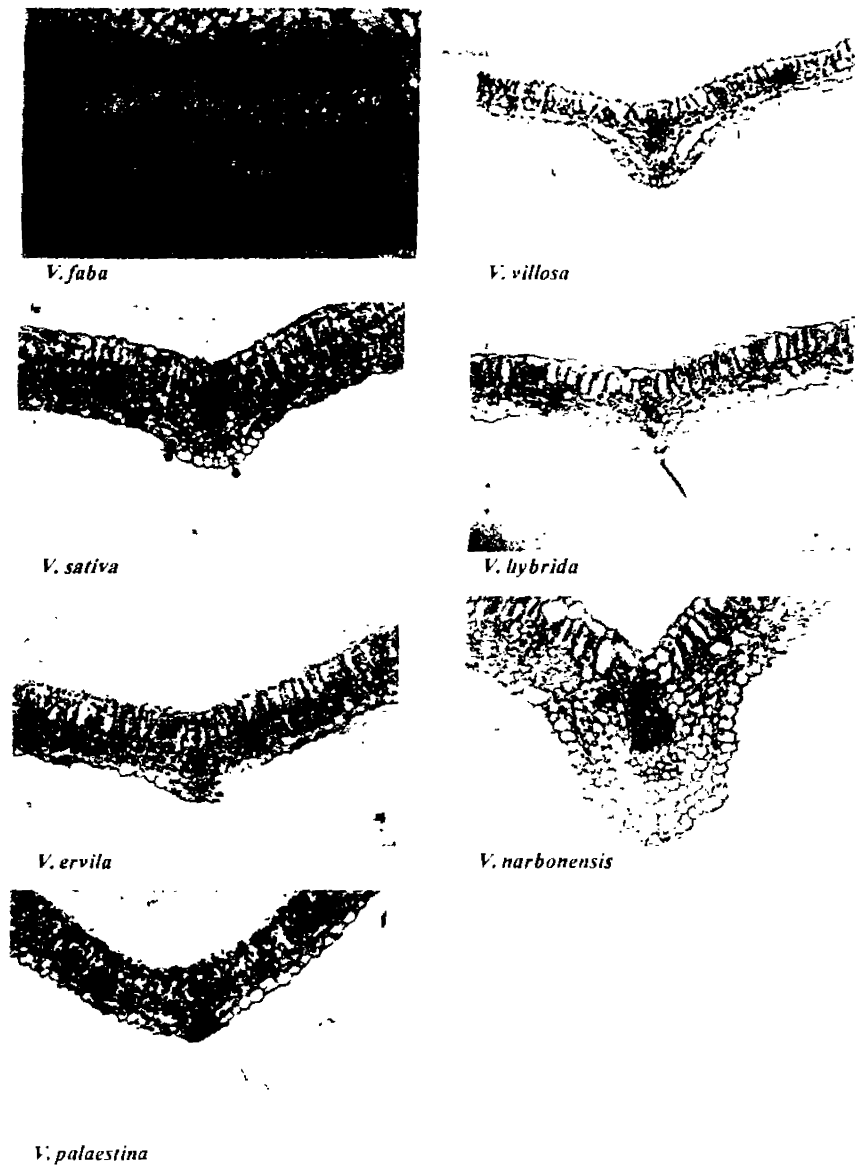


Fig (7): Transections of the leaflet of the tallest basal branch, for different studied species of *Vicia*. (x. 60)

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دراسات تشريحية على بعض أنواع جنس *Vicia*
عبد الفتاح إبراهيم الشعراوي ، فادية أحمد يوسف و سوسن محمود أبوظالب
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اجري هذا البحث في محطة التجارب والبحوث الزراعية بكلية الزراعة جامعة القاهرة بالجيزة لدراسة الصفات التشريحية التي تتميز بها بعض أنواع جنس *Vicia* ، أظهرت القطاعات العرضية في الجذر الابتدائي عند عمر أسبوعين أن العمود الوعائي رباعي أذرع الخشب في النوع *V. faba* وثلاثي أذرع الخشب في باقي الأنواع التي درست. كما كان الخشب الابتدائي مصمما في النوع *V. hybrida* أما في بقية الأنواع فقد تكون نخاع مختلف الاتساع في مركز الاسطوانة الوعائية. أظهرت القطاعات العرضية في السلسلة الأولية للساق الرئيسي أن معظم عمليات التحول من تركيب الجذر إلى تركيب الساق قد تمت في هذه السلسلة بالنسبة للنوع *V. faba* أما في الأنواع الستة الأخرى فقد أظهرت القطاعات العرضية أن منطقة العمود الوعائي بالسلسلة الأولية تحتوي علي خليط من تركيب الجذر وتركيب الساق من حيث ترتيب الأنسجة الوعائية. أوضحت القطاعات العرضية في السلسلة الثانية للساق الرئيسي تركيب الساق الحقيقي في كل من النوعين *V. narbonensis*, *V. faba* حيث ظهر النخاع متسعا وجميع الحزم الوعائية جانبية، أما في بقية الأنواع فقد أظهرت هذه السلسلة قشرة عريضة، ومركز القطاع مشغول بأوعية خشب لحزم وعائية جانبية تقريبا وملتحمة. بعض خلايا البشرة بالسلسلة الخامسة للساق الرئيسي ظهر بها محتويات لونها أصفر داكن أو بني وتميزت إلى خلايا غريبة في النوع *V. sativa* كما ظهرت باللسورات منشورية أو معينة بمنطقة اللحاء الابتدائي والحزم القشرية في النوعين *V. narbonensis*, *V. ervilia*

القطاعات العرضية في السلسلة الوسطية لأطول فرع قاعدي عند عمر ١٢ أسبوع أظهرت أن أكبر مساحة كلية للقطاع العرضي كانت في النوع *V. faba* وأقل مساحة كانت في النوعين *V. hybrida*, *V. palaestina* وبعض خلايا البشرة بالسلسلة الوسطية المذكورة أعلاه كانت تحتوي على مكونات ذات لون اصفر داكن أو بيضاء وتميزت إلى خلايا غريبة في النوع *V. sativa* وتميزت هذه السلسلة بوجود أجسام بشكل شبه مروحة في بعض خلايا البشرة والطبقات الخارجية من القشرة في النوعين *V. palaestina*, *V. villosa* وقد ظهرت هذه التراكيب أيضا في بشرة نصل الوريقة لهذين النوعين.

القطاعات العرضية في نصل الوريقة للورقة الوسطية بأطول فرع قاعدي أظهرت أن النصل في النوع *V. faba* كان أكثر سمكا وكذلك العرق الوسطي، وأقل حجم للعرق الوسطي لوحظ في الأنواع:

V. ervilia, *V. hybrida*, *V. palaestina*