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A comparison of anatomical features of different wheat and rye verieties

BLANKA ROVENSKÁ

Institute of Experimental Botany, Department of Genetics,
Viničná 5, Prague 2, Czechoslovakia

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Abstract

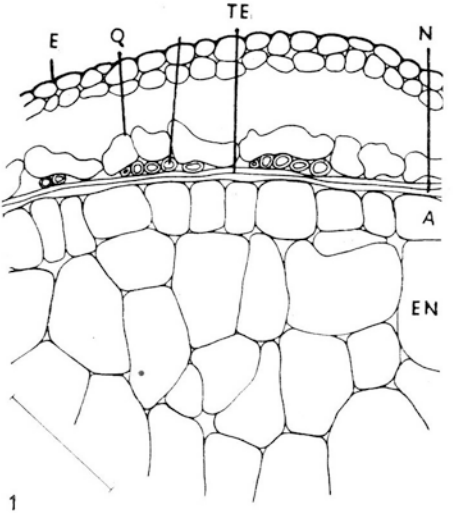
The anatomical features of wheat and rye (*Triticum aestivum* var. *erythrospermum* 'Niva' and *Secale cereale* var. *vulgare* 'České') were investigated. In the present paper the anatomical characters of stems and caryopses of wheat 'Niva' and of rye 'České' are presented.

INTRODUCTION

In recent years the study of the anatomical features of the cultivars of both wheat and rye has been the focus of our interest. We have ascertained those properties which might be used in order to determine the cultivars or then varieties in case of seed exchange.

In wheat there are anatomical properties with whose help some cultivars can be differentiated; in rye this is by no means easy. Rye, not being autopollinating. A pure cultivar in normal growth cannot be maintained. For our investigation we used only those cultivars supplied by ÚKZÚZ (Central Control Testing Institut of Agricultur), Prague, from their selective stations. However it was essential above all, for us, even in these conditions, to determine those anatomical features which are not affected by their surroundings. As the standard cultivar for wheat, we chose, *Triticum aestivum* var. *erythrospermum* 'Niva' and for rye *Secale cereale* var. *vulgare* 'České'. A comparison between stem and caryopsis was carried out.

The anatomical structure of grain from various points of view has been investigated by many authors (F. Netolitzky 1926; L. Krauss 1933; V. G. Aleksandrov et O. G. Aleksandrova 1936a, b,



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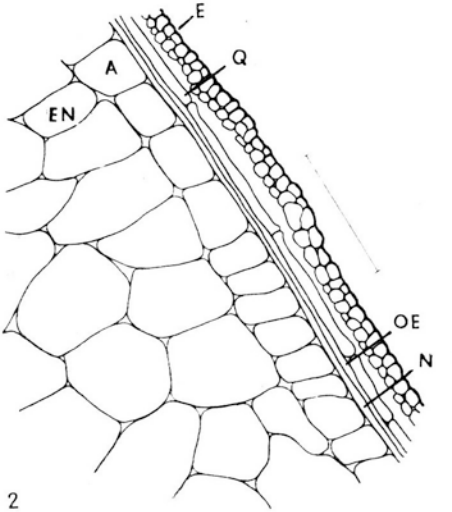

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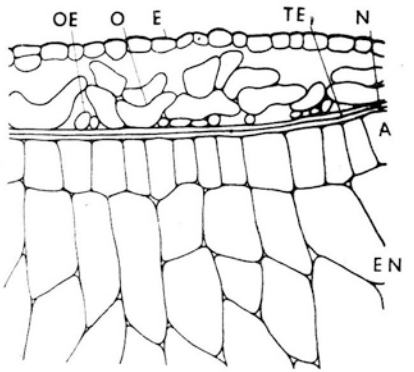

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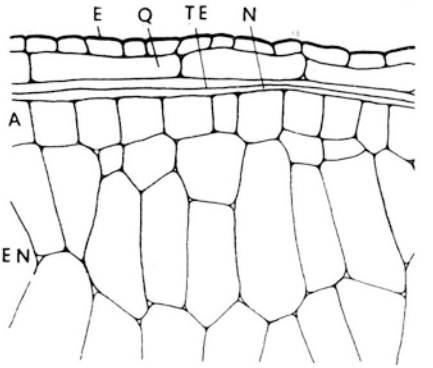

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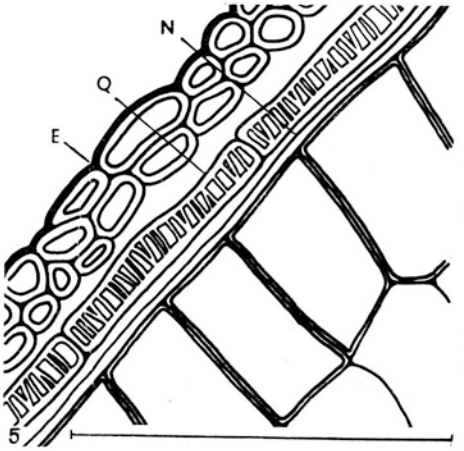

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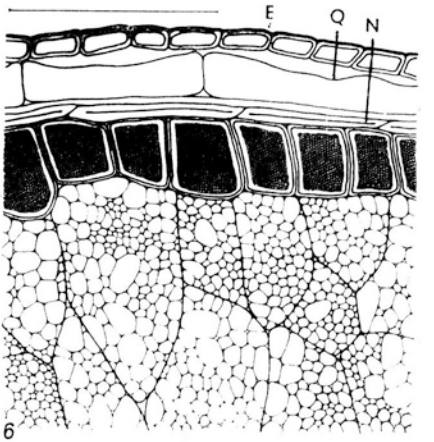

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V. G. Aleksandrov 1943, 1954; H. E. Hayward 1951; K. Esau 1960).

The anatomical structure of the stem likewise, has become such an attractive subject of interest that we will mention just a few authors (P. Vageler 1906; K. Moldenhawer 1914; J. Halmy 1926; L. Nátr 1964).

RIPE GRAIN (CARYOPSIS)

The wheat caryopsis is egg-shaped and slightly flattened at the sides. The rye caryopsis is also egg-shaped, but elongated. The difference in the anatomical structure of the individual tissue in both cases is quite considerable.

In wheat the pericarp on its upper side, is composed of 4 to 5 cell--layers, on the sides, of three (see Figs. 1, 2). In rye the pericarp has 4

Table 1

Caryopsis

	Wheat	Rye
Epidermis	1 transparent layer	1 transparent layer
Subepidermis	1 or 2 „ layers	0 or 1 „ layer
Cross cells	1 layer on top 1 layer at the sides irregularly spaced pits of cell wall	2 layers on top 1 layer at the sides no pits discernible
Tube cells	thick cell walls	thin cell walls
Perisperm	1 compact layer	inner compact integument nucellar epidermis intact

Explanations of the Figs. 1 - 6:

Fig. 1. *Triticum aestivum* var. *erythrospermum* 'Niva'. A detail of the cross-section in the middle of the caryopsis. The upper side.

Fig. 2. 'Niva' — Detail of cross-section in the middle of the caryopsis. Side.

Fig. 3. *Secale cereale* var. *vulgare* 'České'. Cross-section of middle of caryopsis. Upper side.

Fig. 4. 'České'. Cross-section of middle of caryopsis. Side.

Fig. 5. 'Niva'. Cross-section of middle of caryopsis. Side. At the cell-walls of the cross cells the irregular configuration of pits may be seen.

Fig. 6. 'České'. Cross-section of middle of caryopsis at the cell-walls of these cross cells no pits visible.

E — epidermis, *Q* — cross cells, *OE* — tube cells, *TE* — seed coat, *N* — remainder of nucellus, *A* — aleuron layer, *EN* — endosperm. Unit of measurement 100 μm

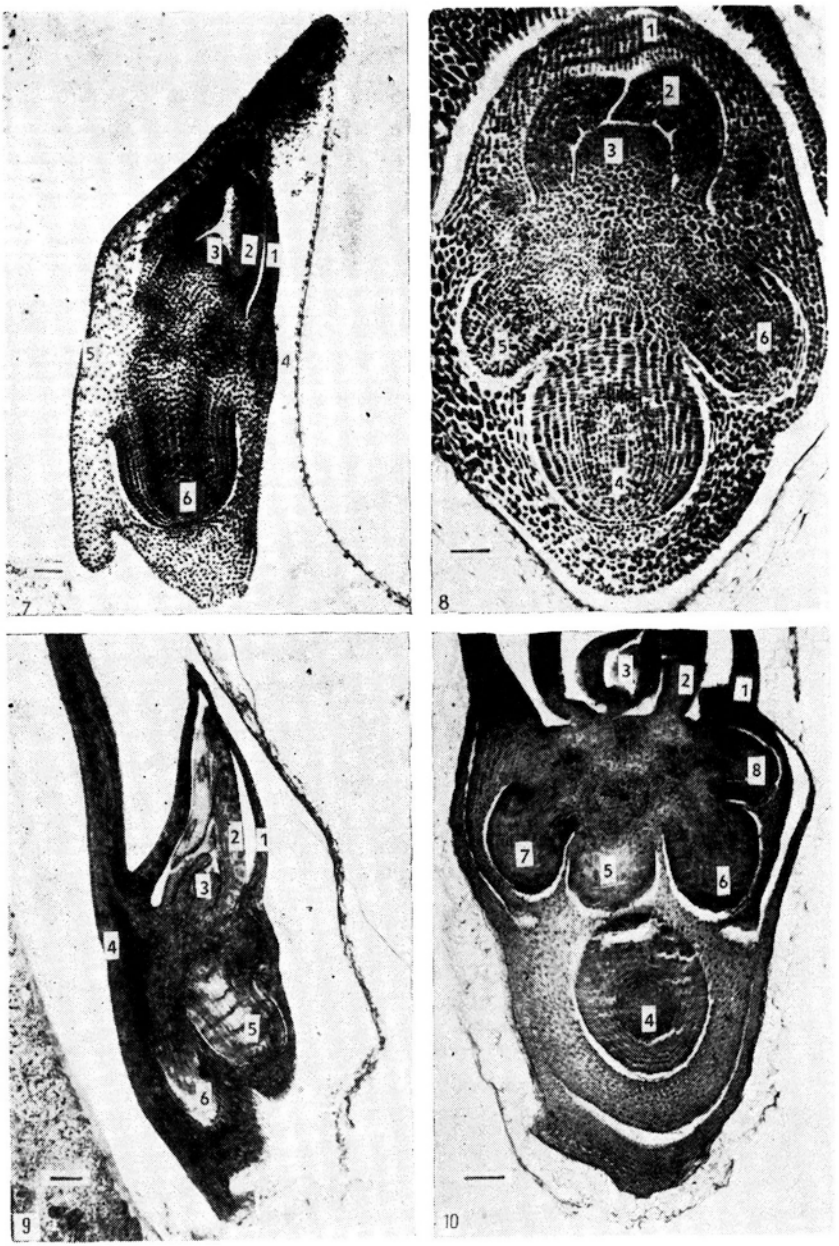

Fig. 7. 'Niva'. Photo of longitudinal front to back section of embryo. *1* — coleoptile, *2* — leaves, *3* — shoot apex, *4* — epiblast, *5* — scutellum, *6* — root apex, *7* — coleorhizis. Unit of measurement 100 μm

Fig. 8. 'Niva'. Photo of longitudinal right to left section of embryo. *1* — coleoptile, *2* — leaves, *3* — shoot apex, *4* — primary root, *5* and *6* — adjacent root. Unit of measurement 100 μm

to 5 layers and is two-ayered on the sides (Figs. 3, 4). In wheat the first epidermal cell-layers and the second subepidermal ones are transparent. These cells when surface-viewed are irregularly 5 or 6 sided and extend along the axis of the caryopsis. In the cross and longitudinal section they are oblong. The cells of the second subepidermal layer are similar in shape if this layer is developed. In rye too, the epidermal cells are like those of wheat and if the subepidermal cells layer is developed it is similar to the epidermis. The cross cells show a strikery difference in shape. In wheat, on the upper side of the caryopsis, these cells, when surface viewed are aligned in regular more or less straight rows. These are oblong and narrow on both shorter sides and rounded at the corners. Over the whole circumference the cell wall shows numerous pits.

The longitudinal axis lies at a tangent to the grain axis. In the cross section these cells, on the upper side, are irregularly wavy (Fig. 1). On the sides they are elongated. (Fig. 2). The cell walls of cross cells are somewhat thickened and have an irregular configuration of pits best discernible in polarised light (Fig. 5). In rye on the upper side there are two layers of cross cells and these overlap (Fig. 3). On the sides and on the under side of the caryopsis there is one layer of these cells (Fig. 4). A surface view shows them to be irregularly oval. Over the whole circumference these cells have minute pits. At the cross-section on the upper side these cells are irregularly wavy and among them there are large intercellular areas. On the sides of the caryopsis they appear in an elongated form with rounded corners slightly elevated towards the epidermis. The pits are not conspicious and their configuration at the cross-section in polarized light is not discernible (Fig. 6). Below the cross cells there are tube cells which are remainders of the inner seed epidermis. These are intact only at the apper side of the caryopsis. In wheat they have a thick cell wall but in rye a thin one.

In these caryopses the seed coat is formed of a double layer inner integument and of a nucellar epidermis. In wheat these layers are wrinkled thus forming a compact layer. In rye the two cell layers of inner integument are likewise wrinkled and form a compact layer but the cell walls of the nucellar epidermis remain intact and thickened (Fig. 6). There are very striking differences in the embryos (Figs. 7, 9). In wheat at the junction of the coleorhizis and the coleoptile on the

Fig. 9. 'České'. Photo of longitudinal front to back section of embryo. *1* — coleoptile, *2* — leaves, *3* — shoot apex, *4* — scutellum, *5* — adjacent root, *6* — primary root. Unit of measurement 100 μm

Fig. 10. 'České'. Photo of longitudinal right to left section of embryo. *1* — coleoptile, *2* — leaves, *3* — shoot apex, *4* — primary root, *5* — adjacent root lying primary root, *6, 7, 8* — adjacent roots. Unit of measurement 100 μm

Photos: J. Stoklasa and J. Fiala
Drawings: E. Křivánková

opposite side of the scutellum there is epiblast. In the case of rye there is no epiblast.

If we examine the longitudinal a right to left section of the basal part of the embryo we discover that in wheat there are from 3 to 5 roots the central one being the primary root (Fig. 8). In rye there are from 4 to 6 roots (Fig. 10). At the longitudinal — "front to back" — section of the same embryo we see in wheat only the central root — the primary one (Fig. 7). In rye in the same longitudinal section we can see two roots one above the other, the primary one being the one near the scutellum. In wheat the coleorhizis is smooth and in rye hairy.

THE STEM

In the structure of the stem internodes there are considerable anatomical differences between wheat and rye. These are best visible at the cross-sections passing through the centre of the internodes. We have studied this internode below the ear and the middle part of the stem and the basal internode.

Table 2

Stem

	Wheat	Rye
Internode under ear	As in rye	As in wheat
Internode middle of stem	As under ear, See Fig. 11	Different in tissue arrangement and vascular bundles, See Fig. 12
Internode at the base of stem	In the sclerenchyma small vascular bundles large vascular bundles as in middle of stem, See Fig. 14	Parenchyma near small vascular bundles large vascular bundles as in middle of stem, See Fig. 15

In the wheat (Fig. 11) there is a multilayered sclerenchyma showing stripes of spongy parenchyma. These are mostly at the sides of the small collateral vascular bundles which in both, wheat and rye, lie near the epidermis. Below this there is parenchymatic tissue in which there are large collateral vascular bundles enclosed in sclerenchymatic sheath. These large vascular bundles are arranged in the form of an irregular round cross-section of the stem. Among these large vascular bundles the tissue of the parenchyma reactes to the middle holow of the stem. In this way the tissue is located both at the internode below the ear and in the middle of the stem. In rye the tissue at the cros-section of the internode below the ear resembles that of wheat. At the central stem

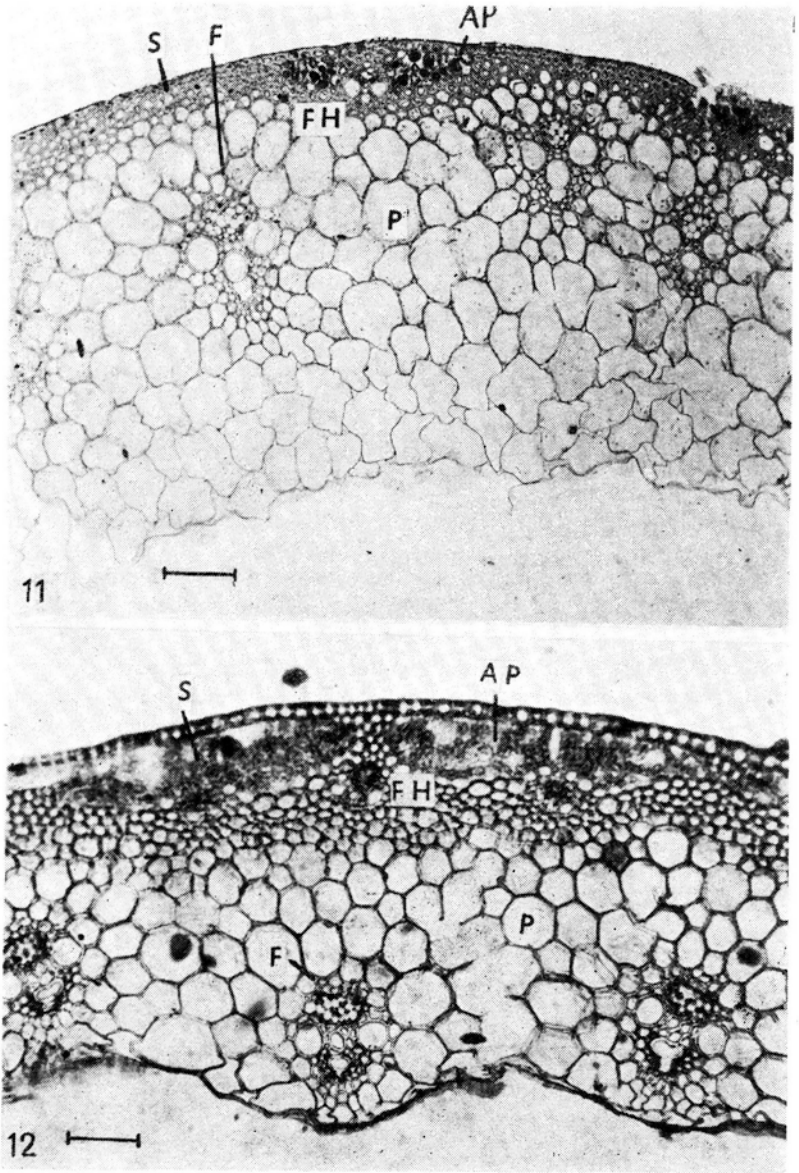

Fig. 11. 'Niva'. Photo of cross-section of internode at mid stem. *S* — sclerenchymatic tissue below epidermis. *F* — large vascular bundle, *FH* — small vascular bundle, *P* — parenchyma, *AP* — spongy parenchyma. Unit of measurement 100 μm

Fig. 12. 'České'. Photo of cross-section of internode at mid stem. *S* — sclerenchymatic tissue which here and there interrupt the spongy parenchyma *AP* below the epidermis, *F* — large vascular bundle above the phloem part of which the sclerenchymatic fiber is clearly visible. *FH* — small vascular bundle, *P* — parenchyma. Unit of measurement 100 μm

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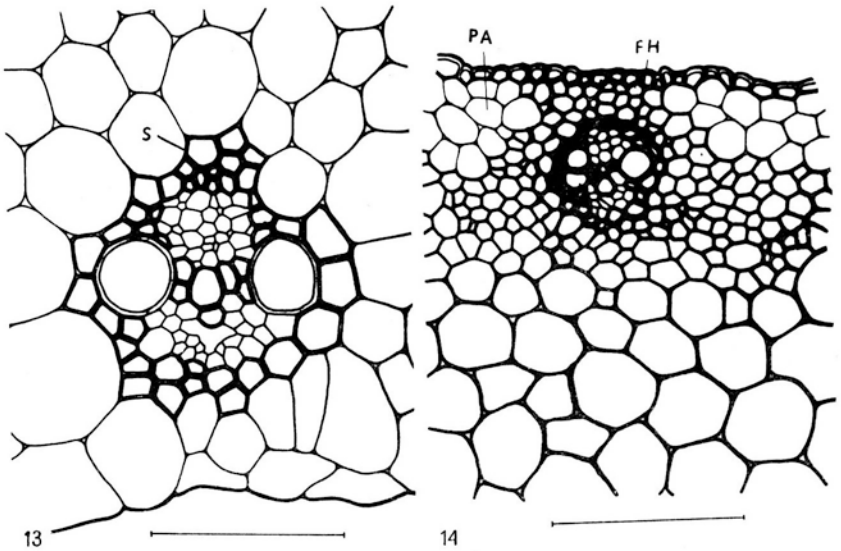

Fig. 13. 'České'. Large vascular bundle at cross-section of middle part of stem. *S* — sclerenchymatic fiber in the phloem side of the vascular bundle. Unit of measurement 100 μm

Fig. 14. 'České'. Cross-section of basal internode. There is parenchymatic tissue near small vascular bundles. *FH* — small vascular bundle, *PA* — parenchymatic tissue. Unit of measurement 100 μm

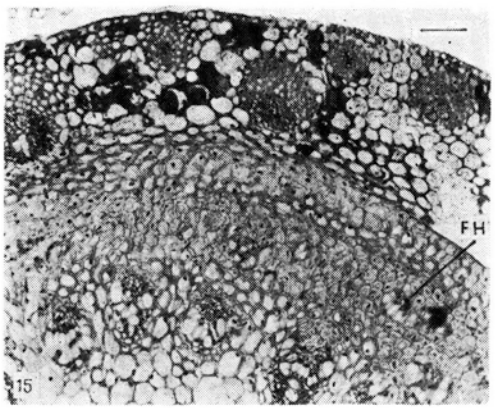

Fig. 15. 'Niva'. Photo of cross-section of basal internode. Small vascular bundles are surrounded by sclerenchymatic fiber. *FH* — small vascular bundle. Unit of measurement 100 μm

Photos: J. Stoklasa and J. Fiala
Drawings: E. Křivánková

internode (Fig. 12) the tissue is differently arranged and the appearance of the vascular bundles is also different. Below the epidermis the stripes of spongy parenchyma and of sclerenchyma alternate. The stripes of spongy parenchyma however are so wide that below the epidermis,

a layer of sclerenchymatic stripes is formed broken only in few places mostly in the vicinity of the small vascular bundles. Below the stripes of spongy parenchyma there is a multilayered sclerenchyma. Below this lies the parenchyma with two irregular rows of large vascular bundles along the cross-section of the stem. The outer row is near the sclerenchyma the inner one at the central hollow of the stem. These large collateral vascular bundles have on the outer (phloem) side and the inner (xylem) side, sclerenchymatic fibres, which at the sides of the vascular bundles pass through a single-layer sclerenchymatic sheath (Fig. 12).

At the cross-section of the internode at the base of the stem we find neither in wheat nor in rye, any spongy parenchyma under the epidermis which might interrupt the continuous ring of sclerenchyma containing small vascular bundles. Only in the case of rye at the sides of the small vascular bundles there is some parenchyma. In wheat the large vascular bundles are the same as in the middle of the stem but in rye at the outer (xylem) side they have a thick sclerenchymatic fiber passing throught the single layer sclerenchymatic sheath (Fig. 13). Between the vascular bundles and reaching as far as the central hollow of the stem there is sclerenchyma with thick walls.

On the basis of there anatomical differences we have endeavoured to present a clear table of the features.

Although we are aware that many of the features we have presented here have already been described by other authors we have attempted to make a comparison which could be used in order to determine possible interbreeding or the effect of cross varieties.

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Porównanie niektórych cech anatomicznych różnych odmian żyta i pszenicy

Streszczenie

W ostatnich latach badano cechy anatomiczne różnych odmian żyta i pszenicy (*Triticum aestivum* var. *erythrosperum* cv. 'Niva' i *Secale cerale* var. *vulgare* cv. 'České').

Zwrócono uwagę na te cechy, które mogą być użyteczne przy określaniu odmian, zwłaszcza w wypadku nasion pochodzących z wymiany.

Przedstawiono cechy anatomiczne łodygi i ziarniaka u pszenicy 'Niva' i żyta 'České'.