Some relations of selected phenological phases to the start of vegetation period

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Abstract This study concentrates on the beginning of the vegetation period and the phenological respond of some wild and cultivated plants. The timing of phenological phases in temperate zones is driven mainly by temperature. Trends and relationships between the start dates of selected phenological phases of some plants and temperature sums were investigated at six different locations representing both the lowlands and hilly areas of eastern part of Czech Republic and North Carpathian on the territory of Slovak Republic. The database consists of selected phenological phases of hazel, apple tree, birch, winter wheat and spring barley through the period 1961-2005.

The results show the significant trends of the onset of spring phases to earlier onset dates. The results also show that the start of phenological phases is strongly influenced by accumulated temperature sums and generally by regional and local climate conditions. This indicates a possibility to use phenological data as an indicator for climate variability studies.

Introduction

Climate variability as well as possible long term climate change has its impact in the living nature. The analysis of the observations from International Phenological Gardens generally shows the trend to the earlier start of the vegetation period in Europe /Chmielewski, F.M. Rötzer, T., 2002, Bagar, R., Nekovar, J., 2003/, while some regional analysis show a certain variability of this parameter in last decades /Shutova at all., 2006, Luknarova at all, 2004/. The development and the growth of plants are of a few phenomena responding to the impact of the changing weather and climate which is systematically observed for relatively long period. On the other hand by using phenological parameters one can characterize an instant stage of the surface, which influences the weather parameters. Thus, the plant phenology can contribute to climate change studies as well as to the global description of the changes going on in the particular region. Temperature data are mainly used in order to define general start of the vegetation period and temperature is the most frequent parameter being related to the time periods of plant growth and development in order to study the impact of the weather on plant life. The temperature limits the plants in their growth and different plants show different temperature limits when starting the physiological processes. The lower developmental temperature threshold for main plants of temperate zone below which the development stops is set for 2-5 °C. That is why 5 °C is considered as the start of vegetation period. This threshold was also taken to calculate general start of the vegetation period in the particular year in this article. However, there are many examples when the plants start to develop before the temperature reached above mentioned threshold.

This article deals with phenological characteristics in relation to the temperature sums in six distinguished localities in northern part of Carpathian belt and Czech-Moravian highlands.

Regional characteristics and data

The phenological characteristics in six localities/stations in different geographical regions are investigated. Two of them, Spišské Vlachy, 400 m a.s.l. and Sliač, 320 m a.s.l. characterize closed mountain basins while Piešťany are located in the northernmost part of Panonian Plains with the elevation of 160 m a.s.l. The data from the region of Lednice /165 m a.s.l./ still represent the lowland close to Morava valley while Přibyslav /490 m a.s.l./ and Čáslav /250 m a.s.l./ are placed in the northern part of Czech-Moravian highlands and belong to the catchment of the River Labe. The investigated regions belong to the mild climate zone. A regular rotation of four seasons and variable weather throughout the year are typical for this region. Snow cover is not stable, and winters in all localities, mainly at the lower altitude in Piešťany and Lednice are often without permanent snow cover. On the other hand the differences in winter and summer average temperatures are notable as well as the differences in temperature sums. The continental influence rises from the west to the east on the line Čáslav – Piešťany – Spišské Vlachy and causes more severe winters in the eastern part of the region and milder winter condition in the western part. This results in sooner setup of spring temperature condition in the western part. The mountain basins are more vulnerable to spring frosts and accumulated cold air remains in the basins for longer time. Annual amplitudes of temperature are higher in the basins with the influence of lower winter temperatures.

The localities for this study were selected mainly with the regard to the available phenological and climatic data. There are only a few localities in the region where both phenological and climatic observations were run in parallel for longer time period. Further to that the climatic stations are very good defined in the space with precisely defined conditions during the whole period of observation while the exact locality of phenological observations, mainly the observation of annual agricultural crops but also of some perennials varied in elevation and orientation and the distance of the observation from the climatic station was not constant. Thus, the given phenological data represent rather wider vicinity than a concrete well defined locality.

Both the phenological observations as well as the climatic measurements in all locations started before 1950. This led us to use the period of 1961-2005 as the period of evaluation. However, the gaps in phenological observations occurred in some years either because of the particular crop was not seeded or the observations were interrupted because of organizational matters. Because of pure quality of phenological data in the beginning of sixties and because of the location of the climatic station in Spišské Vlachy has changed during this period only the period 1965-2005 was investigated. Calculated numbers were not used to replace the missing phenological data and the years with missing data were excluded from the evaluation. Easy recognizable phenological phases of hazel, apple tree, birch, winter wheat and spring barley were selected for the calculation.

Method and results

All dates of phenological phases shown in the pictures are interpreted in days of year. Temperature sums were calculated from the daily averages respecting the occurrence of the particular phonological phase. Thus, the period during which the sums of temperatures were calculated differs from plant to plant. There were two periods over which the temperature sums were calculated for each plant. One started from the beginning of vegetation period and lasted until the occurrence of respective phenological phase of the particular plant. Second sums represent the sums of all daily averages over 5° C from the beginning of the year until the occurrence of respective phenological phase.

The beginning of vegetation period was defined as the third day with the consequent period of daily mean temperatures over 5° C. In case of drop of temperatures below 0° C in following days the start of vegetation season was moved to the next period respecting above-mentioned criterion. This criterion was applied before March 20, which is the mean date of the beginning of the vegetation period in the coldest areas of investigation. The first phenological phase occurred was beginning of flowering of hazel. This phase in many cases advances the beginning of vegetation period defined by temperatures. It shows that the biological threshold of dormancy of hazel is well below 5° C and/or that hazel reacts quickly to the rise of temperature. Thus, the statistics of the presented phenological phases covers the period from very first phenological occurrence following the dormancy period. The beginning of flowering of hazel observed in the region, has also shown the biggest variability.

Both the beginning of vegetation period and flowering of hazel show different trends in different regions. Visible trend to the sooner beginning of vegetation period is shown at the stations located west to the Carpathian belt together with the station Piešťany located in the most northern part of the Panonian Plains, which is in accordance with the general observations in investigated region and Central Europe /Šťastný, P., Nejedlik, P., 2006, Bagar, R., Nekovář, J., 2003/ while the stations located in the mountain basins show either no trend or a very slight trend to later beginning of vegetation period, see Fig. 1. The mean beginning of vegetation season varies only for 14 days but there are big regional differences in the beginning of vegetation season in the particular year because of the occurrence of late periods and days with the daily mean temperature below the freezing point. The vegetation period started first in 2002 in between end of January in the lowlands and half of March in the mountain basins while the latest start in 1970 shows much lower variability of only 24 days. Beginning of flowering of hazel, which is the closest phenological phase to the beginning of vegetation period, shows much bigger differences in the earliest and latest occurrence than the same differences in the beginning of the vegetation season calculated out of the daily averages, Fig. 2. Thus, these two parameters do not correspond though the 45 years averages of them differ maximally for four days. Hazel had started to flower in some cases even 30 days before the vegetation season started or 40 days after the beginning of the vegetation season. The trends in the time series of the flowering of hazel show much bigger differences than the trends of the beginning of vegetation period with no regional attribute. Two of the most westerly-located stations Čáslav and Přibyslav show relatively strong trend towards sooner beginning of flowering of hazel regarding cca 20 days over 45 years period. The rest of stations show either very low trend or even a clear trend towards the later dates was recognized visible in Piešťany. The temperature sums of the daily means over 0°C differs considerably from year to year, Fig. 7-12. In some years the hazel started to flower after the sum only 30 degrees was accumulated while in some other years these sums reached more than 400 degrees. This wide range of temperature sums does not allow us to recommend a certain phenological phase which occurs in early spring as a general indicator of the beginning of vegetation season.

The second early phenological phase in evaluation is unfolding of leaves of birch. The average date of all localities is very close and ranges only from the 101st to the 120th days of year and also the first recorded foliage of birch ranges only from the 79th to the 97th days of year. The trends in unfolding of leaves of birch differ from one place to another. Again, there is a clear trend towards the sooner occurrence in westerly positioned station of Přibyslav with high elevation in the highlands, while the rest of stations show either very week trends or even the slight trends towards toward later dates. The unfolding of leaves of birch always occurred after the beginning of vegetation season, 30-40 days in average. On the other hand the temperature sums over 0° C accumulated from the beginning of vegetation season reached 253° C to 441° C in averages from station to station and in extremes they range from 157° C to 653° C. In some cases unfolding of leaves of birch came only in the beginning of May and no relation in between the elevation and this phenophase of birch were found.

The trends in the beginning of flowering of apple tree differ from one locality to another and generally follow variable trends of the flowering of hazel and foliage of birch. No attribution of any trend to the locality was found. The mean beginning of flowering of apple tree in the investigated localities is between 46 and 56 days after the start of vegetation period, which is very low territorial variability. The range of all temperature sums to the day of flowering except Čáslav station is only 10 % of the average sum. This expresses very close relation of the temperature sums accumulated and the start of flowering.

Mean phenological characteristics as well as mean temperature sums of winter wheat and spring barley do not differ much. The common characteristic is a visible trend to sooner headings at all stations at both winter wheat and spring barley time series. The temperature sum accumulated before barley heading is generally for cca 100 °C bigger than at the winter wheat, which is understandable because of winter wheat usually, passes the emergency phase already in autumn. Nevertheless, the differences in heading time of winter wheat and spring barley are usually less than 10 days.

Heading as a later phenological phase requires higher accumulation of temperature. This consequently brings much higher stability at both winter wheat and spring barley in its occurrence during the vegetation season as well as in temperature sums. Further to that the regional differences of these characteristics were much lower than the regional differences of first flowers of hazel and apple tree. Both cereals show much stronger relation in between the occurrence of heading and the temperature sums than expressed at other investigated plants.

Conclusions

The vegetation season starts on an average shortly before March 10 in the lowlands and spreads to the mountain areas to 400-500 m a.s.l. within 10 days. Forty five year trends generally show a clear trend to the sooner start of vegetation season mainly in Czech-Moravian highlands and low positioned localities. However, the trends in some mountain basins of northern Carpathian are more steady and do not indicate any clear shift either to sooner or later start of vegetation season. High territorial variability of the beginning of vegetation season can result from the definition of this parameter. Late cold waves in spring time which bring the daily means bellow the freezing point occur much often in mountain basins and this fact shifts the beginning of vegetation season in these positions for 10-20 days in many years. The trends of the first flowers of hazel, which in many years foreruns the start of vegetation season as well as trends in the first flowers of apple tree and the unfolding of leaves of birch show also a certain level of variability but generally tend to the sooner start of above mentioned phenological phases. A strong and clear trend to the sooner start is visible at the heading of winter wheat and spring barley. This phenological phase also showed much stronger stability in its occurrence and in the sums of accumulated temperature. On the other hand the relation in between the flowering of apple tree and the unfolding of leaves of birch and temperature sums accumulated before these phases is pretty weak.

Acknowledgement

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List of figures:

Legend:

ZVO – the beginning of vegetation season
ZK – the beginning of flowering
ZA – the unfolding of leaves
KL – the heading
Σdays(ZK-ZVO) – sum of days in between ZK and ZVO
Σdays(ZA-ZVO) – sum of days in between ZA and ZVO
Σdays(KL-ZVO) – sum of days in between KL and ZVO
TS days (ZK-ZVO) – temperature sum of T>0° C in between ZK and ZVO
TS days (ZA-ZVO) – temperature sum in between ZA and ZVO
TS days (KL-ZVO) – temperature sum in between KL and ZVO
TS5 – temperature sum T>5° over a particular time period

Fig.1. The beginning of vegetation season defined out of climate data

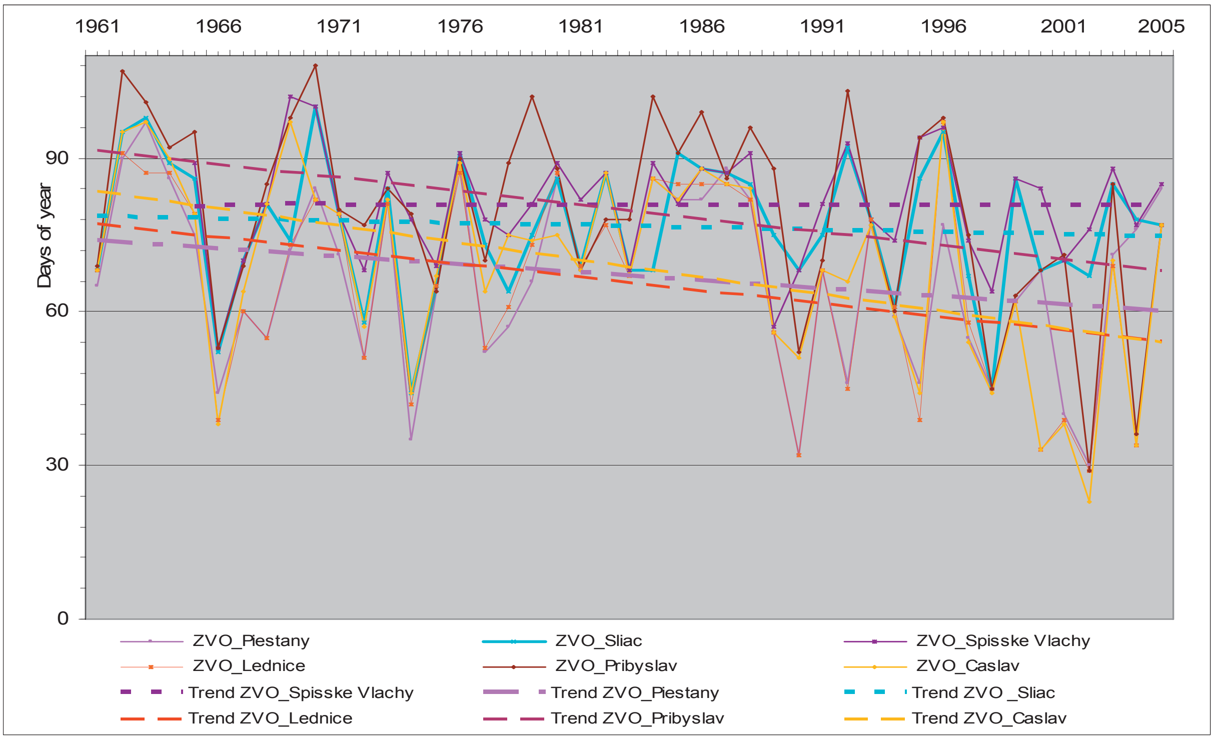

Fig. 2. The beginning of flowering of Hazel

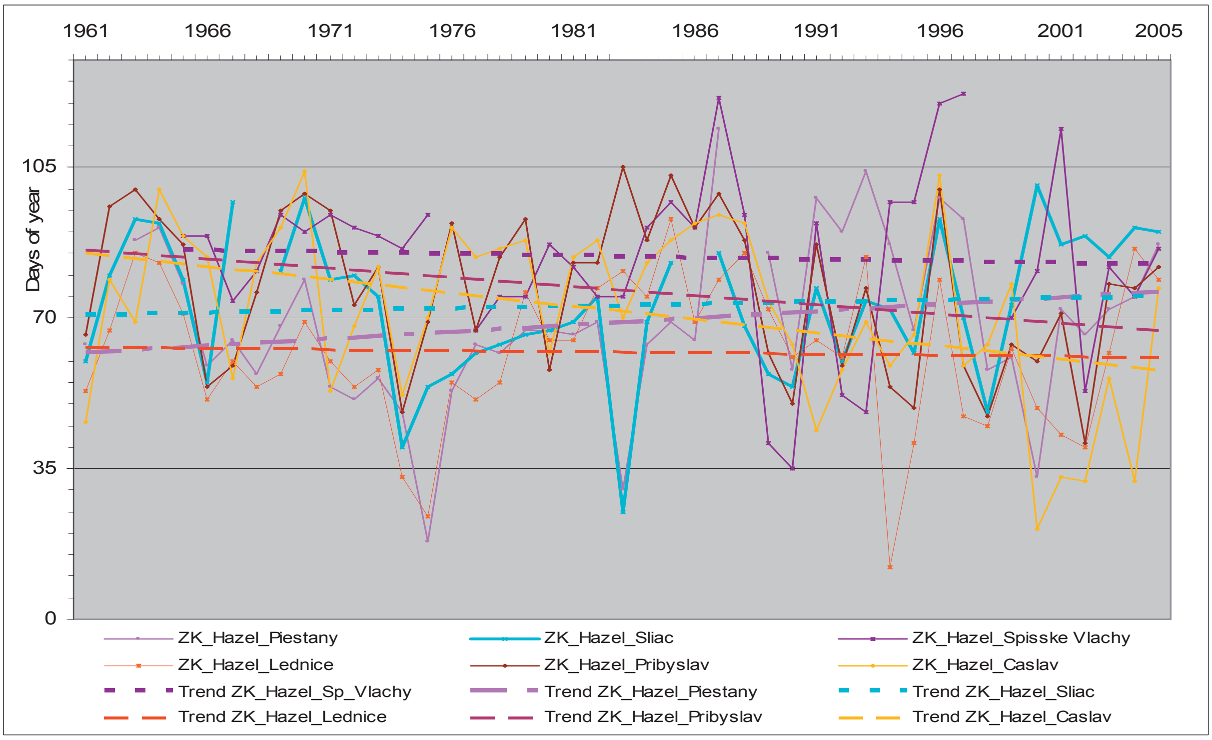

Fig. 3. The first leaves of Birch

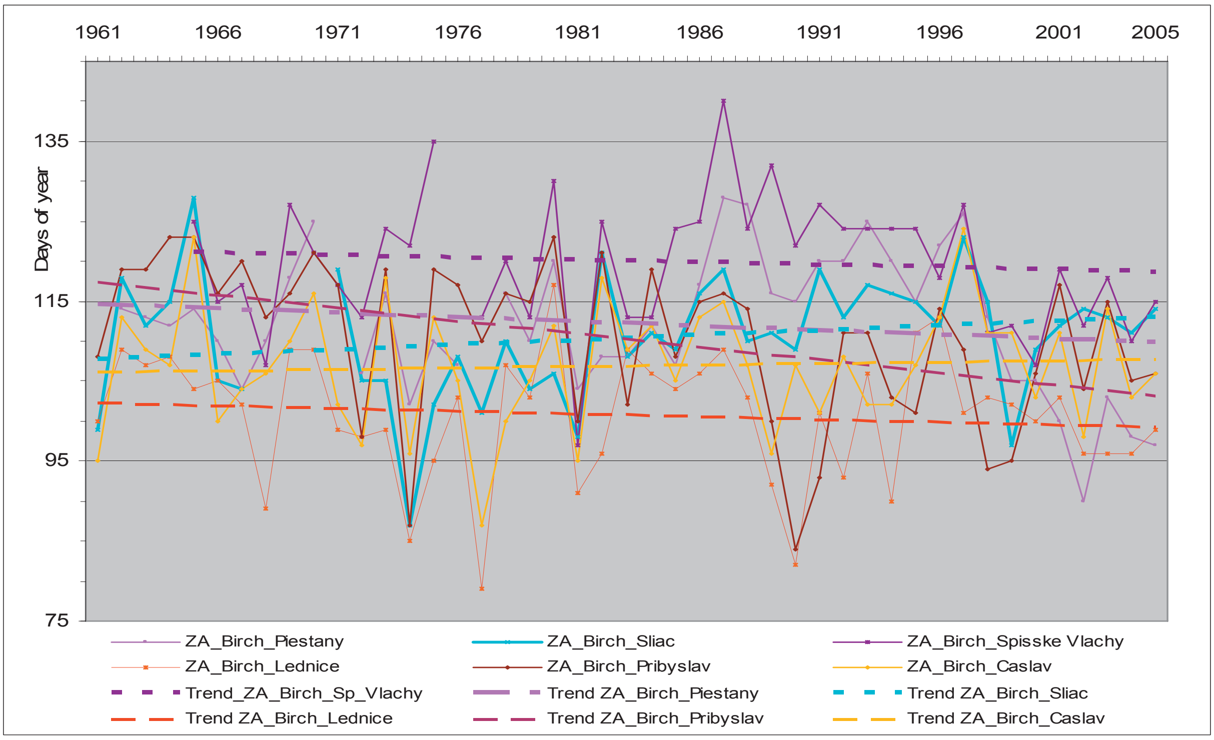

Fig. 4. The flowering of Apple Tree

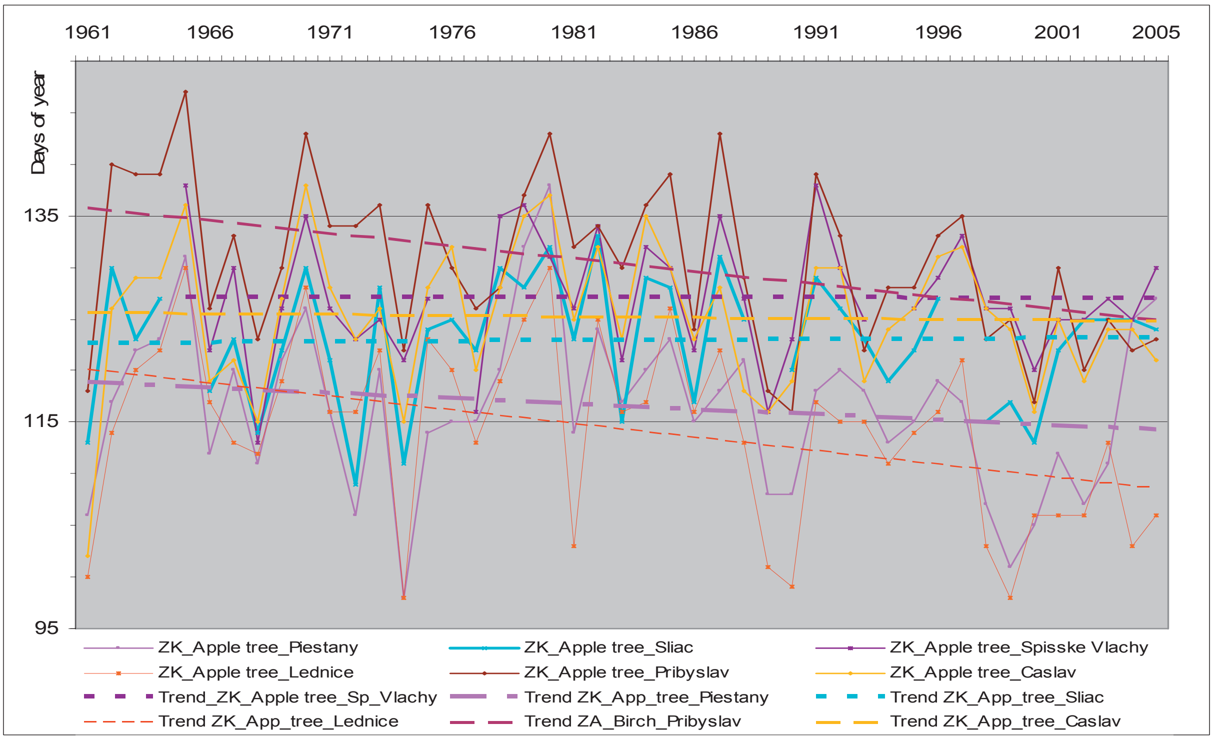

Fig. 5. The heading of Winter Wheat

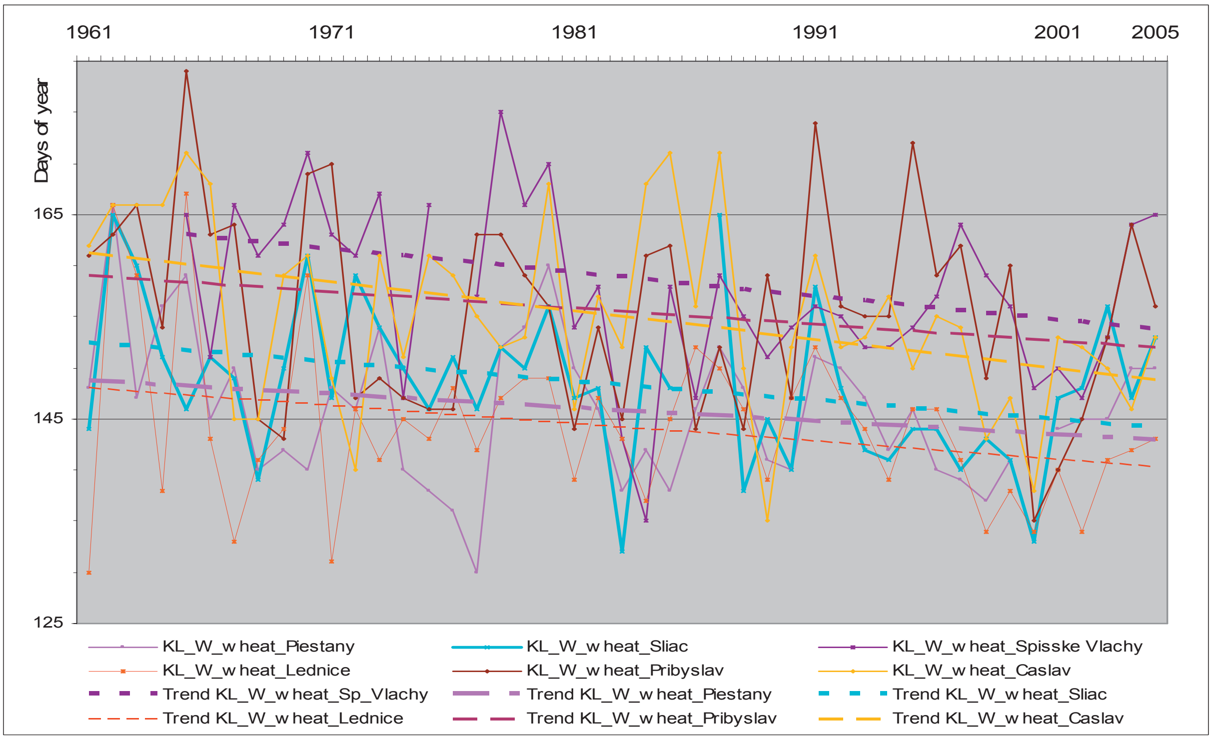

Fig. 6. The heading of Spring Barley

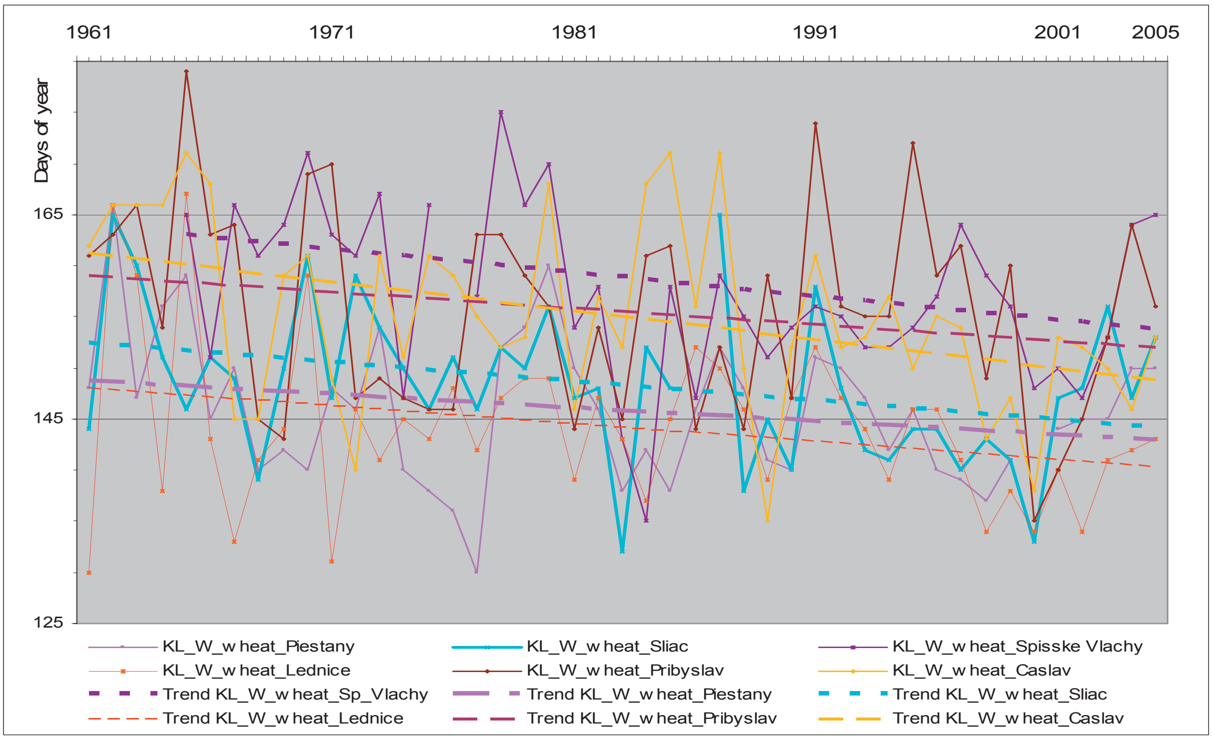

Fig. 7. Phenological characteristics and temperature sums in Spišské Vlachy

Fig. 8. Phenological characteristics and temperature sums in Sliač

Fig. 9. Phenological characteristics and temperature sums in Přibyslav

Fig. 10. Phenological characteristics and temperature sums in Čáslav

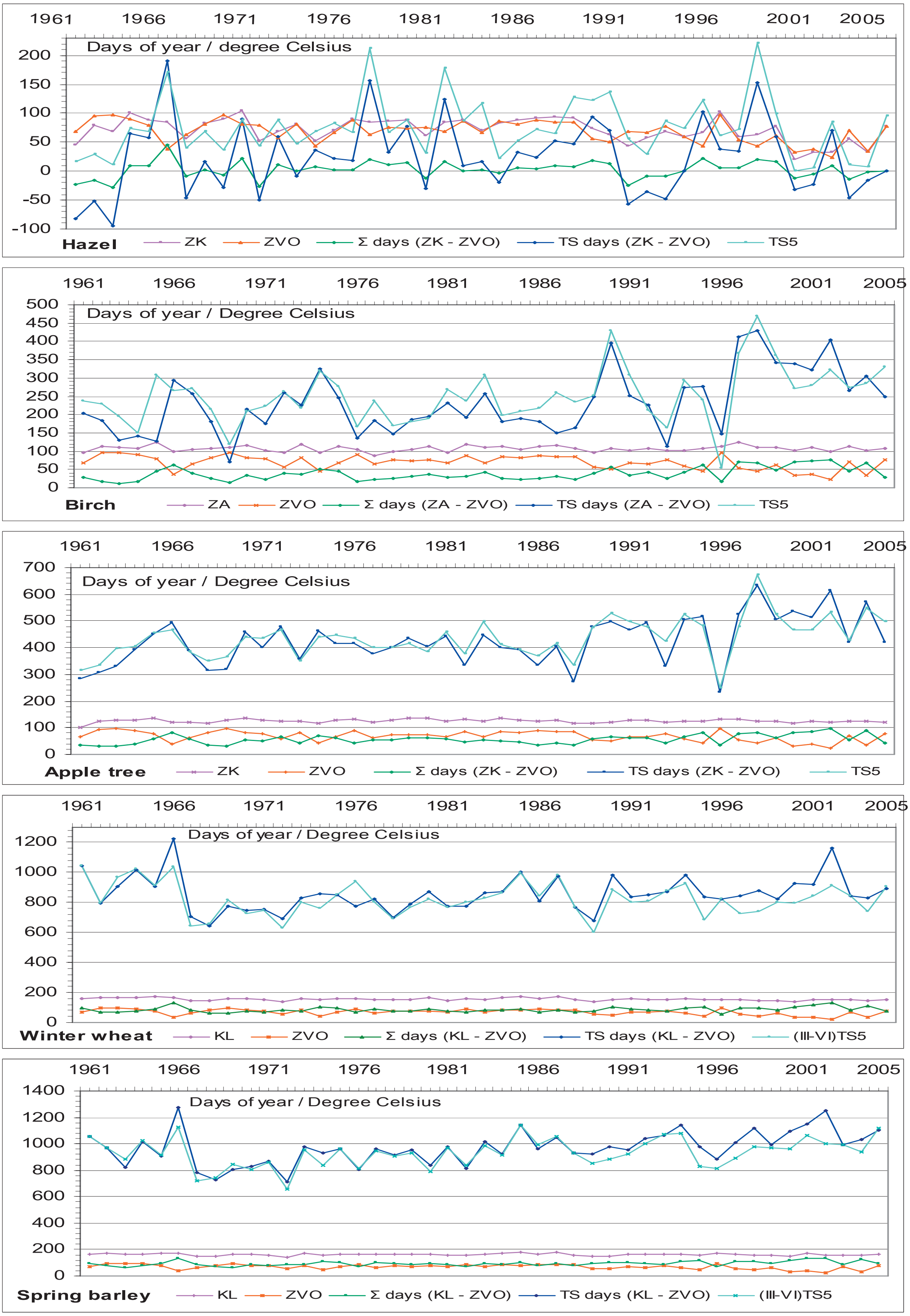

Fig. 11. Phenological characteristics and temperature sums in Lednice

Fig. 12. Phenological characteristics and temperature sums in Piešťany