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ORIGINAL PAPER

The phenology of cherry blossom (*Prunus yedoensis* "Somei-yoshino") and the geographic features contributing to its flowering

Yukitaka Ohashi · Hiroshi Kawakami · Yoshinori Shigeta · Hiroshi Ikeda · Nobuko Yamamoto

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Abstract We investigated relationships between the flowering phenology of *Prunus yedoensis* "Somei-yoshino" (cherry blossom) and the local temperatures in Japan. Our observations were carried out across the Okayama Plain, which included Okayama City (about 700,000 inhabitants), from the winter of 2008 to the spring of 2009. Local air temperature (AT) and the globe temperature (GT) were recorded at the tree height. The flowering dates (FDs) of *P. yedoensis* were earliest in the central commercial area (located at the center of the plain), followed by the north residential area (further inland), and finally the south residential area (seaward). The recorded FDs were related to the period-averaged daily maximum/minimum AT and GT, and the phenologically effective AT and GT defined in this study. Of these parameters, the phenologically effective GTs correlated most with the FDs. Since the GT is determined by AT, solar and infrared radiations, and wind speed, our previous result suggests that a combination of these three components surrounding the tree is more important for budding and flowering than is AT alone. The supposition is supported by the flowering of *P. yedoensis* being the latest at the coastal region of the Okayama Plain where the AT were higher than at the inland region, excluding the urban area; it is probably caused by stronger winds there than at the other sites.

Keywords *Prunus yedoensis* · Phenology · Flowering date · Air temperature · Globe temperature

Y. Ohashi (✉) · H. Kawakami · N. Yamamoto
Graduate School of Informatics, Okayama University of Science,
1-1 Ridai-cho,
Kita-ku, Okayama 700-0005, Japan
e-mail: ohashi@big.ous.ac.jp

Y. Shigeta
Graduate School of Natural Science and Technology,
Okayama University,
3-1-1 Tsushima-naka,
Kita-ku, Okayama 700-8530, Japan

H. Ikeda
The University Museum, The University of Tokyo,
7-3-1 Hongo,
Bunkyo-ku, Tokyo 113-0033, Japan

Present Address:
Y. Shigeta
Department of Environment System, Rissho University,
1700 Magechi,
Kumagaya, Saitama 360-0194, Japan

Introduction

Reports worldwide state that the spring flowering dates of many plants have been gradually advancing over the last several decades, due to the global warming and the urban heat-island. Examples of plants with earlier spring flowering dates include the locust tree (*Robinia pseudoacacia*) in Hungary (Walkovszky 1998); wild peach (*Prunus davidiana*), apricot (*Prunus armeniaca*), black locust (*Robinia pseudoacacia*), and early lilac (*Syringa oblata*) in Beijing, China (Lu et al. 2006); deciduous trees and conifers in Norway (Nordli et al. 2008); and olive (*Olea europaea*) in Italy and Spain (Orlandi et al. 2010). Furthermore, the faster growth of some plants has been suggested to be due to the urban heat-island by many researchers. Examples of such plants include snowdrop (*Galanthus nivalis*), forsythia (*Forsythia* sp.), sweet cherry (*Prunus avium*), and apple (*Malus domestica*) in ten European cities (Roetzer et al. 2000); the weeping forsythia (*Forsythia suspensa*) found at cities in Hungary (Lakatos and Gulyas 2003); London plane tree (*Platanus acerifolia*) planted along the urban streets of New York, USA (Dhami 2008); and *P. acerifolia* and sour cherry (*Prunus cerasus*) planted in Rennes, France (Mimet et al. 2009).

Whilst the majority of phenological studies pertain to the northern hemisphere, recent studies in the southern hemisphere have indicated significant changes and shifts to earlier flowering (Hudson and Keatley 2010) using both traditional phenological records (Keatley et al. 2002; Keatley and Hudson 2007; Hudson 2010; Grab and Craparo 2011) and also herbarium collections (Gallagher et al. 2009; MacGillivray et al. 2010).

As a result of numerous observations, predictions of plant phenology by using mathematical and statistical models have been developed (e.g., Piper et al. 1996; Snyder et al. 1999; Egea et al. 2003; Thompson and Clark 2006; Thompson and Clark 2008; Clark and Thompson 2010). For example, Ruml et al. (2011) developed prediction models for the flowering and maturation of the apricot. In their study, a phenological model was developed using daily maximum air temperatures, owing to apricot growth being better correlated with daily maximum rather than daily mean or minimum air temperatures. Previously, Aono and Omoto (1990), and Aono and Moriya (2003) developed the DTS index (the number of days transformed to standard temperature) to predict the flowering dates of cherry blossoms (*Prunus yedoensis*). This index is expressed by an exponential function of daily mean temperature, which is based on the chemical kinetic formula. Other indices such as an accumulated temperature or degree-days have been proposed for the flowering phenology (e.g., Oliveira 1998; Beaubien and Freeland 2000; Matsumoto 2003; Lee et al. 2007).

Flowering cherry blossoms contribute to beautiful scenery during the short period of spring in Japan. In particular, the well-known *P. yedoensis* (called "Somei-yoshino" in Japanese), is the most frequently planted cherry blossom on nearly all the streets, parks, and riverbanks of Japan, irrespective of whether the region is urban or rural. The trees are genetically identical, as they are clones originating from a single individual (Innan et al. 1995). Therefore, the flowering would occur simultaneously under the same climatological conditions, because differences between individuals are minimal. As a result, this feature provides a phenological indicator of outdoor temperature. Hence, many Japanese researchers have been investigating the flowering of *P. yedoensis* in relation to the urban heat-

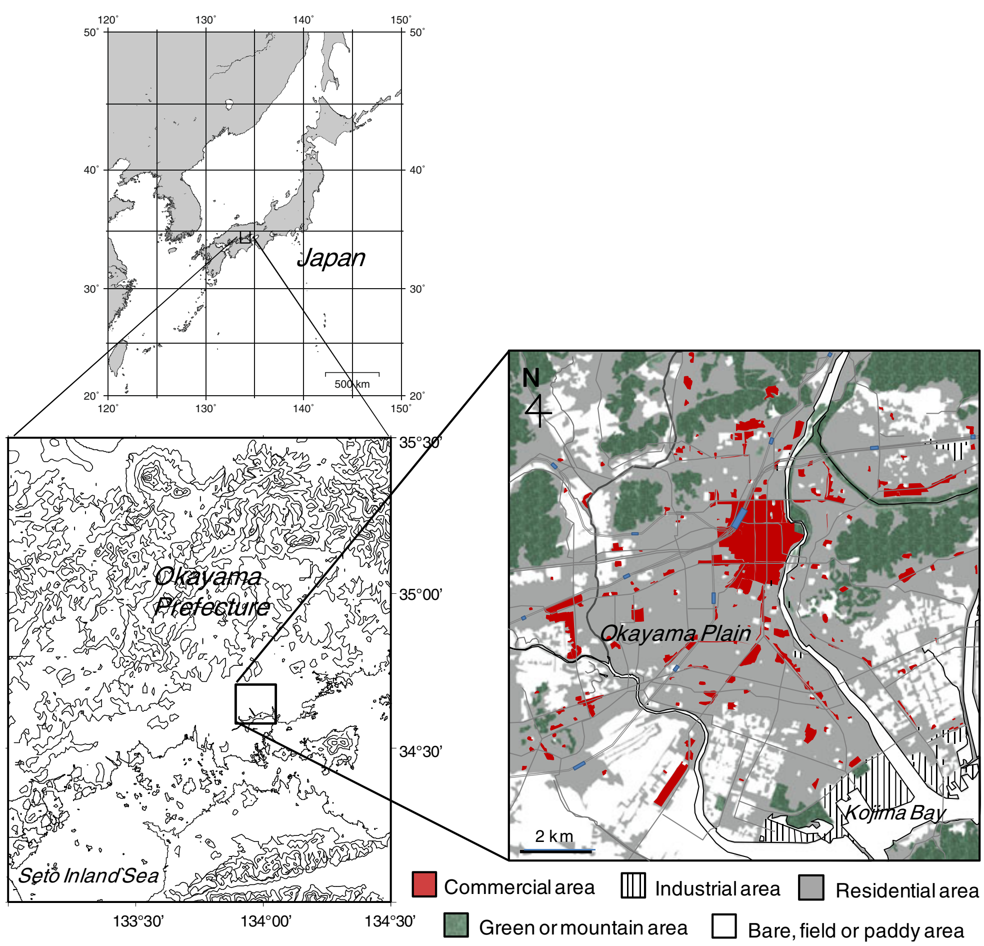


Fig. 1 Maps of our field study area, the Okayama Plain within Okayama Prefecture in Japan. The *right map* indicates land-use distribution of the observation region

island effect and/or global warming phenomena for a long time (e.g., Shinohara 1951; Maruoka and Itoh 2009; Aono and Saito 2010) in cities across Japan, such as Tokyo (Matsumoto et al. 2006), Osaka (Omoto and Aono 1990), Kumagaya (Matsumoto and Fukuoka 2003), and Sendai (Saijo and Wada 2010). Most researches have revealed that the flowering of *P. yedoensis* planted in urban areas was about 1 week earlier than those planted in rural areas.

Here, we focus on several topics introduced by previous researches. First, there may be a correlation between flowering phenology and temperature with respect to locality. Basically, most previous researches used temperature data measured by meteorological observation sites that were not in the immediate vicinity of flowering trees, yet plants probably grow and flower in response to air conditions surrounding the plants. However, Matsumoto et al. (2006) compared the flowering dates of *P. yedoensis* with neighboring air temperatures at 26 sites in elementary schools of Tokyo. Second, other meteorological parameters, in addition to air temperature, may also influence plant growth and flowering. Caffarra and Donnelly (2011) examined budburst responses to various factors, such as chilling, air temperature, photoperiod, and light intensity. They indicated that important factors differ depending on tree species.

In this study, we investigated the flowering date (hereafter FD) of *P. yedoensis* planted at different locations across the Okayama Plain in the west of Japan. In addition, the air temperature (hereafter AT) and globe temperature (hereafter GT) were measured in close proximity to observe *P. yedoensis* trees; in particular, the GT indicates an equilibrium temperature controlled by solar and infrared radiations, AT, and wind speed. These temperatures were analyzed for relation to the phenology of *P. yedoensis*.

Materials and methods

Study area

Our study area was Okayama City (Okayama Prefecture, Japan), which is one of the major cities in the west of Japan, with about 700,000 inhabitants. The climatological (meteorological) and phenological observations were successively conducted within an approximate 12 km-square area of the Okayama Plain, which included Okayama City. Figure 1 illustrates the land-use distribution of our study area. The commercial urban area exists around the center of the study area. Buildings and human activities concentrate here. In addition, the residential area, with houses and apartments, surrounds the central commercial area. While the mountains, 200–300 m in height, extend to the north of the study area, Kojima Bay lies to the south. In general, the climate of Okayama City is temperate with low rainfall compared to other areas of Japan. During the years 1971–2000, the annual average temperature was 15.8°C and precipitation was 1,141 mm.

Figure 2 shows the distribution of the 47 survey sites in this study, where visual observations of the flowering phenology of *P. yedoensis* were conducted (all circles in the figure). At 26 of these sites, the temperature in the surrounding atmosphere of *P. yedoensis* trees was measured (closed circles in the figure). Almost all sites selected were in town parks. Table 1 summarizes the information for each site number, location name, and flowering/temperature observations.

Flowering phenology

We selected the *P. yedoensis* trees for the study observation carefully; trees appearing diseased or damaged on the branches or the trunk, or trees that were very young or aged, were excluded from the study. Observations of bud growth were conducted once a week from December 1, 2008 onwards. However, once trees were nearing budburst, we observed bud phenology on a daily basis.

The FD was determined based on the definition of the Japan Meteorological Agency, whereby 5 or 6 flowers must be observed on the unit tree. Because we observed more

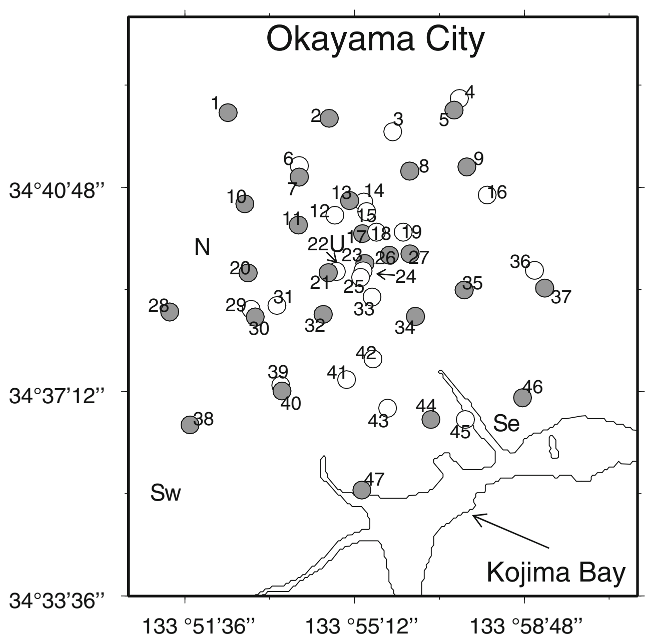


Fig. 2 Locations of the 47 observation sites of flowering phenology. Measured elements in each site are listed in Table 1. *Closed circles* show the sites of both flowering and temperature observations. Alphabetical marks, *N*, *U*, *Sw*, and *Se* represent the observation stations of surface wind speed by the Atmospheric Environmental Regional Observation System

Table 1 List of observation sites. Site number, location name, and flowering/temperature observations are summarized

Site number	Location name	Flowering observation	Temperature observation
1	Haga	Yes	Yes
2	Tsudakadai	Yes	Yes
3	Handa-cho	Yes	No
4	Gion 1	Yes	No
5	Gion 2	Yes	Yes
6	Sasagase	Yes	No
7	Okayama Shoka Univ.	Yes	Yes
8	Takeda	Yes	Yes
9	Takashima-higashi	Yes	Yes
10	Yasaka	Yes	Yes
11	Mikado	Yes	Yes
12	Kami-ifuku	Yes	No
13	Okayama Pref. Grounds	Yes	Yes
14	Minamigata 1	Yes	No
15	Minamigata 2	Yes	No
16	Takaya	Yes	No
17	Nishigawa	Yes	Yes
18	Nishi-nakasange	Yes	No
19	Korakuen	Yes	No
20	Kita-nagase	Yes	Yes
21	Daiku 1	Yes	Yes
22	Daiku 2	Yes	No
23	Shimo-tamachi	Yes	Yes
24	Edagawa	Yes	No
25	Kasuga-cho	Yes	No
26	Mizunote	Yes	Yes
27	Onarigawa	Yes	Yes
28	Myoken Shrine	Yes	Yes
29	Nakasendo-nishi	Yes	No
30	Tatsumi-nishi	Yes	Yes
31	Nakasendo-higashi	Yes	No
32	Nishi-furumatsu	Yes	Yes
33	Uchida	Yes	No
34	Hirai	Yes	Yes
35	Ikenouchi	Yes	Yes
36	Fukudomari	Yes	No
37	Miyoshi	Yes	Yes
38	Hotoen	Yes	Yes
39	Toshinden Joka Center	Yes	No
40	Ohsumi-seseragi	Yes	Yes
41	Hibari	Yes	No
42	Toyonari-kita	Yes	No
43	Fukunari	Yes	No
44	Fukuhama-minami	Yes	Yes
45	Fukushima	Yes	No
46	Okayama Fureai Center	Yes	Yes
47	Urayasu	Yes	Yes

than one tree within a site, the final FD for each site was decided as the day on which the flowering trees exceeded 50% of all observed trees, in accordance with Matsumoto and Fukuoka (2003). Figure 3 shows example photographs of *P. yedoensis* bud-growth taken during the course of our study. We made our final decisions on flowering phenology using a combination of direct field observations and photographs collected on each survey date.

AT and GT

Previous research has suggested that the FD of *P. yedoensis* is influenced by the AT at 1 or 2 months before flowering. Omoto and Aono (1989) proposed a method to estimate the FD using DTS (the number of days transformed to standard temperature). The AT was integrated using an exponential function from the start date, which was estimated for 1 or 2 months before flowering (from the end of March to the beginning of April). Thus, ATs after February may influence the flowering phenology of *P. yedoensis*.

As was mentioned in the introduction, the GT can be utilized to consider the temperature determined by solar and infrared radiations and wind speed, which differs from AT. That is, the GT variations approximately indicate behavior of bud or tree-body temperatures. The GT is generally measured by using a globe thermometer, as described later.

Thus, we measured the surface AT and GT from December 1, 2008 to the date after flowering, with the study finishing on April 14, 2009. Thermistor thermometers (accuracy of ±0.3°C; RTR-52; T&D Corporation) were used for both temperature measurements. The surface AT was obtained on a 1-minute sequential basis from the thermistor sensor, which was covered with a radiation shield and set up at a height of about 2.5 m on a pole within the observation site. Meanwhile, the GT was also sampled once a minute at a height of 2.5 m, and measured using a globe thermometer. Although the copper globe thermometer of 7.5 or 15.0 cm in diameter is usually used for GT measurements, we used a plastic globe thermometer with a diameter of 6.0 cm instead. This alternative instrument was selected to avoid problems (misidentified as suspicious matters or mischief) that may arise in the long-term attachment to the observation trees. Hence, it should be noted that the measured GT using our thermometer is different to that of the usual GT. Photographs of the temperature measurements are shown in Fig. 4.

Results and discussion

Measured AT, GT, and FD

Figure 5 shows the daily maximum/minimum TAs and TGs averaged for all observation sites from December 1, 2008 to April 1, 2009. The maximum/minimum ATs gradually decreased until around January 10, 2009, with an average minimum AT of about −3°C. Subsequently, the AT tended to increase amplitude. The average maximum/minimum GTs also had a pattern similar to that of AT. Although the minimum GT value was comparable to that of the minimum AT, the maximum GT value was around 10°C higher than that of AT. This implies that daily solar radiation is important for any material surface temperature.

There was also spatial variation in temperature. The AT variance (the standard deviation represented with bars in Fig. 5) for the daily minimum temperature was comparable to that of the GT variance. However, the daily maximum variance of GT was significantly larger than that of AT. In other words, the GTs showed large differences according to sites.

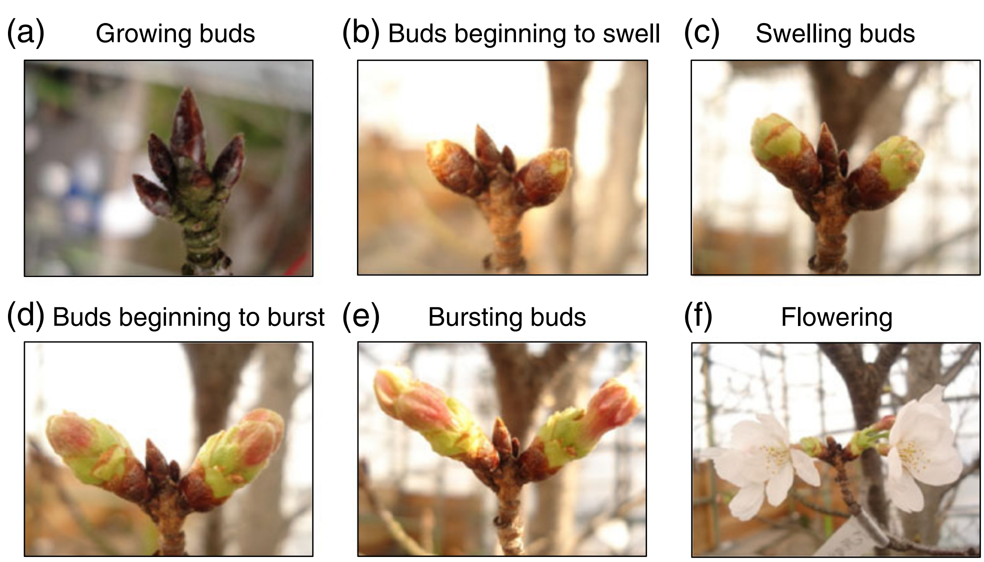


Fig. 3 Example photograph of *Prunus yedoensis* bud-growth: (**a**) growing buds, (**b**) buds beginning to swell, (**c**) swelling buds, (**d**) buds beginning to burst, (**e**) bursting buds, and (**f**) flowering

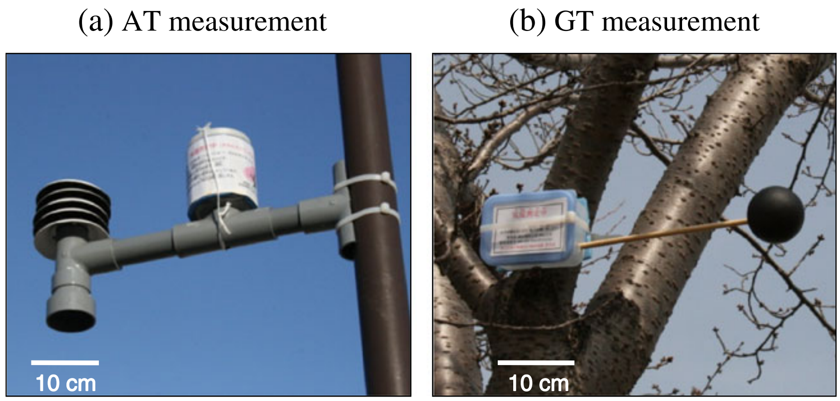


Fig. 4 Temperature measurements used in our study: (**a**) AT (air temperature) and (**b**) GT (globe temperature)

The observational result of flowering of *P. yedoensis* is shown in Fig. 6. This figure shows that the earliest FD was March 19 at site 18, while the latest FD was March 29 at sites 16 and 43. Although the Japan Meteorological Agency published the FD of Okayama City as March 21, our study reveals large regional differences across Okayama City. As a whole, flowering in the central commercial area (the center of region; Fig. 1) seemed to be earlier than that in the surrounding areas, based on the comparison of FDs and land-use distribution. However, there was no significant correlation for the FDs with daily minimum/maximum AT or GT averaged during the observational period (Table 2).

Phenologically effective temperature

Matsumoto (2003) carried out phenological observations on *P. yedoensis* in relation to AT measurements in Kumagaya City (about 200,000 inhabitants), Japan. In his study, as the planted site of *P. yedoensis* was near to the central urban area, budburst growth tended to be earlier. Moreover, the study defined the phenologically effective temperature, T_{eff}, from the accumulated value of daily minimum AT of more than 5°C:

$$T_{eff} = \sum_{i=1}^{N} (MinT_i - 5), \quad for\ MinT_i \geq 5°C \tag{1}$$

where $MinT_i$ and N are the daily minimum AT on the i-th day and the number of days of the daily minimum AT of more than 5°C, respectively. We integrated data from December 1, 2008 to March 20, 2009 into Eq. 1. The value of 5°C is specified as a minimum growing indicator for plant physiology (Matsumoto 2003).

Accordingly, we calculated each T_{eff} for the 26 AT sites, as shown in Fig. 7a. This figure shows that T_{eff} is roughly higher at the central commercial area, followed by the south or middle residential area, and the north residential area. The T_{eff} difference within the plain is considerably large, with a value of about 150°C. This result suggests that the AT difference per day corresponded to about 1.4°C. The T_{eff} for GT may also be calculated here (Fig. 7b). Differing from the AT, the lower T_{eff} sites for GT appeared to be

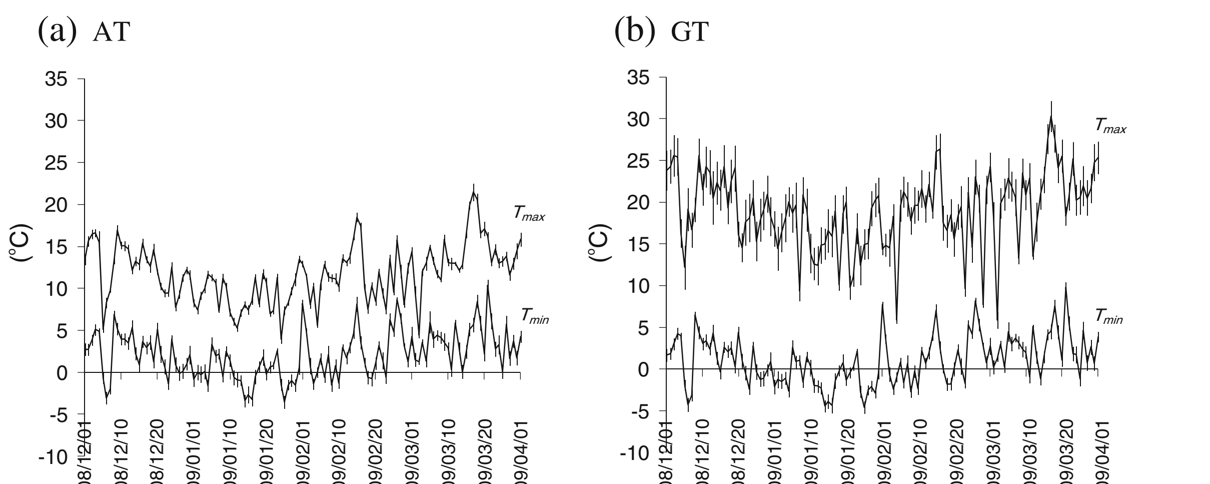


Fig. 5 Daily maximum temperature (T_{max}) and daily minimum temperature (T_{min}) averaged for all the temperature sites, and measured from December 1, 2008 to April 1, 2009: (**a**) AT and (**b**) GT. *Bars* indicate the standard deviation

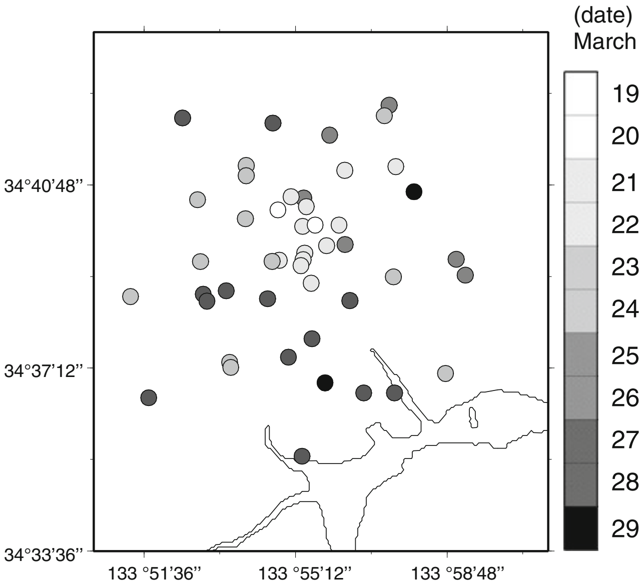


Fig. 6 Spatial distribution of FDs (flowering dates) observed at 47 sites

distributed around even the south-situated residential area, in addition to the north-inland residential area.

Table 2 summarizes Peason's correlation coefficients between the FDs and various temperatures from December 1, 2008 to March 20, 2009 for the 26 sites with associated temperature measurements. As indicated in this table, the phenologically effective temperature T_{eff} better than the aforementioned daily maximum/minimum temperatures correlated with the FD. In particular, the T_{eff} for GT had a high correlation (r=−0.46; p<0.05) compared to that for AT.

Regional classification

The FDs observed at 26 sites in the spring of 2009 are indicated in Fig. 8. In addition, this figure also shows the results of the FD observation tentatively conducted at the same sites in the spring of the previous year, 2008. The x axis of this figure lists the site numbers in roughly latitudinal order from the north to the south. In both years, the FDs observed at the central commercial sites (e.g., site numbers 17, 18, 23, 24, and 26) tended to be earlier than those observed at the surrounding residential areas. Meanwhile, at residential areas the earlier flowering sites were situated further north rather than further south. That is, the *P. yedoensis* trees flowered earliest in the central commercial area, followed by the north residential area, and finally the south residential area, across the Okayama Plain. These records were subsequently confirmed by simple visual observations in the springs of both 2010 and 2011.

Accordingly, we indicated the daily variations in T_{eff} for (a) AT and (b) GT until March 20, 2009, as shown in Fig. 9. Based on the FD presented in Fig. 8, again we divided the observation sites into the following three areas for convenience: the north residential area, central commercial area, and south residential area. The values of T_{eff} for both AT and GT were the highest at the central commercial sites. Here, T_{eff} for AT approximately ranged from 160°C to 195°C just before flowering, while T_{eff} for GT ranged from 70°C to 110°C. This was followed by the south residential sites, with T_{eff} of 105°C to 155°C for AT. Finally, the north residential area had the lowest T_{eff} for AT records of all 3 areas. However, the south residential T_{eff} for GT of 40°C to 70°C was comparable to those of the north residential sites and lower than those of urban sites. Thus, it is noteworthy that the geographic features of T_{eff} for AT and GT differ from each other.

Cluster analysis

Our findings in this study indicate the possibility of regional classification based on flowering phenology and phenologically effective temperature. The hierarchical cluster analysis, which is one of multivariate statistical analyses, has been adopted widely such as genetic or species diversities (e.g., Shahidullah et al. 2009), morphology (e.g., Zeinali et al. 2009), flowering rate (e.g., Soheilivand et al. 2007), and flowering phenology (e.g., Cruz et al. 2007; Torres and Galetto 2011) in the plant science. This analysis is suitable for grouping the multivariate data involving some variables which give their features. Accordingly, we also conducted the hierarchical cluster analysis to identify optimum groups of the assimilated data. The objective variables were selected as the FD, T_{eff} for AT, and T_{eff} for GT. That is, our clustering analysis was applied for the results of Figs. 6 and 7. Clustering was executed by using Ward's method for the normalized data.

A dendrogram of the cluster analysis is presented in Fig. 10. Two major groups were identified: the lower group in the figure comprised sites 17, 21, 23, 26, and 32, while the upper

Table 2 Peason's correlation coefficients between the FDs and various temperatures from December 1 in 2008 to March 20 in 2009 at 26 sites: average value of daily maximum temperature, average value of daily minimum temperature, and T_{eff}, for AT and GT. The symbol * is the statistical significance of the correlation with p<0.05

Variable	Daily max. temp. T_{max} AT / GT	Daily min. temp. T_{min} AT / GT	Phenologically effective temp. T_{eff} AT / GT
FD (flowering dates)	−0.17 / −0.22	−0.18 / −0.33	−0.20 / −0.46*

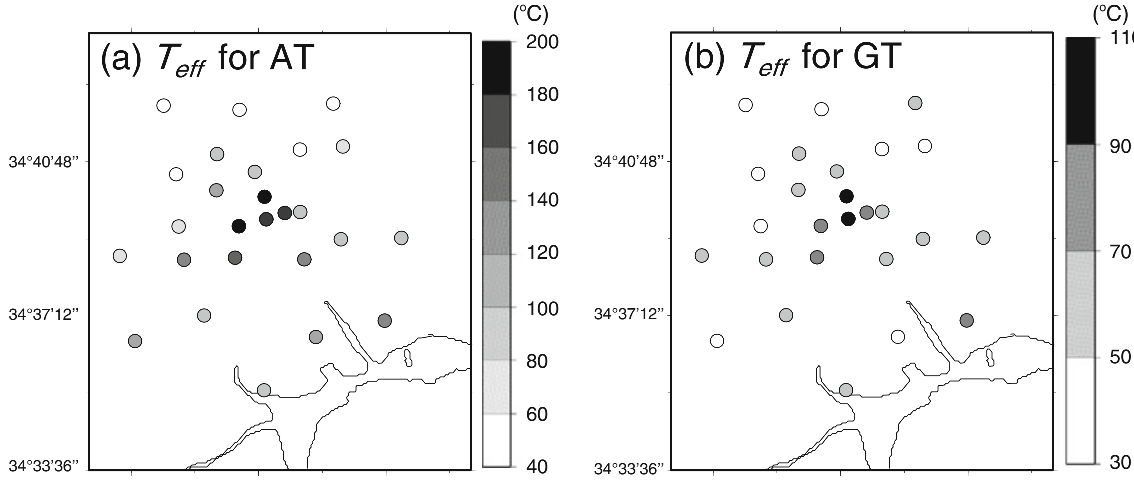


Fig. 7 Spatial distribution of T_{eff} (phenologically effective temperature) for (**a**) AT and (**b**) GT measured at 26 sites. These temperatures indicate the accumulative value of effective temperature of more than 5°C for phenological growth

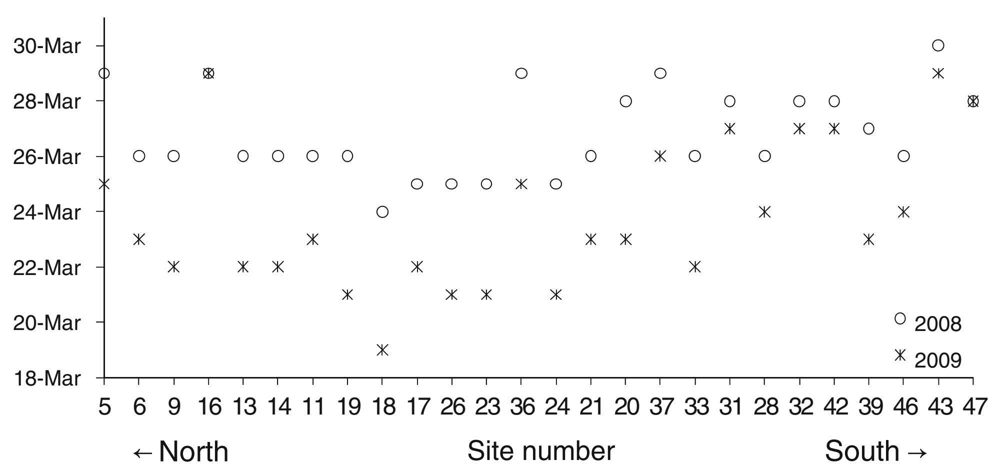
group comprised all other sites. All of the sites in the lower group were located in the central commercial area. This result suggests that both climatic and phenological features in the urban area may be comprehensively distinct from the surrounding areas.

Wind environment

The observations indicate that there may be differences in the climatological conditions in the north residential, central commercial, and south residential areas, which in turn may influence the flowering phenology of *P. yedoensis* trees. Based on the strong correlation between the GT and FD, the climatological conditions are probably associated to wind speed and a combination of solar and infrared radiations. Figure 11 shows the measurement of daily mean wind speed near the surface at the station N (north residential area), station U (central commercial area), station Sw (southwest residential area), and station Se (southeast residential area). These stations are the locations of the Atmospheric Environmental Regional Observation System, which was set up by the Ministry of the Environment, Japan (Fig. 2). The wind speeds were measured at a height of 13 m above the ground. The figure is shown as a histogram of the number of days and a cumulative rate of the number of days. Wind conditions at Se tended to be the strongest, while those at U were the weakest. The result shown in this figure clarifies that the surface wind speed in the south residential area was steadily higher than that in the north residential area. In particular, the wind speed in the central commercial area was extremely low due to crowds of tall buildings. Thus, there is large heterogeneity in the geographic wind conditions within the Okayama Plain.

The relationship between wind speed (station Se) and GT (sites 44 and 46) measured in the southeast residential area is shown in Fig. 12. The daily GT negatively correlated with daily mean wind speed. This result means that as wind speed increased, the GT became lower. Since the wind induces a turbulent sensible-heat flux from the globe-thermometer surface, the GT would fall in a strong wind environment.

Fig. 8 Flowering dates (FDs) observed at 26 sites in the spring of both 2008 and 2009. The site numbers in roughly latitudinal order from the north to the south, which were observed in both years



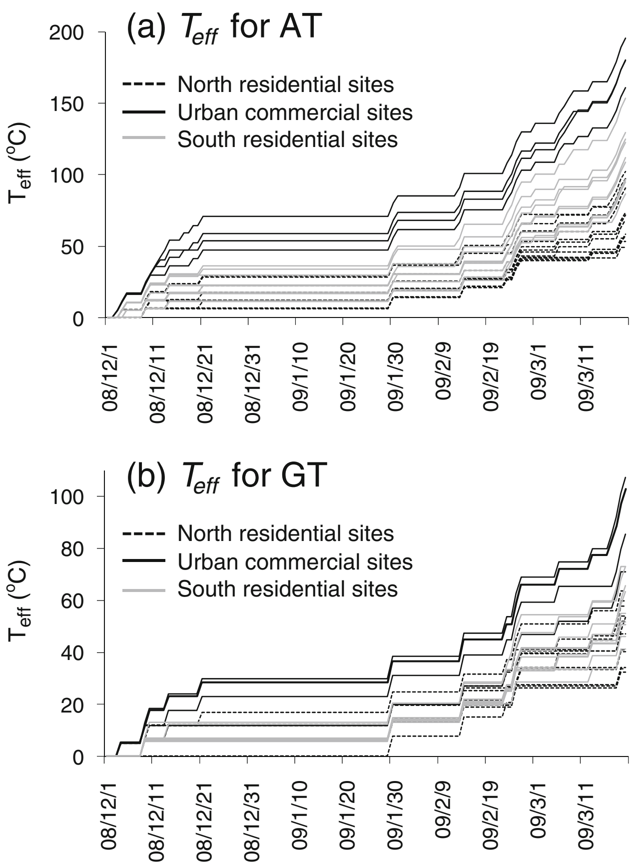


Fig. 9 Daily evolution of T_{eff} for (**a**) air temperature (AT) and (**b**) globe temperature (GT) until March 20, 2009

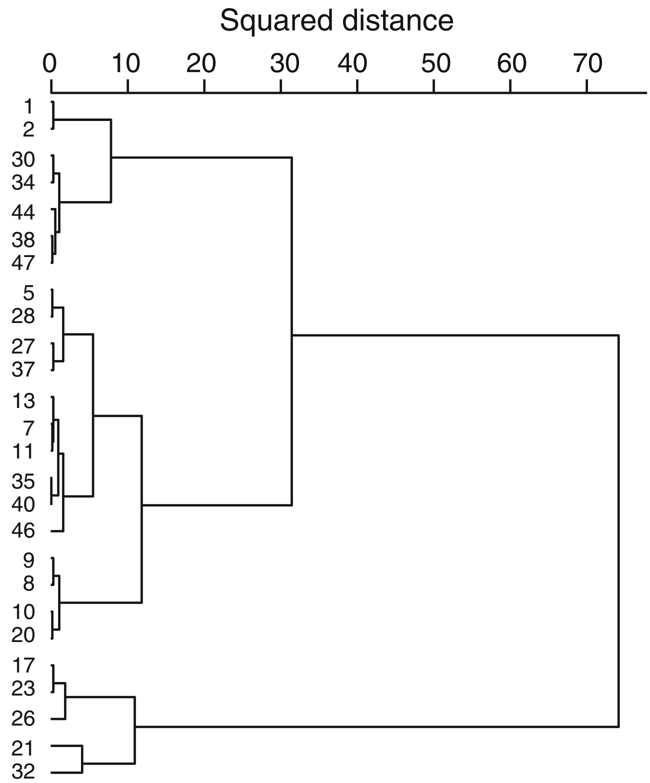


Fig. 10 Dendrogram of flowering dates (FDs), T_{eff} for air temperature (AT), and T_{eff} for globe temperature (GT) at 26 sites. The *numerals* indicate site numbers shown in Table 1

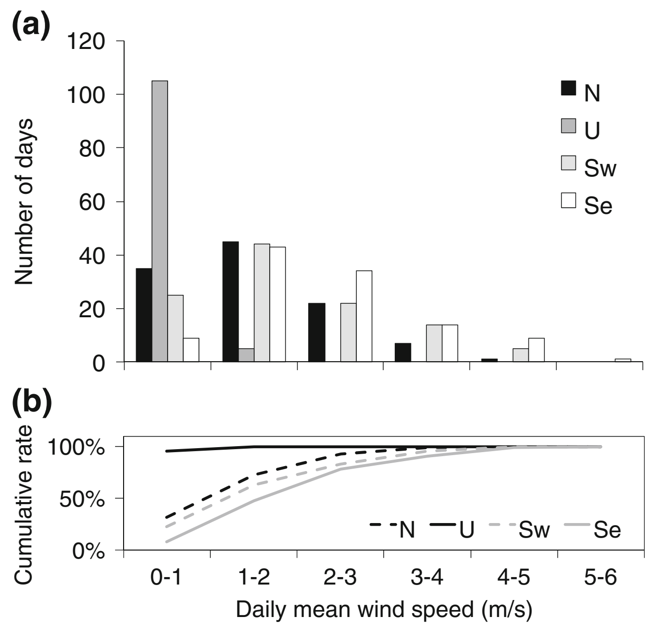


Fig. 11 Daily mean wind speed near the surface measured at the N (north residential area), U (central commercial area), Sw (southwest residential area), and Se sites (southeast residential area). (**a**) A histogram of the number of days. (**b**) The cumulative rate of the number of days are indicated

The inward radiation fluxes into the GT, which is also important for the GT response, were unfortunately measured at just two stations of the Atmospheric Environmental Regional Observation System within the south residential area. However, the amount of inward radiation was considered to be almost the same across all residential areas within the spatial scale of our observational plain. Hence, it is concluded that the difference in GTs between the north and south residential areas is mainly produced by differences in the wind environment.

Conclusions

We investigated the relationship between flowering phenology and local temperature climatology. We focused our study on the well-known *Prunus yedoensis* “Somei-yoshino”, which is the most frequently planted cherry blossom across Japan, as a phenological tree of outdoor temperature. Within the study, the flowering date (FD), air temperature (AT), and globe temperature (GT) were observed at many parks within about a 12 km-square area of the Okayama Plain (Okayama City, Okayama Prefecture) in Japan.

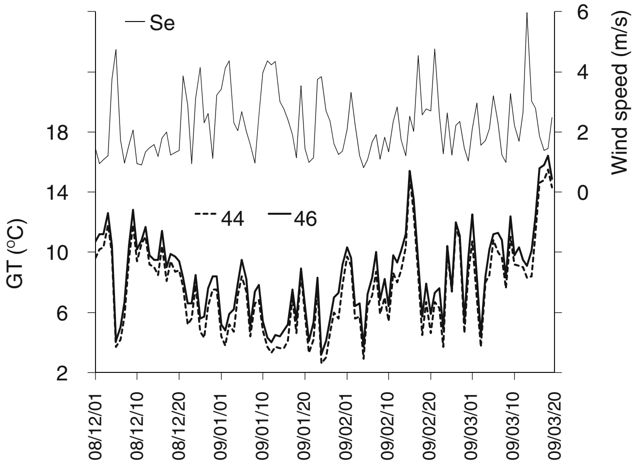


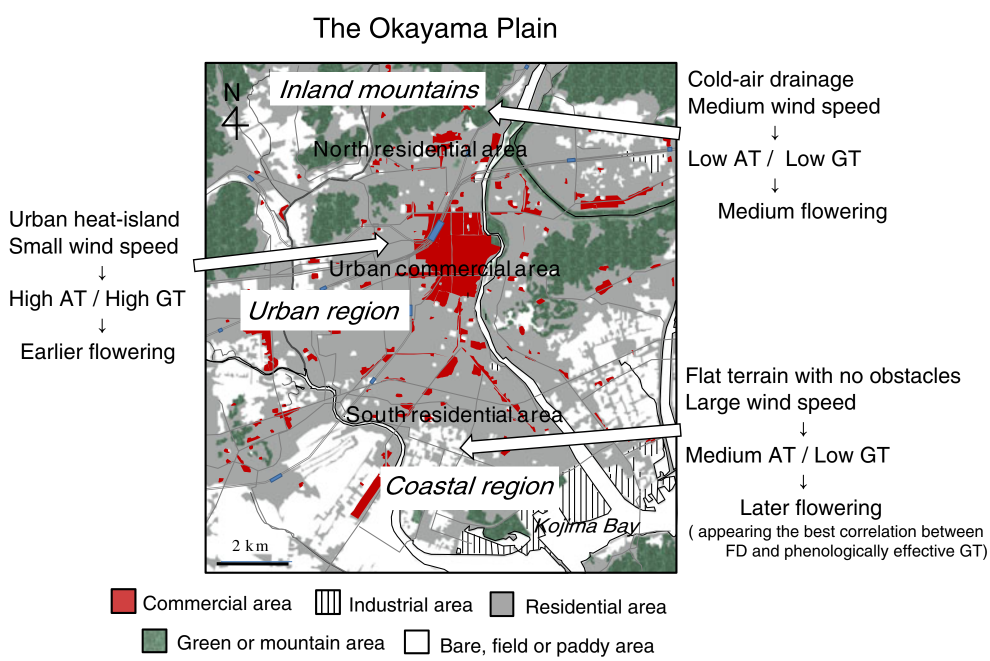
Fig. 12 Daily mean globe temperatures (GTs) (*thick lines*) measured at sites 44 and 46, and daily mean wind speed (*thin line*) measured at Se (southeast residential area), from December 1 in 2008 to March 20 in 2009

The FDs of *P. yedoensis* trees were regionally distinct, with flowering first occurring in the central commercial area, followed by the north residential area, and finally the south residential area. Based on our results, we suggested that the phenologically effective temperature T_{eff} for GT should be utilized for flowering predictions, rather than for the daily maximum or minimum ATs. Our findings indicate that flowering phenology is regulated by the surface heat budget (i.e., the accumulatively absorbed energy) of buds or entire tree, which is strongly influenced by solar and infrared radiations and wind speed, in addition to surrounding AT. In other words, temperatures of the bud or tree itself may be important for FD of *P. yedoensis*.

From our observations, the *P. yedoensis* phenology and climatology of the Okayama Plain can be detected as the three regions; Fig. 13 illustrates the climatological geography of the Okayama Plain, where the geographic features are roughly divided into inland mountains, urban region, and coastal region. Across Japan, the flowering of *P. yedoensis* is known to begin gradually from the south to the north. However, as seen in this study, the onset of flowering is spatially dispersed within the plain, separated from such an island scale. That probably depends on certain local meteorological factors, which must differ from a general response to AT. In particular, it is interesting that we were able to specify the urban climatological and phenological conditions by using hierarchical cluster analysis in our study. The following regional classification was obtained in the Okayama Plain (Fig. 13).

- North residential area with inland mountains. Here, the lowest AT of the plain continued until FD due to influence of mountain cold-air drainage. The wind speed was medium conditions within the plain.
- Central commercial area in urban region. Here, the highest AT and GT of the plain continued until FD, which is caused by heat-island phenomena and the small wind speed due to crowds of tall buildings. This resulted in the earliest FD within the plain.
- South residential area near coastal region. Here, the low GT continued until FD due to larger wind speed than the other areas. Its climate condition delayed FD within the plain.

Fig. 13 Summary illustration of our observations in the Okayama Plain. The plain is divided into three regions: inland mountains, urban region, and coastal region



Thus, for a local scale such as plain terrain, the flowering phenology of *P. yedoensis* seems to be comprehensibly controlled by some meteorological elements. It would be very interesting as a future study to see whether similar results appear in other plants or other plains.

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