# Documentation of the Phenocalendar of *Allaeanthus luzonicus* (Blanco) Fern.-Vill. (Family Moraceae) to Sustain Its Utilization

20

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**Abstract**

This chapter introduces an innovation leveraging on the phenological calendar of the growth and development of *Allaeanthus luzonicus* (Blanco) Fern.-Vill. to ensure a sustainable inflorescence supply for household consumption. *A. luzonicus* is a favorite indigenous vegetable in Northern Philippines, but it is wild-growing and seasonal in availability; hence edible inflorescences are available only during the regular flowering season in the months of January to March each year. So, we sought to establish and explore the species' phenocalendar to have longer supply of inflorescence. We first documented the species' growth and development stages and compared its phenology under four climate types in three provinces in Northern Philippines where the indigenous vegetable is most utilized. We also discovered that there are off-season varieties of *A. luzonicus* which flower outside the regular flowering period of January to March. Thus, a production system that integrates the documented phenocalendar and off-season varieties is recommended for year-round inflorescence supply.

**Keywords**

*Allaeanthus luzonicus* · Indigenous vegetable · Phenocalendar · Growth and development · Sustainable utilization

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## 20.1 Introduction

Many local communities in the Philippines harness the abundance of nature for household food sufficiency and nutritional security. Dubbed as indigenous foods (IF), these plant species are usually gathered from the wild; and thus sometimes called foods from the wild; other times, *manna* from heaven. Biblically, *manna* pertains to the miraculously supplied food to the Israelites in the wilderness.

Through an R&D Project which surveyed and characterized the indigenous food plants (IFPs) in Ilocos Norte, Philippines, 46 indigenous plant species are consumed across the province, constituting a significant part of the rural diet (Antonio et al. 2011). Sourcing these species from the wild and serving them in their dining tables have rooted in the Ilocano life, food culture, and plant heritage. They are served either as vegetable viand, salad, sauteed dish, delicacy and snack, among others, adding new flavor and color for diet diversity. While these plant resources are generally underutilized and neglected, they are gaining importance in transforming our food system to become sustainable and climate resilient with raised bar for diet quality and diversity.

One of the identified indigenous vegetables is *Allaeanthus luzonicus* (Blanco) Fern.-Vill., Family Moraceae, locally called himbabao (Tag.), alokon (Ilk.), alibabag (Itawis), or birch flower (Engl.) (Antonio et al. 2011). *A. luzonicus* is native to the Philippines and Sulawesi (POWO 2022). It is found throughout the Philippines. Its distribution is likewise cited in Indonesia, and spread to some parts of Hawaii, USA, but it is considered nonnative there.

It is a popular and much-loved indigenous vegetable in the Province of Ilocos Norte, including the rest of the provinces in Northern Philippines. The staminate inflorescence added with some leaftops are the edible plant parts, and favorite for various dishes such as vegetable stews, viand, sauteed or salad prepared singly or in combination with other vegetables (Antonio et al. 2016). The plant's wild-growing habit and the edible parts' seasonal availability (usually in the months of January to March every year) have hampered the sustainable utilization of the plant.

So, we collected, analyzed, and integrated data from projects done on the plant which were implemented by the Mariano Marcos State University to develop a phenological calendar (phenocalendar in short) to extend the supply of the edible inflorescence. Specifically, we analyzed data to answer the following questions: (a) what are the species' biological stages?; (b) how does the plant's phenology vary under Climate types I, II, III, and IV (Modified Corona's Classification of Climate based on average monthly rainfall) in three provinces in Northern Philippines?; (c) what are the components of the plant that support its traditional use for food?; (d) what plant behaviors can be harnessed to contribute to a sustainable inflorescence supply?; (e) what other milestones can be integrated into a production system which we will propose to establish or enhance a commercial market niche for the crop?

## 20.2 Body

### 20.2.1 Plant Parts Used and Flower Characteristics

*A. luzonicus* is a dioecious tree (Fig. 20.1a) growing wild to semi-wild (Pancho 1979). The staminate plant produces an elongated catkin (Fig. 20.1b), measuring 3–58 cm long, while the pistillate plant produces globose to sub-globe head (Fig. 20.1c), measuring 2–3 cm in diameter (Antonio et al. 2018). Both types of inflorescences, together with tender leaves, are edible. But in Northern Philippines, the staminate inflorescence is more preferred than the pistillate inflorescence for vegetable stew. It produces a peculiar inviting aroma, adds texture, and provides additional roughage to any vegetable dish. When cooked, it turns vibrant green, soft, and a bit slick or slimy.

In terms of flowering behavior, *A. luzonicus* is annual, seasonal, and indeterminate (flowers emerge and open from proximal to distal orientation). Its flowering habit is either: (a) synchronous, characterized by distinct vegetative and reproductive phases, following the developmental cycle described below; or (b) asynchronous, characterized by two or more stages occurring simultaneously, i.e., simultaneous vegetative, leaf falling, and flowering all together.

It flowers once a year, usually from January to March every year, coinciding with the summer months in the Philippines. Since a tree, inflorescences are harvested by

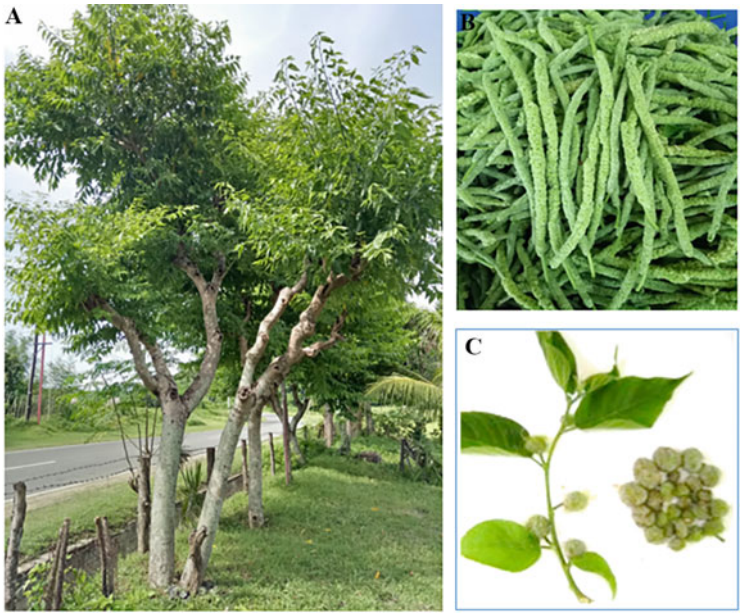



**Fig. 20.1** *A. luzonicus* (Blanco) Fern.-Vill. (**a**) Growing habit, (**b**) staminate inflorescence, and (**c**) pistillate inflorescence. (Photo credit: Menisa A. Antonio, Mariano Marcos State University)

pruning the whole tree or major branches. More information on plant flowering will be discussed in the succeeding sections of this chapter.

### 20.2.2 Nutrient and Nonnutrient Components

In a phytochemical screening done by Antonio and Vivit (2017), *A. luzonicus* inflorescence contains the secondary metabolites flavonoid, phenol, steroid, coumarin, triterpene, tannin, cardiac glycoside, and xanthoprotein. The identified secondary metabolites or phytochemicals offer several medicinal and pharmacological applications providing chemo-protection against various biotic and abiotic factors as these secondary metabolites are often associated with improving nutrient absorption and boosting the immune system (Saxena et al. 2013).

In a related work, the antioxidant potential of *A. luzonicus* inflorescence was evaluated through DPPH radical scavenging activity (RSA) (Antonio and Vivit 2017). *A. luzonicus* gives a good antioxidant food, affording total efficacy of about 89% at 200 μg/ml. When compared with four other indigenous vegetables from Ilocos Norte, *A. luzonicus* inflorescence is most potent, affording 87% RSA at a concentration as low as 150 μg/ml.

In addition, the edible parts also contain minerals such as calcium, phosphorus, iron, sodium, and vitamins such as beta-carotene, thiamin, riboflavin, niacin, and ascorbic acid (Table 20.1) (DOST-FNRI FCT. Released Dec 1, 2019).

### 20.2.3 Growth and Development Cycle

We selected and observed *A. luzonicus* trees that grow independently in the four ecological zones (central lowland, northern coastal, southern coastal, eastern interior) and mountainous area in Ilocos Norte (Fig. 20.2). We monitored them for 3 years (2016–2018), done weekly during the start of reproductive stage to end of flowering (January to March), and bimonthly during the vegetative phase. Two to three trees from each area were considered. Four branches (one branch on each side of the tree) were tagged which served as samples for monitoring purposes. Phenological events (Table 20.2) and flowering periods were recorded. Phenophase descriptions are adapted from the Project Budburst Phenophase Field Guide (http://www.windows.ucar.edu) and the methods were adapted from the National Phenology Network (Haggerty and Mazer 2008).

Additionally, weather data consisting of minimum and maximum temperatures, precipitation, and adverse weather condition were obtained from the two weather stations of Ilocos Norte (MMSU-PAGASA Agrometeorological Station and Laoag Synoptic Station). Other weather data from automatic weather stations installed in different areas of Ilocos Norte were also considered. The climate in the study areas was extracted from NAMRIA.

**Table 20.1** Food composition table of *A. luzonicus*. DOST-FNRI FCT. Released Dec 1, 2019

| Components | *Flower (boiled)* | *Leaves (boiled)* |
|---|---|---|
| Proximates (per 100 g edible portion) | | |
| Water (g) | 86.8 | 88 |
| Energy, calculated (kcal) | 52 | 49 |
| Protein (g) | 2.9 | 1.6 |
| Total fat (g) | 0.9 | 0.5 |
| Carbohydrate, total (g) | 8.1 | 9.6 |
| Total ash, total (g) | 1.3 | 0.3 |
| Other carbohydrates (per 100 g edible portion) | | |
| Sugars, total (g) | 1 | 0.9 |
| Minerals (per 100 g edible portion) | | |
| Calcium (mg) | 278 | 116 |
| Phosphorus (mg) | 75 | 54 |
| Iron (mg) | 4.3 | 1 |
| Sodium (mg) | 13 | 12 |
| Vitamins (per 100 g edible portion) | 5.1 | – |
| Retinol, vitamin A (μg) | 0 | 0 |
| Beta-carotene (μg) | 300 | 925 |
| Retinol activity equivalent (μg) | 25 | 77 |
| Thiamin, vitamin B1 (mg) | 0.06 | 0.03 |
| Riboflavin, vitamin B2 (mg) | 0.13 | 0.07 |
| Niacin (mg) | 0.8 | 0.5 |
| Ascorbic acid, vitamin C (mg) | 10 | 9 |
| Lipids (per 100 g edible portion) | | |
| Fatty acids, saturated, total (g) | | |
| Fatty acids, monounsaturated, total (g) | – | – |
| Fatty acids, polyunsaturated, total (g) | – | – |
| Cholesterol (mg) | – | – |

#### 20.2.3.1 Observed Growth and Development Phases

Plant growth and development generally consists of vegetative and reproductive phases. In *A. luzonicus*, there is no clear delineation of the end of the vegetative phase and the start of the reproductive phase. In this chapter, we call this phase as the intermediate phase, which corresponds to the post-vegetative and pre-reproductive changes that occur in the plant.

The vegetative phase in *A. luzonicus* lasts for 7–8 months, usually from late March to October of every year. This period consists of leaf bud emergence, full leaf development, and leaf maturity and senescence (Fig. 20.3). The reproductive phase is usually from 4 to 5 months, from November to March. It is characterized by floral bud emergence, inflorescence market maturity, and inflorescence physiological maturity.

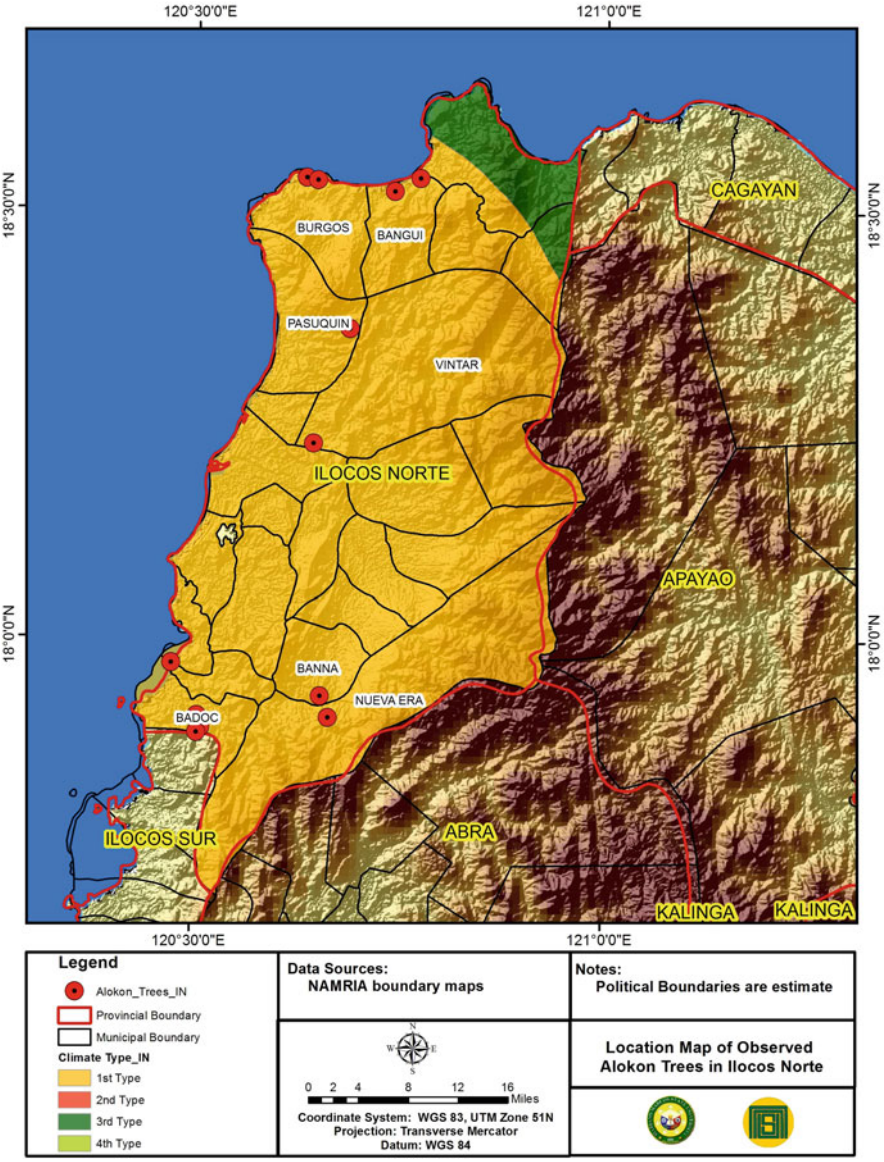



**Fig. 20.2** Location of observed *A. luzonicus* trees in the different ecological zones of Ilocos Norte. Map by Engr. Rodel T. Utrera, Mariano Marcos State University

The flowering period marked by floral bud emergence to last inflorescence harvest (Fig. 20.3) lasts for 2–3 months, generally from January to March, peaking in February. The intermediate phase is characterized by the deciduous changes which consists of leaf yellowing and abscission, and leafless period. These periods

**Table 20.2** Phenophases monitored in *A. luzonicus*

| | Phenophase | Description |
|---|---|---|
| 1 | Emerging leaves or leaf budding | In at least 4 locations on the plant, an emerging leaf is visible. A leaf is considered "emerging" once the green tip is visible |
| 2 | 95% full leaves or vegetative stage | Report the date when nearly all (at least 95%) of the growing leaf buds have already reached its mature size (majority of leaves have elongated or fully expanded) |
| 3 | Leaf maturity | Report the date when nearly all (at least 95%) of the leaves began to dry up or turn yellow |
| 4 | Leaf abscission initiation | At least 10% of the leaves fell |
| 5 | Leaf abscission completion | All leaves fell |
| 6 | Leafless period | Record the duration of leafless period |
| 7 | Emerging flower buds or inflorescence bud initiation | In at least 4 locations on the plant, an emerging flower bud is visible. A flower is considered "emerging" once the green tip is visible |
| 8 | Harvestable inflorescence | Report the date when inflorescence reached market maturity |
| 9 | Physiologically mature inflorescence | Report the date when the inflorescence become light yellow |
| 10 | End of flowering | Report the date when no more flower buds emerged and the matured inflorescences fell |

usually last for one to 1 ½ months, and 3–4 weeks, respectively. This phase is in the months of November to December.

Several sample trees exhibited extreme cases, which do not conform to the above general growth and development cycle. These cases were as follows: (a) Early flowering in the month of December to January, stop flowering, then 2° floral flushing in May, June, July (the tree is found in the Municipality of Badoc); (b) Late flowering in April to May (tree also found in Badoc); (c) Long-duration flowering from November or December to May or June but peaking in the regular season then gradually declines until June or July (trees found in Brgy 4 and 6 in Vintar; Brgy Labut in Badoc; and Brgy Saoit in Burgos).

### 20.2.4 Phenology of *A. luzonicus* Under Four Climate Types

In addition to the observed trees in the Province of Ilocos Norte (Fig. 20.2), several trees in different towns of Cagayan and Apayao (Fig. 20.4) were also identified and monitored to compare the effect of different climate types on the phenological cycle of the species. In addition to the sample trees in the identified study towns, observations were also made on trees in the rest of the towns in Cagayan; however this was done only once in 2018. Similar phenological events (Table 20.2) and flowering periods were observed in Cagayan and Apayao.

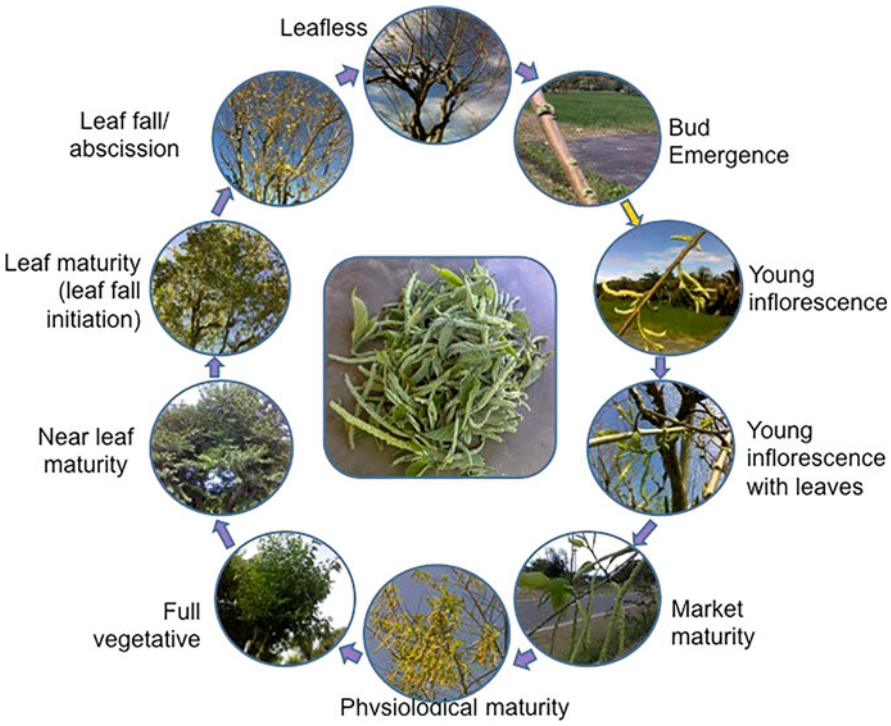



**Fig. 20.3** The morphological structures of *A. luzonicus* at various phases in its growth and development cycle

#### 20.2.4.1 Phenophases in Different Ecological Zones of Ilocos Norte

During the start of the three-year documentation in January 2016, some of the sample trees from the different ecological zones have entered varied stages. Some were already on the leaf fall initiation to completion stage, while others were on leafless stage, i.e., all leaves have fallen off. Leaf abscission occurs in a staggered manner. Still, other trees were on leaf or floral bud emergence.

The following are observations from the ecological zones of Ilocos Norte.

1. *Southern Coastal in Ilocos Norte.* Figure 20.5 shows the phenology of *A. luzonicus* in the southern coastal area of Badoc, Ilocos Norte. In 2016, flowering started in late January, peaked in mid-February, and ended in early March. The tree completed the phenophases of leaf maturity, leaf abscission, leafless, and flower bud initiation in chronological order (synchronous). In 2017, flowering started in late March, peaked in late April, and ended in early June. Leaf and flower bud initiation occurred simultaneously. In 2018, the phenophase pattern was the same as in year 2016 but the flowering period was until the later part of March. The flowering period in 2017 was late compared to 2016 and 2018. In October 19–20, 2016, Super Typhoon Lawin devastated Ilocos Norte.

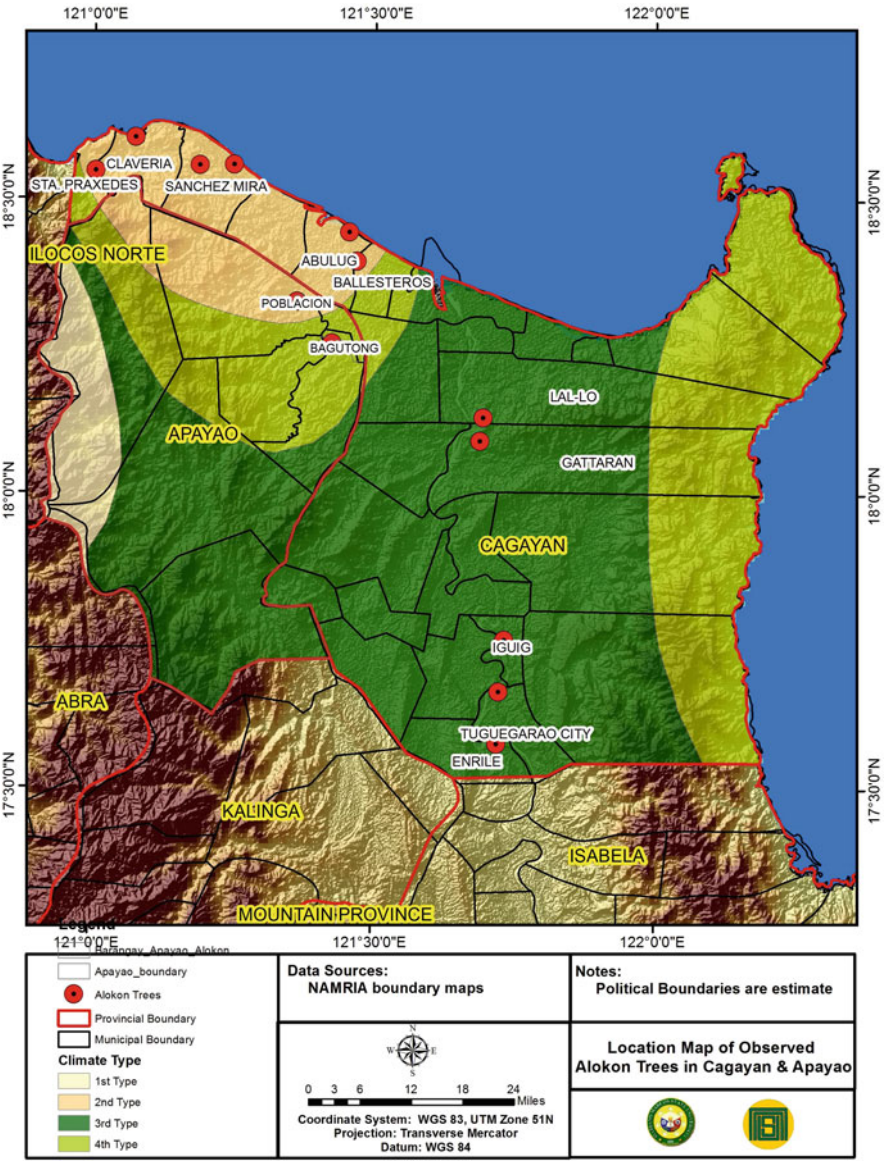
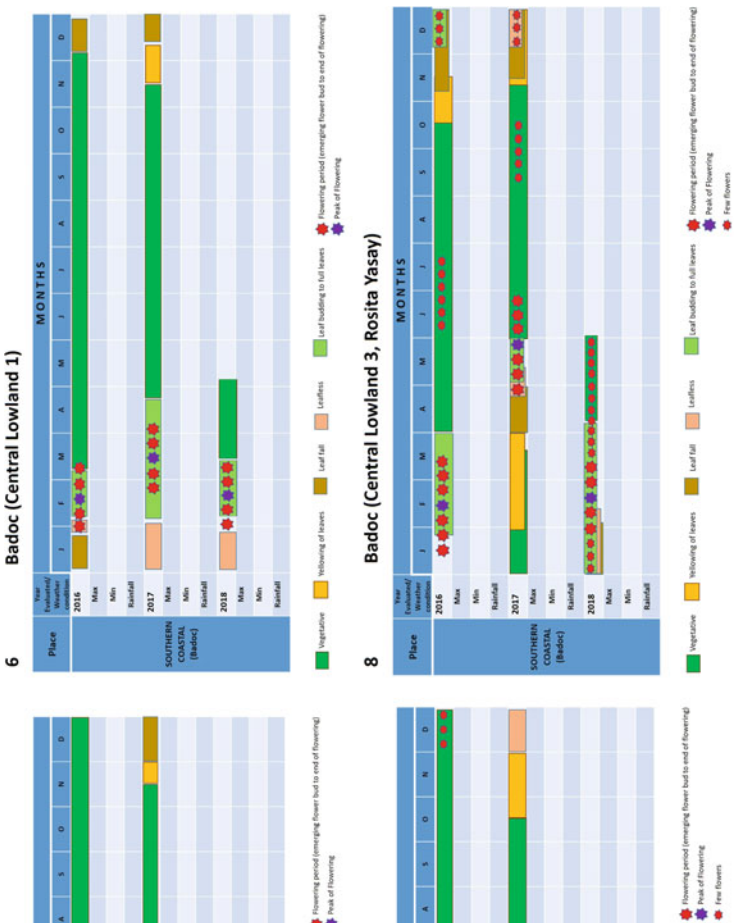



**Fig. 20.4** Location of observed *A. luzonicus* trees in the Provinces of Cagayan and Apayao. Map by Engr. Rodel T. Utrera, Research Directorate, Mariano Marcos State University

The trees were affected and defoliated forcedly, and after some time they sprouted again and entered vegetative phase. The weather disturbance might have caused the prolonged vegetative period of the trees (November to December) and the late flowering time (March) in 2017.




**Figs. 20.5–20.8** Phenology of *A. luzonicus* in the southern coastal (**5**) and three sites in the central lowland (**6**, **7**, **8**) in the municipality of Badoc, Ilocos Norte

2. *Central Lowland in Ilocos Norte*. Figures 20.6, 20.7, and 20.8 show the phenology of *A. luzonicus* in the central lowlands of Badoc, Ilocos Norte. Phenophases and flowering behavior of the trees differ from each other. The flowering time of one of the sample trees (Fig. 20.6) followed the same pattern as in Fig. 20.5 except in 2017. In 2016, flowering started in late January, peaked in mid-February, and ended in March. In 2017, flowering was a month later (February) than in 2016, and the flowering period was from February to early April. In 2018, the trees followed the same pattern and time as in 2016. In 3 years, all the trees completed the phenophases in chronological manner (yellowing, leaf abscission, then leafless) prior to bearing flower buds.
   Figures 20.7 and 20.8 show the trees with different flowering behavior in the central lowland of Badoc. Flowers were abundant during the rainy season (June to July) in 2016, and started to bear few flowers in December (Fig. 20.7). In 2017, the flowering period started in late April and ended in late June. In 2018, the flowering period started in early January and ended in late February. Another sample tree, which is found also in the same community in Brgy. Labut, Badoc, exhibited another flowering behavior (Fig. 20.8). In 2016, the flowering period started in mid-January when the tree was totally leafless and ended in mid-May. It started to bear few flowers again in June to July ($2^0$ floral flush) when the tree was in its vegetative stage. Matured leaves started to fall in early November, then bore few flowers in leafless branches in December. In 2017, the flowering period started in late April and ended in June. It bore flowers again in September to October, then in December. In 2018, flowers were abundant from late January to early March, although flowering continued until May. Leaf maturity, leaf abscission, leafless, leaf formation, and flowering occurred simultaneously (asynchronous). The tree owner-grower revealed that his tree indeed exhibits long-duration flowering (almost all throughout the year). The "variety's" behavior coupled with the cultural technique of no pruning employed by the grower-owner contributed to the prolonged flowering period in the tree.
   Figure 20.9 shows the phenology of *A. luzonicus* in Vintar. Documentation started in December 2016 when the tree was in its leaf and flower budding stage. In 2017, the tree bore flowers from late January to mid-June. It bore few flowers in November to February 2018. It was observed that the tree continuously bears flowers but not all the time abundant. The peak of flowering was in April in the year 2017, while in January in the year 2018.
3. *Northern Coastal in Ilocos Norte*. Two trees were documented and monitored in the Municipality of Burgos, and one in the Municipality of Bangui. One of the sample trees in Burgos and the sample tree in Bangui had the same flowering pattern (Figs. 20.10 and 20.11). In 2016, flowers emerged when the trees were at their leaf abscission stage in January, but flowering occurred a little earlier in Burgos and both ended at the same time. In 2017, these two trees started to bear flowers in February and ended in April. The tree in Bangui had prolonged flowering period because the branches were not pruned during the peak of flowering. The usual practice of the owner is to top-prune the branches during its peak of flowering, so the flowering period was ended there. In 2018, the

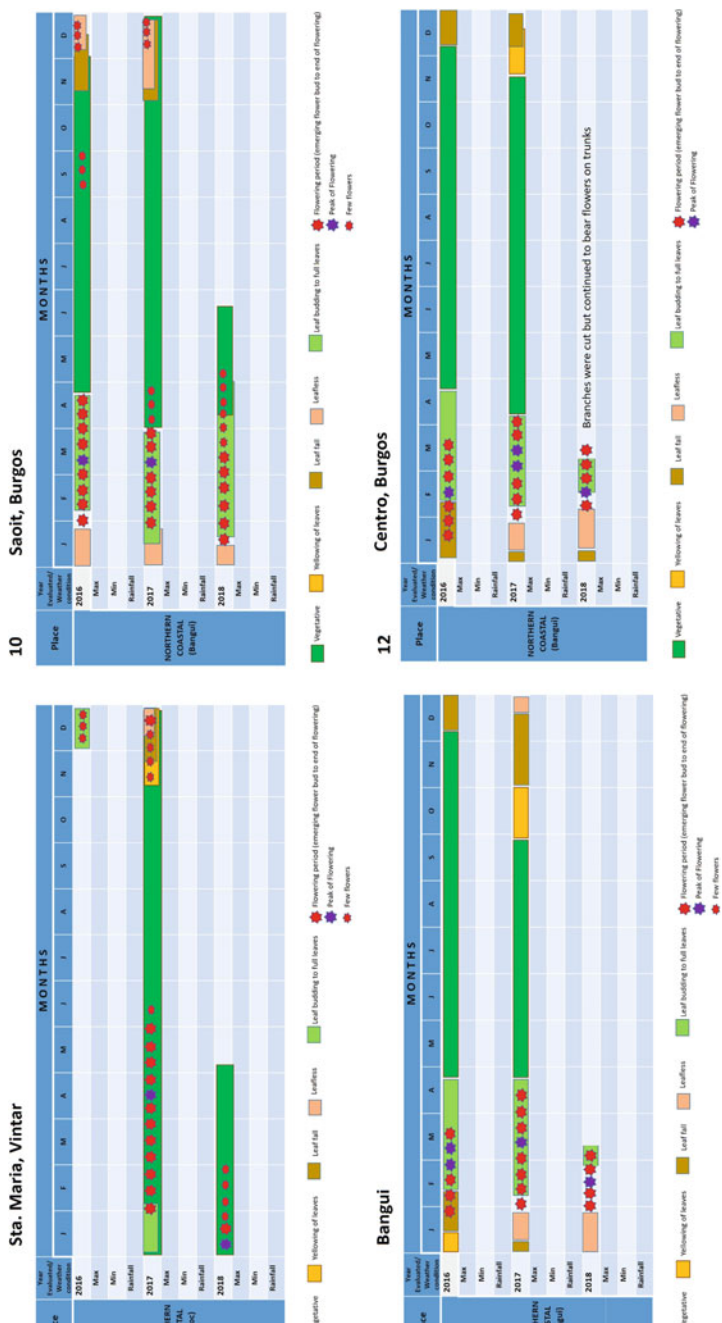



**Fig. 20.9–20.12** Phenology of *A. luzonicus* in the central lowland in the Municipality of Vintar (**9**) and southern coastal in the Municipality of Burgos (**10, 12**) and Municipality of Bangui (**11**), Ilocos Norte

flowering period of these two trees started in February and ended in early March because the branches were cut but continued to bear flowers on trunks and sprouts. These trees completed the phenophases (leaf yellowing, abscission, and leafless) before flowers emerged in 2017 and 2018.

Another tree in Burgos had a different flowering pattern (Fig. 20.12). This tree had the same growth and flowering pattern as the long-duration flowering trees in the Municipalities of Badoc and Vintar. It produced flowers almost all throughout the year but not as abundant as the yield during its regular flowering period (January to April). This tree exhibited the usual phenological pattern, i.e., leafless first before the flower emerged.

4. *Mountainous area in Ilocos Norte*. In a village in Tadao in the Municipality of Pasuquin (Fig. 20.13), the tree was on its leafless stage when the monitoring period was started in January 2016. Flowering period started in late January and ended in mid-March. Leaf maturity started in December and leafless period ended in late February. Flower buds immediately occurred after 3 weeks of leafless period and ended in April. Leaf maturity occurred earlier (late August) in 2017 than in 2016 (December). In 2018, leaf buds emerged first before the flower buds. Flowering started in the later part of January and ended in the early part of March. The flowering season in the year 2016 and 2018 had the same pattern.
5. *Eastern Interior in Ilocos Norte.* In the Municipality of Nueva Era (Fig. 20.14), the tree was on its leaf fall stage when the monitoring period was started in 2016. Flower buds emerged when the leaf falling stage was about to end. Flowering period started in mid-March and ended in late April. In 2017, flowering started 1 month earlier than in 2016. Flower buds also emerged when the leaf falling stage was about to end. In 2018, leaf maturity and leaf abscission stages occurred simultaneously, in different parts or branches of the tree. Flowering period occurred in early March, the branches were cut when there were abundant flowers, but still continued to bear flowers on trunks.

   Another tree (Fig. 20.15) in Nueva era exhibited a different pattern when compared to the tree in Fig. 20.14. The regular flowering period was in February but frequently cut during its peak of flowering but still continued to bear flowers on trunks. Few flowers were also present in January (Fig. 20.15).

#### 20.2.4.2 Phenophases in the Province of Cagayan and Apayao

*A. luzonicus* in Cagayan and Apayao also follow the same flowering behavior based on phenophases observed in Ilocos Norte. Phenophases such as leaf abscission, leafless period, floral bud emergence and burst, leaf emergence, secondary floral burst, etc. were documented through interview with local residents. *A. luzonicus* flower earlier (as early as November/December) in coastal barangays in Sanchez Mira, i.e., Brgy Marzan, than in the rest of the province.

According to key informants, there are two general flowering periods in the Province of Cagayan, namely: (a) January to March, flowering peak in March, in the Municipalities of Sta. Praxedes, Claveria, Sanchez Mira, Ballesteros, and Abulug; and (b) April to June in the Municipalities of Gattaran, Iguig, and Tuguegarao. A few cases of early flowering varieties, asynchronous habit, and


**Fig. 20.13–20.15** Phenology of *A. luzonicus* in a mountainous village in the Municipality of Pasuquin (13), and in the eastern interior Municipality of Nueva Era (14, 15), Ilocos Norte

double flowering (i.e., in the Municipalities of Lal-lo and Enrile) were likewise noted in some areas.

Ocular observation started in June 2017 in almost all the municipalities of Cagayan. Figures 20.16, 20.17, and 20.18 show the phenology of *A. luzonicus* in the province based on ocular observation. Most of the trees in June 2017 were in their vegetative stage (Figs. 20.16 and 20.17) except for some trees in a part of Lal-lo and Gattaran which were on leafy flowering stage. If we follow the flowering season mentioned by the informants, the June flowering could be the regular season in that part of Lal-lo and Gattaran.

*A. luzonicus* trees monitored in November 8–9, 2017, were on their leaf shedding stage in the Municipalities of Claveria, Sanchez Mira, Ballesteros, and Lallo while others were on leaf maturity stage in Gattaran, Alcala, and Enrile. A tree in Sanchez Mira was seen on full flowering stage on November 8, 2017, which was probably due to the removal of its bark.

In March 2018, most of the trees visited are now on their peak of flowering. Bud emergence could have started in February. The trees in Lal-lo (near Magapit Bridge) which flowered in June are again flowering in February and March (Fig. 20.18), which may now coincide with the mentioned second flowering.

In the Province of Apayao, the sample trees being monitored in Luna and Flora generally follow the flowering period of trees observed in the Municipalities of Claveria, Abulug, and Ballesteros.

### 20.2.5 Off Season Varieties of *A. luzonicus*

Since there is no identified and registered variety of *A. luzonicus* yet, preliminary identification of ecotypes or varieties was done to identify plants with excellent flowering behavior and gives a desired consumer appeal and acceptability at the same time. Trees were selected based on flowering habit and maturity, identifying preferably those trees that flower outside the general flowering period as observed above. Subsequently, the selected varieties were evaluated for the sensory qualities of the edible part, particularly texture, aroma, taste, slick/sliminess, tenderness, still-green trait after cooking, and general acceptability.

From the accessions monitored, six accessions were selected for their desired flowering behavior (Table 20.3). These include three accessions (Accn Yasay1, Yasay2, Badoc1-CL) from the Municipality of Badoc, two accessions (Accn 4Vintar and Accn 6Vintar) from the Municipality of Vintar, and one accession (Accn Salucag1) from the Municipality of Burgos, all situated in the Province of Ilocos Norte. The specific flowering period together with the consumer acceptability rating for each accession is indicated in Table 20.3. These accessions are geo-tagged and prioritized for mass propagation.

The six accessions were selected for having early flowering (as early as November or December), double flushing, and long-duration flowering. In addition, their desirable flowering behavior is complemented by the excellent sensory qualities earning a general acceptability rating of liked moderately to liked very

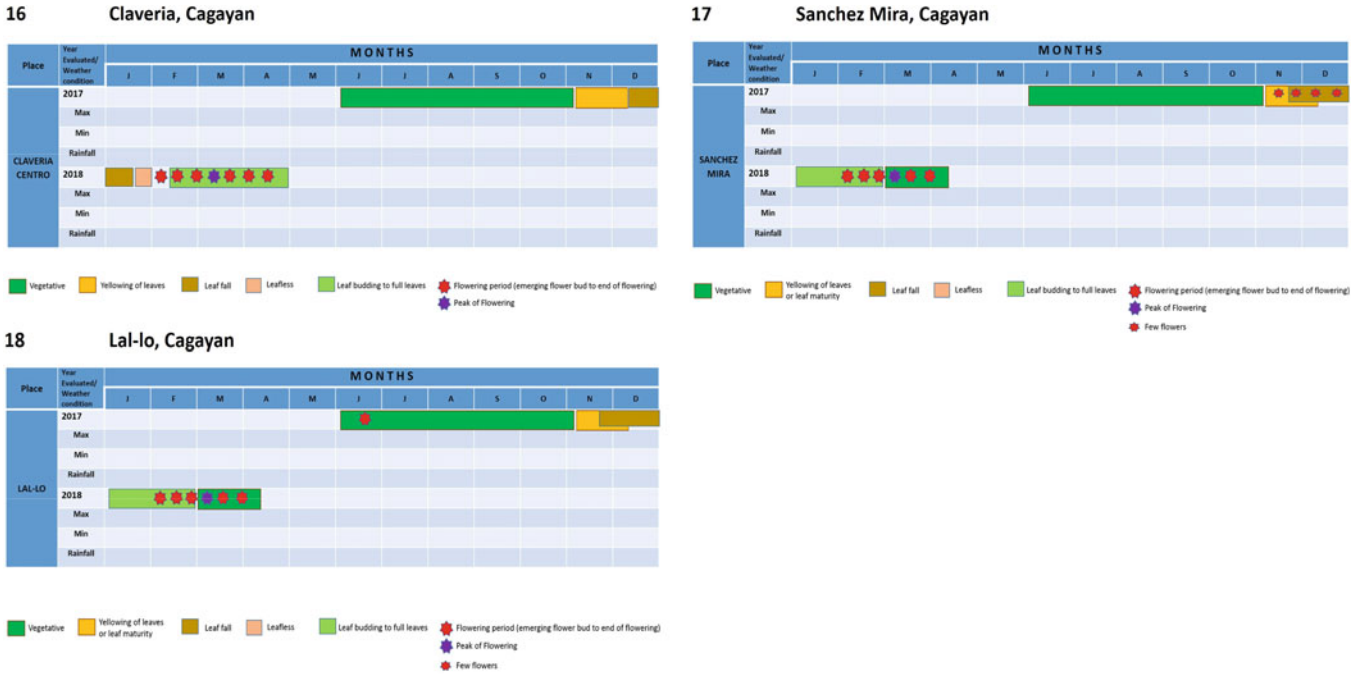



**Fig. 20.16–20.18** Phenology of *A. luzonicus* in the Municipalities of Claveria (16), Sanchez Mira (17), and Lal-lo (18), Province of Cagayan

**Table 20.3** *A. luzonicus* varieties with desired flowering behavior and sensory qualities

| Accession/ location | Inflorescence length (cm) | General acceptability | Flowering period | Special character |
|---|---|---|---|---|
| Yasay1 Badoc, Ilocos Norte | 3.2–10-4 | Liked very much; slick | January–March June–July, December | Early flowering in December; double flushing in June/July; long-duration flowering Asynchronous |
| (Yasay2) Badoc, Ilocos Norte | 3.2–10-4 | Liked very much; slick | January–May | Long-duration flowering Asynchronous |
| Badoc1 Badoc, Ilocos Norte | 6–11 | Liked moderately; slightly slick | April–June/ June–July, December | Early December; Late or double flushing in April–July |
| 4 Vintar, Ilocos Norte | 6–10.8 | Liked moderately; slightly slick | November–December; February–June | Early and long-duration flowering Asynchronous |
| 6 Vintar, Ilocos Norte | 6–11 | Liked moderately; slick; still green | February–July; September–December* | Long-duration flowering *flowers at this period are significantly lesser than during February–June |
| Salucag1 Saoit, Burgos, Ilocos Norte | 3.6–8.7 | Liked very much; slick | April–June; September–October; December | Early & long-duration flowering Asynchronous |

much (Table 20.3). All six accessions are moderately slick to slick. Slickness, similar to the slickness of *Corchorus* sp., is a desired sensory quality of *A. luzonicus*. One of the accessions (Accn 6Vintar) has a still-green feature, retaining a vibrant green after at least one hour from cooking. This indicates less oxidation in this accession.

### 20.2.6 Phenocalendar in Climate Types I, II, III, and IV

The study areas fall under four climate types (Fig. 20.19). The study areas in the Province of Ilocos Norte belong to climate Type 1, to which majority of areas in Ilocos Norte belong. In the Modified Corona's Climate Classification based on rainfall distribution, Type I climate is characterized by two pronounced seasons: dry from November to April and wet during the rest of the year (https://www.pagasa.dost.gov.ph). The maximum rain period is from June to September. On the other hand, the Province of Cagayan belongs to three climate conditions (Type II, III, and IV). Type II climate prevails in the Municipalities of Sta. Praxedes, Claveria, Sanchez Mira, Pamplona, Abulug, and part of Ballesteros while Type III climate prevails in majority of the municipalities of Cagayan. Type II climate is

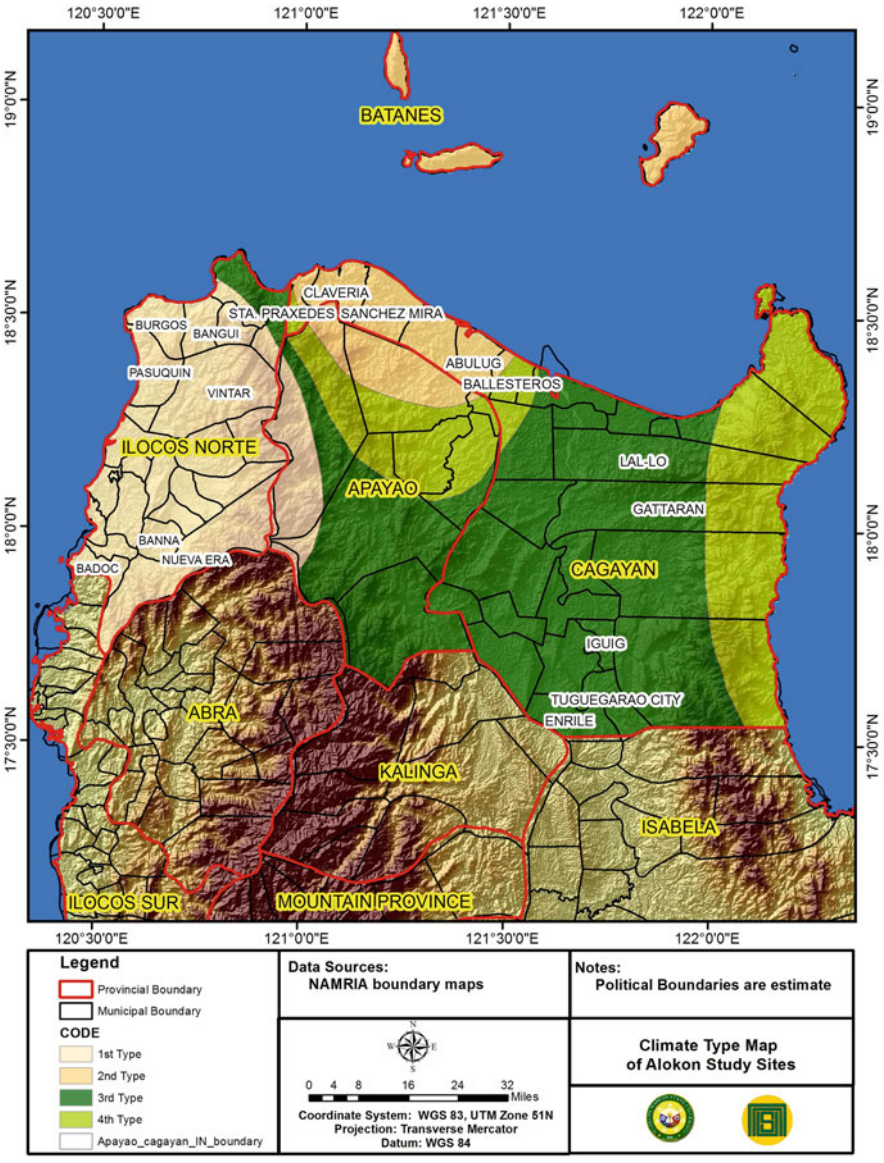



**Fig. 20.19** Climate map in the study areas. Map by Engr. Rodel T. Utrera, Mariano Marcos State University

characterized by no dry season with a very pronounced maximum rain period from December to February. Type III climate, on the other hand, is characterized by no very pronounced maximum rain period, with a very short dry season lasting only from 1 to 3 months (https://www.pagasa.dost.gov.ph).

The Municipality of Sta. Ana and portions of Gonzaga, Lal-lo, Gattaran, Baggao, and Penablanca belong to Type IV. They are characterized by more or less even distribution of rainfall throughout the year (https://www.pagasa.dost.gov.ph). Meanwhile, four climate types prevail in the Province of Apayao. The study sites in Luna and Flora belong to Types II and IV, respectively.

Flowering period in Ilocos Norte under Type 1 climate is generally from January to March, peaking in February (Fig. 20.20). With the identified off-season varieties, flowering is almost year round, except in the month of August.

Meanwhile, flowering in northwestern Cagayan with Type II climate, and northern Apayao both with Type II (i.e., Municipality of Luna) and Type IV climates (i.e., Municipality of Flora) is generally from January to March, too. However, flowering is behind Ilocos Norte by about 2–3 weeks; hence, peak of flowering is in the month of March (Fig. 20.21).

Flowering in most towns of Cagayan, which have Type III climate is generally from April to June (Fig. 20.21). Despite this general flowering pattern observed per climate type, there exist few to some cases of early flowering, double flowering, and late flowering in above areas.

#### 20.2.6.1 Factors Affecting Phenophases and Flowering Behavior

The development of *A. luzonicus* appeared to be influenced by climate type in the study areas. This is evident in the different flowering periods observed in the three provinces (Figs. 20.20 and 20.21).

Additionally, phenophases were influenced by temperature and daylength (photoperiodism) and moisture before and during the phase occurrence. In the Province of Ilocos Norte, the usual low temperature (Fig. 20.20) and short daylength in the months of November to December appeared to favor leaf abscission and flowering. Additionally, weather disturbance such as Typhoon Lawin in October 2017 caused delay in the flowering period, especially in the Municipality of Badoc where its effect was most pronounced.

The low temperature (as low as 12 °C) usually started in November to December, extending up to February (as low as 9 °C) of the succeeding year, is likened to vernalization, which makes a plant receptive to flowering stimulus. Although it has no direct role in inducing flowering, vernalization stimulus is perceived by dividing cells, e.g., shoot tips and embryo, in temperate and some tropical species (http://www.biologydiscussion.com). Vernalization treatment which includes exposure to about 0–5 °C can substitute the role of gibberellin in flowering and its effect is quite demonstrated in a number of species such as *Arabidopsis thaliana.*

*A. luzonicus* is also a photoperiodic species. Like garlic whose bulbing is favored by short days, *A. luzonicus* flowering seemed to be induced by the short-day length in November to December. The floral-stimulating action of photoperiodism is well reported in many species. The reported transfer of photoperiodic induction stimulus to non-induced plants is observed during propagation studies done in *A. luzonicus*. Once induced to flower (cell determined), new cuttings continue to flower even if they haven't yet developed roots and regenerated into new plants.

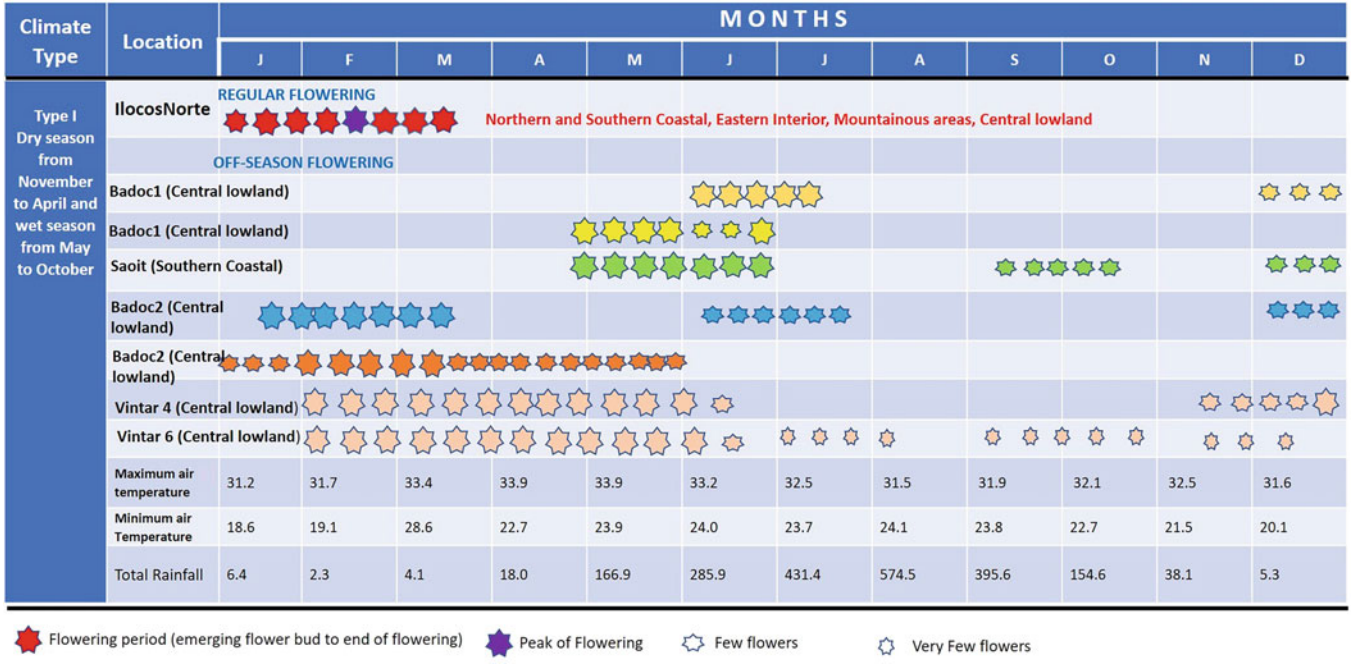



**Fig. 20.20** Flowering of *A. luzonicus* under Climate Type I of Ilocos Norte

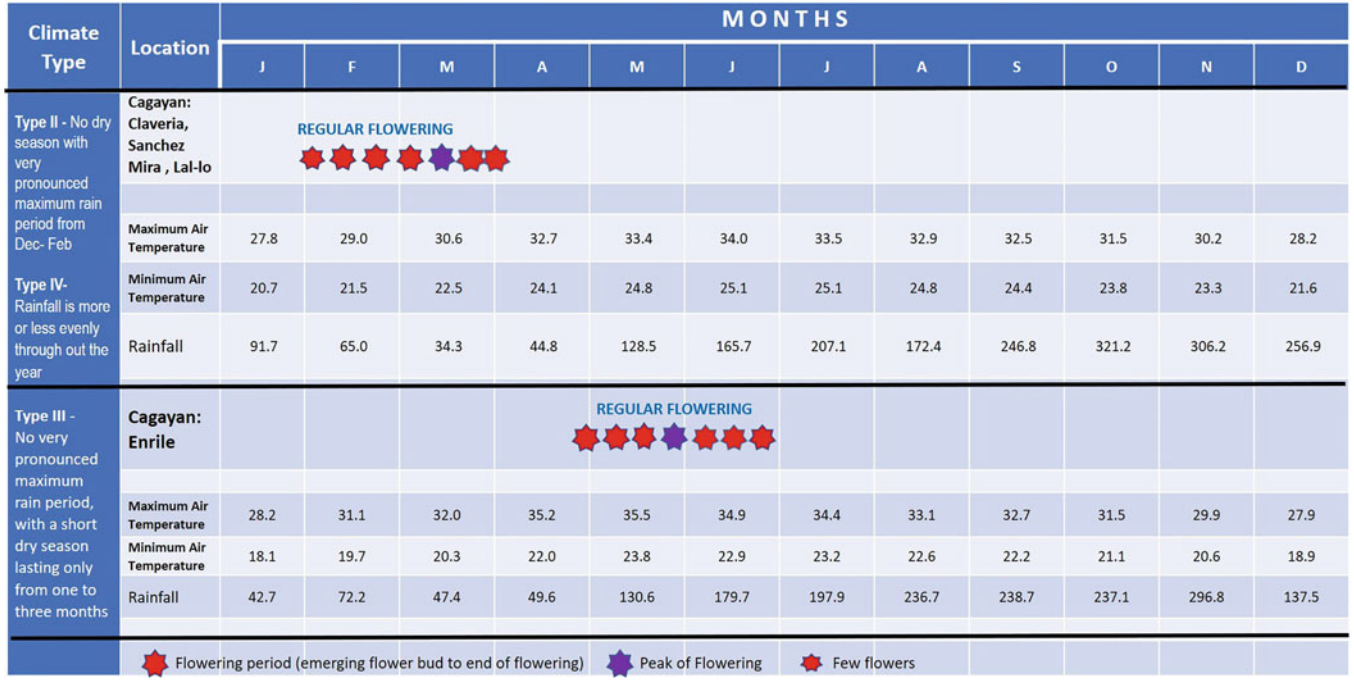



**Fig. 20.21** Flowering of *A. luzonicus* under Climate Types II and IV, and Type III in Cagayan and Apayao

The effect of temperature is also observed on the rate of development in *A. luzonicus* inflorescence. An important assumption here is that plant growth is a linear function of temperature. An increase in temperature results in an increase in development rate (Sivertsen et al. 1999). On flower characters, low temperature is not favorable to inflorescence elongation as manifested in the stunted growth of inflorescence as observed in trees in the Municipality of Bangui. Observing the same trees, the increase in temperature in the month of March favored inflorescence development as indicated in the longer and faster rate of elongation. The usual period it takes from bud emergence to market maturity is 2 weeks. But this was shortened to 1 week during the hotter month of March.

In the regular flowering season during the summer months (starting March), during which temperature, solar radiation, and evapotranspiration rise while rainfall becomes nil, there are distinct features observed on flowering, as follows: (a) inflorescence emerge starting on the first axil and every axil thereafter, (b) many inflorescence arise directly from the stem, somewhat similar to cauliflory, (c) inflorescence is plenty (1 to 9 per spike), with few or no leaf at all, and iv) spikes have shorter internodes or distances between axils.

During the rainy season when sufficient moisture becomes available for plant growth, second flush of flowers occurs (but in few varieties only). Inflorescence produced is only few (1 to 3 per spike), but longer than inflorescence produced in summer or regular season, had big and numerous leaves, and usually start emerging at third or fourth axil. Likewise, spikes were observed to be longer, thus a factor of longer internodes. This is presumably a direct effect of the relative abundance of water which favors vegetative growth. Similar hypothesis is drawn for the slightly extended vegetative phase in January in Cagayan as the months of December and January usually have continuous rain.

Biotic factors were also inferred to affect the flowering behavior of *A. luzonica*. The sample trees did not manifest similar flowering behaviors. One possible reason could be attributed to the age of the trees. Trees pass through specific developmental phases as they age, including juvenile to adult, and vegetative to reproductive phases (Groover 2017). The timing of these transitions is regulated genetically but is also highly influenced by the environment. Transition to reproduction is influenced by conserved mechanisms in angiosperm trees, which determine when to flower by integration of information from physiological changes associated with size and carbohydrate metabolism with measurement of seasonal and environmental factors.

Variety is another factor in the observed differences on flowering behavior such as the occurrence of long-duration (year-round) flowering, second floral flushing, and early and late flowering. At present, there is no identified and registered variety of *A. luzonicus* yet.

## 20.3 Summary, Conclusions, and Recommendations

The growth and development cycle in *A. luzonicus*, also referred to as phenological cycle in this context, consists mainly of vegetative, intermediate, and reproductive phases. Under Ilocos Norte conditions, the vegetative phase lasts for 7–8 months (March to October) while the reproductive phase lasts for 4–5 months (late November to March). The specific phases are accompanied by morphological changes in the plant such as leaf bud emergence, full leaf development, leaf maturity, leaf yellowing and senescence, leaf abscission, leafless, floral bud emergence, flower development, and flower physiological maturity. Regardless of ecological zone in Ilocos Norte, trees follow a similar phenological cycle and period of occurrence over the three-year observation period. But a few trees exhibit extreme cases, not conforming with the regular cycle (hence called asynchronous) and period of occurrence.

Comparing trees under four climate types in the Provinces of Ilocos Norte, Cagayan, and Apayao, the phenological cycles are similar but flowering period varies. The flowering period under Type I climate of Ilocos Norte is generally from January to March, peaking in February. Flowering in Type II (northwestern Cagayan and northern Apayao, i.e., Municipality of Luna) and Type IV climates (northern Apayao, i.e., Municipality of Flora) is generally from January to March but behind Ilocos Norte flowering by about 2 to 3 weeks; hence, peak of flowering is in the *month of March*. Flowering under Type III climate in Cagayan is generally from April to June. Climate, weather factors such as temperature and daylength (photoperiodism), and biological factors such as age and variety of tree seemed to affect the occurrence and duration of the different phases, and some flower characteristics.

There exist six accessions which exhibit early flowering, double flowering, and year-round flowering (but still peaks during the regular flowering season).

Flower induction is employed in some high value crops, such as mango and dragonfruit, for off-season crop production. While cultural intervention can be tested also in *A. luzonicus*, a production system integrating the species' phenological cycle and off-season varieties is an alternative for year-round inflorescence production. Thus, a phenocalendar for a sustainable crop production is hereby developed (Fig. 20.22). The Provinces of Ilocos Norte, Cagayan, and Apayao are viable sources of raw materials to meet consumption requirements in the months of January to June. For the remaining months of the year (excluding August), the off-season varieties will supply the inflorescence requirement. The raw material requirement for the month of August can be met by using frozen, freeze-dried, or ready-to-cook formulations of the inflorescence. Freezing technique is already in place. Blanching and freeze-drying duration are currently being standardized for freeze-dried *A. luzonicus*. Additionally, research on the development of ready-mix or ready-to-cook viands of *A. luzonicus* is also underway.

The phenocalendar-based crop production system is simple and economical, not requiring cultural interventions or chemical inputs. The following recommendations are hereby put forward in support of the developed phenocalendar: (a) Validate the consistency of the phenocalendar in response to climate change. (b) Mass propagate

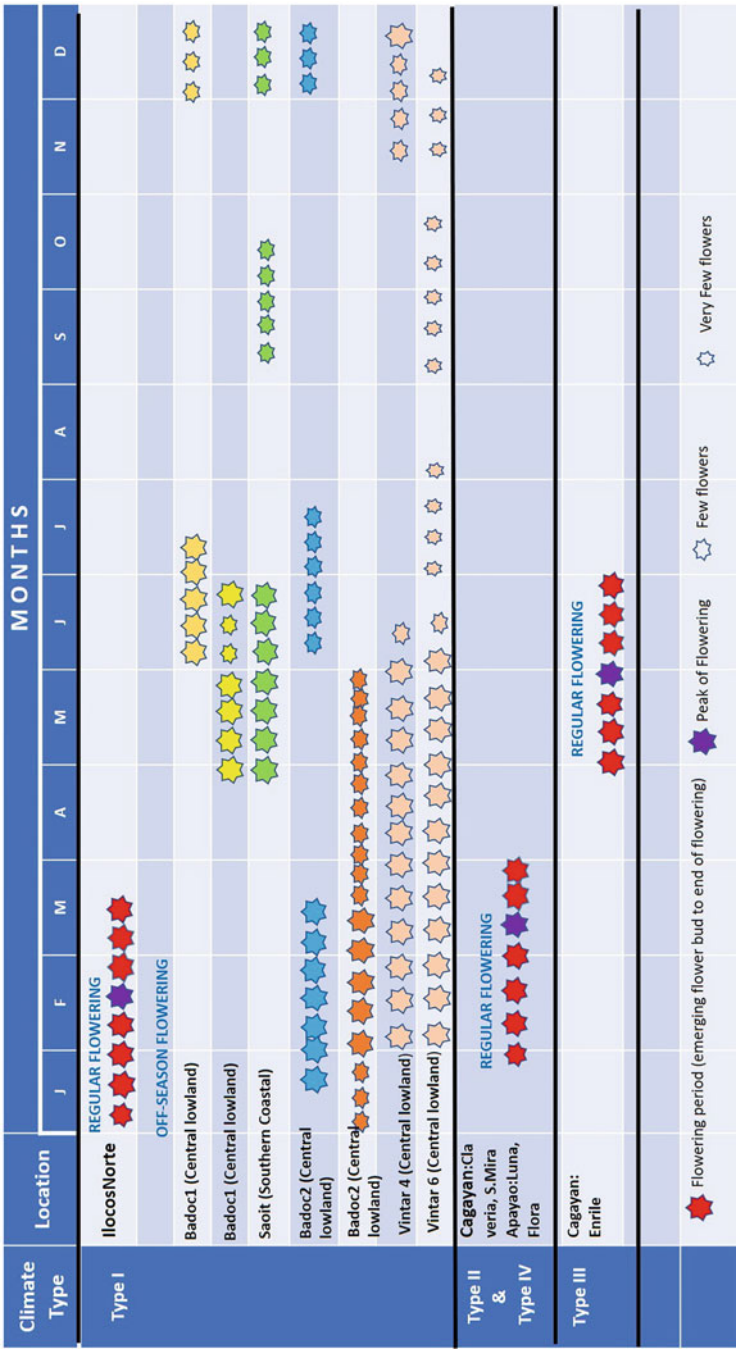



**Fig. 20.22** Phenocalendar-based inflorescence production in *A. luzonicus*

the identified varieties and promote additional planting. (c) Accelerate proactive research on product development to address future need and supply gaps (i.e., market glut, supply shortage).

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