Climatic Environment Adapted to Tropical and Subtropical Crops

By YUKIO NAKAGAWA

Division of Pomology, Fruit Tree Research Station

It is known that distribution of crops is determined predominantly by climatic conditions and secondarily by edaphic conditions[4),5)]. Since this seems to be true with tropical crops too, it might be possible to make clear the climatic condition adapted to each tropical crop by analyzing climatic environments of major producing areas of each crop. However, this approach faces two bottlenecks, i.e., lacking of sufficient data of meteorological elements in tropical region, and insufficient information on geographical distribution of tropical crops. To break these bottlenecks comprehensive surveys will be necessary. Nevertheless, an approximate estimation can be made from the data on climate and crop distribution now available. In this paper, a result of such kind of approach carried out with coconut palm, oil palm, cacao, rubber, banana, sugarcane, pineapple and coffee is described.

Climate adapted to major tropical and subtropical crops

Table 1 summarizes meteorological elements of current production areas of major tropical and subtropical crops including rice and wheat.

1) Coconut palm

Very small values of coefficient of variation were found among coconut producing areas with accumulated temperature (higher than 10°C), mean temperature of warmest month and that of coldest month, indicating that temperature condition of each producing areas was almost similar. Coconut palm was found distributed to areas having 5,500–6,500°C of accumulated temperature with an average of 6,000°C. Mean temperature of warmest month ranged from 27 to 29°C and that of coldest month was above 22°C in most coconut producing areas.

Annual precipitation was about 2,400 mm in most of the coconut areas, although the variation was greater than that of temperature among different areas. Majority of areas have more than 60mm in driest month. Needless to say, low frequency of typhoon is desirable. Out of 17 areas studied, 12 areas belong to Af climatic zone, 3 areas to Aw, and 2 areas to Am of the Köppen's climatological classification.

2) Oil palm

Oil palm producing area was almost similar to areas of coconut production. The only difference was that several oil palm areas have four to five months with monthly mean precipitation less than 50 mm. Out of 14 areas, 6 belong to Am, 5 to Aw, and 3 to Af of the Köppen's climatological classification.

3) Cacao

As cacao is strongly influenced by wind, the cacao is grown in areas without storm. In coastal areas or in areas of an elevation higher than 600 m, stable production is not obtained without windbreaks. Temperature of cacao producing areas was almost similar

Table 1. Meteorological elements of producing areas of selected tropical and subtropical crops

Crops	Accumulated temperature (°C)				Monthly mean temp. of warmest month (C°)				Monthly mean temp. of coldest month				Annual precipitation (mm)				No. of producing area studied
	Max.	Min.	Av.	C.V. (%)	Max.	Min.	Av.	C.V. (%)	Max.	Min.	Av.	C.V. (%)	Max.	Min.	Av.	C.V. (%)	
Coconut palm	6,500	5,500	6,005	5.5	28.9	26.6	27.9	2.3	27.2	20.9	24.8	7.9	4,300	900	2,347	36.6	17
Oil palm	6,300	5,500	6,000	3.3	30.3	26.1	27.8	3.6	26.7	23.9	24.9	3.2	4,300	700	2,178	42.2	14
Cacao	6,900	5,600	6,012	6.4	29.7	26.4	27.5	3.3	27.5	22.8	24.9	5.7	7,100	600	2,000	79.0	16
Rubber	6,400	5,800	6,123	3.0	29.3	26.6	27.9	2.9	26.7	24.2	25.7	3.0	5,100	1,700	2,815	37.8	13
Banana	6,900	4,200	5,650	10.0	29.7	22.3	27.4	5.2	27.5	15.8	23.3	11.6	4,300	600	1,855	48.8	20
Sugarcane	6,600	3,300	5,332	14.0	34.5	21.7	27.9	8.0	27.0	11.5	20.8	20.9	3,200	600	1,504	37.0	43
Pineapple	6,400	2,900	4,862	18.1	29.8	21.3	26.4	9.2	26.7	15.0	19.7	18.2	3,500	600	1,856	41.2	16
Coffee (Arabica)	5,400	2,800	3,663	19.1	26.1	19.5	21.7	7.9	23.9	14.0	18.1	16.6	2,500	800	1,463	33.5	11
Coffee (Robster)	6,100	4,000	5,471	14.7	28.1	21.7	26.3	9.3	25.8	20.5	23.4	8.1	5,100	1,200	2,200	61.3	7
Rice	6,600	1,000	3,025	52.2	32.2	20.7	26.4	9.3	—	—	—	—	2,600	300	1,520	33.8	76
Winter wheat	5,800	400	2,257	53.7	36.1	14.7	24.5	18.6	15.8	9.5	2.8	—	1,500	300	783	29.7	54

Notes: Accumulated temperature=degree-day, above 10°C
Max.=Maximum, Min.=Minimum, Av.=Average. C.V.=Coefficient of variation

to that of coconut and oil palm areas. Annual precipitation was averaged 2,000 mm, although variation among areas was large. In most areas, there are two to three months with monthly mean precipitation less than 50 mm. Out of 16 areas studied, 8 areas belong to Aw, 4 areas to Af, 3 to Am, and 1 to Bs of the Köppen's classification.

4) Rubber

Temperature of rubber producing areas was higher than that of above mentioned crops. Average of accumulated temperature of rubber areas exceeds 6,100°C. No areas were found where mean temperature of coldest month lowers below 24°C. Annual precipitation was also higher than that of above crops, showing an average of 2,800 mm. No place was found where annual precipitation is less than 1,700 mm. In Hai-nan Island (Kiung chew) and Tainan of Taiwan, where accumulated temperature is less than about 5,000°C, yields are apparently low.

Out of 13 areas studied, 8 areas belong to Af, 3 to Am, and 2 to Aw of the Köppen's classification.

5) Banana

Accumulated temperature of banana areas was averaged 5,700°C. It is lower than that of coconut, oil palm, and cacao areas. Mean temperature of coldest month was also low, being 16–28°C.

According to Simmonds (1959), monthly mean temperature lower than 21°C suppresses banana growth to some extent, while that of 15.5°C completely inhibits the growth. Therefore in areas with mean temperature of coldest month less than 21°C harvest may be delayed. Out of 20 areas studied, 9 belong to Aw, 6 to Am, 3 to Af, and 1 to each of BS and Cwa.

6) Sugarcane

Sugarcane is distributed in areas with accumulated temperature lower than that of banana areas. Average of that of all areas studied was 5,300°C. Mean temperature of coldest month is also lower than that of banana areas, showing 11–13°C in some areas. Such cold winter areas were found in northern India, southern Louisiana of USA, and Argentine, where frost damage occurs in spring season in some years. Annual precipitation of sugarcane areas was apparently lower than that of banana areas. In many areas there is a distinctive dry season. Out of 43 sugarcane producing areas studied, 21 belong to Aw, 7 to Am, 5 to Cfa, 4 to Cwa, 3 to Af, 2 to BS, and 1 to BW of the Köppen's classification.

7) Pineapple

Accumulated temperature of all pineapple areas studied was average 4,900°C. It is lower than that of banana areas by 400°C. Average of mean temperature of coldest month of pineapple areas was also lower than that of banana areas by about 1°C. When monthly mean temperature goes down below 16–17°C in winter season, growth of plants was apparently delayed with a prolonged growth duration.

Average of annual precipitation of pineapple areas showed 1,900 mm, slightly greater than that of sugarcane areas. Out of 16 areas studied, 4 belong to Af, and 3 to each of Cfa, Cwa, Aw, and Am.

8) Coffee (Arabica)

Average of accumulated temperature of producing areas was 3,700°C, showing the temperature requirement apparently lower than that of other crops. Many areas have annual precipitation of 1,000 to 1,500 mm, with a distinct dry season. Dry season promotes flower bud formation, resulting in an increased number of fruits.

Out of 11 areas studied, 3 being to Aw, 3 to Cfb, 2 to Am, 1 to each of Cwb, Cfa, and Af of the Köppen's classification.

9) Coffee (Robster)

Accumulated temperature of producing areas was 5,500°C, higher than that of arabica coffee by about 2,000°C. Annual pre-

cipitation was 2,200 mm, remarkably higher than that of arabica coffee. However in most areas, there is a distinct dry season. Out of 6 areas studied, 4 belong to Aw, 1 each to Am, and Af of the Köppen's classification.

Conclusion

It can be found in Table 1 that accumulated temperature of producing areas of rice and winter wheat which are very much progressed in varietal improvement and cultural technology is characterized by the large values of coefficient of variation among areas. It seems that the improvement of variety and cultural management has widen the range of climatic adaptability of these crops. On the other hand, tropical crops like coconut, oil palm, cacao, rubber, banana, sugarcane, pineapple and coffee showed the small values of coefficient of variation with temperature, indicating that they are grown under more or less similar temperature. It is not known whether such a limited range of climatic adaptability of these crops is the nature of these crops or it can be widened by the varietal improvement and cultural management improvement.

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