Reference 11 Effects of temperature on rice development

Summary

Rice phenology (the succession of rice development stages) depends, among other factors, on air and water temperature and on photoperiod (day-length), and thus changes throughout the year. Phenology is essentially a function of varietal choice and sowing date. A good knowledge of rice development enables one to predict the best timing of crop management interventions. The timing of these interventions—e.g. application of fertilizer, weeding, last drainage before harvesting—is directly linked to rice development. Temperature also directly influences yield: high temperatures at flowering and low temperatures at panicle initiation stage both lead to spikelet sterility and, therefore, yield loss.

The rice plant develops over three phases (Reference 8): (i) the vegetative phase, from germination to panicle initiation; (ii) the reproductive phase, from panicle initiation to flowering; and (iii) the maturation phase, from flowering to maturity. Development rate is not constant, but fluctuates as a function of air and water temperature and of photoperiod (day-length); these factors are especially important during the vegetative phase. Cold during this phase slows down rice development and lengthens growth duration. Rice varieties can be characterized by a *base temperature* below which development stops (T_{base}), an optimal temperature (T_{opt}) at which development rate is the fastest, and above which this rate remains relatively constant, and a *'temperature-sum'* (T_{sum}, expressed in degree-days, °C*d), which represents the total number of thermal units necessary for the plant to reach flowering.

Table 11.1 illustrates this principle, assuming constant daily temperatures. At 10°C, a rice cultivar with a base temperature (T_{base}) of 10°C or lower will not develop and will never reach flowering. At 20°C, a rice cultivar with T_{sum} = 1000°C*d, and T_{base} = 10°C will need a total of 1000/(20–10) = 100 days to reach flowering. At 25°C, development will be faster: it will take only 1000/(25–10) = 66 days to reach flowering. At 30°C, development rate is comparable to the development rate calculated for 25°C, assuming T_{opt} = 25°C. In reality, development rate will start to slow down as temperature increases, especially at very high temperatures. Development rates will also decrease with an increase in day-length beyond 11 hours per day.

Table 11.1. Effect of temperature on the development of a variety of rice (simplified hypothetical example)

Constant temperature (°C)	T_{base} (°C)	T_{opt} (°C)	T_{sum} (°C*days)	No. days to reach flowering
10	10	25	1000	–
20	10	25	1000	100
25	10	25	1000	66
30	10	25	1000	66

Reference 11

Effects of temperature on rice development

Air temperature also has a direct effect on yield. In general, low temperatures at panicle initiation stage may cause spikelet sterility. Minimum air temperatures below 18°C will generally cause sterility. Sterility generally reaches 100% if the minimum air temperature drops below 16°C. Sterility can also occur due to extremely high temperatures during flowering. The percentage of sterile grains increases from 0 to 100% when the mean air temperature increases from 35°C to 45°C.

To illustrate how sowing date and varietal choice may influence yield and growth duration, results of an experiment conducted at WARDA's experimental farm at M'Bé (Côte d'Ivoire), in 2000 and 2001 are presented in Figures 11.1 and 11.2. Five cultivars (Bouaké 189, WITA 9, WITA 3, CK4 and Suakoko 8) were transplanted every month from December 2000 to September 2001, under irrigated conditions and with intensive fertilization.

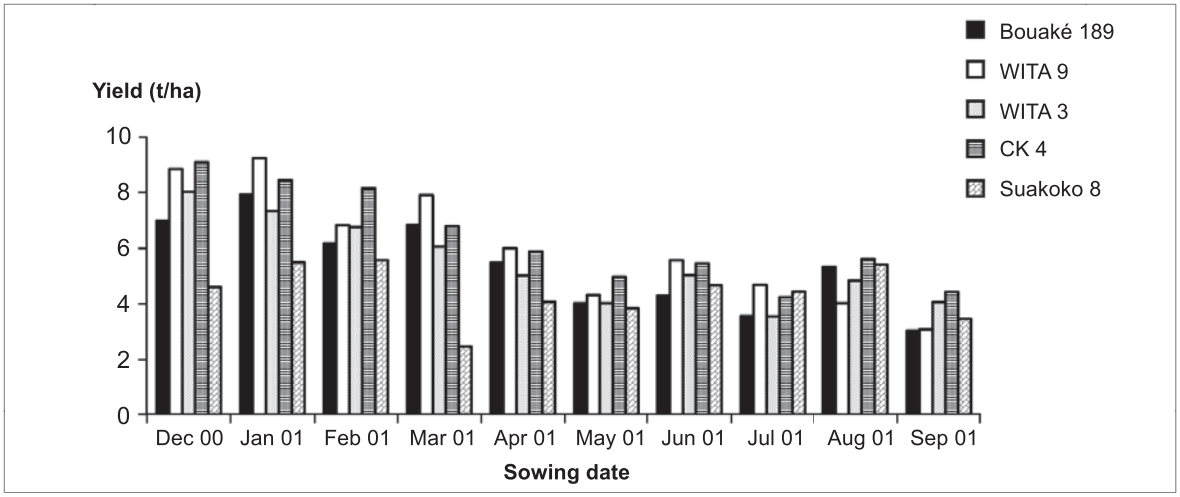

Figure 11.1. Yield variations for five inland-valley rice varieties (Bouaké 189, WITA 9, WITA 3, CK4 and Suakoko 8) as a function of sowing date. 'Rice garden' trials, conducted at WARDA, M'Bé, Côte d'Ivoire, 2000–2001.

Figure 11.1 shows the great variability that can be obtained in terms of yield as a function of sowing date and varietal choice. In this experiment, best yields were obtained in the off-season for varieties WITA 9 and CK4. Sowing in September to November is not advisable as these dates may lead to a decrease in yields because of cold around panicle initiation.

The effect of the sowing date on growth duration divides the five varieties into two groups: Suakoko 8 and CK4 in one group, and WITA 3, WITA 9 and Bouaké 189 in the other. The first two varieties are more susceptible to photoperiod and their development slows down when days become longer. In December and January, harmattan wind and low temperatures influence plant development and lengthen their growth cycle (Figure 11.2).

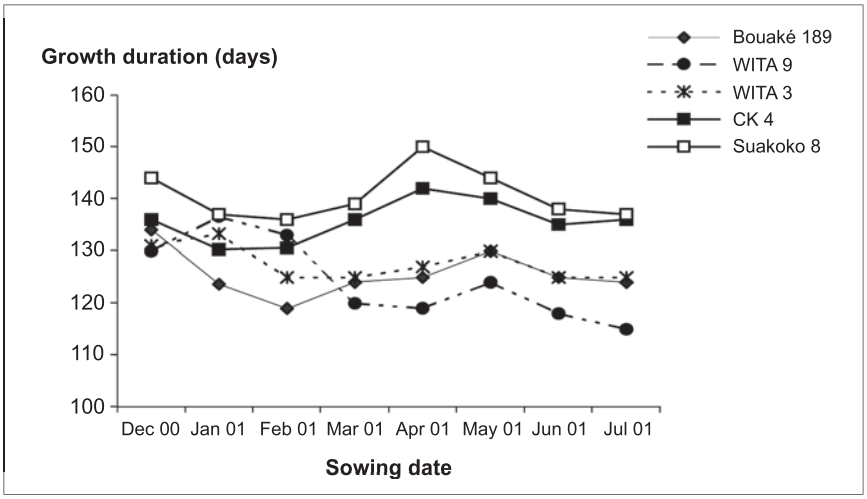

Figure 11.2. Growth duration of five inland-valley rice varieties (Bouaké 189, WITA 9, WITA 3, CK4, Suakoko 8) as a function of sowing date. 'Rice garden' trials, conducted at WARDA, M'Bé, Côte d'Ivoire, 2000–2001.

At the WARDA experimental farm in M'Bé (Côte d'Ivoire), for Bouaké 189, sown in July, the growth cycle reaches about 17 weeks under direct-sowing conditions, and about 18 weeks after transplanting (Figure 11.3; Tables 11.2 and 11.3). The period between panicle initiation and flowering usually covers about one month, as does the period between flowering and maturity. Thus, the Bouaké 189 vegetative phase lasts approximately 10 weeks when transplanted, and 9 weeks when directly sown. The difference is due to transplanting shock. During the off-season, the vegetative phase becomes one to two weeks longer because of the effect of cold on the development of the rice plant.

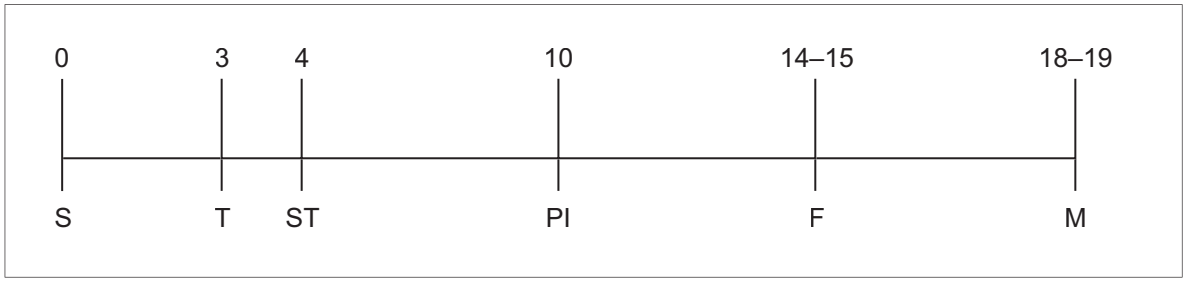

Figure 11.3. Phenology of Bouaké 189 (expressed in number of weeks), when sown in July and transplanted, M'Bé, Côte d'Ivoire. S: sowing; T: transplanting ; ST: start of tillering; PI: panicle initiation; F: flowering; M: maturity.

Table 11.2. Development stages of Bouaké 189, sown in July, M'Bé, Côte d'Ivoire

Development stage	No. days after sowing	No. weeks after sowing
Emergence	3	
Start of tillering	20	3
Mid-tillering	40	6
Panicle initiation	60	9
Elongation	80	11
Heading	85	12
Flowering	90	13
Maturity	120	17

Table 11.3. Development stages of Bouaké 189, transplanted in July, M'Bé, Côte d'Ivoire

Development stage	No. days after sowing	No. weeks after sowing
Emergence	3	
Seedlings transplanted	20	3
Start of tillering	30	4
Mid-tillering	50	7
Panicle initiation	70	10
Elongation	90	13
Heading	95	13–14
Flowering	100	14–15
Maturity	130	18–19

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