Mausam, (1996), 47, 3, 281-286

632.11 : 633.1

Effects of soil temperature and certain weather parameters on the growth and yield of ragi (*Eleusine Coracana*)

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(Received 19 November 1993, Modified 11 August 1995)

सार — रागी (एलुसाइनी कोराकैना, गिअर्टनर) (वार. CO 11) की बढ़ोतरी तथा पैदावार पर मिट्टी और वायु के तापमान तथा धूप की अवधि के प्रभाव का मूल्यांकन किया गया। विश्लेषण के परिणामों से पता चला कि फसल की बढ़ोतरी तथा फूल आने की अवस्थाओं में मिट्टी में 15 सें. मी. तक की गहराई के अनुकूलतम तापमान ने रागी के दाने और पुआल की पैदावार को काफी प्रभावित किया है। मृदा तापमान 30 सें. मी. की गहराई में औसत वायु तापमान से अधिक पाया गया।

संचित ऊष्मा रागी के दाने और पुआल के अनुकूल पाई गई। दिन में धूप भी फसल के दाने और पुआल के अनुकूल रही।

ABSTRACT. The influence of soil temperature, air temperature and sunshine hours on the growth and yield of ragi (*Eleusine coracana*, Geartner) (Var. CO 11) was evaluated. The results of analysis indicated that soil temperature at crop growth and flowering stages significantly influenced the yield of grain and straw of ragi, the best fit being at 15 cm depth. Soil temperature at 30 cm depth was higher than the mean air temperature.

Accumulated heat units correlated positively with grain and straw of ragi. Sunshine hours also correlated positively with yield of grain and straw.

Key words — Soil temperature, Air temperature, Sunshine hours, Accumulated heat units, Ragi yield.

1. Introduction

The effect of environmental factors on the growth rate of plants has been observed for many years. Temperature influences the plant growth throughout the growing phases and has been the objective of intensive study by many researchers (Allison and Daynard 1970, Muchow 1989, Muchow *et al.* 1990, Liang *et al.* 1991 and Brar *et al.* 1991). In general, higher the temperature upto a certain point over the minimum required for growth, more rapid is the growth rate (Boswell 1926). It is, therefore, necessary to know how much heat units must be accumulated to obtain a given maturity level.

It is of interest to geneticists also who may predict more accurately when inbreds and single crosses should be planted so that the different growth phases will occur at the same time or to breed a variety that matures at a period of minimum insect and disease damage. In the present investigation, the effect of seasonal temperatures and soil and the sunshine hours on the yield of ragi (*Eleusine coracana* Geartner) crop (Var. CO11), was studied.

2. Materials and method

A field experiment was laid out in Tamil Nadu Agricultural University, Coimbatore during kharif

TABLE 1

Mean soil temperature at 5 cm depth (°C)

T. No.	Crop growth stage				Mean
	Seedling	Growth	Flowering	Maturity	
1	25.9	25.8	25.5	24.9	25.5
2	24.9	24.9	25.8	25.8	25.4
3	25.6	25.9	25.9	24.8	25.6
4	25.6	25.9	25.8	24.8	25.5
5	25.8	25.9	26.2	25.0	25.7
6	26.3	26.0	26.3	24.9	25.9
7	25.8	26.0	26.0	25.3	25.8
8	25.8	26.2	25.9	24.9	25.7
9	26.1	25.9	25.9	25.0	25.7
CD (P=0.05)	0.1	0.1	0.2	NS	NS

TABLE 2

Mean soil temperature at 15 cm depth (°C)

T. No.	Crop growth stage				Mean
	Seedling	Growth	Flowering	Maturity	
1	26.6	26.4	26.2	25.6	26.2
2	27.0	26.4	26.4	27.1	26.7
3	26.3	26.6	26.7	25.4	26.3
4	26.4	26.5	26.7	25.7	26.3
5	26.2	26.7	26.0	26.2	26.5
6	26.2	26.8	26.6	25.8	26.4
7	26.5	26.9	26.9	25.7	26.5
8	26.6	27.1	26.7	25.7	26.5
9	25.7	26.9	26.9	25.3	26.5
CD (P=0.05)	0.2	0.1	0.1	NS	NS

TABLE 3

Mean soil temperature at 30 cm depth (°C)

T. No.	Crop growth stage				Mean
	Seedling	Growth	Flowering	Maturity	
1.	27.7	27.2	27.0	27.3	27.3
2	27.7	27.0	27.3	27.9	27.5
3	27.0	27.2	27.4	26.3	27.0
4	27.0	27.1	27.4	26.6	27.0
5	27.7	27.2	27.8	26.6	27.3
6	27.4	27.5	28.0	26.8	27.4
7	27.7	27.8	28.4	26.7	26.6
8	27.3	27.9	27.7	26.7	27.4
9	27.6	27.7	27.9	26.2	27.4
CD (P=0.05)	0.1	0.1	0.3	NS	NS

season of 1989. The treatmental details are furnished in Table 4.

The treatments (sowing and transplanting at weekly intervals) were replicated four times in randomized replicated block design. Uniform fertilizer dose of 120 : 60 : 60 kg/ha N, P and K were applied for each treatment. Plant height and tiller counts were recorded. Daily maximum and minimum air temperatures and sunshine hours recorded by the Meteorological Observatory of the Tamil Nadu Agricultural University were used in this investigation. Daily soil tempertures for the different treatments at three different depths, *viz.*, 5, 15 and 30 cm depth were recorded both in the morning (8.30 a.m.) and evening (2.00 p.m.). Accumulated heat units by Summation Index Method over a base temperature of 40°F (4.4°C) were calculated for the individual treatments for each phase of crop growth, *viz.*, seedling establishment (0-25 days), growth stage (26-40 days), flowering stage (41-55 days) and maturity stage (56-95 days). Grain and straw yield data were statistically analysed and relationship among different parameters was discussed.

TABLE 4

Treatmental details of ragi crop during kharif season of 1989

T. No.	Date of		
	Sowing	Planting	Harvest
1	18 May	8 June	10 September
2	25 May	15 June	17 September
3	1 June	22 June	24 September
4	8 June	29 June	31 September
5	15 June	6 July	7 October
6	22 June	13 July	15 October
7	29 June	20 July	21 October
8	6 July	27 July	28 October
9	13 July	3 August	5 November

3. Results and discussion

(a) *Soil temperature*

Mean soil temperature for three depths (5, 15 and 30 cm) was averaged over the four growth phases of ragi crop as furnished in Tables 1-3.

Within any depth, significant variations were observed among the different stages, the highest being in the flowering (26-40 days) and plant growth period (41-55 days).

The mean soil temperature at 5 cm depth, at any particular growth phase of the crop period, was less than that of the mean air temperature of the

TABLE 5

Accumulated heat units (°C) over different growth phases of ragi crop

T. No.	Crop growth phases				Total
	Seedling	Growth	Flowering	Maturity	
1	561	332	327	893	2113
2	554	333	334	896	2117
3	557	326	337	890	2110
4	549	333	337	878	2097
5	547	336	333	866	2082
6	543	337	334	851	2065
7	554	334	334	837	2060
8	561	333	338	822	2054
9	558	335	330	817	2040
CD (P=0.05)	4	NS	NS	11	21

TABLE 6

Sunshine hours per day during the growth phases and the yield of ragi

T. No.	Crop growth phases				Mean sunshine hours/day	Yield (q/ha)	
	Seedling	Growth	Flowering	Maturity		grain	straw
1	6.93	6.95	6.88	6.90	6.92	55.0	99.6
2	6.62	6.45	6.74	6.81	6.66	60.3	85.3
3	6.25	6.53	6.39	6.63	6.45	40.7	87.6
4	5.91	5.33	5.62	5.84	5.68	31.9	53.7
5	5.73	5.65	5.69	5.81	5.72	27.3	62.6
6	5.41	5.64	6.03	6.29	5.84	19.0	90.7
7	5.17	5.44	5.31	5.35	5.38	13.0	56.7
8	5.16	5.21	5.19	5.34	5.48	12.8	50.3
9	4.81	5.10	4.95	5.06	4.98	14.0	58.7
CD (P=0.05)	1.10	1.21	1.16	1.08	1.31	11.3	26.9

corresponding period. At 15 cm depth, the mean soil temperature was almost equal to the corresponding air temperature. At 30 cm depth, the soil temperature is always higher than that of the atmospheric temperature of the corresponding period. However, the correlation between these two parameters was not significant.

Mean soil temperature at seedling, though exhibited a positive relationship with grain and straw yield, did not attain statistical significance. Soil temperature at the growth phase at all the three depths exhibited significantly negative correlations with grain yield, the best fit being the soil temperature at 15 cm depth ($r = -0.901^{**}$) followed by that at 30 cm ($r = -0.823^{*}$) and at surface layer ($r = -0.735^{*}$). Soil temperature at 15 cm alone correlated significantly ($r = -0.633^{*}$) with straw yield. Similar negative correlation of grain and straw yield with soil temperature at flowering stage in all the depths were observed. Soil temperature at all the depths at maturity stages did not influence the yield of ragi grain or straw.

(b) *Heat units*

Accumulated heat units for the different phases of crop growth are furnished in Table 5.

The total accumulated heat units for the different treatments ranged from 2040 to 2117. The treatmental variations were not significant. However, there was a significant positive correlation between total heat units and grain and straw and total dry matter yield of ragi, the correlation coefficients being 0.952**, 0.713* and 0.720*, respectively. When the yield of grain (Y) was regressed on the total heat units (X) it yielded the following equation :

$$Y = 0.63\,X - 1280 \qquad (1)$$

From above equation, it is clear we need more than 2032 accumulated heat units for the production of grains. The rate of production of grain being 0.63 q/ha per unit rise in heat unit (*i.e.*, 1°C) beyond 2032. Similarly, the regression equations for ragi straw and total dry matter were as follows :

$$Y = 0.54\,X - 1054, \qquad r = 0.713 \qquad (2)$$

$$Y = 0.95\,X - 1877, \qquad r = 0.72 \qquad (3)$$

The heat units accumulated during the maturity were the highest (817 to 893) followed by seedling establishment stage (543 to 561) and plant growth and flowering stages (326 to 337 and 327 to 338). The variations in the accumulated heat units among different phases of crop growth was statistically significant at 5% level.

(c) *Sunshine hours*

The mean sunshine received by the different treatments ranged between 4.98 (T_9) and 6.92 (T_1) hours per day (Table 6). Sunshine hours per day recorded for the May sown crop ($T_1 - T_3$) were significantly higher than those for the crop sown later upto July ($T_4 - T_9$). These variations in sunshine hours per day were reflected in yield of the crop.

Sunshine hours correlated positively with grain, straw and dry matter yield, the 'r' values being +0.959**, +0.831** and +908** respectively. When regressed the following equations were obtained :

$$Y = 25.6\,X - 119.4 \quad \text{for grains } (r = +0.959) \qquad (4)$$

$$Y = 28.4\,X - 97.8 \quad \text{for straw } (r = +0.831) \qquad (5)$$

$$Y = 52.2\,X - 206.6 \quad \text{for total dry matter } (r = +0.908) \qquad (6)$$

4. Conclusion

The results of field trial indicated that soil temperature at 5, 15 and 30 cm depth during the crop growth and flowering stages influenced the yield of grain and straw of ragi significantly. Total accumulated heat units of the entire growing period correlated positively with crop production and showed that more than 2032 heat units are required for grain prouction.

** Significant at 1% level
* Significant at 5% level

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