

Effect of Temperature on Radiation-use Efficiency in Toria (*Brassica campestris* var. Toria) Crop

D.S. Nehra, Raj Singh, Ram Niwas and O.P. Bishnoi
Department of Agri. Meteorology,
CCS Haryana Agricultural University, Hisar 125 004, India

Abstract : A field experiment was conducted on toria (*Brassica campestris* Var. toria) crop for three seasons (1989-90 to 1992-93) to study the effect of temperature on radiation-use efficiency (RUE). Two cultivars, 'Sangam' and 'TH 68', were sown on three dates. Delay in sowing from first week of September to first week of October significantly increased the RUE. Efficiencies varied from 3.07 to 4.07 g dry matter MJ⁻¹ of intercepted photosynthetically active radiation for toria crop in three different years. Across years, varieties and sowing dates, RUE and mean temperature of the whole season were negatively associated ($r = -0.75$).

Key words: Temperature, radiation-use efficiency, toria, sowing dates, photosynthetically active radiation.

Of the two components of dry matter production, i.e., light interception and radiation-use efficiency (RUE), the former has received more attention. Gifford *et al.* (1984) mentioned that much of the impact of water supply and nitrogen fertilizer on crop growth was through light interception. Gallagher and Biscoe (1978) found that accumulation of dry matter was more closely related to the amount of radiation absorbed by the crop than to RUE, which was relatively stable.

Temperature is a major climatic determinant of crop growth rate. Muchow and Coates (1986) found a stable RUE through sowing dates that exposed the sorghum crop to different temperatures. Squire *et al.* (1984) showed, for pearl millet, that RUE was nearly constant as temperature increased from 20 to 30°C. Finally, Kiniry *et al.* (1989) concluded, for maize and other crops, that within species variability in RUE did not appear to be related to difference in temperature. However, these studies did not present contrasting tempera-

tures. Hammer and Vanderlip (1989) found a significant genotype x temperature interaction on RUE, when sorghum hybrids were grown at highly contrasting temperatures (17°C versus 25°C). They found that the low temperatures reduced RUE, and this effect was significant for one of the two genotypes used. The objective of this work was to study the effect of temperature on RUE in toria (*Brassica campestris* var. toria) crop.

Materials and Methods

Field experiments were conducted during winter seasons of 1989-90, 1991-92 and 1992-93 on a sandy loam soil at the CCS Haryana Agricultural University, Hisar. Two varieties of toria viz., Sangam (VI) and TH-68 (V2) were sown on three dates viz., September 2, 15 and October 2, 1989 (season 1); September 13, 27 and October 10, 1991 (season 2), and September 21, October 1 and 10, 1992 (season 3). All recommended agronomic practices were adopted to raise the crop. Row to row spacings of 45 cm and plant to plant

spacings of 10 cm were maintained. After 20 days of sowing, the intercepted photosynthetically active radiation (IPAR) was measured by LICOR quantum sensor at top and bottom of the canopy. The quantum sensor was moved at 10 cm interval distance placed over a horizontal metre rod perpendicular to rows. The average value of quantum sensor reading was computed. Reflected PAR was measured by inverting the quantum sensor above the crop canopy. The radiation observations were taken at 10 day interval. Plant samples were taken on the same day when PAR observations and dry matter production m^{-2} was determined. Leaf area was measured with LICOR leaf area meter and leaf area index was calculated. Mean value of extinction coefficient (k) was determined by using the formula:

$$k = \ln(I/I_0)/F$$

where,

- I_0 = light energy at top of canopy,
- I = light energy at bottom of the crop canopy, and
- F = leaf area index.

Daily total radiation (R_s) was calculated using the expression:

$$R_s = RA(1-r) (a + b(n/N))$$

where,

- RA = solar constant,
- r = albedo of the crop,
- a, b = constants (0.256 and 0.61),
- n = actual bright sun shine hours, and
- N = maximum possible sun shine hours.

The incoming daily PAR was then calculated by multiplying R_s by 0.45 (Rosenthal and Gerik, 1991). Daily PAR intercepted by the canopy was then determined by using the following formula:

$$IPAR = PAR(1 - e^{-kf})$$

where,

- $IPAR$ = intercepted photosynthetically active radiation,
- PAR = photosynthetically active radiation incident on crop surface,
- k = extinction coefficient, and
- F = leaf area index.

Table 1. Effect of sowing date on IPAR and DM accumulation at maturity, RUE, days taken from emergence (E) to maturity (M) and mean temperature from E to M. mean of two varieties and three replication

Sowing date	IPAR (MJ m^{-1})	DM (g m^{-1})	RUE (g MJ^{-1})	Days E-M	Mean Temp. E-M ($^{\circ}\text{C}$)
02 Sept. 1989	238.7	798.7	3.35	94	22.7
15 Sept. 1989	219.2	748.4	3.41	100	21.4
02 Oct. 1989	199.0	716.6	3.60	107	18.5
LSD	20.4	42.5	0.13	-	-
13 Sept. 1991	245.6	754.4	3.07	101	22.4
27 Sept. 1991	192.1	645.1	3.36	107	19.2
10 Oct. 1991	173.1	626.6	3.62	114	16.8
LSD	28.6	40.9	0.18	-	-
21 Sept. 1992	192.3	663.0	3.45	98	20.0
01 Oct. 1992	158.7	642.8	4.05	107	18.4
10 Oct. 1992	142.1	578.0	4.07	116	17.2
LSD	26.2	45.6	0.26	-	-

Table 2. IPAR, DM accumulation at maturity, RUE, days from emergence (E) to maturity (M) and mean temperature from E to M, mean of three dates of sowing and three replications.

Years	Variety	IPAR (MJ m ⁻¹)	DM (g m ⁻¹)	RUE (g MJ ⁻¹)	Days E-M	Mean Temp. E-M (°C)
1989-90	Sangam	218.9	764.5	3.49	97	21.1
	TH-68	205.7	690.4	3.35	87	21.4
	LSD	10.1	57.1	0.10	-	-
1991-92	Sangam	205.7	746.4	3.62	93	19.2
	TH-68	186.4	634.2	3.40	87	19.6
	LSD	14.8	86.4	0.17	-	-
1992-93	Sangam	176.4	661.1	3.74	97	18.5
	TH-68	162.3	594.8	3.66	86	18.6
	LSD	10.8	51.1	0.06	-	-

The efficiency with which the crop used absorbed PAR in the production of dry matter, was measured as the slope of the relationship of dry matter produced by the crop with the amount of light energy absorbed as:

$$\begin{aligned} \Sigma RUE &= \Sigma DM / \Sigma \text{ absorbed PAR} \\ \Sigma DM &= \text{cumulative dry matter} \\ RUE &= \text{radiation-use efficiency} \end{aligned}$$

Results and Discussion

Toria crop sown in October matured late and accumulated less dry matter per unit area at harvest (Table 1). The fact that late sown crop produced less dry matter at harvest, in spite of more days taken for maturity, indicated the adverse effect of delayed planting on crop growth and development. The decrease in dry matter per unit area with delay in sowing might also be due to decrease in IPAR (Table 1). The same trend in dry matter was observed in other two seasons also.

Crop growth is the produce of IPAR and RUE. The delay in sowing from September to October had a direct effect on RUE. However, IPAR decreased with delay in sowing. This increase in RUE with delay in sowing probably was due to decreased mean air temperature (Table 1).

The RUE varied significantly among the different sowing dates. The mean RUE of toria crop of all the three seasons was $3.55 \pm 0.32 \text{ g MJ}^{-1}$. The variety Sangam required more days to mature than TH-68 during all three growing seasons (Table 2). Sangam produced significantly higher dry matter per unit area than TH-68. Similar trend was also recorded in other two seasons. The PAR was minimum in TH-68 and maximum in Sangam during all the three growing seasons. The lower dry matter production in TH-68 was probably due to lower IPAR and RUE of this cultivar (Table 2).

Significant ($P < 0.05$) and negative association between RUE and mean temperature ($T^{\circ}\text{C}$) existed (Fig. 1). In contrast, Andrade *et al.* (1993) reported a positive relationship between RUE and mean air temperature in maize. This difference in crop response might be due to C₃ (toria) and C₄ (maize) crop. The negative association between RUE and mean temperature is attributable to decrease in IPAR with decrease in mean air temperature due to delay in sowing. The regression equation was $RUE = 5.714 - 0.1099T$, with a correlation coefficient of -0.75 and a standard error of the slope of 0.017.

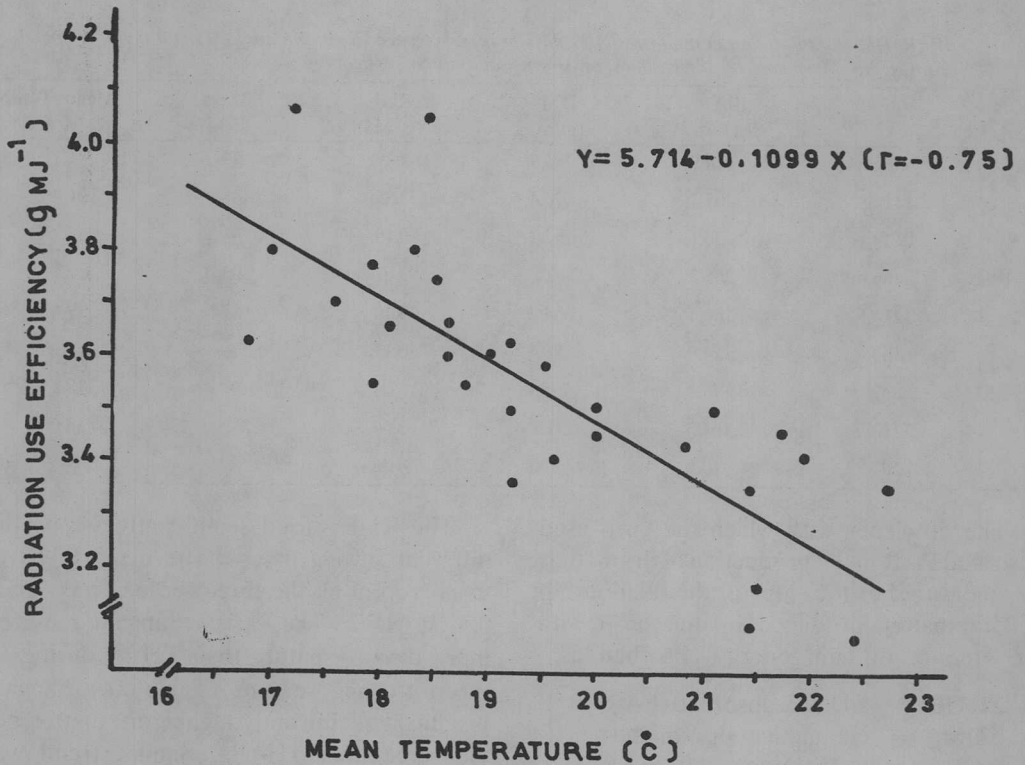


Fig. 1. Variation of radiation-use efficiency with mean temperature.

The decreased RUE above 17.0°C was conspicuous.

The study suggests that sowing date affect RUE through its effect on temperature. Sangam variety is efficient in production of dry matter with use of one unit of intercepted photosynthetically active radiation.

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