INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2002/04–2–217–219
http://www.ijab.org

# Effect of Sowing Date, Irrigation and Plant Densities on Radiation Interception and its Utilization Efficiency in Lentils

MUHAMMAD AZAM, ABID HUSSAIN, SYED AFTAB WAJID AND MUHAMMAD MAQSOOD
*Department of Agronomy, University of Agriculture, Faisalabad–38040, Pakistan*

## ABSTRACT

Lentils were sown on different dates with different irrigation levels and plant densities during 1993/94 and 1994/95 on experimental area, Department of Crop Production and Water Management, University of Agriculture, Faisalabad. Results showed that early sowing increased radiation interception by 80% over late sowing. Fully irrigated crops enhanced interception of radiation by 89% over control. A plant density of 200 plants $m^{-2}$ intercepted more radiation over 100-or 250 plant $m^{-2}$. In both the seasons, total dry matter production was positively related with efficiency for TDM was 3.65 g. DM $MJ^{-1}$. Seed yield was also linearly related with the intercepted radiation and its efficiency was at 1.14 g seed $MJ^{-1}$.

**Key Words:** Growth; Radiation interception; Radiation utilization; Efficiency; Lentils

## INTRODUCTION

Economic yield of a crop is a function of growth rate, duration of growth, and the proportion of growth realized in the grain component (Gallagher & Biscoe, 1978). Growth rate depends on the ability of a crop to capture light and the efficiency of conversion of intercepted light into biomass. Thus growth of a crop may be analysed in terms of radiation interception and the efficiency of utilization of intercepted radiation (Monteith, 1977; Gallagher & Biscoe, 1978). There are few data on the relationship between lentil growth and intercepted radiation (Wilson *et al.*, 1983; Mckenzie & Hill, 1991).

This paper analyses the growth and yield of lentils in relation to the amount of intercepted radiation and its utilization under semi arid conditions of Faisalabad.

## MATERIALS AND METHODS

Two field experiments were conducted during 1993-94 and 1994-95 to investigate the response of lentil at the Crop Production and Water Management Research Area, University of Agriculture, Faisalabad. Both the experiments were designed as split-split plot with three replications. For both experiments treatments were two sowing dates (7 November, 6 December) as main plot, 3 irrigations levels (nil, full irrigation, irrigation at podding) as sub-plot and 3 population densities (100, 150, 200 plants $m^{-2}$) as sub-sub plot respectively. Each sub-plot was 2 m x 14m having 8 rows with row to row distance of 25 cm. A buffer plot of 1.25 m between each subplot was maintained to avoid the border effect of irrigation among different treatments.

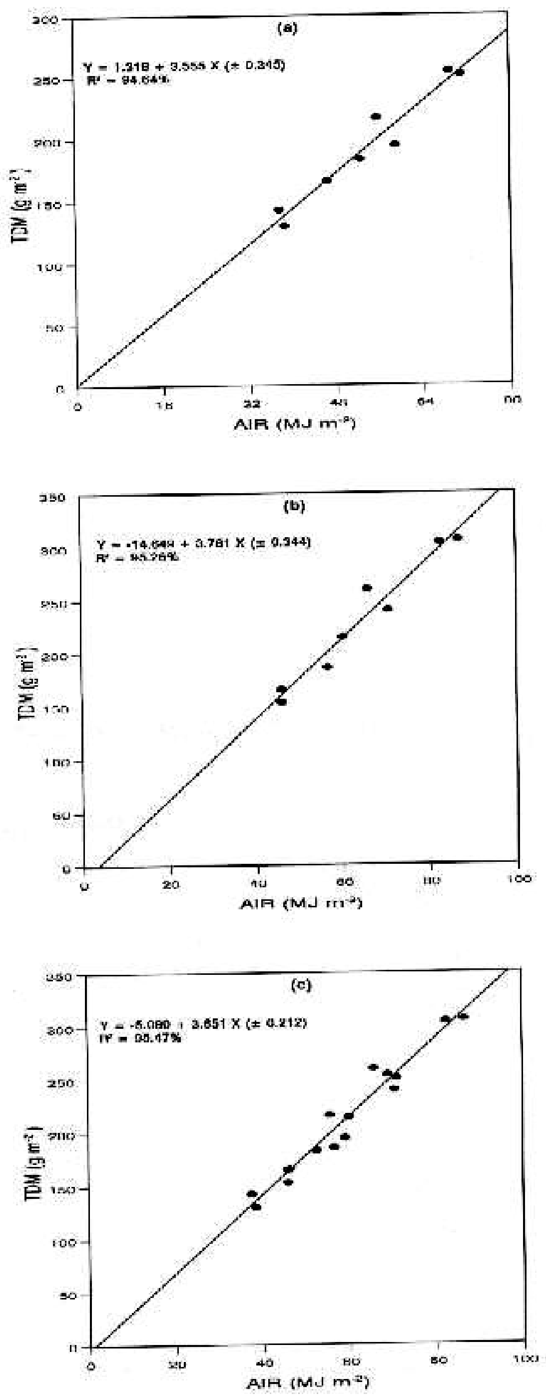
**Estimation of radiation.** The fraction of radiation

**Table I. Effect of sowing date, irrigation and plant population on radiation intercepted and its utilization efficiency in lentils during 1993-94**

| Treatment | Incident PAR ($MJm^{-2}$) | | Accumulated intercepted radiation ($MJm^{-1}$) | | Radiation use efficiency ($gMJ^{-1}$) | |
|---|---|---|---|---|---|---|
| | 1993/94 | 1994/95 | 1993/94 | 1994/95 | 1993/94 | 1994/95 |
| **Sowing date** | 585 | 597 | | | | |
| 7 Novemver sowing | | | 68.98 a | 82.62 a | 3.66 a | 3.72 a |
| 6 December sowing | | | 38.37 b | 45.95 b | 3.04 b | 3.23 b |
| **Irrigation** | | | | | | |
| $I_O$=Nil | | | 37.50 c | 45.96 c | 3.62 a | 3.58 a |
| $I_F$=Full irrigation | | | 71.04 a | 86.81 a | 3.15 b | 3.26 b |
| $I_P$=Irrigation at podding | | | 52.49 b | 60.08 b | 3.28 b | 3.69 a |
| **Plant Population** | | | | | | |
| 100 plants $m^{-2}$ | | | 46.45 c | 56.58 c | 3.24 b | 3.37 b |
| 150 plants $m^{-2}$ | | | 55.56 b | 65.78 b | 3.58 a | 3.61 a |
| 200 plants $m^{-2}$ | | | 59.01 a | 70.48 a | 3.23 b | 3.45 ab |
| Mean | | | 53.68 | 64.28 | 3.35 | 3.48 |

Figures in the same column having different letters differ significantly at ($P < 0.05$) by LSD test

**Fig. 1. The relationship between accumulated intercepted radiation (AIR) and total dry matter production during 1993-94 (a), 1994-95 9b) and pooled (c)**




intercepted ($F_i$) was estimated from leaf area index (LAI) using the exponential attenuation equation as suggested by Monteith and Elston (1983).

$$F_i \quad = \quad 1 - \exp.(- K \times LAI)$$

Where

K is an extinction coefficient for total solar radiation and its value of 0.27 for lentil was used as suggested by Mckenzie (1987). The amount of photosynthetically active radiation (PAR) was assumed to equal half (0.5) of the total incident short wave radiation (Szeicz, 1974). Multiplying these totals by the appropriate estimates of $F_1$ gave an estimate of the amount of PAR intercepted by the crop canopy. The radiation utilization efficiency of TDM (åT) was calculated as:

$$åT \quad = \quad TDM / \Sigma Sa$$

This analysis was extended to calculate the efficiency of seed yield (åSY). All sets of data were analysed to assess the significance of treatment effects (Steel & Torrie, 1984).

## RESULTS AND DISCUSSION

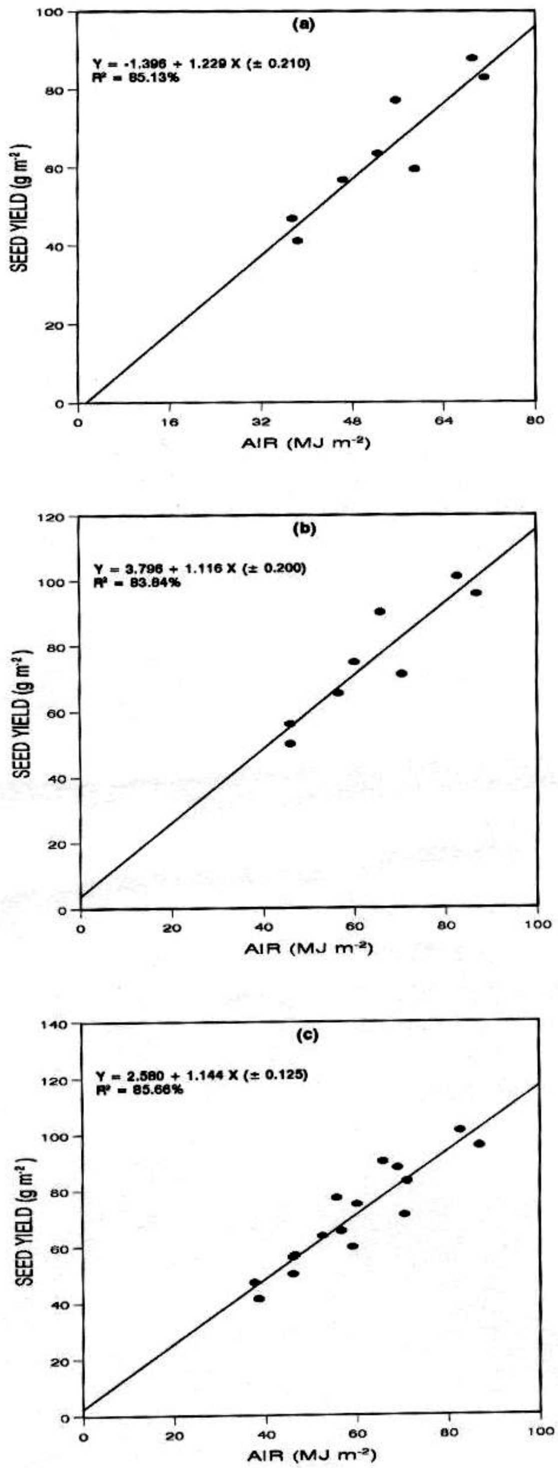
**Incident and intercepted radiation.** In 1993/94 the total amount of incident PAR received during the growing season was 585 MJm$^{-2}$ of which only 9.18% was intercepted. Equivalent figure, in 1994/95, for the incident PAR was 597 MJm$^{-2}$ of which 10.78% was intercepted (Table I).

The amount of intercepted PAR differed significantly among treatments. Early sowing intercepted more PAR by 79.78% in 1993/94 and 79.80 of in 1994/95 than the late sowing (Table I). Similarly fully irrigated crop ($I_F$) intercepted markedly more PAR over control (nil) by about 89.14%. Partially irrigated crops were also superior in the amount of intercepted PAR over control. A population of 200 plant m$^{-2}$ also enhanced PAR interception over 150- or 100 plants m$^{-2}$ in both the seasons (Table I).

Marked differences were found in the amount of PAR intercepted between treatments upto the final harvest. The higher interception of PAR in early sowing (November) over late sowing (December) were probably due to longer duration. Results also showed that the magnitude of this response was greater with $I_F$ or $P_3$ populations which increased the size of the canopy over late sowing, lower or nil irrigation or low populations. Similar results were reported in lentils (Mckenzie & Hill, 1991) and chickpea (Hussain *et al.*, 1998). But the amount of intercepted PAR was substantially lower than that reported in the above mentioned studies, probably due to lower LAI values in this study.

**Radiation utilization efficiency.** There were significant differences in radiation utilization efficiency for TDM (åT) among treatments (Table 1). Early sowing increased åT by 44.54% in 1993/94 and 31.58% in 1994/95. In contrast, crop not irrigated had greater åT over fully irrigated crops in both seasons. Also, the $I_O$ treatment had higher åT over $I_P$ (1993/94) but at par during 1994/95. A population density of 150 plants m$^{-2}$ was superior in åT over 100-and 200 plants

**Fig. 2. The relationship between accumulated intercepted radiation (AIR) and seed yield during 1993-94 (a), 1994-95 (b) and pooled (c)**




$m^{-2}$ during the seasons. Overall, average åT values were 3.35 $gMJ^{-1}$ in 1993/94 and 3.48 $gMJ^{-1}$ in 1994/95, respectively. This study demonstrated a linear relationship between yield (TDM) and accumulated PAR (Fig. 1). Similar results were reported for lentils in New Zealand by (Mckenzie and Hill (1991). The value for åT given by the common regression line (slope) was 3.65 g (± 0.21) $MJ^{-1}$. This value is substantially higher than those (1.39-1.60 g $MJ^{-1}$) found in New Zealand. Most work on grain legumes showed åT of 1.2 to 2.5 g DM MJ in New Zealand (Husain *et al.*, 1988; Zain *et al.*, 1983; Wilson *et al.*, 1983). With chickpea Hussain *et al.* (1996) reported åT of 1.56 g $MJ^{-1}$ under Faisalabad conditions. Fasheun and Dennett (1982) reported a utilization efficiency of 4.1 g DM $MJ^{-1}$ in faba bean. Over both seasons, radition utilization efficiency for seed yield (åSY) of 1.14 g (+ 0.13) $MJ^{-1}$ was found (Fig. 2). The mean seasonal values of åSY at 0.73 g $MJ^{-1}$ for chickpea and 0.72-90 g $MJ^{-1}$ for faba bean were reproted by others (Husain *et al.*, 1988; Hussain *et al.*, 1996).

In conclusion, both TDM and seed yield in lentil were dependent upon the amount of intercepted radiation and its utilization efficiency during both the seasons. Early sown fully irrigated crops and a density of 150 plants increased seed or TDM yield by enhancing the amount of intercepted radiation as well as its utilization efficiency.

## REFERENCES

Fasheun, A. and M.D. Dennett, 1982. Interception of radiation and growth efficiency in field beans (*Vicia faba* L.). *Agric. Meteorol*., 26: 221

Gallagher, J.N. and P.V. Biscoe, 1978. Radiation absorption, growth and yield of cereals. *J. Agric. Sci. Camb*., 19: 47–60.

Husain, M.M., G.D. Hill and J.N. Gallagher, 1988. The response of fieldbean (*Vicia faba* L.) to irrigation and sowing date 2. Growth and development in relation to yield. *J. Agric. Sci. Camb*., 111: 233–54.

Hussain, A., M. Nawaz, Z. Ahmad, I.H. Shad and M.A. Shahzad, 1996. Radiation interception and yield of chickpea (*Cicer arietinum* L.). *J. Agric. Res*., 39: 403–8.

Hussain, A., M. Nawaz and F.M. Chaudhry, 1998. Radiation interception and utilization by chickpea (*Cicer arietinum* L.) at different sowing dates and plant population. *Agric. Sci*., 3: 21–5.

McKenzie, B.A., 1987. The growth, development and water use of lentils (*Lens culinaris* Medik.). *Ph.D. Thesis,* Lincoln College, Univ. Canterbury, New Zealand.

Mckenzic, B.A. and G.H. Hill,1991. Intercepted radiation and yield of lentils (*Lens culinaris*) in Canterbury, New Zealand. *J. Agric. Sci. Camb*., 117: 339–46.

Monteith, J.L., 1977. Climate and efficiency of crop production in Britain. *Philosophical Transactions of Royal Society, London,* 281: 277–94.

Monteith J.L. and J.F. Elston, 1983. Performance and productivity of foliage in the field. *In:* Dale, J.E. and F.L. Milthorpe (Eds.), *The Growth and Functioning of Leaves*, pp. 499–518. Camb. Univ. Press, Butterworths, London.

Steel, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics,* 2nd Ed., pp: 172–7. McGraw Hill Book Co., Singapore.

Szeicz, G., 1974. Solar radiation for plant growth. *J. Appl. Ecol.,* 11: 617–36.

Wilson, J.W., W.S. Jermyn, W.R. Hanson, 1983. Lentil growth analysis. *Lens Newsletter*, 10: 17.

Zain, Z.M., J.N. Gallagher, J.G.H. White, and J.B. Reed, 1983. The effect of irrigation on radiation absorption, water use and yield of conventional and semi-leafless peas. *Proc. Agron. Soc.*, New Zealand, 13: 95–102.

**(Received 03 March 2002; Accepted 14 March 2002)**