Forage Res., **37** (4) : pp. 241-244 (2012)

IMPACT OF RADIATION AND THERMAL INTERCEPTION ON BY-PRODUCT OF CLUSTERBEAN CROP UNDER DIFFERENT GROWING ENVIRONMENTS

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SUMMARY

A field experiment was carried out on sandy loam soil during two consecutive **kharif** seasons (July to September) at Dry Land Research Farm, CCS Haryana Agricultural University Hisar, India (29°10′ N latitude, 75°46′ E longitude and 215.2 m altitude), to study light interception and its impact on grain yield and by-product of clusterbean crop. Treatments consisted of two seeding dates, two seeding densities and three seed rates designed in split plot with three replications. The other package of practices for raising the crop was followed as recommended by the university. The photosynthetically active radiation (PAR) was measured with quantum sensor during noon hours at bottom and top of the crop canopy at flowering and pod formation stages. The transmission, reflection and absorption coefficients of PAR were calculated in all the treatment combinations. The air temperature data were taken from agrimet observatory situated at research farm and used for computation of thermal units required by the crop. Radiation and thermal use efficiencies were computed for all the treatments. The transmission and reflection coefficients showed a reverse trend that of absorption coefficient in all the treatment combinations. The dry matter production was recorded at flowering, pod formation stages and harvesting of the crop. Grain yield and its quality parameters (gum and crude protein per cent) were recorded at the harvest of the crop. The crop sown in last week of June absorbed higher PAR as compared to mid July sown crop at flowering and pod formation stages. Row spacing also influenced the PAR absorption and it was higher in narrow (30 cm) than wide (45 cm) spaced crop. The higher seed rate also increased the PAR absorption. June sown crop was more efficient in radiation and heat utilization for biomass production over July sown crop. Wider row spacing was more efficient in radiation use over narrow spaced crop. Increase in seed rate also improved the radiation and thermal use efficiency of the crop. Wider row spacing of 45 cm recorded higher grain yield and more gum content as well as crude protein as compared to 30 cm row spacing. Grain yield increased with seed rate, however, 15 and 20 kg/ha seed rates produced statistically similar yields. The crude protein did not differ among the treatments. Thermal Units (TU) and absorbed PAR explained 60-67 per cent variation in grain yield.

Key words : Radiation , thermal interception, clusterban, environment

Clusterbean (*Cyamopsis tetragonoloba* (syn. *C. psoralioides*, Fabaceae) is an annual short duration legume plant that grows in semi-arid regions under harsh edapho-climatic conditions. Clusterbean crop is produced in India, Pakistan, Sudan, USA, South Africa, Brazil, Malawi, Zaire and Australia. India is the major producer of guar and guar gum in the global market. India produces approximately 80 per cent of world's total production. Guar is largely consumed as a vegetable as green like snap beans in the Indian subcontinent and also used in making pickles. Clusterbean is used as feed to cattle or used as a green manure. It bears many bean-like pods, each of which contains six to nine small, rounded seeds. The guar seed is typically made up of 40 to 46 per cent germ, 38 to 45 per cent endosperm and 14 to 16 per cent husk.

The by-product of clusterbean as gum is obtained from the grounded endosperm. Guar gum has

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a vast range of industrial applications and the major share of demand comes from various industrial sectors only. India is the leading net exporter of guar seeds and guar gum. The consumption pattern of guar seeds is largely influenced by the demands from the petroleum industry of United States of America and the oil fields in the Middle East as the derivative products of these seeds are quite useful in the petroleum drilling industries. Canada, China, Chile, Australia, Austria, Brazil, Germany, Italy, Japan, United Kingdom, USA, Ireland, Sweden, Greece, Portugal, Mexico are the major importer of guar gum. The seeds of clusterbean crop are rich source of high quality of galactomannam gum and crude protein and attained the status of commercial crop (Henry, 2001).

Plants depend on their genetic constitution and environmental conditions of soil and climate for their growth and development. The interaction of plant with thermal environment lies with the phenomena of growth and development. Solar radiation interception and its efficiency play major role in dry matter production. The fraction of radiation energy intercepted during the growing period depends on total incident radiation that is intercepted due to canopy development during its various phenophases. The canopy architecture influences the distribution of radiation energy for dry matter accumulation which affects the efficiency of radiation energy use in photosynthetic way. It is necessary to understand the knowledge of plant environment interaction for increasing yield of crop.

MATERIALS AND METHODS

The investigation was conducted at Dry Land Research Farm, CCS Haryana Agricultural University Hisar (29°10′ N latitude, 75°46′ E longitude and 215.2 m altitude), India during two consecutive **kharif** seasons of 2007-08 and 2008-09 with clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]. cv. HG 2-20 under rainfed conditions on sandy loam soil. The experiment was laid out in split plot design with two seeding dates (last week of June and mid July), two seeding densities (30 and 45 cm) and three seed rates (10, 15 and 20 kg/ha) with three replications. The other package of practices for raising the crop was followed as recommended by the university. The photosynthetically active radiation was also measured by quantum/photometer (Li-185B) in the range of 400-700 nm at top and bottom of the crop canopy at flowering and pod formation phenophases during 0800-1600 h of the day. The reflected radiation was obtained by keeping the sensor inverted at 1 m above the canopy and the sensor was also kept on ground across the rows diagonally at random places to get transmitted radiation at the ground. Intercepted photosynthetically active radiation by the crop, IPAR= (1-r) PARi. The absorbed photosynthetically active radiation was computed as (APAR) = (1-r-t) PARi, where, r is reflected PAR, t is transmitted PAR and PARi is incident PAR.

The air temperature data were taken from agrimet observatory situated at research farm and used for computation of thermal units required by the crop. Radiation and thermal use efficiencies were computed for all the treatments.

Grain yield and its quality parameters (gum and crude protein per cent) were recorded at the harvest of the crop. All the experimental data were statistically analysed by the procedure as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The optical characteristics of clusterbean cultivar HG 2-20 under different treatments are presented in Table 1. The crop sown in last week of June absorbed higher photosynthetically active radiation (PAR) as compared to mid July sown crop at flowering and pod formation stages in both the seasons. The values of absorbed photosynthetically active radiation ranged between 88.8 and 93.8 per cent at both the phenophases. However, there was a little decline in PAR absorption after flowering. This might be due to senescence of leaves. Row spacing also influenced the PAR absorption and it was higher in less spaced 30 cm crop in both the seasons. The increasing seed rate also increased the PAR absorption and it was highest in crop sown with 20 kg/ha seed rate and followed by 15 and 10 kg/ha seed rate. But quantitative increase was 2.3 and 1.6 per cent at flowering stage during 2007-08 and 2008-09, respectively, and it was not much. The transmission reflection coefficient showed a reverse trend that of absorption coefficient in all the treatment combinations. Row spacing showed a reverse trend that of seed rates and PAR absorption decreased with increase in row spacing. The values of absorption coefficients ranged between 88.8 and 93.3 per cent from flowering to pod formation stage. Last week of June sown crop was more efficient in radiation and heat utilization for biomass production as compared to mid July sown crop. Wider

TABLE 1
Optical characteristics (%) of clusterbean under different treatments

Treatment	Flowering						Pod formation					
	Transmitted		Reflected		Absorbed		Transmitted		Reflected		Absorbed	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Sowing time												
Last week of June	2.0	3.0	4.2	4.9	93.8	92.1	3.4	5.2	4.1	5.5	92.5	89.3
Mid July	4.9	4.4	4.3	4.3	90.8	91.3	3.7	5.5	4.9	5.7	91.4	88.8
Spacings (cm)												
30	2.6	3.6	4.1	4.5	93.3	91.7	2.2	5.2	4.5	5.3	93.3	89.5
45	4.4	3.8	4.4	4.7	91.2	91.6	4.9	5.5	4.6	6.0	91.5	88.5
Seed rates (kg/ha)												
10	4.5	3.7	4.3	4.7	91.2	91.4	4.4	5.3	4.7	5.6	91.1	88.4
15	2.9	3.7	4.2	4.4	92.9	91.7	3.7	5.2	4.5	5.2	91.8	89.1
20	2.4	3.8	4.1	4.8	93.5	92.0	2.6	5.6	4.5	5.6	92.8	89.5

row spacing was more efficient in radiation use over narrow spaced crop. Increase in seed rate also improved the radiation and thermal use efficiencies of the guar crop. During second growing season, the radiation and thermal use efficiencies were lower than that of first crop season. Irrespective of treatments, the radiation use efficiency values varied from 1.0 to 1.5 g/MJ during both the crop seasons. The corresponding values for thermal use efficiency ranged between 0.21 and 0.29 (Table 2).

The date of sowing significantly influenced the grain yield and its contributing parameters. The highest grain yield was recorded in last week of June sown crop (17.96 and 15.64 q/ha) and it was lower by 2.42 and 3.38 q/ha during 2007-08 and 2008-09, respectively. The maximum yield in first sown crop might be due to highest PAR absorption during both the crop seasons. Wider row spacing of 45 cm recorded higher grain yield and more gum content as well as crude protein as compared to 30 cm row spacing in both the years. This might be due to better radiation and heat use efficiency of wider row spaced crop. Kumar *et al*. (2004) and Yadav *et al*. (2008) found that 30 cm spacing produced significantly higher grain yield than 45 cm spacing. Grain yield increased with seed rate, however, 15 and 20 kg/ha seed rates produced statistically similar yields. The crude protein did not show much difference among the treatments. The radiation absorption and thermal time were regressed with grain yield and the relationship of thermal time

TABLE 2
Effect of sowing time, row spacing and seed rate on radiation use efficiency (RUE), thermal use efficiency (TUE), grain yield, gum and crude protein content of clusterbean genotype HG 2-20

Treatment	RUE (g/MJ)		TUE ($g/m^2/°C$ d)		Grain yield (q/ha)		Gum (%)		Crude protein (%)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Sowing time										
Last week of June	1.4	1.3	0.28	0.26	17.96	15.64	30.76	32.04	30.68	29.45
Mid July	1.3	1.0	0.27	0.22	15.54	12.26	30.44	31.90	30.20	29.19
Row spacings (cm)										
30	1.3	1.2	0.27	0.23	16.15	13.46	30.32	31.86	30.50	29.22
45	1.4	1.2	0.28	0.24	17.35	14.45	30.88	32.07	30.38	29.43
Seed rates (kg/ha)										
10	1.3	1.1	0.25	0.21	15.46	12.63	31.35	32.53	30.93	29.69
15	1.4	1.2	0.29	0.25	17.37	14.51	30.47	32.23	30.28	29.49
20	1.5	1.3	0.29	0.26	17.43	14.73	29.98	31.14	30.10	28.79

(TU) and absorbed photosynthetically active radiation (APAR) was quantified and the regression equations are expressed as under :

Yield (2007-08)=16.024+0.0085 TU+0.183 APAR R^2=0.60
Yield (2008-09)=89.86+0.0081 TU+ 0.183 APAR R^2=0.67

Thermal units (TU) and absorbed photosynthetically active radiation explained from 60-67 per cent variation in crop grain yield. These regression models are location specific; however, these could be used for estimation of grain yield using radiation and thermal use efficiencies.

REFERENCES

Gomez, K. A., and A. A. Gomez, 1984 : *Statistical Procedures for Agricultural Research.* John Wiley and Sons, New York. pp. 680.

Henry, A. (2001). Clusterbean–An industrial crop of Indian Arid Zone. Retrospect and Prospects. pp. 42. In : National Symposium on Impact of Human Activities on Thar Desert Environment managed by Arid Zone Research Association of India at CAZRI, Feb. 15-17, 2001.

Kumar, V., B. D. Yadav, J. S. Yadav, and R. Kumar, 2004 : *Forage Res.,* **30** : 72-74.

Yadav, B. D., V. Kumar, and U. N. Joshi, 2008 : *J. Arid Legumes,* **5** : 62-64.