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INFLUENCE OF CANOPY ATTRIBUTES ON THE PRODUCTIVITY OF GROUNDNUT

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SUMMARY

The influence of canopy structure and geometry on groundnut productivity was examined in two genotypes, TMV 2 and TMV 2-NLM. The latter is a mutant of TMV 2 with narrow leaves. The two genotypes were grown on an alfisol field under irrigated and water deficit conditions during 1994-95 post-rainy and 1995 rainy seasons at ICRISAT centre. The crop growth rate (CGR) of TMV 2-NLM was greater than TMV 2 under adequately irrigated conditions by 11% during 1994-95 post-rainy and by 13% during 1995 rainy season. Under water deficit conditions, CGR of TMV 2-NLM was 32% higher than in TMV 2. TMV 2-NLM also had greater radiation use efficiency, 0.81 g mj^{-1} compared to 0.68 g mj^{-1} in TMV 2. The light extinction co-efficient of TMV 2-NLM was 0.51 as compared to 0.58 of TMV 2 under irrigated conditions, suggesting greater penetration of incident radiation into the canopy of TMV 2-NLM compared to that TMV 2. Although TMV 2-NLM produced greater total dry matter, the partitioning of dry matter to the pods (P_f) was less compared to TMV 2. Under water deficit conditions the P_f was reduced by 18% in TMV 2-NLM compared to 13% reduction in TMV 2. These results suggest scope for enhancing the crop productivity by tailoring canopy architecture. However, further research efforts are required to improve partitioning ability of groundnut genotype to match enhanced crop growth rates.

Key words : **Canopy structure, crop growth rate, extinction coefficient, groundnut, partitioning, radiation use efficiency.**

INTRODUCTION

Plant and crop ecologists have long recognized the importance of canopy structure in crop productivity. Matching canopy size and duration to the seasonal moisture and irradiance pattern either through agronomic or genetic means is one of the main task of crop improvement. This enables the production in a target environment to be optimized (Monteith and Elston 1982). Orientation of leaves forming plant canopies plays a decisive role in the radiation penetration into the canopies, which influence the canopy photosynthesis and hence the crop productivity (Monsi *et al.* 1973, Mathews *et al.* 1988b). Various workers have reported the influence of canopy structure on crop productivity in barley (Monteith 1965, Aungus and Wilson 1972), and soybean (Shaw and Weber 1967). The mechanical manipulation of horizontal leaves canopy to erect leaves and tailoring of canopy architecture resulted in higher crop photosynthetic rate in rice (Tanaka 1972). The dry matter production of many crops has been linked with light interception and radiation use efficiency (RUE) considered constant for a given crop species (Monteith 1977, Muchow and Sinclair 1994). RUE is critical in determining the productivity of pigeonpea under both well watered and moisture-deficit regimes (Nam *et al.* 1998). However, in groundnut, very little work has been done to exploit variability in canopy geometry in the crop improvement. This could perhaps be due to the lack of

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availability of isolines with varied canopy structure to pinpoint the contribution of canopy attributes to the productivity. The present study examines the influence of canopy structure on various physiological attributes contributing to productivity.

MATERIALS AND METHODS

The genotypes TMV 2 and TMV 2-NLM, selected for this study have similar genetic background, with the latter being a mutant of TMV 2 with a narrow leaf character. Thus, test material was appropriate to study the canopy effects on productivity. The experiments were conducted during 1994-95 post-rainy (December to April) and 1995 rainy (June-September) seasons on alfisol at ICRISAT centre Patancheru, Andhra Pradesh. At the time of land preparation a basal dose of 40 Kg ha^{-1} P_2O_5 was applied and broad beds of 1.2 m width with furrows of 0.3 m between the beds were prepared. Seeds of TMV 2 and TMV 2-NLM were treated with captan and thiram at the rate of 3 g kg^{-1} seed and planted with a spacing of 30 cm beween the rows and 10 cm in between the plants within rows. During the 1994-95 post-rainy season, experiment was laid in a randomized block design with four replications under adequately irrigated conditions. During the 1995 rainy season, the experiment was conducted in a split-plot design with two moisture regimes as main plots and two genotypes as sub-plots, with four replications. Sowing was done on December 2, during the 1994-95 post-rainy season and on June 6, during the 1995 rainy season. During the 1995 rainy season, two moisture regimes, adequately irrigated (equivalent to 80% of cumulative evaporation) at weekly interval (T1) and 25% of water given in T1 at weakly interval (T2), were imposed from 52 days after sowing (DAS) to the final harvest. Final harvest was done at 142 and 110 DAS during 1994-95 post-rainy and 1995 rainy seasons, respectively.

Plants were sampled from a ground area of 0.6 m^2 at 15-day interval starting from 30 DAS, as described by Nageswara Rao *et al.* (1988). Fractional radiation interception was measured at the time of sampling for growth analysis using a light quantum sensor. Total dry matter (vegetative weight of above ground parts + pod weight), pod weight, crop growth rate and partitioning co-efficient were estimated as described by Nageswara Rao *et al.* (1988). Pod weights were adjusted for their higher energy content by multiplying with a factor of 1.65 (Duncan *et al.* 1978).

Radiation use efficiency (RUE) was determined as the slope of the regression of cumulative light intercepted by the canopy and the total biomass produced at the sequential growth harvests. Light extinction coefficient was calculated as the slope of regression between the fractional radiation intercepted and leaf area index (LAI).

RESULTS AND DISCUSSION

In the 1994-95 post-rainy season, mean minimum and maximum temperatures during the early growth stages of crop were about 14 °C (range was 9-20 °C) and 28 °C (range was 24-33 °C), respectively (Table 1). The mean minimum and maximum temperatures increased steadily as the season progressed and they reached to a mean minimum of 21 °C (ranged between 16-27 °C) and maximum of 37 °C (ranged between 34-41 °C) during the seed development stages. During the 1995 rainy season, the temperatures did not fluctuate much and mean minimum and maximum temperatures were about 22 °C (range was 21-24 °C) and 30 °C (range was 27-32 °C) respectively.

Table 1. Air temperature (maximum and minimum) during the 1994-95 post-rainy and 1995 rainy seasons at ICRISAT centre.

Season	Standard Weeks	Days after Sowing	Temperature range (°C) Max.	Min.
1994 - 95 (Dec.-Apr.)	50-52,1-8	0-80	24-33	9-20
	9-11	80-100	31-36	11-23
	12-17	100-142	31-41	16-27
1995 (June-Sept.)	25-40	0-112	27-32	21-24

TMV 2-NLM, under adequately irrigated conditions (T1), produced 11% and 23% more total dry matter (TDM) than TMV 2 during 1994-95 post-rainy and 1995 rainy seasons, respectively. Under water deficit conditions (T2), TMV 2-NLM produced 38.4% more TDM than TMV 2 during the rainy season (Table 2). The genotypic

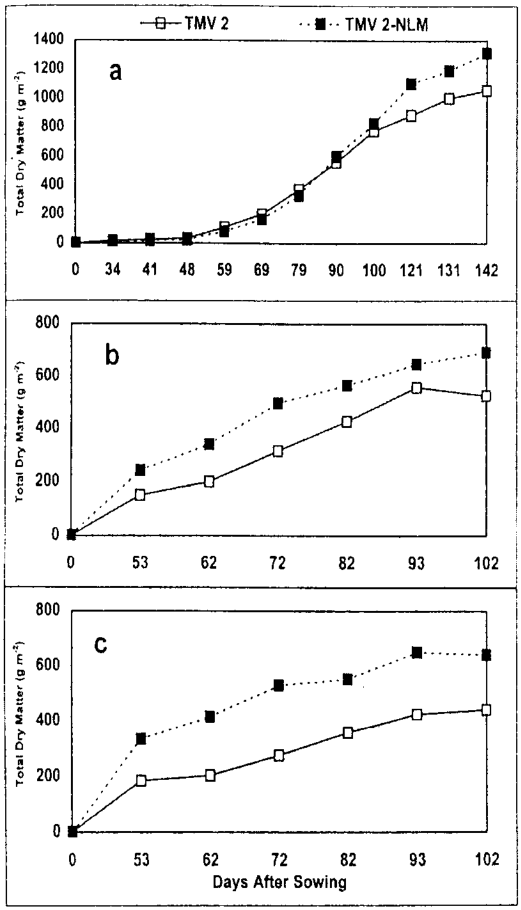

Fig. 1. Accumulation of total dry matter at different growth stages in TMV 2 and TMV 2-NLM grown during post-rainy 1994-95 season under irrigated conditions (a), rainy 1995 season under irrigated conditions (b) and rainy 1995 season under water deficit coditions (c).

differences in TDM production were greater during the rainy season as compared to the post-rainy season. The TDM accumulation in these two genotypes during the post-rainy season coincided with the increase in air temperature during the growing season (Table 1 and Figure. la). At early stages (upto 80 DAS), both the genotypes grew at a slower rate as the average minimum temperature was 14 °C, which is much below the optimum level. But with the rise in the mean minimum and maximum temperatures to optimum levels of 17 °C and 32 °C, respectively during the later stages (80-100 DAS), the growth rate increased in both the genotypes (William *et al.* 1978, Cox 1979). During this phase genotypic difference were noticed as TMV 2-NLM accumulated TDM at higher rate than TMV 2. With further rise in the mean maximum and minimum temperatures to 37 °C and 21 °C respectively during the seed development stage (100 DAS to final harvest, an inhibitory response to growth was noticed and this was more prominent in TMV 2 than TMV 2-NLM. During the rainy season, this type of trend in the rate of TDM accumulation in these two genotypes was not noticed. TMV 2-NLM kept on accumulating more biomass than TMV 2 at all growth stages after emergence under both irrigated and water deficit conditions (Fig. 1b and c). The genotypic differences in groundnut in response to 35 °C and above temperature were reported earlier also (Ketring 1984, Talwar *et al.* 1999). These observations, like earlier reports (Leong and Ong 1983, Talwar *et al.* 1999, Varaprasad *et al.* 1999), suggested that plant growth and development rates were predominantly determined by temperature.

Table 2. Yields (t ha⁻¹) of TMV 2 and TMV 2 NLM grown under irrigated (T1) and water deficit conditions (T2) during two seasons at ICRISAT centre.

Genotypes	Post rainy 1994-95		Rainy 1995			
	TDM	Pod	TDM		Pod	
	T1	T1	T1	T2	T1	T2
TMV 2	11.7	7.3	6.1	5.2	2.3	1.4
TMV 2 NLM	13.0	7.4	7.5	7.2	1.9	1.3
Mean	12.4	7.4	6.5		1.8	
SE±	1.22	1.01	0.43		0.07	
cv%	17.7	25.3	7.8		13.3	

The greater TDM production in TMV 2-NLM was due to its higher crop growth rate than TMV 2 under both irrigated and water deficit conditions during both the seasons (Table 3). As compared with TMV 2, TMV 2-NLM had 11% and 13% higher crop growth rate under adequately irrigated conditions during both the seasons and 31% higher crop growth rate under water deficit conditions during 1995 rainy season. The two genotypes accumulated different amount of TDM with the same amount of light radiation intercepted. TMV 2-NLM produced more TDM than TMV 2 with each unit of radiation intercepted during both the seasons (Table 4). The two genotypes differ in their leaf area, TMV 2-NLM having the narrower leaves. This indicated that TDM production and radiation use efficiency are highly influenced by leaf size as has been reported by others (Methews *et al.* 1988 b).

The lower extinction coefficient of narrow leaf mutant under both the treatments (Table 4) indicated that the mutation caused a change in canopy geometry and made it more open and therefore, allowed more light to reach the bottom leaves. The percentage light interception by both the genotypes increased with the increase in leaf area index (LAI) till the saturation point was achieved (Figure 2 a-c). The narrow leaf mutant of TMV 2 intercepted more light radiation with similar LAI. This indicated that more TDM production is due to the openness of canopy structure in the mutant which allows it to harvest more light radiations during the growing season. These results suggested that

Table 3. Crop growth rate (CGR, g dry^{-1}) and dry matter partitioning to pods (P_f) of TMV 2 and TMV 2 NLM grown under irrigated (T1) and water deficit conditions (T2) during two seasons at ICRISAT centre.

Genotypes	Post-rainy 1994-95		Rainy 1995			
	CGR	Pf	CGR		Pf	
	T1	T1	T1	T2	T1	T2
TMV 2	11.9	0.57	6.3	5.2	0.52	0.45
TMV 2 NLM	13.2	0.54	7.1	6.8	0.50	0.41
Mean	12.5	0.56	5.8		0.47	
SE±	0.81	0.021	0.42		0.005	
CV%	11.5	7.3	9.5		14.9	

Table 4. Radiation use efficiency (RUE, g mj^{-1}) and extinction coefficient (EC) of TMV 2 and TMV 2 NLM grown under irrigated (T1) and water deficit conditions (T2) during two seasons at ICRISAT centre.

Genotypes	Post-rainy 1994-95		Rainy 1995			
	RUE	EC	RUE		EC	
	T1	T1	T1	T2	T1	T2
TMV 2	0.97	0.54	0.39	0.26	0.62	0.51
TMV 2 NLM	1.13	0.46	0.48	0.35	0.56	0.50
Mean	1.20	0.53	0.37		0.55	
SE±	0.064	0.032	0.022		0.003	
CV%	18.1	11.4	9.1		12.4	

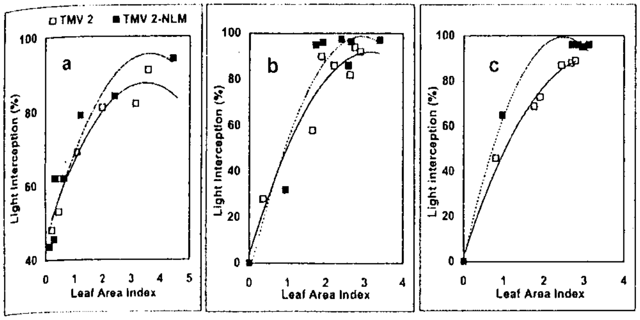

Fig. 2. Relatioship between leaf area index and light interception in TMV 2 (solid line) and TMV 2-NLM (broken line) grown during post-rainy 1994-95 season under irrigated conditions (a), rainy 1995 season under irrigated conditions (b) and rainy 1995 season under water deficit conditions (c)

total dry matter accumulation was linearly related to amount of radiation intercepted, which depended upon the canopy geometry (Heathe and Hebblethwaitte, 1985, Bennett *et al.* 1993).

Pod yield in TMV 2 was higher than its mutant, TMV 2 NLM, under both irrigated and water deficit conditions during the 1995 rainy season (Table 2). Although the mutant had higher crop growth rate but dry matter partitioning to the pods was lower than TMV 2 under both irrigated and water deficit conditions (Table 3). The reduction in partitioning under water deficit condition as compared to irrigated condition was more in TMV 2-NLM (18%) than TMV 2 (13%). The genotypic variation in partitoning was reported earlier also in groundnut (Mathews *et al.,* 1998 a).

The present study suggests that the crop growth rate can be manipulated by modifying canopy architecture. However, separate approaches are required to improve partitioning ability along with over all crop growth rates.

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