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SELECTION FOR HIGH CANOPY ASSIMILATION RATE IS A GOOD STRATEGY TO INCREASE PRODUCTIVITY IN SUNFLOWER

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SUMMARY

Experiments were carried out at the University of Agricultural Sciences, Bangalore, during 1993, to screen the germplasm lines with high dry matter production to achieve higher seed yields since total dry matter production (TDM) was shown to have positive effect on seed yield in sunflower. Significant genotypic variations for leaf area index (LAI) at flowering, assimilation rates (DM/LAD or DM/LA), TDM and seed yield and harvest index were observed both in summer and rainy season. Certain genotypes (Acc 1630, Acc 1603, Acc 421 etc.) which posses high TDM also had higher seed yields and higher LAI or assimilation rates. Correlation study again confirmed that the TDM had a direct and significant effect on seed yield. The TDM or seed yield which is indirectly influenced by LAI or assimilation rate were also found to be positively correlated.

Therefore selection of genotypes such as ACC 1630, Acc 1603, Acc 421 etc. which have high assimilation rates with high LAI may further increase the seed yield when used in breeding programmes.

Key words: Sunflower, LAI, assimilation rate

INTRODUCTION

Sunflower is becoming increasingly popular as an important edible oil yielding and economic crop of India, especially in Karnataka. Though several high yielding varieties or hybrids such as BSH-1, KBSH-1, MFSH series etc. are recommended for cultivation in India, yet there is a need for further improvement in yield to meet the growing oil demands of our country. In this context, it is a well recognised fact that the seed yield of sunflower is dependent on total biomass production (Sheshagiri Rao, 1989) and partitioning efficiency or harvest index (Vronskih, 1988).

Though there is a possibility to improve the crop yield by increasing harvest index through decreased plant height genetically (Vronskih, 1988), the reduced plant height causes reduction in functional photosynthetic leaf area by decreased number of leaves. Reducing internodal length beyond certain level, keeping number of leaves constant also reduces photosynthetic rates by mutual shading of leaves. Thus no major improvement can be accomplished. Therefore, it is imperative that an alternative approach be sought.

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In this direction several agronomic approaches such as nitrogen application (Kameswara Rao and Gangasaran, 1991), optimising the plant density (Shivaram, 1986) etc. have been shown to increase seed yield through high plant biomass production. This in turn was related to leaf area index at various stages of crop growth. However, the dry matter production in turn is a product of leaf area index (LAI) and assimilation capacity of a genotype (Rollier, 1982). Amongst these, assimilation rate of sunflower is usually high and well above most C_3 plants (Connor and Sadras, 1992). Therefore, it appears that LAI is the most limiting factor for productivity when assimilation rate is not a limiting factor (Rollier, 1982). LAI is superdominantly inheritable character (Škorić, 1985). Therefore exploitation of genotypic variability for high TDM through high LAI or assimilation rate may be worthwhile in accomplishing higher productivity. The present investigation was carried out to select genotypes with high TDM and leaf area index and/or assimilation rate from a diverse germplasm lines.

MATERIAL AND METHODS

Experiments were conducted at Project Co-ordinator Unit (Sunflower), the University of Agricultural Sciences, Bangalore, during summer and rainy season 1993 on red loamy soils. These experiments were laid out in RBD with four replications having five lines of 3.0 metre length per replication using varied number of germplasm lines (which are given along with results (Table 1 and 2). The crop was sown in 45 x 30 cm spacing and maintained by following a package of practices for sunflower cultivation.

Observations on leaf area index (LAI) at flowering and total dry matter (TDM) and seed yield at harvest were collected from randomly selected 1.5m row lentgh which covers five plants in each replication during both summer and rainy season. Net assimilation rate, i.e., DM/LAD (summer) and DM/LA (rainy season) were computed as follows,

$$\text{DM/LAD (g/day)} = \frac{\text{TDM produced at harvest (g)}}{\text{Leaf area duration up to flowering (days)}}$$

$$\text{DM/LA (mg/cm}^{-2}) = \frac{\text{TDM produced at harvest (g)}}{\text{Leaf area at flowering (cm}^2)} \times 1000$$

where, leaf area at flowering or leaf area duration up to flowering were considered since maximum leaf area can be expected at the time of flowering only in sunflower. Relationships between growth and yield parameters were also assessed across the germplasm lines.

RESULTS AND DISCUSSIONS

Wide genotypic variations were observed in terms of LAI at flowering, assimilation rate (DM/LAD: summer or DM/LA: rainy season), TDM and seed yield at harvest during both summer and rainy season (Table 1 and 2). Similar variations across the genotypes in these parameters were shown by Shivaram (1986). The interesting feature here is that, the genotypes viz., Acc 1630, Acc 1603, Acc 421 etc. that had high grain yield also maintained high biomass either through high LAI or by high assimilation rate or by both. This data across the large germplasm collection indicates the possibility of selecting genotypes for these traits which influences the ultimate seed yield.

Table 1. Genotypic variation in some growth and yield characters of sunflower (summer, 1993).

		LAI at flowering	LAD	DM/LAD	H.I.	TDM at harvest	Seed yield
1	M 787-7-2	1.98	87.5	1.22	0.43	499	218
2	62 B	1.22	69.6	0.78	0.26	277	76
3	KBSH-1	1.26	53.6	1.22	0.25	319	78
4	383 B	1.33	50.0	0.95	0.26	222	60
5	EC-68415	2.75	95.2	1.20	0.32	566	181
6	M-685-7-2	1.50	63.7	0.85	0.27	263	72
7	M-787-5-2	2.08	69.4	0.95	0.42	320	134
8	339 B	1.68	48.9	1.00	0.29	252	77
9	M-733-10-3	1.01	50.0	0.72	0.30	184	59
10	MSFH-17	1.50	58.4	1.17	0.29	322	93
11	Acc 1599	1.87	68.3	1.03	0.35	351	125
12	Mordan	1.54	66.2	0.78	0.38	259	99
13	EC-68414	2.95	111.1	0.88	0.26	481	128
14	BSH-1	1.81	73.7	1.26	0.41	468	195
15	Acc 1651	2.80	92.4	1.53	0.34	651	221
16	Acc 1628	3.20	100.1	1.81	0.24	850	206
17	Acc 1620	2.16	79.4	1.40	0.34	553	198
18	Acc 1616	2.92	92.9	1.61	0.25	740	190
19	Acc 1630	3.78	137.6	1.60	0.29	1033	301
20	Acc 1648	3.73	124.6	1.27	0.33	749	248
21	Acc 1635	1.52	170.4	0.97	0.38	337	131
22	Acc 1606	3.20	102.7	0.91	0.42	469	210
23	Acc 1634	2.14	82.3	1.06	0.35	422	151
24	Acc 1643	1.88	60.8	1.18	0.30	350	106
25	Acc 1638	2.16	76.2	1.11	0.29	381	112
26	Acc 1610	1.87	70.3	1.11	0.19	352	70
27	Acc 1611	2.05	91.2	1.14	0.36	531	193
28	Acc 1600	2.27	83.6	1.46	0.27	599	159
29	Acc 1603	2.03	83.3	1.86	0.33	801	273
30	Acc 1653	1.24	64.2	0.93	0.35	301	109
31	352-B	1.45	39.4	1.50	0.27	301	85
Mean		2.13	78.0	1.18	0.32	458	147
CD (P=0,05)		0.29	15.6	0.26	0.02	91	30

Note: LAD up to flowering (days)
DM/LAD (g/day)
TDM and seed yield (g/1.5m row or 5 plants)

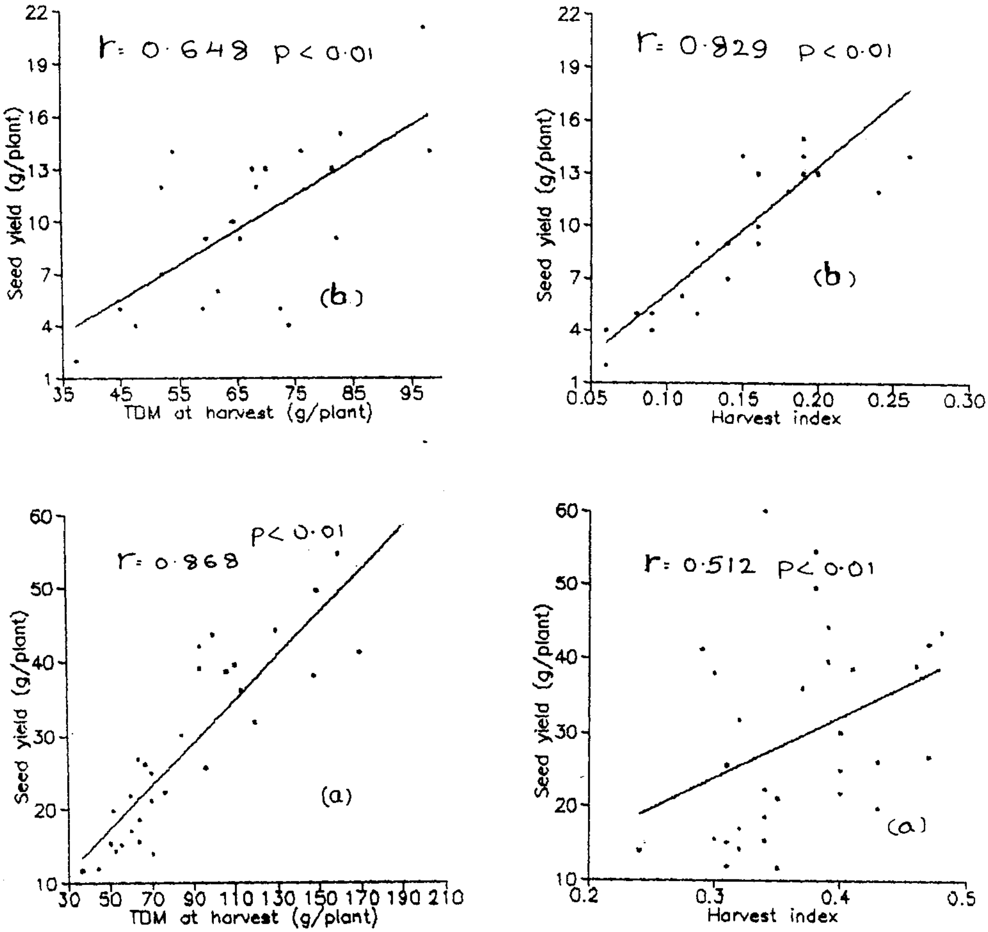

Figure 1. Relationship between TDM at harvest, HI and seed yield during summer (a) and rainy season (b).

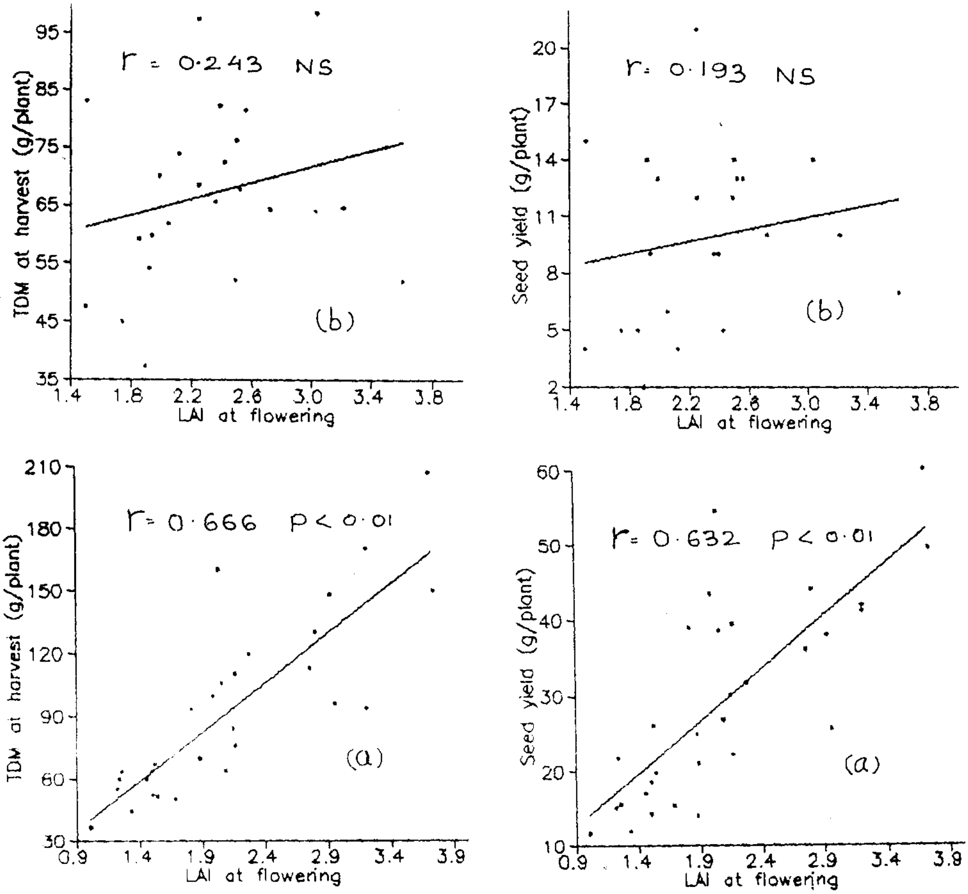

Figure 2. Relationship between LAI and, TDM and seed yield during summer (a) and rainy season (b).

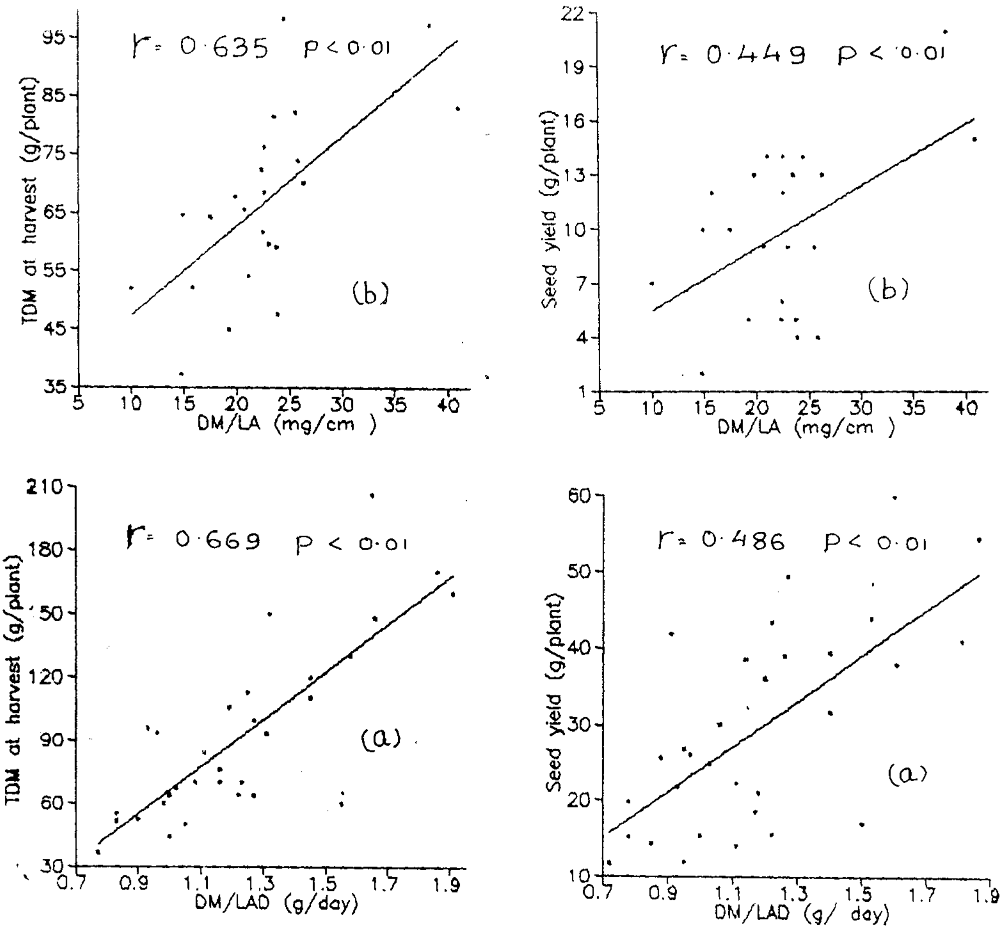

Figure 3. Relationship between assimilation rate (DM/LAD or DM/LA) and TDM at harvest and seed yield during summer (a) and rainy season (b).

Table 2. Genotypic variation in some growth and yield characters of sunflower (rainy season, 1993)

Germplasm	LAI at flowering	DM/LA	TDM (g) at harvest	H.I.	Seed yield (g)
1. Acc 92	3.65	10.7	264	0.14	37.0
2. Acc 1233	1.89	14.7	187	0.06	12.0
3. Acc 1405	1.74	19.2	225	0.12	26.5
4. Acc 1257	2.05	22.4	309	0.11	34.5
5. Acc 1279	2.42	22.3	362	0.08	28.5
6. Acc 128	1.50	23.8	238	0.09	20.5
7. Acc 1546	2.52	19.9	339	0.20	66.5
8. Acc 421	2.25	38.2	487	0.21	105.0
9. Acc 1548	2.12	25.8	369	0.06	21.0
10. Acc 1569	2.49	15.8	261	0.24	61.5
11. Acc 315	2.25	22.6	343	0.18	62.5
12. Acc 1506	1.92	21.1	271	0.26	71.0
13. Acc 1424	1.51	40.9	416	0.19	79.5
14. Acc 436	2.50	22.6	381	0.19	73.5
15. Acc 1055	3.21	14.9	323	0.16	53.0
16. Acc 701	1.85	23.7	296	0.09	26.5
17. Acc 1566	2.39	25.5	411	0.12	48.5
18. Acc 1564	2.56	23.5	408	0.16	66.5
19. Acc 1602	2.36	20.7	328	0.14	45.5
20. Acc 1506	1.99	26.3	351	0.19	65.0
21. Acc 1546	1.94	23.0	299	0.16	46.5
22. Acc 1549	2.72	17.5	322	0.16	51.0
23. Acc 1879	3.03	24.5	492	0.15	71.5
Mean	2.30	22.8	337	0.15	51.0
CD (P=0,05)	0.36	5.74	66.5	0.02	12.5

Note: DM/LAD (mg/cm^{-2} leaf area)
TDM and seed yield (g/1.5m row or 5 plants)

The relationships between growth and yield parameters show that TDM and harvest index are significantly and positively related to seed yield in both seasons (Fig. 1a & b). Similar relationships were observed in the studies of Rollier (1982). Assimilative area (LAI) has a significant and positive relation with total biological yield and seed yield during summer season (Fig. 2a). Similar responses were reported by Giriraj *et al.* (1987). However, in rainy season, LAI had little effect on these parameters (Fig. 2b). Pirani (1988) also showed a lesser effect of LAI on seed yield across 24 cultivars. This suggests that LAI may be a major limiting factor for productivity only during summer because leaf area development is not a problem in rainy season. However, when assimilation rate is not limiting during any conditions, LAI will have direct influence on TDM and seed yield in sunflower (Abbate and Tuttobene, 1982).

The relationship between assimilation rate and TDM or seed yield was significantly direct in both seasons (Fig. 3a & b). Hence, assimilation rate may contribute more towards seed yield regardless of the season. Nevertheless, both LAI and assimilation rate still play an important role in deciding canopy photosynthesis of a crop and thus seed yield.

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LA SELECCION PARA UNA ALTA TASA DE ASIMILACION DE LA CANOPIA ES UNA BUENA ESTRATEGIA PARA INCREMENTAR PRODUCTIVIDAD EN GIRASOL

RESUMEN:

Se llevaron a cabo experimentos en la Universidad de Agricultura Ciencias, Bangalore durante 1993, para evaluar líneas con alta producción de materia seca y alcanzar rendimientos mas altos, ya que la producción de materia seca mostró tener un efecto positivo en el rendimiento de semilla de girasol. Se observaron variaciones genotípicas para índice de área foliar (IAF) en floración, tasa de asimilación, materia seca total y rendimiento en semilla e índice de cosecha tanto en verano como en las estaciones lluviosas. Ciertos genotipos (Acc 1630, Acc 1603, Acc 421 etc.) que poseen alta materia seca también tuvieron rendimientos de semilla más altos e índice de área foliar y tasas de asimilación mas altos. La materia seca total o rendimiento de semilla que están influenciados por el IAF o las tasas de asimilación estuvieron correlacionados positivamente entre ellos. Por tanto la selección de genotipos tales como Acc 1630, Acc 1603, Acc 421 etc. los cuales taniendo tasas de asimilación con alto índice de área foliar pueden incrementar los rendimientos cuando se usan en programas de mejoras.

LA SÉLECTION POUR UN TAUX D'ASSIMILATION LUMINEUSE ÉLEVÉ EST UNE BONNE STRATÉGIE POUR AMÉLLORER LA PRODUCTIVITÉ DU TOURNESOL

RÉSUMÉ:

Ces recherches ont été conduite á l'Université des Sciences Agronomiques de Bangalore en 1993. Dans la mesure o il a été prouvé que la production de matière séche totale (TDM) a un effet positif sur le rendement en grain chez le tournesol, nous avons testé des lignées à haute production en matière séche afin d'obtenir de meilleurs rendements en grain. Des variations génotypiques significatives pour l'indice de surface foliaire (LAI) à la floraison, les taux d'assimilation (DM/LAD et DM/LA), le TMD, le rendement en grain et l'indice de récolte ont été observées aussi bien en saison pluvieuse que séche. Certains génotypes (Acc 1630, Acc 1603, Acc 421 etc..) qui possédaient des TDM élevés ont exprimé également des rendements en grains, des LAI et des taux d'assimilations supérieurs. L'étude de corrélation a confirmé que le TDM avait un effet direct et significatif sur le rendement en grain. De ce fait, la sélection de génotypes tels que Acc 1630, Acc 1603, Acc 421 qui se caractérisent par un taux d'assimilation et un LAI élevés peuvent tre utilisés par la suite dans des programmes de sélection afin d'améliorer le rendement en grain.