Turmeric - maize and onion intercropping systems II. Leaf area index and dry matter accumulation

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ABSTRACT

Experiments were laid out at Bhavanisagar and Coimbatore (Tamil Nadu, India) to study the influence of intercropping on leaf area index and dry matter accumulation in whole plants of turmeric (*Curcuma longa*), maize (*Zea mays*) and onion (*Allium cepa*) when grown in intercropping and sole cropping systems. Maize was intercropped with turmeric in two proportions (50 and 100 per cent of the recommended population levels). Onion was also introduced as additional intercrop with maize with 23 per cent of the population of sole crop. These crops were also raised as sole crops. Leaf area indices and dry matter accumulation of maize and turmeric at different stages were influenced significantly by intercropping systems, in both locations. Intercropping maize in turmeric significantly reduced the growth of the latter. This effect was quite obvious where maize was raised as intercrop at 100 per cent of the recommended population. Sole cropping of turmeric resulted in higher leaf area indices than turmeric raised as intercrop. Raising onion as additional intercrop did not influence dry matter accumulation of component crops appreciably.

Key words : dry matter, intercropping systems, leaf area, maize, onion, turmeric.

Abbreviations

DAP : Days after planting

DMP : Dry matter production

LAI : Leaf area index

PAI : Photosynthetically active radiation

Introduction

Traditional cropping systems such as intercropping may provide substantial yield advantages over sole cropping due to improved temporal (Natarajan & Willey 1980 a; Reddy, Floyd & Willey 1980; Willey & Osiru 1972) and spatial

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(Harris, Natarajan & Willey 1987; Reddy & Willey 1981) use of resources.

Greater land use efficiency and dry matter production by intercropping has been attributed to better light interception as a result of better light distribution (Cordero & McCollum 1979; Natarajan & Willey 1980 a & b) or due to greater efficiency of light utilization as a result of intercepted light being spread over a greater leaf surface (Reddy & Willey 1981). Frequently, leaf area indices of component species in intercropping systems are reduced when compared to that of sole cropping systems (Enyi 1973). Previous studies have shown that turmeric - maize and onion intercropping systems produced greater land use efficiencies than do sole cropping systems of the same species (Rao & Reddy 1990; Sivaraman & Palaniappan 1994). However, no attempt has been made to relate this greater land use efficiency to leaf area index and production of total dry matter to harvestable plant parts. The objectives of this study were to determine leaf area index and dry matter accumulation in turmeric - maize and onion grown in intercropping and sole cropping systems.

Materials and methods

The field design and materials used were as described previously (Sivaraman & Palaniappan 1994). The following intercropping systems were laid out as main plots in a split plot design. However the effect of sub-plot treatments on leaf area index and dry matter accumulation are not discussed in this paper. Maize and onion were also raised as sole crops at 100 per cent population adopting recommended package of practices for comparison.

T = Sole crop of turmeric

$T + M_1$ = Turmeric (100) +Maize (100)

$T + M_2$ = Turmeric (100) + Maize (100) + Alternate rows of maize cut for fodder on 60th day

$T + M_3$ = Turmeric (100) + Maize (50)

$T+M_3+O$ = Turmeric (100) + Maize (50) + Aggregatum onion (23)

(Figures in parentheses indicate percentage of the recommended sole crop population)

Small plots (6m x 4 m) in the respective experimental plots were used for sequential dry matter harvest and leaf area determination. The leaf area was measured using a leaf area meter (Model LI 3000 area meter of LI COR, Lincoln, USA) and expressed in cm^2 per plant. Turmeric leaf area was determined by using the above equipment and measuring the leaf area of five plants in the centre per plot, drying leaves to calculate specific leaf weight, and dividing the total leaf dry weight from the plot by the specific leaf weight. This measurement provided an estimate of the total leaf area for the plot. Maize leaf area was determined in a similar manner using five plants per plot to determine specific leaf weight and dividing the total leaf dry weight from the plot by the specific leaf weight. Leaf area measurement for onion was not done. The LAI measurements and dry matter sampling in various treatments were made at monthly intervals from 30 DAP for maize and 60 DAP for turmeric. For each dry matter sampling, five plants each of turmeric and maize were uptooted at each stage with minimum damage to roots. In the case of maize, whole plants were chopped into manageable pieces and oven dried at

60°C till a constant weight was reached. In turmeric, sampling was done similarly by uprooting five plants from the demarcated area from the plot and separating them into shoots, rhizomes and roots, and oven dried at 60°C till a constant weight was reached. Dry matter weights of individual components were added to arrive at total dry matter accumulation. Dry matter production in onion was estimated only at the time of harvest. The effects of sub-plot treatments on leaf area index and dry matter accumulation are not discussed in this paper.

Results and discussion

Leaf area indices of turmeric and maize at different stages were influenced by intercropping systems significantly at both locations. Raising maize as intercrop at a higher population density of maize (8.3 plants/m^2) resulted in a higher LAI. Leaf area indices of sole crop of maize were lower than that of intercropped maize, whereas, LAI values of sole cropped turmeric (T) were consistently higher throughout the crop growing season at both locations (Tables 1 & 2, Figs. 1 & 2). In general, values of LAI were higher in Coimbatore than in Bhavanisagar, but the trend was similar in both locations. In the case of T + M_2, LAI of maize was reduced by half due to harvesting alternate rows for fodder at 60 DAY. T + M_3 and T + M_3 + O showed lower values of LAI due to lower population density of maize (4.2 plants/m^2) planted along with turmeric. The values of LAI in sole crop of maize were marginally lower at all the stages in both locations when compared to LAI of maize in T + M_1 at all stages and up to 60 days after planting (DAP) in T + M_2. This could be due to better utilization of available nutrients in the soil by maize intercropped with turmeric which otherwise remains under utilized by turmeric because of its slow growth in the early stages.

Leaf area indices of turmeric were significantly reduced by intercropping during early growth stages when compared to sole cropping of turmeric. After harvest of maize, LAI values of turmeric converged in such a way that the differences were smaller during later months. Maximum values of LAI were reached at 210 DAP in all the treatments and varied from 5.48 (T + M_1) to 5.99 (T) in Bhavanisagar and 5.74 (T + M_1) to 6.59 (T) in Coimbatore. LAI declined sharply from 240 DAP onwards in all the treatments due to senescence.

Values of DMP of maize and turmeric were significantly influenced by intercropping systems (Tables 3 & 4 and Figs. 3 & 4). Raising maize as intercrop at 100 per cent sole crop population with turmeric (T + M_1) recorded the maximum DMP at 90 DAP. After harvest of alternate rows of maize for fodder, DMP declined sharply at 60 DAP in T + M_2. Values of DMP in maize increased at higher rate in T + M_1 and T + M_2 up to 60 DAP and relatively at a lower rate in T + M_3 and T + M_3 + O where only 50 per cent of the sole crop population was planted. The values of DMP of sole crop maize were marginally lower when compared to intercropped maize (T+M_1). However, in other treatments (T + M_2, T + M_3 and T + M_3 + O) lower values were recorded when compared to sole crop of maize.

Maize raised as intercrop suppressed the growth of turmeric significantly. This effect was quite obvious in T + M_1 when compared to other intercropping treatments. The growth of turmeric was

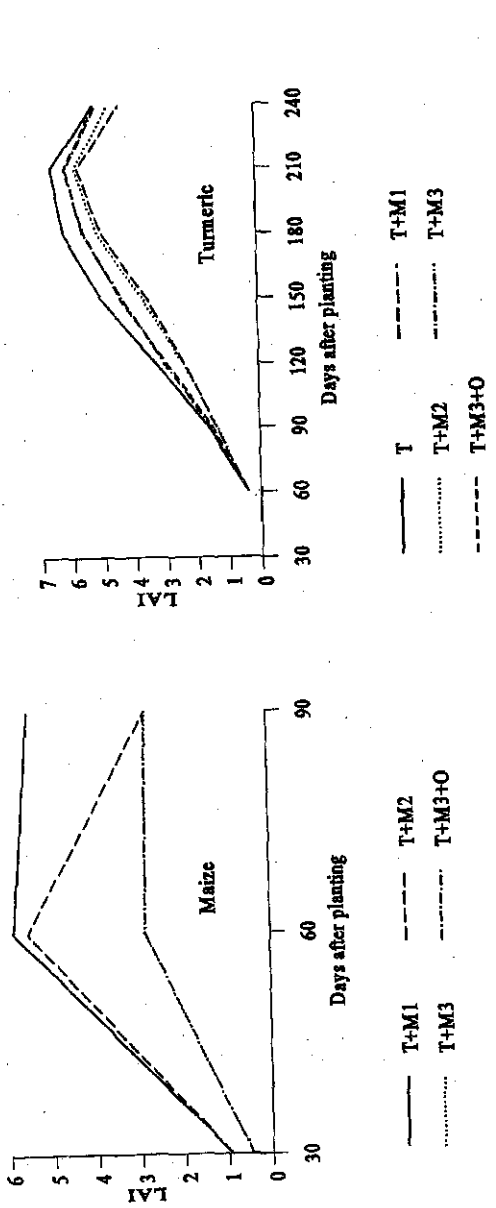

Fig. 1. Leaf area index of component crops in intercropping systems (Bhavanisagar)

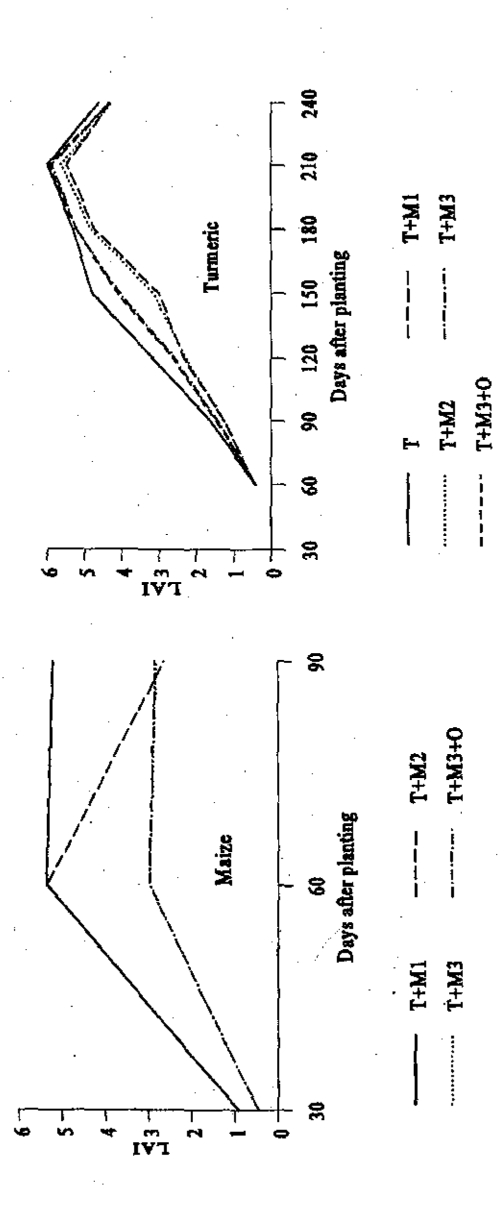

Fig. 2. Leaf area index of component crops in intercropping systems (Coimbatore)

Table 1. Influence of intercropping systems on leaf area index (Bhavanisagar)

Treatment	Maize (DAP)			Turmeric (DAP)						
	30	60	90	60	90	120	150	180	210	240
T	–	–	–	0.414	1.617	3.167	4.805	5.322	5.989	4.617
T + M_1	0.89	5.37	5.22	0.414	1.253	2.333	3.005	4.741	5.480	4.313
T + M_2	0.90	5.36	2.53	0.418	1.258	2.280	3.152	4.843	5.628	4.248
T + M_3	0.45	2.97	2.81	0.419	1.417	2.567	4.061	5.237	5.868	4.320
T + M_3 + O	0.45	2.98	2.84	0.416	1.463	2.613	4.124	5.226	5.940	4.323
SE_d	0.01	0.02	0.44	0.005	0.053	0.040	0.041	0.032	0.033	0.046
$LSD_{0.05}$	0.03	0.05	1.01	NS	NS	0.092	0.094	0.073	0.075	0.105
Sole crop	0.85	5.30	5.00	–	–	–	–	–	–	–

DAP = Days after planting

Table 2. Influence of intercropping systems on leaf area index (Coimbatore)

Treatment	Maize (DAP)			Turmeric (DAP)						
	30	60	90	60	90	120	150	180	210	240
T	–	–	–	0.410	1.663	3.297	5.032	6.214	6.587	5.176
T + M_1	0.91	5.59	5.49	0.414	1.397	2.403	3.579	4.985	5.742	4.361
T + M_2	0.91	5.57	2.80	0.418	1.381	2.433	3.727	5.142	5.841	4.703
T + M_3	0.45	2.88	2.80	0.421	1.597	3.025	4.365	5.586	6.123	5.101
T + M_3 + O	0.46	2.86	2.82	0.419	1.527	2.940	4.419	5.557	6.164	5.174
SE_d	0.01	0.02	0.03	0.005	0.020	0.018	0.044	0.052	0.042	0.062
$LSD_{0.05}$	0.03	0.06	0.07	NS	0.046	0.042	0.102	0.110	0.092	0.141
Sole crop	0.90	5.51	5.37	–	–	–	–	–	–	–

DAP = Days after planting

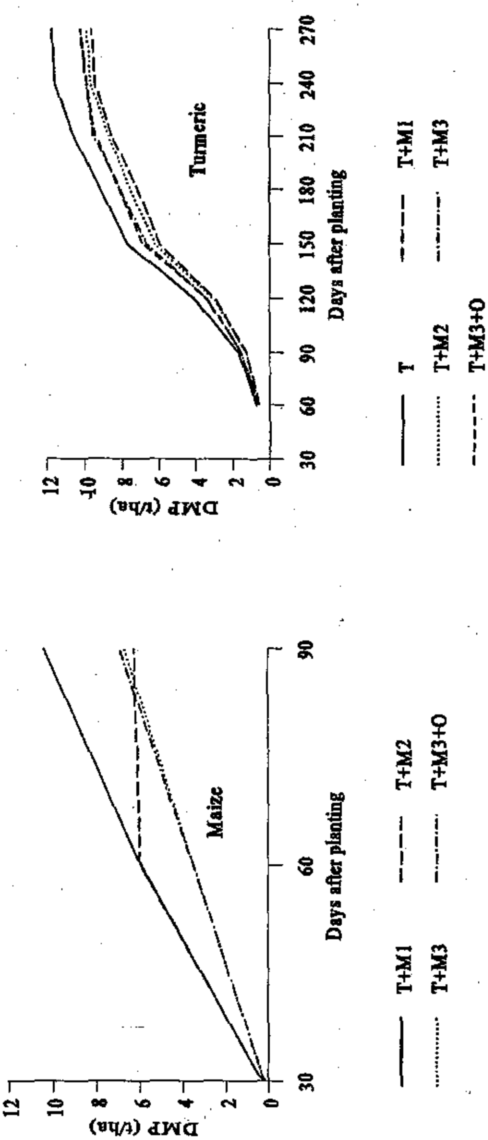

Fig. 3. Dry matter production of component crops in intercropping systems (Bhavanisagar)

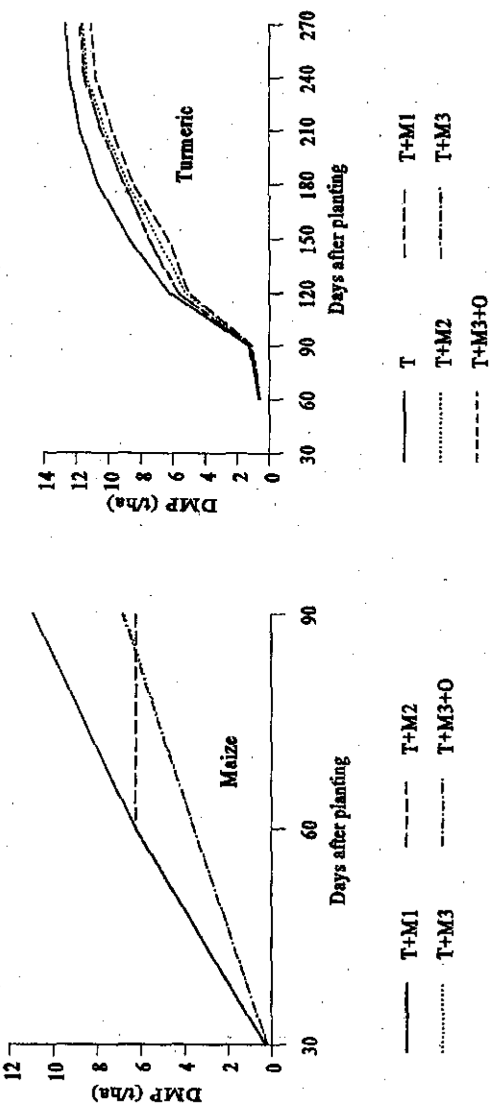

Fig. 4. Dry matter production of component crops in intercropping systems (Coimbatore)

Table 3. Influence of intercropping systems on dry matter production in maize and turmeric (Bhavanisagar)

Treatment	Onion (DAP)	Maize (DAP)			Turmeric (DAP)							
	65	30	60	90	60	90	120	150	180	210	240	270
T	–	–	–	–	0.73	1.72	4.11	7.72	9.17	10.60	11.60	11.77
T + M_1	–	0.28	5.95	10.42	0.59	1.26	3.03	5.99	7.17	8.56	9.47	9.67
T + M_2	–	0.28	5.99	6.25	0.61	1.28	3.12	6.24	7.57	8.73	9.68	9.92
T + M_3	–	0.19	3.51	6.71	0.64	1.56	3.41	6.71	8.08	9.55	9.95	18.19
T + M_3 + O	0.900	0.19	3.52	6.93	0.66	1.56	3.42	5.89	8.15	9.43	9.97	10.24
SE_d	–	0.02	0.03	0.03	0.01	0.27	0.06	0.07	0.07	0.07	0.04	0.05
$LSD_{0.05}$	–	0.04	0.08	0.08	0.03	0.63	0.15	0.15	0.10	0.15	0.09	0.12
Sole crop	1.566			9.93	–	–	–	–	–	–	–	–

DAP = Days after planting

* = At harvest

Table4. Influence of intercropping systems on dry matter production in maize and turmeric (Coimbatore)

Treatment	Onion (DAP)*	Maize (DAP)			Turmeric (DAP)							
	65	30	60	90	60	90	120	150	180	210	240	270
T	–	–	–	–	0.64	1.26	6.20	8.75	10.67	11.82	12.42	12.71
T + M_1	–	0.28	6.25	10.92	0.56	1.08	5.01	6.33	8.48	9.80	10.84	11.12
T + M_2	–	0.28	6.25	6.24	0.56	1.09	5.22	6.94	8.81	10.27	11.35	11.58
T + M_3	–	0.19	3.58	6.77	0.60	1.18	5.67	7.48	9.04	10.52	11.51	11.70
T + M_3 + O	0.631	0.19	3.58	6.84	0.60	1.19	5.69	7.53	9.08	10.47	11.56	11.80
SE_d	–	0.02	0.02	0.03	0.01	0.01	0.05	0.01	0.04	0.04	0.03	0.05
$LSD_{0.05}$	–	0.05	0.06	0.07	0.02	0.02	0.12	0.03	0.10	0.09	0.06	0.12
Sole crop	0.972			10.25	–	–	–	–	–	–	–	–

DAP = Days after planting
* = At harvest

significantly reduced by the presence of maize in two population levels tested at both the locations. Leaf area development and dry matter production of turmeric during various growth stages (up to 240 DAP) were significantly reduced by the presence of maize, particularly when planted at 100 per cent of the recommended population (T + M_1). The values of LAI and the DMP of turmeric were consistently higher in sole cropped turmeric than in intercropped plots due to the absence of competition from maize for nutrients and PAR. Though intercropped turmeric grew tall and luxuriant in the shade provided by maize, the total DMP recorded was higher in sole cropping of turmeric. Similar results were reported by Ridley (1912) who observed that turmeric grew luxuriantly under shade but it produced larger and better rhizomes in the open exposed to sun. Turmeric yields were suppressed when intercropped at high maize population but conversely, maize yields were not affected by turmeric (Sivaraman & Palaniappan 1994). This suppression in growth and productivity of turmeric by maize at high population was possibly due to any one or both of the causes, i.e., shading of turmeric by the faster growing maize and/or the coincidence of their developmental and nutrient demand profiles. Though intercropped turmeric exhibited tall and luxuriant growth in the shade provided by maize, total dry matter production was higher when raised as sole crop. Turmeric with its shallow and limited root system in the initial stages might have been unable to compete effectively for nutrients with the more profusely rooted maize. The leaf area index of most root crops increases slowly after planting partly due to the use of relatively low plant densities (Looms & Rapport 1976) and their inherent slow growth. The inability of turmeric to recover the lost growth due to intercropping of maize may possibly be due to the long competitive period (105 days) with maize. This is further supported by the data that there was no appreciable reduction in growth parameters due to the inclusion of onion as a third crop in the system along with maize at 50 per cent of the recommended population level and harvesting onion at 65 DAP (Sivaraman & Palaniappan 1994). Similar results have been reported by Tsay, Fukai & Wilson (1988) who found a good recovery in growth as that of sole crop of cassava after harvest of short duration soybean variety.

The growth of onion in terms of dry matter production was higher in Bhavanisagar than in Coimbatore probably due to favourable soil conditions. The yield of onion in intercropping systems was low when compared to sole cropping of onion (Sivaraman & Palaniappan 1994). This reduced growth and yield of onion may possibly be due to the reduced proportion (23 per cent) of the recommended population planted in the intercropping system and the competition for resources from the associated crops. Total dry matter production in the intercropping systems was higher than the component crops raised as sole crops individually. This also resulted in higher yields and land use efficiency of intercropping systems than sole cropping systems (Sivaraman & Palaniappan 1994).

The study indicated that with a high maize population, the mixed canopy of turmeric and maize could effectively intercept and absorb more of available PAR throughout the growing season, than sole crop of turmeric, maize or onion. The tall stature and leaf development at the upper portion of maize canopy apparently contributed to more light interception and less light reflection in the mixed turmeric-maize canopy. Similar results have been reported by Tsay, Fukai & Wilson (1988) in cassava -soybean intercropping systems. The study indicated that in these intercropping systems the rapidly growing maize and onion could use the space between the slow growing turmeric crop with minimal effect on turmeric growth.

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