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EFFECT OF SHADE ON GROWTH, NODULATION AND YIELD OF COWPEA (*VIGNA UNGUICULATA* (L) WALP)

In many of the crops solar energy available is a crucial factor determining the final yield. This factor is to be considered when recommending intensive cropping and multiple cropping along with plantation crops like coconut, as the returns from the associated crops would depend on their response to shade. A field experiment was conducted at the College of Horticulture, Vellanikkara, Trichur during May to October, 1 981 to assess the feasibility of cowpea for intercropping in coconut garden. *Kanakamani* was the variety of cowpea used. The trial was laid out in randomised block design with five replications, in a sandy clay loam soil, The treatments consisted of four intensities of shade i. e., S_0 (open), S_1 (25 per cent shade), S_2 (50 per cent shade) and S_3 (75 per cent shade). Artificial shading to the desired level was provided by placing unplaited coconut leaves on erected pandals. The sides of the pandals were also covered in order to avoid entry of slant rays, leaving a clearance of one metre from ground level. This clearance was given to allow wind movement. An 'Aplab' luxmeter was used for adjusting the shade intensities at intervals of about a month, The plot size was 1 x 4 m. Observations. included leaf area index, total dry weight, specific leaf area, leaf weight ratio, number of effective and total nodules on roots, yield of grain, yield of haulm and harvest index. Of these, leaf area index was recorded 30, 60 and 75 days after sowing, nodule number 30 and 60 days after sowing, and total plant dry weight at harvest also in addition to the above three stages. Data on nodule number 60 days after sowing are not presented as the differences between treatments at this stage were not significant. Specific leaf area and leaf weight ratio were calculated for the stages between 30 and 60 days and between 60 and 75 days after sowing. Net assimilation rate was worked out between 75 days and harvest also in addition to the above two stages.

The results of the present study indicated that the grain yield of cowpea fell substantially because of shading (Table 1.) Even the low shade of 25 per cent reduced the grain yield by more than 50 per cent and with more intense shading the yields progressively decreased. When the light intensity was reduced by 75 per cent, the yield was only 9 per cent of that at full sunlight.

The above yield trend was, however, inconsistent with the extent of response of the crop in terms of dry matter accumulation (Table 1). The dry matter accumulation under low, medium and high levels of shade, when expressed as percentage of that under full illumination were 75.1, 39.8 and 27.9 respectively, while the grain yields undar these shade levels were to the tune of 42.0, 25.5 and 9.2 per cent, respectively, of that in the open. Such a larger extent of decline of grain yield, than dry matter yield with increasing shade intensities may be taken to indicate that cowpea failed to translocate the accumulated carbohydrate to the economic part in proportionate amounts under shade. The data on harvest index would further substantiate this (Table 1). The percentages of dry matter translocated to the grains were 34.1, 26.2, 27.9 and 13.6 at 0,25, 50 and 74 per cent shade, respectively.

The decline in dry matter accumulation is in agreement with the finding of Dolan (1972) in pea; Crookston *et al.* (1975) in beans and Benjamin *et al.* (1981) in soybean. This decline could be attributed to mutual shading and leaf parasitism. Since, when shaded, the light reaching the canopy was limited, a larger proportion of leaves would tend to fall below saturating light intensities or even below compensation point. An assessment of the extent of mutual shading that might have occurred can be had from the data on leaf area index and net assimilation rate (Table 2). Shading failed to influence LAI at any of the growth stages. With a canopy having the leaf area index on par with that of plants grown without shade, the lower leaves of the shaded plants must have suffered substantial para«itism. The data on net assimilation rate would further indicate the extent of such mutual shading. As expected, there was a significant fall in NAR at higher levels of shade. The canopy was sparse during the early stage and became denser between 30th and 60th days. After that there was a drastic decline in LAI, which is attributable to the leaf senescence and shedding. Contrary to the expected trend, the NAR also went down during the period, presumably due to the deterioration of photosynthetic ability of the leaves of this stage. The specific leaf area (Table 2) showed a significant increase with increasing intensities of shade. This being the ratio of leaf area to leaf weight, an increase in specific leaf area with shading may represent an adaptive mechanism for each unit weight of dry matter partitioned into leaves, a greater amount of area is exposed to available light (Cooper and Quails, 1967). The difference in leaf weight ratio (Table 2) remained non-significant during the early stages, but it showed a substantial increase with shading between 60th and 75th days which is attributable to low leaf senescence and leaf fall, under shade. Sheldrake and Narayana (1976) obtained similar results in chick pea and pigeon pea. An important conclusion that may be drawn from the above results is that cowpea is to be considered sensitive to shade as there is a substantial and large decline in grain yield with increasing shade. Cowpea, therefore, may not be a crop suitable for cultivation as an intercrop of coconut.

Nodulation in terms of both the total number of nodules as well as the number of effective nodules was significantly influenced by shading during the early stages (30 das). Nodulation decreased steadily upto 50 per cent shade and with more intense shading, the difference was not perceptible. A decrease in nodulation and nitrogen fixation by shading has been reported by Allison (1935). Such a decrease in nitrogen fixation by legumes under shade is associated with decline in canopy photosynthesis and reduced photosynthetic supply to nodules (Lawn and Brun, 1974). This decrease in symbiotic nitrogen fixation is of practical importance especially as one of the expected advantages of intercropping with

Table 1

Effect of shade on yield of grain, yield of haulm, harvest index and total plant dry weight of cowpea

Shade intensity (per cent)	Yield of grain (kg ha-1)	Yield of haulm (kg ha-1)	Harvest index	Total plant dry weight (g plant— 1) (Days after sowing) 30	60	75	Harvest	Total No. of nodules plant—1 (30 das)	No.of effe-ctive nodules plant— 1 (30 das)
0 (no shade)	1582.22	3037.69	0.34	0.95	15.94	17.04	17.04	27.12 (5.265)	18.64 (4.37)
25 (low shade)	664.79	2118.31	0.26	0.67	8.87	13.30	12.34	16.88 (4.19)	8.12 (2.997)
50 (medium shade)	403.56	1111.24	0.27	0.43	6.02	6.29	6.55	11.52 (3.5)	6.32 (2.586)
75 (high shade)	145.78	976.14	0.13	0.48	4.41	5.44	4.58	11.32 (3.46)	5.92 (2 62)
SEM +	76.90	308.30	0.03	0.08	1.70	0.87	1.56	(0.23)	(0.24)
CD (0.05)	237.13	950.14	0.10	0.20	5.20	577	4.82	(0.70)	(0.74)

das = days after sowing

Figures in parenthesis indicate x + 1 transformed values

Table 2

Effect of shade on leaf area index, specific leaf area, leaf weight ratio, net assimilation rate and nodulation of cowpea at different growthstages

Shade intensity (per cent)	Leaf area index (days after sowing) 30	60	75	Specific leaf area cm^2 g^{-1} Between 30th and 60th days	Between 60th and 75th days	Leaf weight ratio Between 30th and 60th days	Between 60th and 75th days	Net assimilation rate g m^{-2} day^{-1} Between 30th and 60th days	Between 60th and 75th days
0 (no shade)	0.71	3.97	0.81	376.54	339.09	0.46	0.21	4.76	3.27
25 (low shade)	0.59	3.00	2.53	447.08	446.78	0.45	0.28	2.57	0.65
50 (medium shade)	0.37	2.99	1.91	533.26	464.36	0.44	0,32	1.90	0.84
75 (high shade)	0.55	2.15	1.62	621.81	557.93	0.48	034	1.76	1.11
SEM +	0.08	0.64	0.38	20.24	26.12	0.02	0.02	0.72	0.96
C.D. (0.05)	NS	NS	NS	62.36	81.67	NS	0.06	2.29	NS

NS = Not significant

legumes is the gain in symbioticallv fixed atmospheric nitrogen. Though an assessment of the extent of contribution from the soil nitrogen could not be made from the present study, the possibility of a net loss of nitrogen from the soi| due to removal by the legume under shade, however, cannot be excluded especially when the crop is raised for grain purpose.

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