Journal of Agrometeorology 21 (2) : 210-212 (June 2019)

Short Communication

Light interception in sugarcane based intercropping system

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Intercropping of economically viable short duration crops with sugarcane through utilization of present limited land resources would sustain sugarcane cultivation and help to provide interim return to farmers. Sugarcane is a long duration crop and takes about 3-5 months for canopy development. When planted in wide row spacing of 150 cm, it allows room for growing intercrops during the early stage. Small and marginal sugarcane growers take advantage of this and grow various short duration intercrops like pulses, vegetables, etc. to obtain interim return instead of waiting to get return from sole sugarcane crop (Geetha and Tayade, 2015 and Geetha *et al*., 2015). Solar radiation is a major resource determining growth and yield of component crops in intercropping, particularly when other resources like water and nutrients are not severely limiting the crop growth.In the interception of light (LI) by a canopy, difference between the incoming solar radiation and reflected radiation by the soil surface (Villalobos *et al*., 2002), is a determining factor in crop development and provides the energy needed for fundamental physiological processes such as photosynthesis and transpiration. The quantity of radiation intercepted by plant cover is influenced by a series of factors such as leaf angle, the properties of the leaf surface affecting light reflection, thickness and chlorophyll concentration, which affect the light transmission, size and shape of the leaf phyllotaxis and vertical stratification, and the elevation of the sun and distribution of direct and diffuse solar radiation. Out of the total light energy received by the leaf, only 5 is converted into carbohydrates for biomass production while, losses of light energy are 60 per cent by non-absorbed wavelengths, 8 per cent by reflection and transmission, 8 per cent by heat dissipation and 19 per cent is used for Metabolism(Varlet-Gancher *et al*, 1993).The light deficiency in the canopy is the main limiting factor sugarcane production but the lower radiation use efficiency (RUE) under wide row planted. Light energy which in not utilised during the early sugarcane growth stage can be utilized in a better way by intercropping. The main aim of crop production is to harvest solar energy through crop plants, which in turns depends upon the efficiency of light interception and its utilisation. Sugarcane intercropping system paves way for better utilisation of land, water and radiation under wide row planting (Dhanapal *et al*., 2018). Field experiments were taken up with a view to evaluate suitable intercrop with higher light interception and economic yield in sugarcane.

Field experiments were conducted during 2014-15 and 2015-16 under wide row spacing in sugarcane, at two different locations of ICAR- Sugarcane Breeding Institute, Coimbatore in split plot design with three nitrogen levels (100% N (RDN-280 kg ha^{-1}), 75 % N (210 kg ha^{-1}) and 50% N(140 kg ha^{-1})) as main plot and intercrops such as finger millet, black gram, soybean, sesame, amaranthus, sunn hemp and sole sugarcane as subplot treatments.Each treatment was replicated thrice. The soils of the experimental fields are moderately drained with adequate drainage, taxonomically classified as *typichaplustalf*. The experiment was conducted in red sandy loam soil in 2014-15 and black clay soil in 2015-16. The available major nutrient content ranged from 228 and 275 kg ha^{-1} N, 40 and 48 kg ha^{-1} P and 610 and 664 kg ha^{-1}K at both the locations respectively in the upper 30cm soil.During the crop season, rainfall of 537 and 679 mm was recorded during 2014-15 and 2015-16 respectively. The mean temperature ranged in between 21.24 and 33.10^{o}C with a mean relative humidity of 54.58–85.5 per cent at both the years of cropping.

The sugarcane (Co 86032) was planted in wide row (150cm) spacing, while the intercrops were sown as per treatment schedule on both sides of the ridges at three fourth height in between two rows of sugarcane (Main crop). At 10th day the intercrops were thinned so as to maintain optimum plant population to avoid inter and intra species competition. The crops were maintained under uniform conditions of irrigation and plant protection. The fertilizer recommendation followed for sugarcane was 280:62.5:120 kg of N: P_2O_5:K_2O ha^{-1}. Since the population of the intercrops was 50 per cent of the sole crop, half the recommended doses of fertilizers were applied to the intercrops; no fertilizer was applied to sunn hemp. The light interception with a spectral range of 400 – 700 nm recorded as µmol (photons) m^{-2} s^{-1}) was measured during 6.00 am - 6.00 pm on 45th day using quantum meter (LI- 1400,LI COR Inc., Lincoln, NE, USA) with two 1.0 m line quantum sensors and a point quantum sensor. In each plot, the total incoming radiation was measured using point quantum sensor; one line quantum was placed below the intercrop and the other at ground level in sugarcane. The percentage of light intercepted by the canopies of the system was calculated as follows:

$$PLI = \frac{(LI - LT)}{LI} \times 100$$

Where,

PLI = percentage of light intercepted

LI = light incident above the crop canopies and

LT = light transmitted below the crop canopies

The intercrops were harvested at maturity before the full earthing up operation of sugarcane and the yield were recorded. The sugarcane was harvested at the age of 12 months. The cane in the border and the sampling rows were harvested first and removed from the field, then the cane in the net plot area were harvested at ground level, trash and tops were removed, bundled and weighed and with it the weight of the sample canes weight was also added to arrive at the cane yield and expressed in t ha^{-1}. Data were subjected to statistical analysis as suggested by Gomez and Gomez (1984) to evaluate significant differences between treatments.

Percentage of light interception

The sugarcane intercropping system had an impact on the light interception percentage (Table 1). At 45 days after planting, sole sugarcane intercepted less total light compared to the sugarcane intercropping systems. Intercrop canopies has intercepted light more effectively than sole crops since they are short duration and faster growth and development of their canopy. The pooled mean data revealed that, the intercrop amaranthus has intercepted more light (65.26 %) followed by sunn hemp (47.97 %) and sesame (28.90 %). Higher light interception of amaranthus and sunn hemp was due to their dense foliage than the young sugarcane crop wherein hardly one to two leaf are there to intercept solar radiation. The larger interspaces between the wide spaced sugarcane rows can be effectively utilized by the intercrops for better exploitation of the natural resources like light, carbon dioxide, soil moisture and nutrients.Thus, solar radiation which would otherwise be wasted due to poor growth of sugarcane early in the season is utilized more efficiently by intercropping. The results are in accordance with the findings of Kailasam (1994) and Thavaprakash and Velayutham, (2008).

Table 1: Per cent of light interception by sugarcane and intercrops in sugarcane based cropping system

Cropping system	Two years mean data	
	Sugarcane	Intercrop
Sole Sugarcane	31.98	—
Sugarcane + Finger millet	29.24	21.53
Sugarcane + Black gram	32.36	22.20
Sugarcane + Soybean	32.65	24.72
Sugarcane + Sesame	33.64	28.90
Sugarcane + Amaranthus	33.32	65.26
Sugarcane + Sunn hemp	31.56	47.97

In pooled mean of intercropping system, the light interception by sugarcane + amaranthus was found higher (49.29%), followed by sugarcane + sunh hemp (39.76%) than all other intercropping system.

Correlation of light interception with yield

The percentage of light (PAR) interception was significantly ($P<0.0001$) affected by intercropping system.The light interception of all intercrops had positive correlation with the yield (grain and green leaf in the case of amaranthus) during both the years. The regression equation were developed between per cent light interception (PLI) and yield of intercrops (Y) as well as sugarcane dry matter (DM).

Yield = 1.0513 * PLI – 16.713 $R^2 = 0.509^{**}$

Dry matter = 4.2492 * PLI – 22.987 $R^2 = 0.847^{**}$

where yield (Y) is in q ha^{-1} and dry matter (DM) is in gm^{-2}

This shows that the intercropping leads to an increase in the total amount of PAR intercepted and in turn relatively improved the total inter-crop productivity. Similar results has been obtained by Awal *et al.* (2006) and Zhang *et al.* (2008).

In the case of sugarcane, the percentage of light intercepted was less compared to all the intercrops at 45 days after planting. This is due to the fact that, sugarcane is a slow growing crop which takes about 90 days for full ground cover for effective utilization of incident light (PAR). Similar observation was made by Nava *et al,*(2016) and mentioned that, leaf area is most critical during the period of early growth when the canopy is not yet closed and only a portion of incident radiation is intercepted. However, light interception at this point is positively correlated with dry weight (gm^{-2}) produced and is evident from the correlation results.Choudhary *et al*. (2017) also reported that, at harvest, cane and CCS yield of sugarcane was positively correlated with maximum temperature, wind velocity and pan evaporation.

From the study, it is concluded that cultivation of intercrops such as finger millet and amaranthus in sugarcane under wide row (150 cm) system of planting with 100 per cent of recommended N application to the main crop will intercept more light which in turn improve the system productivity.

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Received : September 2018; Accepted: March 2019