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Effect of alley cropping on light transmission ratio, growth and yield of winter sorghum (*Sorghum bicolor*) under semi-arid environment

S.B. DEVARANAVADGI, C.S. HUNASHAL, M.B. PATIL, H. VENKATESH AND S.Y. WALI

University of Agricultural Sciences, Bijapur Campus, Karnataka 586 101

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ABSTRACT

An experiment was conducted during 1997–98 and 1998–99 to study light relations and its effect on performance of winter sorghum [*Sorghum bicolor* (L.) Moench] as influenced by different hedge row species. Among the hedge row species, *Gliricidia sepium* allowed the maximum light with highest light transmission ratio (at 30 DAS 78.60%; at 60 DAS 91.85% and at 90 DAS 85%). *G. sepium* gave maximum green biomass yield (4.299 tonnes/ha) in addition to maximum grain yield (1.101 tonnes/ha), possibly mainly owing to erect growth behaviour of *G. sepium*. The results indicated that in semi-arid environment *G. sepium* + winter sorghum alley cropping system was promising owing to its better light relations in the system.

Key words : Alley cropping, LTR, *G. sepium*, Sorghum, Green biomass

Alley cropping is one of the most important agroforestry technologies developed and being adopted. It is an integrated land-management practice in which fast-growing and coppicing trees or shrubs are planted in a hedge row at required spacing and the inter-spaces are utilized for foodgrain or forage production. Light is one the important resources for which there will be a competition between the component crops in alley cropping systems because they differ in their growth habits. Unlike moisture and nutrients light cannot be stored for later use. In situations where water and nutrients are not limiting factors, the rate of dry-matter production by crops is primarily determined by the amount of solar radiation intercepted by its canopy. In an alley cropping system, hedge row species may shade the annual crops resulting in reduction of crop yields. A number of potential tree or shrub species are cultivated as hedge species in alley cropping. The studies on light relations caused by different hedge row species on associated field crops are meager. In the present investigation an effort was made for assessing the light incidence on winter sorghum grown in association with different hedge row species raised in alley cropping models.

MATERIALS AND METHODS

The experiment was conducted at the farm of Regional Research Station, Bijapur, located in the northern dry zone of Karnataka. The tract has a typical semi-arid climate with low and erratic rainfall. The average rainfall of the experimental site was 594 mm with 38 rainy days and the mean annual temperature is 28.4° C. The soil was clay loam with a bulk density of 1.46 g/cc. The field moisture-holding capacity and wilting points were 44.71% and 25.43% respectively. The soil pH was 7.9 with low electrical conductivity. The organic carbon was medium with poor available nitrogen and poor phosphorus. However, the soils were rich in available potash content. The soil belongs to vertisols with medium black profiles. The practice of agriculture is the predominant land-use system. The area comprises about 80% Vertisols, where contour bunds and field boundary bunds are exclusively adopted for effective soil and water conservation, such bunds normally occupy about 5–6% of arable land and are frequently susceptible to breaching due to swelling and shrinking nature of Vertisols. Hence, alley cropping or hedgerow cropping is recommended as an alternate to earthen bunding. But the studies on light relations in different alley cropping models are rare.

The present study was carried out in the established alley cropping experimental site involving 6 hedge row species and a rubble bund (control) which were established during 1996 in medium black soils. The six hedge row species under test were *Gliricidia sepium*, *Leucaena leucocephala*, *Albizia lebbeck*, *Dalbergia sissoo*, *Cassia saimea* and *Desmenthus virgatus*. The study on performance of hedge row crop, field crop and light incidence was carried out under field conditions. The tree alleys were oriented along contours in nearly east–west direction. The sowing of winter sorghum was taken across the slope by using bullock-drawn drill. The yield of both components was worked out for per hectare. The light index

was recorded in lux by using lux meter. The study was taken up during 1997–98 and 1998–99.

Winter sorghum was raised as test crop and it was sown during the second fortnight of September during both the years. The grain and stover yields of winter sorghum for net plot was recorded in kg and per hectare yield levels expressed in tonnes/ha. The grain biomass production and number of coppice shoots/plant were recorded. The green biomass yield was expressed as tonnes/ha.

The study on light incidence as affected by different hedge row species was conducted as per the procedure prescribed by Yoshida *et al.* (1972). The light intensity was measured at noon at the crop canopy level by using lux meter. In view of the orientation of the row in east–west direction, and also since the crop season falls during winter, i.e. October–February, where the insolation (incoming solar radiation) is incident from Southern hemisphere, the effect of shadow of tree species on sorghum crop would be nearly same at any time of the day.

The light incidence on winter sorghum with different hedgerows was compared with the control (without hedgerow rows) and expressed in percentage in lux (Devaranavadagi, 2000) as light transmission ratio (LTR). One observation was made at crop canopy level at a spot between the hedgerow and first crop line and another observation was made at the centre of alley at crop canopy level and the average of these 2 readings was recorded and expressed as percentage.

RESULTS AND DISCUSSION

The different hedgerow species significantly affected the grain yield of winter sorghum (Table 1). Among the different hedgerow treatments, the maximum grain yield of winter sorghum was recorded with *G. sepium* which was significantly superior to that of others. The next best was *Desmanthus virgatus*. The minimum grain yield was recorded in *A. lebbeck*. Similar to the grain yield, the hedgerow species had significant effect on stover yields as well. The stover yield recorded with *G. sepium* was highest, followed with *D. virgatus*. The minimum stover yield was observed in *A. lebbeck*.

The total green biomass production of different hedgerow species varied significantly (Table 2). The highest green biomass was produced by *G. sepium,* followed by *L. leucocephala.* The lowest in the order was *D. sissoo.* Similar to green biomass the coppice shoots/plant of different hedgerow species exhibited significant differences. Among species, highest coppice shoots/plant were noticed in *D. virgatus*, followed by *L. leucocephala* and *G. sepium.* The minimum number of coppice shoots were produced by *A. lebbeck.*

The light transmission ratio (LTR) varied significantly at different growth stages of sorghum as influenced by different hedgerow species (Table 3). The LTR in *G. sepium* was significantly higher compared to other hedgerow species, whereas the LTR was lower with *D. sissoo* at different growth stages of winter sorghum (Table 3).

Table 1. Grain and stover yields (tonnes/ha) of winter sorghum as influenced by different hedgerow species

Treatment	Grain yield			Stover yield		
	1997–98	1998–99	Average	1997–98	1998–99	Average
Leucaena leucocephala	0.680	0.760	0.720	1.134	1.336	1.235
Gliricidia sepium	1.030	1.171	1.101	1.505	1.746	1.627
Cassia siamea	0.735	0.804	0.770	1.252	1.514	1.383
Albizia lebbeck	0.620	0.704	0.662	1.081	1.288	1.184
Desmanthus virgatus	0.856	0.972	0.914	1.323	1.608	1.465
Dalbergia sissoo	0.633	0.718	0.675	1.141	1.322	1.231
CD (P=0.05)	0.088	0.110	0.069	0.152	0.145	0.101

Table 2. Total biomass (tonnes/ha) and coppice shoots/plant for different hedgerow species as influenced by winter sorghum

Treatment	Total biomass			Coppice shoots/plant		
	1997–98	1998–99	Pooled	1997–98	1998–99	Pooled
Leucaena leucocephala	3.053	3.367	3.210	4.35	5.28	4.81
Gliricidia sepium	4.070	4.528	4.299	4.18	4.75	4.46
Cassia siamea	1.865	2.581	2.223	3.05	3.33	3.19
Albizia lebbeck	1.859	2.173	2.010	2.00	2.38	2.19
Desmanthus virgatus	2.042	2.175	2.108	5.45	5.78	5.61
Dalbergia sissoo	1.567	1.749	1.658	2.25	2.48	2.36
CD (P=0.05)	0.325	0.268	0.203	0.30	0.21	0.18

Table 3. Light transmission ratio (%) at different growth stages of winter sorghum as influenced by different hedgerow species

Treatment	30 DAS			60 DAS			90 DAS		
	1997–98	1998–99	Average	1997–98	1998–99	Average	1997–98	1998–99	Average
Leucaena leucocephala	75.31	72.29	73.80	88.39	86.63	87.51	74.30	76.81	78.06
Gliricidia sepium	80.03	77.33	78.60	92.23	91.48	91.85	86.65	83.84	85.24
Cassia siamea	75.15	71.98	73.56	88.64	88.55	88.59	82.04	80.40	81.22
Albizia lebbeck	76.04	73.85	74.94	85.78	85.49	85.63	78.95	75.91	77.43
Desmanthus virgatus	74.78	71.48	73.13	86.60	85.83	86.21	78.45	78.60	78.53
Dalbergia sissoo	72.5	69.29	70.92	83.96	84.50	84.23	78.38	75.71	77.04
CD (P=0.05)	NS	4.25	3.12	NS.	3.04	2.65	2.86	4.13	2.40

Days Days after sowing

The response of winter sorghum to light transmitted through different hedge row species and received by it, in terms of its final yield, is shown in Fig. 1. A general increase in grain yield vis-a-vis the LTR was observed. Sorghum grown under *Gliricidia sepium* gave the highest yield, as the LTR in this case was 92%. On the other hand, *Dalbergia sissoo* and *Albizia lebbeck,* which transmitted only 82–86%, resulted in sorghum yield of less than 0.700 tonne/ha. However, the sorghum grown under *Desmanthus virgatus* gave 0.90 tonne/ha at LTR of only 86%. This could be due to erect growth nature of the tree species.

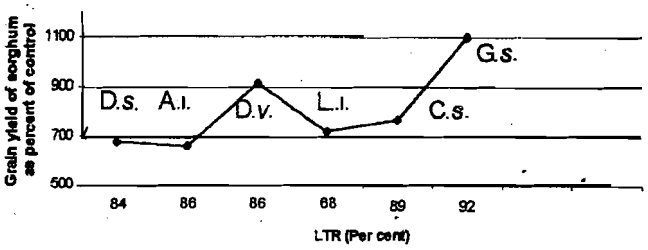

Fig. 1. Grain yield versus light transmission ratio through different hedgerow tree species

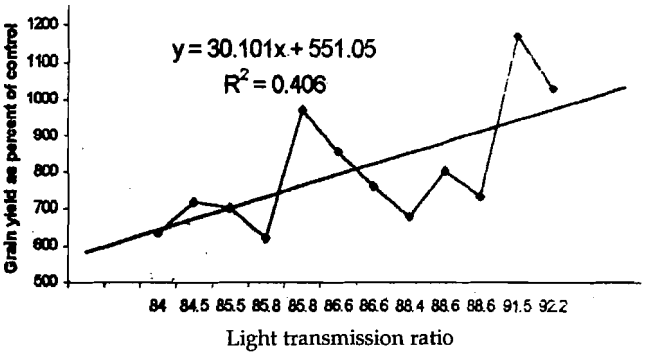

Fig. 2. Grain yield of sorghum versus LTR at 60 DAS

Grain yield data of sorghum grown under the different tree species for 2 years plotted against corresponding LTR at 60 DAS of sorghum crop, showed a linear trend, with a correlation coefficient of 0.63.

The linear model developed was :

$$Y = 30.101 (LTR) + 551.05$$

where Y is in kg/ha. The model needs further testing

The performance of winter sorghum in terms of grain and stover yield was much affected by *D. sissoo* and *A. lebbeck.* Though the green biomass yield was highest in *G. sepium,* the winter sorghum yields were not affected. This indicates the superiority of *G. sepium* + winter sorghum system to others in terms of its biological yield potential. Similar results were obtained by Kalaghatagi *et al.* (1998). The LTR at the growth stages was significantly higher in *G. sepium* compared to other hedge row species. It may be due to erect growth of the coppice shoots of *G. sepium.* whereas other species have spreading branching habit. This factor might have contributed to superior sorghum yield grown in association with *G. sepium.* This confirm the results of Sitompul *et al.* (1992) and Heinman *et al.* (1985) indicating the suitability of *G. sepium* for alley cropping.

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