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Studies on Light Interception in a Sorghum-based Agri-silviculture System in Semi-arid Tract

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Abstract: Studies were conducted on light relations between the overstorey and understorey crops in agri-silvicultural systems with rabi sorghum as test crop. Among the tree species *Hardwickia binata* allowed maximum light penetration through its canopy with highest light transmission ratio (LTR) (30 DAS 91.7%, 60 DAS 91.3%, 90 DAS 90.7% and at harvest 92.2%). The grain yield of rabi sorghum in association with *H. binata* was maximum (924 kg ha^{-1}), but dry woody biomass yield was minimum (1,019 kg ha^{-1}). The trends suggest that there is direct relation between the incident light received by undertorey crop and its grain yield. The higher LTR recorded in case of *H. binata* was possible mainly due to its compact and excurrent branching behavior, which was not found in other tree species. Hence, it can be inferred that for agri-silvicultural systems tree species with compact and excurrent branching and yielding timber may be preferred.

Key words: LTR, agri-silviculture, excurrent branching, understorey, overstorey.

The tree-crop interactions may have significant bearing on the total productivity of an agroforestry system. The above ground resource sharing (light, space) depends upon the tree species and canopy structure. The amount of light intercepted by tree depends on the amount of incident light and fraction of light intercepted through canopy. Low light intensity is an important constraint for higher yield. The degree of shading of annual crops increases with tree density. 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. A number of tree species have been identified for agri-silvicultural systems. The studies on light relations as influenced by different tree species on associated field crops under semi-arid conditions are meager. The present investigation was carried out to assess the light incidence pattern of some tree species on the associated sorghum crop when grown in agri-silvicultural models. The test crop was rabi sorghum.

Materials and Methods

The studies were conducted during 1997-98 and 1998-99 at Regional Agricultural Research Station, Bijapur, where typical semi-arid environment exists with low and erratic rainfall in the northern dry zone of Karnataka. The average rainfall of the experimental site is 594 mm.

The studies were carried out in the established agri-silvicultural experimental site having seven dryland tree species. Earthen bund alone without tree was taken as control. These tree species were raised in three blocks in 1991. Performance of tree crops, field crop and light incidence were recorded. The light interception was

recorded in lux using lux meter. The rabi sorghum was grown as the test crop and grain and stover yields were recorded. The plant height, diameter at breast height (DBH), crown spread and dry biomass were also recorded.

The light interception was measured following Yoshida *et al.* (1972). Light incidence at crop canopy level was measured at noon time (a) along the edge of the plot between tree species and crop canopy and (b) in the middle of the plot by lux meter. Their average was then expressed as the percentage ratio of the light incidence in control plot (no tree species), which is LTR.

Results and Discussion

Tree species had significant effect on rabi sorghum grain yield (Table 1). Control (without trees) produced highest grain yield of 931 kg ha^{-1}. Among the tree species *H. binata* (851 kg ha^{-1}) was the best, followed by *D. sissoo* (694 kg ha^{-1}). The minimum grain yield was recorded with *A. nilotica* (469 kg ha^{-1}). Similarly the tree species had significant effect on the stover yield of rabi sorghum. The maximum stover yield was recorded in control (1381 kg ha^{-1}). Among the tree species *H. binata* (1329 kg ha^{-1}) was found to be superior to others. The minimum stover yield was recorded in case of *A. nilotica* (906 kg ha^{-1}).

The height of tree species varied significantly (Table 1). The tallest plants were of *L. leucocephala* (8.71 m), followed by *A. nilotica* (7.88 m). *H. binata* (5.10 m) was shortest in the order. The DBH of different tree species also exhibited variations (Table 1). The largest DBH was recorded by *A. nilotica* (18.98 cm) closely followed by *A. lebbeck* (16.73 cm). There were significant differences in the crown spread of different tree species (Table 1). The crown spread was maximum in *A. nilotica* (8.36 m) and the minimum was recorded in *H. binata* (3.18 m). The total

Table 1. Pooled data of plant height, diameter at breast height, crown spread, biomass produciton of tree species and grain and stover yields of crop

Treatment	Plant height (m)	DBH (cm)	Crown spread (m)	Total biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Control (No. trees)	–	–	–	–	931	1381
Acacia nilotica	7.88	18.98	8.36	3863	469	906
Albizia lebbeck	6.79	16.73	6.48	3440	522	939
Azadirachta indica	6.45	14.89	5.21	1720	637	1066
Cassia siamea	6.35	11.75	4.38	1482	577	1013
Dalbergia sissoo	5.79	9.87	4.21	1289	694	1127
Hardwickia binata	5.10	10.24	3.18	1019	851	13.29
Leucaena leucocephala	8.71	16.54	6.02	3600	497	921
S.Em±	0.46	0.9	0.56	141.42	17.76	32.98
CD at 5%	0.94	2.01	1.16	291.89	36.38	67.54

Table 2. Light transmission ratio (%) at different growth stages of rabi sorghum as influenced by different tree species

Treatment	1997-98	1998-99	Average	1997-98	1998-99	Average
		30 days			60 days	
Control (No. trees)	100.0	100.0	100.0	100.0	100.0	100.0
Acacia nilotica	63.0	60.0	61.5	59.7	57.6	58.7
Albizia lebbeck	65.3	62.0	63.7	59.7	59.0	59.3
Azadirachta indica	71.0	74.7	72.8	75.3	78.3	76.8
Cassia siamea	69.0	68.3	68.6	73.6	72.7	73.2
Dalbergia sissoo	71.7	73.7	72.6	76.0	77.3	76.7
Hardwickia binata	92.7	89.7	91.7	92.0	90.6	91.3
Leucaena leucocephala	68.7	66.0	67.3	60.0	62.0	61.0
S.Em±	3.48	3.58	2.49	2.94	3.20	2.16
CD at 5%	7.46	7.68	5.10	6.31	6.86	4.43
		90 days			At harvest	
Control (No. trees)	100.0	100.0	100.0	100.0	100.0	100.0
Acacia nilotica	66.0	62.7	64.3	62.0	61.0	61.5
Albizia lebbeck	68.7	63.3	66.0	64.3	62.3	63.3
Azadirachta indica	73.3	77.3	75.3	77.7	79.3	78.5
Cassia siamea	71.6	75.7	73.7	76.3	74.3	75.3
Dalbergia sissoo	74.7	78.3	76.5	77.3	78.3	77.8
Hardwickia binata	90.7	90.6	90.7	92.0	92.3	92.2
Leucaena leucocephala	74.3	64.7	69.5	64.0	65.3	64.7
S.Em±	3.06	2.77	2.06	1.84	2.19	1.43
CD at 5%	6.58	5.95	4.23	3.94	4.70	2.93

biomass production also exhibited significant differences. The total biomass was highest in case of *A. nilotica* (3863 kg ha^{-1}) followed by *L. leucocephala* (3600 kg ha^{-1}). The minimum value was recorded with *H. binata* (1019 kg ha^{-1}).

The LTR varied significantly at different growth stages of rabi sorghum (Table 2). At all the growth stages of rabi sorghum, the LTR in case of *H. binata* was significantly high compared to all other tree species, whereas significantly low LTR was recorded by *A. nilotica* at corresponding growth stages of rabi sorghum.

The trees *A. nilotica*, *A. lebbeck* and *Leucaena leucocephala,* which caused less than 65% LTR, resulted in sorghum yield of 50 to 55% of the potential. On the other hand, *Cassia siamea, Azadirachta indica* and *Dalbergia sissoo* caused 70-80% LTR and the sorghum yield was 60-75% of potential. Finally, the grain yield of sorghum was as high as 90% under LTR of 91% in case of *Hardwickia binata.* It

can therefore be inferred that, selection of tree types can be made based on minimum value of 70% LTR, so that the sorghum component can provide sustainable grain yield.

A linear trend was observed between LTR and grain yield (per cent of control) using individual data of two years. The trend line has a coefficient of determination as high as 0.86. The linear relation is given as:

$$Y = 3.4298 \; x + 40.272$$

where,

x = LTR and

Y = grain yield as per cent of control.

The performance of rabi sorghum in terms of grain and stover yield was much affected by *A. nilotica* and *A. lebbeck*. The rabi sorghum yield is directly affected by tree height and crown spread which reduced in availability of incident light for growth of understorey crop. Similar findings were recorded by Bisaria *et al.* (2000). The LTR at all growth stages of rabi sorghum was significantly higher in *H. binata* as compared to other tree species. It was mainly due to its compact and excurrent branching habit, which allowed more light to under storey crop of rabi sorghum, resulting in highest grain yield. The present results are in conformity with the findings of Itnal (1987) and Korawar (1992). These studies suggest that tree species with compact and excurrent branching resulting in higher LTR are ideal for growing in agri-silvicultural systems in semi-arid environments.

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