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Light interception pattern of fodder trees intercropped with soybean and safflower in malnad region of Karnataka

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ABSTRACT

Fodder tree plantation was established at 5 x 3 m spacing in 2014 with seven fodder tree species *viz.*,1. *Calliandra calothyrsus*, 2. *Albizia lebbeck*, 3. *Leucaena leucocephala*, 4. *Sesbania grandiflora*, 5. *Gliricidia sepium,* 6. *Moringa oleifera* and 7. *Bauhinia purpurea.* The height of pollarding fodder tree species was maintained at 2 m. The soybean and safflower intercrops were sown in the interspaces of fodder tree species in *kharif* and *rabi* season. The experiment was conducted with Randomized Block Design (RBD) with three replications. Light transmission ratio among the fodder tree based agroforestry systems was observed in the system *Albizia lebbeck* + soybean (82.73, 67.03 and 63.77 %) followed by the combination of *Calliandra calothyrsus* + Soybean (74.40, 65.77 and 59.77 %) at 20, 40 DAS and at harvest respectively. Whereas among fodder tree based agroforestry systems with safflower crop, maximum light transmission ratio was found in T_6 - *Moringa oleifera* + Safflower (85.33, 72.57 and 64.60 %) followed by the treatment T_2 - *Albizia lebbeck* + Safflower (75.87, 72.13 and 62.97 %) at 20, 40 DAS and at harvest respectively

Key Words:

Photosynthetically Active Radiation (PAR), light Transmission Ratio, light interception, fodder plantation, pollarding height.

INTRODUCTION

The components of intercrops or agroforestry system often differ greatly in size, with the result that the growth of the smaller understorey species may be inhabited by shading, and possibly also by competition for water and nutrients. Competition for light is the primary limitation when water and nutrients are freely available. However, in, many tropical systems, water (*e.g.* semiarid regions) or nutrient availability (e.g. acidic, leached or degraded soils) is the major limiting factor rather than light (Rao et al. 1998; Bhardwaj et al. 2002). It is not always straight forward to establish the primary limitation when more than one factor is marginal. For example, a species which establishes early has advantage in light capture through more rapid initial shoot growth may also exhibit greater root growth and hence resource capture because of the increased availability of photosynthates. This may in turn further improve shoot growth and light interception to the determent of the less competitive species in the mixture.

Competition between species in mixed stands differs from that between plants within monocultures in that the component species of intercrops may impose different demands on the available resources. The intensity of competition is greatest when site requirements are similar to the point where species with overlapping niches may be unable to coexist within the same community. Vandermeer (1989) suggested that competition may be more severe between similar species than between species with contrasting growth habits. However, the opportunity for complementarity of resource use between species is restricted by the fact that all plants are competing for the same and usually finite resources (light, CO_2, water, nutrients *etc.*).The maximum attainable biomass for individual species depends primarily on the availability of light, water and nutrients. To increase productivity, further, crops must either capture more of these resources or use them more efficiently.

The woody perennial component of agroforestry systems has a well established root system, at least after the initial establishment period. Thus, the woody species already has a substantial advantage in its access to below ground resources when the crop component is sown. This is also true for the capture of light unless the tree canopy is managed (*e.g.* by lopping and pruning) before sowing. Secondly, because of its size and age, the woody component has a considerable advantage in sequestering recourses from a large area and in enhancing soil physical and chemical properties under its canopy (Kessler 1992 and Belskyo et al. 1993).

Above ground resource sharing light and space depends upon the age of the tree species and crops. The amount of light intercepted by the trees depends on the amount of incident and fraction of light intercepted through canopy, however, low light intensity is one of the important constraints for higher yield. The degree of shading to annual crops increases with an increase in the proportion of land occupied by trees, especially canopy cover, in agroforestry. Therefore, a study was undertaken to understand the light interception pattern of different fodder tree species on intercrops under agroforestry systems.

MATERIALS AND METHODS

A field experiment was carried out to study the light interception pattern of different fodder tree species on the intercrops under agroforestry systems in Malnad region of Karnataka (India) during 2018 in *kharif* and *rabi* seasons. The experimental site is located at 15° 26' North latitude, 75° 0' East longitude and an elevation (altitude) of 678m above mean sea level. The experimental plot is situated in transitional tract, representing northern transitional climate zone (Zone 8) of Karnataka (Anon 2014). The mean annual rainfall of the site is 777.95 mm. The mean maximum temperature varied from 26.61 to 36.86 °C and mean minimum temperature varied from 13.58 to 20.92 °C. Higher relative humidity was recorded during June to September and varied from 61.70 to 86.07 %. The soil type of experimental site is medium deep black soils. The fodder plantation was established in 2014 with seven fodder tree species *viz.,* 1. *Calliandra calothyrsus*, 2. *Albizia lebbeck*, 3. *Leucaena leucocephala*, 4. *Sesbania grandiflora*, 5. *Gliricidiasepium,* 6. *Moringa olifera,* 7. *Bauhinia purpurea* and 8.Sole Field Crops (soybean and safflower). The spacing provided for fodder tree is 5m × 3m. The pruning height of fodder tree species was maintained at 2 m. The soybean and safflower crops were sown in the interspaces of fodder tree species in *kharif* and *rabi* seasons, respectively (Fig. 1 and 2). The field experiment was conducted with Randomized Block Design (RBD) with three replications.

The Photosynthetically Active Radiation (PAR) and Light Transmission Ratio (LTR) were measured by using Digital Lux meter at an interval of 120 days. In an open area, the intercepted radiation was calculated using following formula. The intercepted radiation was expressed in foot candles (one foot candle equals to 10.76 lux) and expressed in percentage of PAR of an open area.

Intercepted Radiation = $Q_T - Q_R - Q_G$

Where, Q_T - Total Radiation, Q_R - Reflected Radiation and Q_G - Radiation at ground level.

The light transmission ratio (LTR) is the ratio between the light intensity under tree canopy but above the field crops and light intensity over the field crops in the absence of trees. The light intensity was measured by Digital Lux meter on cloudless (clear sky) days at an interval of 120 days. Light transmission ratio was calculated by using the following formula as suggested by Yoshida et al. (1971) and expressed in percentage.

$$\text{LTR (\%)} = \frac{\text{Light intensity under tree canopy with intercrops}}{\text{Light intensity over intercrops in absence of trees}} \times 100$$

Fig. 1. Light interception under AF system with soybean intercrop.

Fig. 2. Light interception under AF system with safflower intercrop.

RESULTS AND DISCUSSIONS

Intercepted Radiation under fodder tree based agroforestry system with intercrops

Intercepted radiation (Photosynthetically Active Radiation) as influenced by fodder trees under agroforestry system with soybean intercrop at various growth stages during 2018 is described in Table 1. Intercepted radiation data showed that the treatments differed significantly among agroforestry system during the periods of experiment.

In *kharif,* the intercepted radiation of fodder trees with intercrop play an important role in the productive performance of fodder tree species and intercrops under agroforestry system. The result observed significant variation in intercepted radiation among fodder tree species with soybean at various stages of growth of soybean at 20, 40, 60 DAS and at harvest.

Table 1. Intercepted Radiation (PAR %) as influenced by fodder tree based agroforestry system intercropped with Soybean and Safflower.

Agroforestry system	Intercepted Radiation (PAR %) with intercrops							
	Soybean crop				Safflower crop			
	20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest
T_1 – *C. calothyrsus*+ Soybean	35.04	43.65	46.98	29.05	41.69	50.41	53.25	35.74
T_2 – *A. lebbeck* + Soybean	29.63	38.20	42.15	23.95	36.30	44.92	49.48	30.65
T_3 – *L. leucocephala* + Soybean	34.54	42.84	46.66	28.75	41.26	49.54	53.33	35.63
T_4 – *S. grandiflora* + Soybean	34.53	42.81	46.57	28.28	41.20	49.51	52.86	35.41
T_5 – *G. sepium* + Soybean	33.64	41.94	46.16	28.04	40.33	48.61	52.80	34.53
T_6 – *M. olifera* + Soybean	31.81	40.08	43.33	26.19	38.48	46.76	50.00	32.85
T_7 – *B. purpurea* + Soybean	30.79	39.08	43.02	25.15	37.33	45.54	49.70	31.82
T_8 - Sole Crop - Soybean	37.55	46.05	49.31	31.92	44.22	52.73	55.98	38.59
Mean	33.44	41.83	45.52	27.67	40.10	48.50	52.18	34.40
SEm ±	0.342	0.388	0.184	0.478	0.340	0.387	0.410	0.361
CD @ 5%	1.048	1.189	0.563	1.465	1.042	1.185	1.256	1.105

DAS – Days After Sowing; SB – Soybean; PAR - Photosynthetically Active Radiation

The highest intercepted radiation was observed under soybean as sole crop (37.55, 46.05, 49.31 and 31.92 per cent at 20, 40, 60 DAS and at harvest, respectively) as compared to agroforestry systems. Among agroforestry systems studied, the highest intercepted radiation was registered in T_1 - *Calliandra calothyrsus* + Soybean agroforestry system (35.04, 43.65, 46.98 and 29.05 % at 20, 40, 60 DAS and at harvest, respectively), followed by T_3 - *Leucaena leucocephala* + Soybean agroforestry system (34.54, 42.84, 46.66 and 28.75 %, at 20, 40, 60 DAS and at harvest, respectively), respectively; however, it was lowest in T_2 - *Albizia lebbeck* + Soybean agroforestry system (29.63, 38.20, 42.15 and 23.95 % at 20, 40, 60 DAS and at harvest, respectively).

During *rabi* season, the data pertaining to intercepted radiation (Photosynthetically Active Radiation) as influenced by fodder trees under agroforestry systems at different stages of growth with safflower during 2018 is described in Table 1. The result observed significant variation in intercepted radiation among fodder tree species intercropping with safflower at various stages of its growth at 20, 40, 60 DAS and at harvest during 2018.

The maximum intercepted radiation was reported in safflower sole crop (44.22, 52.73, 55.98 and 38.59 % at 20, 40, 60 DAS and at harvest respectively), followed by different AF systems. Among fodder based agroforestry systems, the highest intercepted radiation was found in T_1 - *Calliandra calothyrsus* + Safflower agroforestry system (41.69, 50.41, 53.25 and 35.74 % at 20, 40, 60 DAS and at harvest respectively) followed by T_3 - *Leucaena leucocephala* + Safflower agroforestry system (41.26, 49.54, 53.33 and 35.63 %, at 20, 40, 60 DAS and at harvest, respectively). It was noticed significantly lower values of intercepted radiation under T_2 - *Albizia lebbeck* + Safflower agroforestry system (36.30, 44.92, 49.48 and 30.65 %, at 20, 40, 60 DAS and at harvest, respectively).

Intercepted radiation (PAR) showed a positive significant correlation (R^2 = 0.54 @ 5%) with green tree fodder yield under fodder tree based agroforestry systems. But there was no significant correlation between yield of intercrops (soybean and safflower) and Intercepted radiation (PAR) under fodder tree canopies indicating shade as the major factor for the extent of 35.23 per cent reduction of intercrop yields under trees as compared to sole crop.

The similar studies conducted by Das et al. (2017) on light interception pattern below the canopy at different age of the trees indicated that the light intensity below the mango trees decreased with the increasing tree age. The light intensity below the guava plants was higher than the other plants at a distance of 1 m during all the 5 years of observation. During all the years, the light intensity at a distance of 2 m under the filler plants followed the order Gamhar>Guava>Lemon. According to Siebert (2002), shade trees protect the soil from adverse insolation, help maintain soil organic matter, reduce evaporation from soil, and retain soil productivity. Higher soil moisture benefits soil biota and decomposition. Hence, the inconsistencies on yield of intercrops recorded in the present investigations can be explained by the effect of light intensity on photosynthetic efficiency of the crops (Das et al. 2017).

A study (Anon 1992) revealed that radiation varied from 15 to 60 per cent around *Acacia nilotica* trunk which interferes with the sorghum for light utilization in arid zone. On the other hand, radiation of 13 to 31 per cent variation around *Acacia auriculiformis* affected the black gram yield (Anon 1986).

A similar study reported that wheat grain yield decreased with increasing duration of shading (Nazir et al. 1995). Maize yield decreased almost proportionately up to 50 per cent reduction in radiation (Anon 1993). Crown shading of *Paulownia* had affected wheat grain yield and 1000 grain weight depending upon the distance the trees as compared to control (Lang et al. 1995). In contrast, one of the studies, cowpea yields were higher due to better light interception under *Fatherbia albida* at Hyderabad (Anon., 1992). The maximum amount photosynthetically Active Radiation (PAR) was observed under *F. albida.* Sorghum and horse gram yields were increased under trees as compared to sole cropping (Anon. 1992).

In a similar experiment, Peng et al. (2009) revealed that light passing through the tree canopy experiences change in intensity because of reflectance, absorbance, and transmittance.

Light Transmission Ratio (LTR, %) under fodder trees based agroforestry system with intercrops

Light transmission ratio under fodder tree based agroforestry system with soybean acts as influencing factor for the better performance of soybean crop under agroforestry system. The results observed significant variation in light transmission ratio among different fodder tree species with soybean intercrop in different growth stages at 20, 40 DAS and at harvest during 2018. The data pertaining to light transmission ratio (%) differed significantly as influenced by fodder tree based agroforestry systems with soybean intercrop at different growth stages during 2018 and is presented in Table 2.

Table 2. Light Transmission Ratio (%) as influenced by fodder tree based agroforestry system intercropped with Soybean and Safflower.

Agroforestry system	Light Transmission Ratio (%) with intercrops					
	Soybean crop			Safflower crop		
	20 DAS	40 DAS	Harvest	20 DAS	40 DAS	Harvest
T_1 – *C. calothyrsus*+ Soybean	74.40	65.77	59.77	51.90	42.03	47.30
T_2 – *A. lebbeck* + Soybean	82.73	67.03	63.77	75.87	72.13	62.97
T_3 – *L. leucocephala* + Soybean	70.20	63.57	53.67	55.33	47.17	53.47
T_4 – *S. grandiflora* + Soybean	47.60	48.73	43.60	72.83	68.40	62.63
T_5 – *G. sepium* + Soybean	70.40	56.83	52.23	70.33	63.27	61.27
T_6 – *M. olifera* + Soybean	70.43	61.73	51.33	85.33	72.57	64.60
T_7 – *B. purpurea*+ Soybean	52.77	58.47	53.37	70.27	58.83	55.53
T_8 - Sole Crop - Soybean	100.00	100.00	100.00	100.00	100.00	100.00
Mean	71.07	65.27	59.72	72.73	65.55	63.47
SEm ±	0.889	0.727	1.742	0.713	1.327	1.255
CD @ 5%	2.721	2.226	5.336	2.183	4.065	3.843

DAS – Days After Sowing; SB – Soybean

Among the fodder tree based agroforestry systems, the highest light transmission ratio was observed in T_2 – *Albizia lebbeck* + soybean agroforestry system (82.73, 67.03 and 63.77 %, at 20, 40 DAS and at harvest, respectively), followed by T_1 - *Calliandra calothyrsus* + Soybean agroforestry system (74.40, 65.77 and 59.77 %, at 20, 40 DAS and at harvest respectively) which differed significantly from other fodder tree based agroforestry system. Among the all the treatments, T_4 - *Sesbania grandiflora* + Soybean was having a significant reduction in intercepted radiation with values such as 47.60, 48.73 and 43.60 per cent at 20, 40 DAS and at harvest respectively.

The fodder tree based agroforestry systems intercropped with safflower significantly influenced the light transmission ratio (%) in different growth stages during 2018 and data is described in Table 2. The result reported a significant variation in light transmission ratio among different fodder tree species with safflower intercrop in various stages of growth at 20, 40 DAS and at harvest during 2018. Among the fodder tree based agroforestry systems, the maximum light transmission ratio was found in T_6 - *Moringa oleifera* + Safflower (85.33, 72.57 and 64.60 %) followed by T_2 - *Albizialebbeck* + Safflower (75.87, 72.13 and 62.97 % at 20, 40 DAS and at harvest, respectively), which differed significantly from other fodder tree based agroforestry system. However, the light transmission ratio recorded in T_1 - *Calliandra calothyrsus* + Safflower agroforestry system was minimum with values such as 51.90, 42.03 and 47.30 per cent in different growth stages of safflower.

Light transmission ratio (LTR) was showed a significantly positive correlation with both the intercrops *viz*., soybean (R^2 = 0.86 @ 5%) and safflower (R^2 = 0.95 @ 5%) under fodder tree based agroforestry systems indicating the importance of light intensity on yield of both the field crops. But light transmission ratio (LTR) was not significant with negative correlation with yield of green tree fodder under fodder tree based agroforestry systems.

The similar study on microclimate variation around the tree cover by Harsha and Tewari (1988) revealed that in silvi-pastoral system of *Acacia tortalis,* only 14 to 30 per cent of total incident light was received around trees and were insufficient for the growth of grass. At Dharwad, highest light transmission ratio was observed in teak followed by Eucalyptus, Leucaena and Casuarina (Chandrasekharaiah 1986 and Bhatt 1988).

The study conducted by Nadagoud (1990) noticed that maximum light transmission ratio in teak and minimum in *Dalbergia sissoo* and *Acacia auriculiformis*. Light transmission ratio was lowest near tree line and increased gradually with increasing distance from tree line. The reduction in light transmission ratio was 8, 33, 48 and 51 per cent under anjan, eucalyptus, neem and sissoo, respectively (Korwar 1992). *Acacia nilotica* intercepted light probably resulting in decreased photosynthetic activities of wheat. With reduced photosynthesis, less energy is captured resulting in reduced wheat growth and yield. The reduction in intercrops due to tree canopy have also been reported by various authors (Inamati and Patil 2019; Panwar et al. 2013; Shahapurmath et al., 2020)

CONCLUSIONS

The study revealed that the maximum intercepted radiation was noticed under sole soybean crop (37.55, 46.05, 49.31 and 31.92 %) at 20, 40, 60 DAS and at harvest respectively during kharif season as compared to tree agroforestry systems. However, *Calliandra calothyrsus* + Soybean agroforestry system received next highest intercepted radiation (35.04, 43.65, 46.98 and 29.05 %) at 20, 40, 60 DAS and at harvest respectively. During rabi season, maximum intercepted radiation was reported in safflower sole crop (44.22, 52.73, 55.98 and 38.59 %) followed by agroforestry system *Calliandra calothyrsus* + Safflower (41.69, 50.41, 53.25 and 35.74 %) at 20, 40, 60 DAS and at harvest respectively. Among the fodder tree based agroforestry systems with soybean as intercrop during kharif season, the highest light transmission ratio (82.73, 67.03 and 63.77 %) was found in *Albizia lebbeck* + soybean agroforestry system at 20, 40 DAS and at harvest, respectively. Whereas in rabi season among the fodder tree based agroforestry systems, the maximum light transmission ratio was recorded in *Moringa oleifera* + Safflower (85.33, 72.57 and 64.60 %) at 20, 40 DAS and at harvest respectively.

A significant positive correlation (R^2 = 0.54 @ 5%) was observed between intercepted radiation (PAR) and yield of green tree fodder under fodder tree based agroforestry systems. Light transmission ratio (LTR) showed a significant positive correlation with yield of intercrops *viz.*, soybean (R^2 = 0.86 @ 5%) and safflower (R^2 = 0.95 @ 5%) under fodder tree based agroforestry systems. Hence, PAR and LTR (%) under fodder tree based agroforestry systems with two intercrops might influence on the consistent production of yield of tree fodder and field crops respectively indicating the importance of light intensity on photosynthetic efficiency of fodder trees and crops.

REFERENCES

Anonymous. 1986. Annual Report. Central Research Institute for Dryland Agriculture, Hyderabad, pp. 44-55.

Anonymous. 1992. Annual Report. Central Research Institute for Dryland Agriculture, Hyderabad, pp. 34-35.

Anonymous. 1993. Annual Report. International Centre for Research on Agroforestry, Nairobi, Kenya, pp. 72-76.

Anonymous. 2010. Annual Report. Department of Agriculture, Government of Karnataka 2014. Source, University of Agricultural Sciences, Bangalore 2010.

Belskyo AJ, Mwonga SM and Duxbury JM. 1993. Effects of widely spaced trees and livestock grazing on understorey environments in tropical savannas. Agroforestry systems, 24: 1-20.

Bhardwaj SD, Panwar P. and Kumar M. 2002. Physical and biochemical changes in seeds as a maturity indices for harvesting *Albizia lebbeck* seeds. J. of Hill Research, 18(1): 52-55.

Bhatt R. 1988. Influence of some tree species on sunflower + pigeon pea cropping system. M.Sc. (Agri) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Chandrasekharaiah AM. 1986. Investigations on agroforestry in the transitional tract of Dharwad. Ph.D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Das B., Dhakar MK., Sarkar PK., Shivendra kumar, Vishalnath Dey P, Singh A K. and Bhatt B P. 2017. Performance of mango (*Mangifera indica*) based agri-horticultural systems under rainfed plateau conditions of eastern India. Indian Journal of Agricultural Sciences, 87(4): 521–527.

Harsha LN. and Tewari JC. 1988. Tree crop interaction in agroforestry systems. In: Workshop Proceedings Agroforestry Rural Needs, 6: 535-541.

Inamati SS and Patil SJ. 2019. Growth and Yield Response of Safflower Under Pongamia Based Agroforestry System. Journal of Tree Sciences, 38(2): 85-91.

Kessler JJ. 1992. The influence of karate (*Vitellaria paradox*) and nere (*Parkia biglobossa*) trees on sorghum production in Burkina Faso. Agroforestry systems, 17: 97-134.

Korwar GR. 1992. Studies on alley cropping and agrisilviculture system in black soils under dry land agricultural conditions. Ph. D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Lang JP., Jhu J. and Liu TZ. 1995. Related changes of wheat yield and photosynthetically active radiation in paulownia-wheat intercropping. Field Crop Abstracts, 48(4): 23p.

Nadagoud VB. 1990. Performance of tree species and their influence on seasonal crops in agroforestry systems under irrigation. Ph.D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Nazir MS., Ahmed R., Cheema SA. 1995. Quantitative analysis effects shisham tree shade in wheat. Pakistan Journal of Agricultural Research, 14 (1): 12-17.

Peng X., Zhang Y., Cai J., Jiang Z. and Zhang S. 2009. Photosynthesis, growth and yield of soybean and maize in a tree-based agroforestry intercropping system on the Loess Plateau. Agroforestry Systems, 76: 569–577.

Panwar Pankaj, Pal S, Chakravarty S, Alam M. 2013. Soil quality and production of low land paddy under agrisilviculture systems in acid soil of West Bengal, India. Range Management and Agroforestry, 34 (1): 51-57

Rao MR., Nair PKR. and Ong CK. 1998. Biophysical interactions in tropical agroforestry systems. Agroforestry Systems, 38: 3–50.

Shahapurmath Girish, Inamati SS and Mutanal SM. 2020. Growth and Yield Performance of Fodder Tree Species With Intercrops Under Agroforestry Systems in Dharwad Karnataka, India. Journal of Tree Sciences, 39(1): 26-34.

Siebert SF. 2002. From shade to sun-grown perennial crops in Sulawesi, Indonesia : implications for biodiversity conservation and soil fertility. Biodiversity and Conservation, 11: 1889–1902.

Vandermeer J. 1989. The Ecology of Intercropping. Cambridge University Press, Cambridge, UK, p. 237.

Yoshida S., Forna DA. and Cock JH. 1971. Laboratory Manual for physiological studies on rice. International Rice Research Institute Publications, Phillippines pp. 36-37.

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