

Original Research Article

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Effect of Sunlight on Different Agri-Silvi-Horticulture Combination under Agroforestry System

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ABSTRACT

A field experiment was conducted on already established silvi-horticultural system of agro-forestry at CCS H.A.U. Regional Research Station, Bawal (Rewari) during the Rabi seasons of 2011-12 and 2012-13, in which, *Dalbergia sissoo* and *Prosopis cineraria* were taken as forest tree species and *Psidium guajava* and *Emblica officinalis* as horticulture trees planted at 6×6 m distance. Winter crops (wheat, barley and oat) were taken in association with perennial woody plants forming agri-silvi-horticultural system of agro-forestry. Seeds of wheat cv. WH- 711, barley cv. BH-393 and oat cv. HJ-8 were sown in line in interspaces. Among the agri-silvi-horticulture system, guava + *kejrri* exhibited the highest yield. Maximum light intensity was received by crop as well as agri-silvi-horticulture system during 12.00 noon to 2.00 p.m and highest being in control followed by guava + *khejri*. Similarly the total light intensity was found maximum in control (2108.08 lux) and guava + *khejri* system (563.85, 876.51, 889.47 and 1109.83) during December, January, February and March, respectively. Same trend was observed for incident solar radiation and maximum ISR was observed under guava + *khejri* during all the months. The grain yield of wheat, barley and fodder yield was found significantly higher under control (sole crop) and among the various agri-silvi-horticulture system, guava + *khejri* system resulted into higher yield i.e. 30.74, 33.84 and 559.00 q/ha, respectively. Likewise the straw yield was found maximum in control and highest among the agri-silvi-horticulture system of guava + *khejri* i.e. 38.43 and 40.02 q/ha in wheat and barley, respectively. Total incident radiation was found positively correlated with grain, straw and fodder yield of wheat, barley and oat during all the month of growth, respectively.

Keywords

Sunlight, Agri-Silvi-Horticulture, Agroforestry system

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Introduction

Plants are dependent upon sunlight to fuel their organic activities; insufficient sunlight stunts or prevents plant growth, while overexposure to sunlight is harmful. Plants subsist upon sunlight that they convert into

chemical energy through the process of photosynthesis. The three sunlight factors that affect plant growth are the quality, intensity and duration of light. Light quality is the color or wavelength that reaches the surface of the plant. Red and blue light highly stimulate plant growth, while green light has minimal

effect. Blue light promotes vegetative leaf growth. Red and blue light together stimulate flowering. The trees reduced photosynthetically active radiation (PAR) by 83 to 88% and soil water content by 9 to 22% in the canopy zone than those in the control plot (G. Singh 2008) Due to attenuation of solar radiation and reduced soil water availability under the canopy, there is need to study the effect of tree species on the vegetation diversity and productivity and to define appropriate technical strategies to manage these species not only to increase species diversity but also to maintain sustainable productivity in dry areas. It is extremely drought resistant, supports a higher understorey plant population than other dryland tree species and has a major role to play in agrisilvicultural and silvopastoral systems (Srivastava and Hetherington, 1991). Crop maturity was observed to be delayed by three weeks under *A. nilotica*, by 9 to 10 days under *D. sissoo*, and only by 6–7 days under *P. cineraria* and *A. indica* (Puri and Bangarwa, 1992).

Materials and Methods

The present study was carried out on 10 years old already established silvi-horticultural system of agro-forestry at Bawl, in which, 2 tree species, *i.e.*, *Shisham* (*Dalbergia sissoo* Roxb.) and *Khejri* (*Prosopis cineraria* L.) and 2 horticultural species, *i.e.*, guava (*Psidium guajava*) and *Aonla* (*Emblica officinalis*) were grown. The perennial woody plants were planted at a distance of 6×6 m from row to row and line to line, respectively. Third components of the system, *i.e.*, winter crops (Wheat cv. WH-711, barley cv. BH-393 and oat cv. HJ-8) were taken in association with perennial woody plants, thus forming agri-silvi-horticultural system of agro-forestry. The data was pooled for 2011-12 and 2012-13 and the homogeneity test for both the years was found non-significant. The various

indices estimated in the study are given as under:-

Light interception

Light intensity was measured by 'Luxmeter' (electronic digital Luxmeter) at crop surface. The reading was taken at monthly interval under all the agri-silvi-horticulture system and in open area during the study period. The data were recorded at 8.00 a.m., 10.00 a.m., 12.00 noon, 2.00 p.m. and 4.00 p.m.

Total incident radiation

Total incident radiation was estimated with the sum of incident radiation by the sole crop during all the months of growth and here the months of growth were taken as December, January, February and March.

Incident solar radiation (%)

It is estimated by the given formula:

$$\text{ISR (\%)} = \frac{\text{Total incident radiation received by agri-horti-silviculture system}}{\text{Total incident solar radiation received by sole crop (control)}} \times 100$$

Correlation

Pearson correlation coefficients were measured using the SAS 9.3 version and level of significance was taken as $P = 0.05$.

Statistical analysis

All the statistical procedures were carried out using SAS 9.3 version and the design used was simple randomized block design and the least significant difference (LSD) was measured with the $P = 0.05$ level.

Results and Discussion

The highest light intensity was observed in control during different months starting from

December (106.76, 432.25, 672.00, 599.33 and 297.75) to March (272.00, 438.67, 640.17, 684.50 and 384.75) at 8.00 a.m., 10.00 a.m., 12.00 p.m. 2.00 p.m. and at 4.00 p.m., respectively, in control (Table 1). Guava + Khejri horti-silviculture system significantly resulted into more light intensity available for the winter crops from December to March from 8.00 a.m. to 4.00 p.m. at the interval of two hours while the minimum in *Aonla* + *Shisham* combination. It might be due to mono layered canopy of *Khejri*. Highest species dominance was recorded for vegetation under *P. cineraria*. Highest average population and community biomass in the *P. cineraria* plots indicated highest facilitative effect of *P. cineraria* tree on the canopy zone vegetation. This indicated that presence of tree canopy promoted regeneration and productivity of the vegetation in the dry areas by ameliorating the adverse conditions particularly in dry areas (Frost and Mcdogald 1989; Singh *et al.*, 2003).

Total light incidence

During all the months from December to March, the total light incidence was highly correlated with the wheat and barley grain and straw yield as well as with the oat green fodder yield (Table 4).

However, maximum correlation value of r is observed in the month of January for wheat grain yield ($r = 0.941$), wheat straw yield ($r = 0.928$), barley grain yield ($r = 0.970$), barley straw yield ($r = 0.938$) and oat green fodder yield ($r = 0.886$).

The total light incidence correlation value were again lesser in February months and higher in March month, which means to say to January and March were the most influential months for wheat and barley grain and straw yield as well as for the green fodder

yield of oat (Table 2).

Yield

Wheat grain and straw yield

It is clear from the data in Table 3 that the pooled grain yield (40.74 q/ha) of sole wheat crop was significantly higher than all combinations of agri-silvi-horticulture system. Among agri-silvi-horticultural combinations, the guava based system supported significantly higher grain yield than *Aonla* based combination. Similar trend was observed in straw yield of wheat, where the straw yield of 49.48 quintals per hectare in control (sole wheat) was significantly higher than all other treatments of agri-silvi-horticulture system.

Barley grain and straw yield

The grain yield (43.90 q/ha) of sole barley crop was significantly higher than all combinations of agri-silvi-horticulture system in Table 3. Among agri-silvi-horticulture system guava based system (guava + khejri and guava + shisham) yielded significantly higher grain yield of barley (33.84 and 32.67 q/ha) than *Aonla* based system (aonla + khejri and aonla + shisham) i.e. 29.84 and 29.37 q/ha, respectively, though guava + *Khejri* and guava + *Shisham* were at par. Similarly, *Aonla* + *Shisham* and *Aonla* + *Khejri* systems were at par. Similar trend was observed in straw yield of barley where the straw yield of barley, as sole crop was 52.20 q/ha which was significantly higher than other treatments. Among the agri-silvi-horticulture systems, guava + *Khejri* + barley significantly higher yield than *Aonla* based agri-silvi-horticulture system.

Green fodder yield of oat

Green fodder yield (q/ha) of oat taken as sole crop were significantly higher than all other

treatments (Table 3).

Table.1 Light intensity (lux) in winter crops under agri-silvi-horticulture system (pooled for 2011-12 and 2012-13)

December					
Treatments	8 a.m.	10 a.m.	12 noon	2 p.m.	4 p.m.
Control	106.75	432.25	672.00	599.33	297.75
<i>Aonla+Shisham</i>	39.17	84.67	144.59	100.25	46.00
<i>Aonla+Khejri</i>	49.59	102.50	155.92	109.42	51.25
<i>Guava+Shisham</i>	42.67	90.92	157.17	149.00	46.00
<i>Guava+Khejri</i>	65.67	106.17	164.67	177.67	49.67
C.D. at 5%	23.00	44.52	94.08	56.76	20.04
January					
Control	109.58	344.50	743.42	594.67	216.08
<i>Aonla+Shisham</i>	51.92	81.67	258.67	213.58	85.50
<i>Aonla+Khejri</i>	56.42	132.75	267.09	231.92	102.17
<i>Guava+Shisham</i>	52.50	112.67	310.59	211.25	84.84
<i>Guava+Khejri</i>	55.00	127.92	320.67	268.25	104.67
C.D. at 5%	6.77	35.79	75.39	33.27	37.15
February					
Control	181.42	356.97	688.82	615.75	263.87
<i>Aonla+Shisham</i>	69.75	149.00	243.07	226.00	129.49
<i>Aonla+Khejri</i>	73.12	161.29	249.15	232.79	135.59
<i>Guava+Shisham</i>	69.72	161.60	274.74	232.35	128.75
<i>Guava+Khejri</i>	70.55	165.35	282.40	238.42	132.75
C.D. at 5%	39.75	43.97	60.06	40.89	24.24
March					
Control	272.00	438.67	640.17	684.50	384.75
<i>Aonla+Shisham</i>	99.34	226.67	261.25	250.33	164.33
<i>Aonla+Khejri</i>	102.75	231.33	274.92	263.00	171.67
<i>Guava+Shisham</i>	104.50	233.00	264.67	281.17	170.17
<i>Guava+Khejri</i>	109.17	241.17	295.42	289.75	174.33
C.D. at 5%	35.83	49.01	61.15	91.49	23.45

Table.2 Total light intensity (lux) and ISR (%) in winter crops under agri-silvi-horticulture system (pooled for 2011-12 and 2012-13)

Treatments	December		January		February		March	
	Total L.I (lux)	ISR (%)	Total L.I (lux)	ISR (%)	Total L.I (lux)	ISR (%)	Total L.I (lux)	ISR (%)
Control	2108.08	-	2108.08	-	2108.08	-	2108.08	-
<i>Aonla+Shisham</i>	414.67	19.67	691.33	34.42	817.30	38.79	1001.92	41.40
<i>Aonla+Khejri</i>	468.67	22.23	790.33	39.35	851.92	40.44	1043.67	43.13
<i>Guava+Shisham</i>	485.76	23.04	771.84	38.43	867.15	41.16	1053.50	43.53
<i>Guava+Khejri</i>	563.85	26.75	876.51	43.65	889.47	42.22	1109.83	45.86

Table.3 Effects of agri-silvi-horticulture system on yield of wheat, barley and oat (pooled data for 2011-12 and 2012-13)

Treatments	Yield (q/ha)				
	Wheat		Barley		Oat
	Grain	Straw	Grain	Straw	Green fodder
Control	40.74 ^A	49.48 ^A	43.90 ^A	52.50 ^A	635.00 ^A
Aonla+Shisham	24.35 ^C	30.44 ^E	29.37 ^C	37.97 ^D	446.50 ^E
Aonla+Khejri	25.66 ^C	31.99 ^D	29.84 ^C	38.27 ^D	464.00 ^D
Guava+Shisham	29.65 ^B	37.06 ^C	32.67 ^B	41.71 ^C	487.00 ^C
Guava+Khejri	30.74 ^B	38.43 ^B	33.84 ^B	44.02 ^B	559.00 ^B
LSD (P = 0.05)	1.54	0.60	1.37	1.90	5.01

Means with the same letter are not significantly different.

Table.4 Correlation between total light incidence and yield

Total light incidence (lux)	Wheat yield (q/ha)		Barley (q/ha)		Oat
	Grain	Straw	Grain	Straw	Green fodder
December	0.935*	0.922*	0.966*	0.932*	0.873
January	0.941*	0.928*	0.970*	0.938*	0.886*
February	0.928*	0.913*	0.960*	0.923*	0.858*
March	0.938*	0.924*	0.968*	0.934*	0.876

*Significant at P = 0.05 level

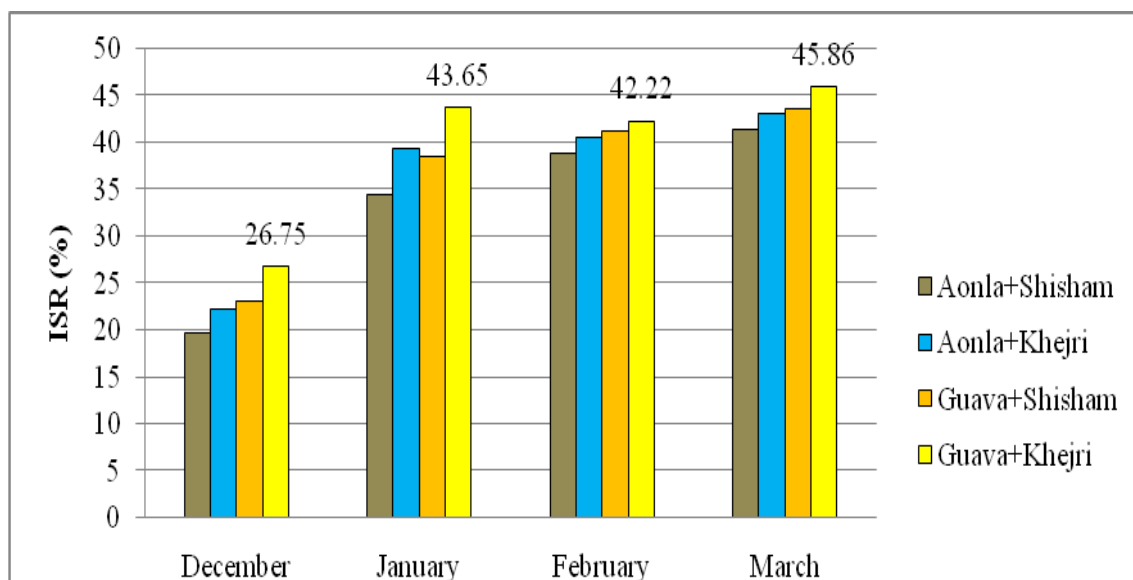


Fig. 1: Incident solar radiation (%) under different agri-horti-silviculture systems

Among the agri-silvi-horticulture system, green fodder yield (559.00 q/ha) of oat in guava + Khejri combination was significantly higher than other combination. It was followed by guava + *Shisham* + oat (487.00 q/ha).

Guava based combination (guava + khejri and guava + shisham) supported significantly higher straw yield of wheat (38.43 and 37.06 q/ha, respectively) than *Aonla* based combination (aonla + khejri and aonla + shisham) under agri-silvi-horticulture system and same trend was observed in barley. Higher crop yield under khejri tree canopy due to improved soil fertility have been reported earlier by several workers (Aggarwal *et al.*, 1993; Yadav *et al.*, 2005; Singh *et al.*, 2008). Kaushik and Kumar (2003) also observed that khejri based agri-silvi system influenced the crop growth and grain yield positively in both *Kharif* and *Rabi* seasons. *Prosopis cineraria* does not appear to have any adverse allelopathic effect on plants under its canopy (Goel *et al.*, 1989). Guava also had positive impacts on crops grown under its canopy. Pateria *et al.*, (2005) observed the maximum productivity of wheat grown under guava might be due to the fact that guava improves water holding capacity of the soil and organic carbon stock in the soil (Jalalzai *et al.*, 2012). Singh *et al.*, (2009) reported that root secretion of guava pushed up the yield of intercrops over its sole cropping. The results are also corroborated with the findings of Khattak *et al.*, (1981) and Wannawong *et al.*, (1991). Malviya and Singh (1998) also reported that guava has some ameliorative effect on chemical properties of the soil.

Based on two year average, it may be concluded that trees modified the microclimate and influenced diversity and productivity of canopy zone vegetation. The

winter crops, *i.e.*, wheat, barley and oat should be grown with guava + *Khejri* combination under agri-silvi-horticulture system. It moderates the micro climatic condition of crop and makes it favourable for production of the crop.

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