Journal of Agrometeorology 18 (2) : 320-323 (December 2016)

Short Comminucation

Microclimate and turmeric yield under different tree species

AMANDEEP SINGH, R. SHARMA, S.K. CHAUHAN and D. ARORA[1]

Department of Forestry and Natural Resources, [1]University Seed Farm Ladhowal,
Punjab Agricultural University, Ludhiana 141 004
Email: amandeepnehal24@gmail.com

Microclimate variations play a major impact on crop environment. The impact of trees on associated crops appears to be mainly competition for bio-resources between crops and trees. Selection of suitable tree species with appropriate canopy and crops with partial shade tolerance and better yield potential are important aspects in agroforestry system (Gill, 1994), which are traditionally and technically followed.Trees reduce the amount of sunlight reaching soils and crops through shading. The extent of reduction varies according to crown dimensions, tree phenology, leaf density and tree geometry.As the tree canopy becomes wider, the photo-synthetic active radiation (PAR) and temperature decreases, while relative humidity under the canopy increases as compared to open condition.Dhillon*et al*. (2010) revealed that tree canopy had major influence on photo-synthetic active radiation (PAR), relative humidity, air temperature and the physiological parameters of turmeric *i.e*. the net photosynthesis, transpiration and water use efficiency.

It is therefore critical to investigate the micro-climatic changes, especially those related to the photosynthesis of plant grown under canopy of trees, which is reflected in the ultimate crop yield. In the changing climatic conditions with projected rise in temperature, such studies have become important to know the micro-climatic changes to accommodate the under-storey crops. Keeping this in mind, the present study was conducted to record the microclimate changes and performance of turmeric crop under canopy of phenologically different tree species.

The present field of investigation was conducted at the Punjab Agricultural University (PAU), Seed Farm, Ladhowal, Ludhiana during the year 2014-2015. The experimental site is located at one km away from Satluj river bedat an elevation of 247m above mean sea level at $30^0 58'$ latitude and $75^0 45'$ longitude in the central agro-climatic zone of the Punjab. The climate of the region is typical subtropical to tropical with long dry season from late September to early June and wet season from July to early September with hot desiccating winds in summer (May-June) and severe cold in winter with occasional ground frost (December-January).

Experiment was conducted in completely randomized design with three replications on-farm trial on three phenologically diverse tree species [*Ailanthusexcelsa* (summer deciduous), *Gmelinaarborea*(winter deciduous) and *Eucalyptus tereticornis*–clone 288 (evergreen)]. Turmeric crop (Punjab haldi 1) was sown (at a spacing of 30×20cm) under 9 year old plantations of three trees species and in open as control in the month of May 2014 and crop was harvested in February 2015. All the crop management practices were performed using standard agronomic package of practices of PAU.

Meteorological data were recorded twice a day at 7.30AM and 2:30PMat an interval of 15 days during the period of study (February 2014 to January 2015) under plantation and in open area. Air temperature (°C) and relative humidity (%) were recorded with the help of digital thermo-hygrometer and soil temperature (°C)with the help of soil thermometer up to the depth of top 10cm. Data for light intensity (100Lux) was recorded with the help of lux-meter. Photo-synthetically active radiation (PAR) ($\mu molm^{-2}s^{-1}$) was recorded with the help of Canopy Analyzer (CI-110 Model).

Turmeric crop yield and yield contributing parameters were recorded at the time of harvesting onfiverandomly selected plants from each plot. The height of these randomly selected plants was measured from the base to tip of plant with the help of tape. Similarly, leaf length and breadth was used to calculate leaf area (cm^2),from five random leaves from each selected plant at maturity. For recording fresh rhizome yield, the rhizomes were properly cleaned after harvesting of turmeric and weighed plant wise, and data were expressed as tha^{-1} by multiplying the numberofplants (30cm´ 20cm spacing) on unit scale.

Air and soil temperature

The fortnightly air and soil temperature recorded under *Ailanthus excelsa, Gmelinaarborea*and *Eucalyptus*

Table 1: Air temperature (°C), soil temperature (°C), relative humidity (%) and light intensity (100Lux) recorded at 15 days interval irrespective of treatment

Treatment	Air temperature (°C)		Soil temperature (°C)		Relative humidity (%)		Light intensity (100Lux)	
Month	1st fortnight	2nd fortnight	1st fortnight	1st fortnight	1st fortnight	2nd fortnight	1st fortnight	2nd fortnight
Feb. 2014	15.6^{l}	20.5^{i}	16.2^{q}	18.9^{no}	68.5^{ih}	67.8^{i}	486.1^{d}	434.5^{def}
Mar. 2014	20.8^{i}	23.1^{h}	19.3^{n}	22.6^{l}	66.3^{j}	46.4^{p}	620.7^{bc}	729.7^{a}
April 2014	28.5^{ef}	23.3^{h}	29.5^{f}	27.8^{i}	50.5^{n}	60.8^{kl}	610.2^{c}	681.5^{ab}
May 2014	33.8^{b}	34.7^{a}	27.1^{j}	33.8^{b}	37.3^{q}	49.6^{o}	473.6^{de}	430.7^{def}
June 2014	31.4^{c}	33.5^{b}	30.7^{c}	36.1^{a}	61.5^{k}	70.2^{f}	472.7^{de}	421.2^{ef}
July 2014	30.3^{d}	32.0^{c}	28.7^{gh}	30.3^{d}	70.3^{f}	69.9^{fg}	419.4^{ef}	407.0^{f}
Aug. 2014	28.0^{f}	30.2^{d}	28.6^{h}	29.5^{e}	78.2^{d}	74.8^{e}	209.4^{hij}	214.6^{hij}
Sep. 2014	29.0^{e}	24.3^{g}	29.2^{ef}	23.8^{k}	70.4^{f}	65.8^{j}	182.0^{ijk}	322.2^{g}
Oct. 2014	23.2^{h}	19.6^{j}	20.8^{m}	18.6^{o}	60.5^{lm}	59.7^{m}	265.9^{gh}	256.5^{h}
Nov. 2014	19.4^{j}	16.4^{k}	17.6^{p}	15.0^{r}	69.2^{gh}	83.7^{b}	232.8^{hij}	171.6^{jk}
Dec. 2014	10.9^{no}	11.3^{n}	12.3^{t}	11.9^{t}	87.6^{a}	81.1^{c}	134.5^{k}	124.7^{k}
Jan. 2015	10.6^{o}	13.5^{m}	10.9^{u}	13.2^{s}	78.2^{d}	68.0^{i}	242.8^{hi}	442.9^{def}
CD (0.05)	0.8	2.3	1.1	64.9				

tereticornis and open space during the study period is depicted in Table 1.Soil temperature was comparatively lower than the air temperature. The maximum air temperature (34.7°C) was recorded in the 2nd fortnight of May and minimum (10.6°C)in 1st fortnight of January (Table 1). Similarly, maximum soil temperature (36.1°C) was recorded in 2nd fortnight of June and minimum (10.9°C) in 1st fortnight of January. The observations in the present study were similar to the findings of Dhillion *et al.*(2010), who observed that the average air temperature under the poplar canopy was lower than in open area, whereas, it was reverse for RH. Similarly, Chauhan *et al.* (2011) recorded that the poplar tree canopy modifies the microclimate, however, little differences under canopy then open condition in the present study may be due to wider spacing among trees. The open area was very near to plantation area and also surrounded by trees on its boundary. The surrounding environment also seems to have been influenced by the trees.

Relative humidity

Fortnightly maximum relative humidity (Table 1) was recorded in the 1st fortnight of December (87.6%) and minimum in 1st fortnight of May (37.3%). Chauhan *et al.*(2013); Alam*et al.*(2014a,b) also recorded increased RH under tree canopy than in open conditions. The higher relative humidity under canopy may be due to increased transpiration by the trees and reduced evaporation losses beneath the trees.

Light intensity

Observations recorded in Table 1 shows that maximum light intensity (72967Lux) was recorded in 2nd fortnight of March and minimum (12471Lux)in 2nd fortnight of December.The reduction under canopy ranged between 48.9 to 56.9 per cent, which probably is higher than the critical level (Alam*et al.,* 2014a,b) to effect the growth and yield of turmeric crop.

Photo-synthetically active radiation(PAR)

PAR values were recorded under trees and in open during study period. PAR was lower under tree species than in open condition*i.e., Ailanthus excelsa* (2415.2µmolm^{-2}s^{-1}), *Gmelinaarborea* (2512.3µmolm^{-2}s^{-1}), *Eucalyptustereticornis* (2596.6µmolm^{-2}s^{-1}) and control (2712.4µmolm^{-2}s^{-1}). Similar observations of variation in PAR were also recorded by Sangwan (2013),thus influencing physiological processes in intercropped turmeric and other crops under canopy of different fruit trees and poplar. The tree canopy intercepts the light and under-storey crops are constraints for proper photosynthetic efficiency.

The observations on the effect of tree species on the performance of turmeric crop (growth and yield attributes) are depicted in Table 2. The data revealed that among growth, plant height was influenced significantly due to the

Table 2: Effect of tree species on different parameters of the crop

Species	Plant height (cm)	Leaf area (cm^2)	Rhizome yield (tha^{-1})
Ailanthus excelsa	85.3 (13.2)	534.1 (15.3)	16.1(-56.3)
Gmelinaarborea	101.7 (34.9)	471.5 (1.8)	15.82 (-50.1)
Eucalyptus tereticornis	88.0 (16.7)	538.1 (16.1)	25.1 (4.0)
Control	75.4	463.3	24.3
CD (p=0.05)	13.4	NS	1.8

* Per cent change than open in parentheses

tree species. The plant height under *Gmelinaarborea*was significantly higher (101.7cm) than other two tree species [*Ailanthus excelsa* (85.3cm) and *Eucalyptus tereticornis*(88.0cm)] as well as in open condition (75.4cm), which may be due to the higher shading effect under *G. arborea* resulting in increased height of under-storey crop for want of light. *G. arborea* is winter deciduous in nature so active vegetative phase of crop was maximum influenced by shading effect. Plants growing in shade are usually taller than those of same age growing in open provided other factors of growth are not restricted. However, the leaf area was numerically higher under *Eucalyptus tereticornis* (538.1cm^2) followed by *Ailanthus excelsa*(534.1cm^2), *Gmelinaarborea* (471.5cm^2) and control (463.3cm^2) but differences were non-significant. Leaf traits play particularly a significant role in carbon assimilation, water relations and energy balance. However, under uniform soil moisture and fertility status, the limiting light and other micro-climatic changes didn't exert significant influence on leaf area. Leaf structure and its orientation, etc. requires detailedstudies to understand the eco-physiology of crops and its effect on yield. Alam*et al.*(2014a) reported that light interception strongly influences the plant growth and 33% shade could be critical for growing crop. However, there is an opportunity to compensate the yield loss through micro-climatic advantages during harsh conditions. Alam*et al.*(2014b) also established the shade adaptive potential of turmeric with leaf protein profiling. In the changing climate scenario, optimum tree shade may mitigate the effect on plant growth.

Rhizome yield

Data presented in Table 2 also depicts that rhizome yield was significantly more under tree-less (24.3tha^{-1}) area and *Eucalyptus tereticornis* (25.1tha^{-1}) than *Ailanthus excelsa* (16.1tha^{-1}) and *Gmelinaarborea* (15.8tha^{-1}). The differences in rhizome yield between *E. tereticornis* and control were at par. In open field, higher amount of solar radiations [Light intensity (623.4 100Lux)] resulted in higher yield, the canopy of clonal *E. tereticornis* trees is also very narrow with straight stem, allowing more insolation [Light intensity (318.2 100Lux)] than other two species to reach the crop. Micro-climatic changes under canopy exerted significant influence on growth, development and yield.High intensity of light favoursroot growth more than shoot growth due to increased transpiration. Sangwan (2013) noticed that carboxylation efficiency of under-storey crops started declining with age, decline in photosynthesis was more under shade. Also there was increase in inter-cellular carbon and all the under-storey crops (turmeric, onion, colocasia, mung and garlic) showed decrease in yield under shade conditions,yield also showed inverse relationship with canopy age. Similarly, Chauhan *et al.* (2013) also recorded decrease in yield of agronomic crops *viz*, turmeric (*Curcuma longa* L.) and mung (*Vigna radiate* L.) under poplar canopy with advancement in age or canopy spread.

Results of present study clearly indicated micro-climatic modifications under tree canopy as compared to open condition, thus influencing the under-storey crop growth and yield. Turmeric was found suitable for cultivation under phenologically diverse species. Decrease in air and soil temperature (4.9-5.6 and 6.9-11.3%, respectively), minor increase (2.3-3.4%) in humidity, and decrease in light intensity (48.9-56.9 %) under three different tree species than open condition influenced the performance of crop growth and yield.

ACKNOWLEDGMENT

The required support of the Director, PAU,Seed Farm Ladhowalin conducting the study is duly acknowledged.

REFERENCES

Alam, B., Chaturvedi, M., Singh, A. K., Navraj, R. and Dhyani, S. K. (2014a).Physiological determinants for adaptive potential of turmeric (*Curcuma longa*) for its growth and yield under different regimes of shade in semi-arid region of central India.*Ind. J.Agrof.,* 16(1):25-29.

Alam, B., Chaturvedi, M., Singh, A. K., Navraj, R. and Dhyani, S. K. (2014b). Micro-climatic modification through agroforestry in the context of climate change: An eco-physiological appraisal. *Ind.J.Agrof.,* 16(1):1-8.

Chauhan, S.K., Dhillon, W. S. and Jabeen, N.(2011). Analyzing the performance of *Colocasiaesculenta* in poplar based agroforestry system. *Asia-Pacific Agrofo. Newsletter,* 39:9-10.

Chauhan, S. K., Dhillon, W. S., Singh, N. and Sharma, R. (2013).Physiological behaviour and yield evaluation of agronomic crops under agri-horti-silviculture system. *Internat.J. Pl. Res.,* 3(1):1-8.

Dhillon, W. S., Srinidhi, H. V., Chauhan, S. K., Singh, C., Singh, N. and Jabeen, N. (2010). Micro-environment and physiology of turmeric cultivated under poplar tree canopy. *Ind. J.Agrof.,* 12(2):23-27.

Gill, A. S. (1994).Effect of tree on the yield of wheat varieties in semi arid conditions. *Van Anusansdhan* 9, (11):8-12.

Sangwan, A. (2013). *Diversification of traditional agriculture through pear based mixed cropping system.* Ph. D. Thesis, Punjab Agricultural University, Ludhiana, pp.151.

Received : December 2015; Accepted: September 2016