ATMOSPHERIC HUMIDITY AND AIR TEMPERATURE STUDIES IN WHEAT-POPLAR BASED AGROFORESTRY SYSTEM

V.K. CHAUHAN* AND R.C. DHIMAN**

Regional Horticulture Research Centre,
Dr. Y.S. Parmar University of Horticulture and Forestry,
Dhaulakuan (Himachal Pradesh).

Introduction

Tree-crop interaction is a complex phenomenon. There are numerous reports indicating both increase and decrease in the production of agricultural crops when grown in association with trees (Chauhan, 2000). The changes are more pronounced with increase in tree size and density (Harsh and Tewari, 1993). Trees modify surrounding environment including soil depending on species and planting arrangements and these modifications in environment cause changes in crop production (Chauhan, 2000). The present investigations were conducted to study the atmospheric humidity and air temperature as influenced by poplar trees in wheat-poplar agroforestry.

Material and Methods

The study was carried out during the winter season of years 1996, 1997 and 1998 at Dhaulakuan Experimental Farm of Dr. Y.S. Parmar University of Horticulture and Forestry, Solan. The farm is situated in sub-tropical, sub-montane zone (30° 30' 20" N latitude and 77° 20' 20" N longitude) at 470 m above mean sea level and receives around 1900 mm annual rainfall. The area experiences average monthly minimum temperature of 3.7°C in December and average maximum monthly temperature of 36.3°C in May, whereas average monthly maximum atmospheric humidity of 86.7% is recorded in August and a minimum of 52.4% in May. Soil is sandy loam with pH of 6.5-8.0 and organic carbon of 0.45%. The soil is medium in N and K content and high in P content.

One year old ETPs of G48 clone were planted during first week of March 1996 at four spacings viz., 8m x 3m, 6m x 4m, 6m x 4m, 5m x 5m and 4m x 6m. Tree rows were oriented in North-South direction. Tree height, diameter at breast height (DBH), crown diameter and crown length were recorded at one year intervals after planting.

The experiment was laid out in a split plot design with three replications, using five tree spacings in main plots and crop varieties in the sub-plots. There were 25 trees/replication. Four wheat varieties viz., HS 295, Sonalika, HD 2285 and HD 2380 were sown in the month of November each year. A plot with no trees and away from the shade of trees was used as control. Fertilizers @ 80kg N/ha, 40kg P/ha and 40kg K/ha were applied as the basal dose. A plot of $1m^2$ was demarcated at the centre of four poplar trees as per Khan (1974) for recording atmospheric humidity

* Scientist (Agroforestry). ** General Manager (Plantation), Wimco Seedlings Ltd., Rudrapur (Uttarakhand).

and air temperature at 11.00 and 15.00 hrs during tillering, jointing and dough stages of wheat growth. Data on these parameters recorded for different years have shown consistency and an average value was worked out and was subjected to statistical analysis for drawing inferences.

Results and Discussion

Tree height, dbh, crown width (North-South and East-West directions) and crown length of poplar trees were significantly influenced by tree spacing (Table 1). Trees grown at 8m x 3m spacing (oriented North-South direction) gave higher values in all the tree growth and crown development parameters over all other spacings. 4m x 6m spacing produced minimum value for each studied parameter. The influence of 6m x 4m and 5m x 5m spacings was intermediary on these parameters. Crown width in both the directions was no significantly different between 5m x 4m and 5m x 5m spacings. Studied parameters were found proportional to inter-row spacings and inversely to within row spacing of trees.

Tree orientation in agricultural fields affects agricultural crop production and tree growth. Trees planted at 8m x 3m spacing (N-S directions) provided wider inter-row spaces and appear to have optimally used site resources for growth when compared with those planted at 4m x 6m and 5m x 5m spacings with the same direction orientation. These results are in consonance with the work reported by Singh and Mittal (1987) and Sharma (1989).

Trees in cropland modify microclimatic parameters under their canopy by influencing atmospheric humidity, air temperature and other factors. These modifications directly influence the productivity of intercrops depending on the prevailing climatic conditions, tree age, distance between and within tree rows and crop varieties. Air temperature in wheat crop was directly proportional to inter-row spacings and inversely to within row spacings of trees (Table 2). Wide inter-row distances of trees allow more infiltration of radiation to ground and free movement of air as compared to narrow inter-row distances. Air temperature responded negatively to

Table 1

Effect of tree spacing on growth attributes of poplar Intercropped with wheat (years 1996-1999)

Spacing	Tree ht. (m)			DBH (cm)			Crown Dia. (m) (N-S Direction)			Crown Dia. (m) (E-W Direction)			Crown length (m)		
	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
8 x 3m	10.9	12.3	13.9	7.7	9.8	12.0	3.6	4.8	5.9	3.4	4.3	5.6	4.0	4.8	6.1
6 x 4m	10.6	11.9	13.3	7.4	9.4	11.3	3.3	4.3	5.4	3.2	4.1	5.0	3.7	4.5	5.4
5 x 5m	10.3	11.4	12.7	7.2	8.7	10.5	3.1	3.9	4.8	3.0	3.7	4.6	3.5	4.0	4.7
4 x 6m	10.2	10.9	12.2	7.1	8.1	9.8	2.8	3.5	4.3	2.7	3.3	4.2	3.2	3.5	4.2
S.E.(m)	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.03	0.04
CD 0.05	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.11	0.09	0.09	0.10	0.07	0.08

Table 2

Effect of tree spacing and crop varieties of wheat on atmospheric humidity and air temperature.

Treatment	Growth											
	Tillering				Jointing				Dough stage			
	11.00 hrs		15.00 hrs		11.00 hrs		15.00 hrs		11.00 hrs		15.00 hrs	
	A.H.	A.T.	A.H.	A.T.	A.H.	A.T.	A.H.	A.T.	A.H.	A.T.	A.H.	A.T.
1	2	3	4	5	6	7	8	9	10	11	12	13
Main plot : Sapcing (s)												
Control(S_0)	64.2	25.8	73.8	27.7	61.7	27.2	70.8	29.6	58.7	28.7	67.9	31.2
8 x 3 (S_1)	65.1	25.4	74.9	27.5	63.1	27.0	71.8	29.4	60.5	28.5	68.7	31.6
6 x 4 (S_2)	65.3	25.0	75.0	27.1	63.6	26.6	72.1	29.0	60.1	28.1	68.9	30.9
5 x 5 (S_3)	65.4	26.6	57.0	26.7	63.6	26.0	72.1	28.2	60.5	27.5	68.9	30.4
4 x 6 (S_4)	65.5	24.3	75.2	26.3	63.2	25.9	71.9	28.2	60.1	27.3	69.0	30.2
SE (m)	0.26	0.17	0.31	0.10	0.16	0.17	0.34	0.12	0.14	0.07	0.17	0.08
C.D.0.05	0.60	0.39	0.71	0.20	0.37	0.38	0.78	0.28	0.33	0.16	0.40	0.20
Subplot: Variety												
HS 295(V1)	65.2	25.3	74.9	27.3	63.1	26.7	71.9	29.2	60.1	28.2	68.9	31.3
Sonalika(V2)	65.2	24.9	74.3	26.9	63.2	26.4	71.2	28.8	59.8	27.9	68.2	30.7
HD 2285 (V3)	65.1	24.7	74.1	26.7	62.9	26.2	71.1	28.6	60.3	27.8	68.2	30.6
HD 2380 (V4)	64.9	25.2	75.9	27.3	62.8	26.8	72.8	29.2	59.6	28.2	69.5	30.9
SE (m)	0.27	0.15	0.34	0.13	0.24	0.16	0.31	0.11	0.27	0.12	0.27	0.05
C.D.0.05	NS	0.30	0.69	0.27	NS	0.32	0.64	0.23	0.55	0.24	.055	0.10

Contd...

1	2	3	4	5	6	7	8	9	10	11	12	13
Interaction (S X V)												
S_0V_1	64.2	26.2	73.9	28.3	61.3	27.7	70.9	30.1	59.2	29.1	68.5	32.0
S_0V_2	64.4	25.7	73.5	27.7	62.1	27.0	70.2	29.7	58.0	28.5	67.2	31.0
S_0V_3	64.4	25.4	73.5	26.8	61.2	26.9	70.6	28.9	59.1	28.3	67.4	30.0
S_0V_4	63.7	25.8	74.7	27.9	62.2	27.4	71.7	29.8	58.5	28.9	68.6	31.7
S_1V_1	65.2	25.7	75.2	27.8	63.0	27.2	72.1	29.7	61.3	28.7	69.1	32.0
S_1V_2	65.3	25.4	74.3	27.4	64.1	27.0	71.2	29.2	60.2	28.6	68.0	31.1
S_1V_3	65.2	25.1	74.4	27.2	63.2	26.7	71.2	29.1	61.2	28.3	68.6	32.0
S_1V_4	64.5	25.6	75.7	27.7	63.3	27.1	72.6	29.6	59.2	28.6	69.4	31.2
S_2V_1	65.4	25.2	75.3	27.3	64.3	26.7	72.2	29.2	59.6	28.2	68.9	31.1
S_2V_2	65.4	24.9	74.6	26.9	63.3	26.4	71.5	29.0	60.3	28.0	68.5	30.8
S_2V_3	65.3	24.7	74.1	26.8	63.2	26.3	71.1	28.7	60.2	28.0	68.2	30.7
S_2V_4	65.6	25.4	76.7	27.4	63.6	26.8	73.4	29.3	60.4	28.4	70.2	31.2
S_3V_1	65.6	24.8	74.5	26.8	63.4	26.4	71.7	28.6	60.3	28.0	68.4	30.9
S_3V_2	65.5	24.4	74.9	26.5	63.4	26.0	71.8	29.3	60.3	27.5	68.9	30.4
S_3V_3	65.3	23.1	74.1	26.3	63.9	25.6	71.1	28.2	60.8	27.0	68.1	29.9
S_3V_4	65.5	24.9	76.6	27.0	63.5	26.1	73.5	28.8	60.4	27.6	70.2	30.5
S_4V_1	65.7	24.6	75.5	26.4	63.5	25.7	72.4	28.2	60.3	27.2	69.5	30.4
S_4V_2	65.4	24.1	74.5	26.2	63.2	25.6	71.5	28.0	60.2	27.1	68.7	30.2
S_4V_3	65.5	24.2	74.3	26.3	63.2	25.7	71.3	28.1	60.2	27.3	68.6	30.2
S_4V_4	64.8	24.4	75.7	26.5	62.6	26.7	72.6	28.3	59.4	27.6	69.3	30.0
SE(m)	0.61	0.33	0.76	0.29	0.55	0.35	0.70	0.26	0.60	0.26	0.60	0.15
SC 0.50	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.30

A.H. - Atmospheric Humidity; A.T. - Air Temperature; NS - Non-Significant.

tree canopy in comparison to control plots confirming the shade effect of trees. The results are in line with the work of Wel and Jiang (1982).

Atmospheric humidity in wheat crop was inversely proportional to inter-row spacings and directly to within row spacings of trees indicating an effect of tree canopy. Trees induce microclimatic changes by reducing soil and air temperature, lower irradiance, wind speed and lower soil- water evaporation. Variation among wheat varieties indicates significant influences on atmospheric humidity throughout the cropping period except jointing stage. 'Sonalika' and 'HD2285' varieties could not produce significant variation for atmospheric humidity and air temperature at each growth stage. This could be due to their similar plant foliage, crop geometry and plant height. These plant factors are directly rlated to biophysical interaction in soil and plant environment. Ramakrishnan *et al*. (1981) demonstrated that modification of air temperature depends on canopy structure and crop density.

Interaction effects of tree spacings and crop varieties could not significantly influence atmospheric humidity and air temperature throughout the cropping period. Rao *et al*. (1998) suggested that modification in micro-climate due to tree canopy depends on prevailing climatic conditions in the area. Tree associated plots showed higher atmospheric humidity in comparison to control plots with respect to each variety. A decreasing trend in air temperature was observed from early to maturity stages of wheat. Leaves started appearing on poplar trees, just after jointing stage and prior to dough stage of wheat growth, thus causing reduction in air temperature due to shade.

Tree canopy is known to reduce wind speed which directly favours accumulation of more humidity under tree crop system. Ramakrishnan and Shastri (1977) while studying the effect of *Acacia tortilis* on micro-climate of guar, reported higher relative humidity by 7% under the trees during active cropping period in comparison to mono crop.

Wheat is grown in winters when poplar trees are leafless for most of the period of the crop growth. The influence of trees on microclimatic factors at the young age of 3 years even during winters is indication of their effect when the tree grow older especially on summer crops when these are with leaves.

Acknowledgement

The facilities provided by the University Authority to carry out these investigations at Regional Horticulture Research Centre, Dhulakuan is gratefully acknowledged.

SUMMARY

An investigation was carried out in the winter seasons of years 1996, 1997 and 1999 to study the atmospheric humidity and air temperature during the active growth stages of wheat (*Triticum aestivum* L.) crop raised under 8m x 8cm, 6m x 4m, 5m x 5m and 4m x 6m spacings of poplar (*Populus deltoides* Marsh.) trees. Height, dbh, crown width and crown length of the trees were significantly higher in tree spaced at 8m x 3m when compared with other spacing. Tree spacing significantly influenced atmospheric humidity and air temperature in wheat crop grown underneath poplar. Atmospheric humidity was directly proportional to within row spacing of trees while air temperature showed the inverse relation. Variation

among wheat varieties were significant for both microclimatic parameters throughout the cropping period except for atmospheric humidity during jointing stage (11.00 hours) of crop growth. Interaction effects of tree spacing and crop varieties could not influence significantly both these parameters during the entire growth period of wheat crop.

कृषिवानिकी प्रणाली में गेहूं–पोपलर की वातावरण नमी और हवा के तापमान का अध्ययन

वी०के० चौहान व आर०सी० धीमान

सारांश

एक गवेषणा 1996, 1997 और 1999 की सर्दियों के महीनों में 8 मी x 3 मी, 6 मी x 4 मी, 5 मी x 5 मी और 4 मी x 6 मी फासला देकर लगाई पोपलर (= वन पिप्पल) (*पापुलस डेल्टायडिस*) वृक्षों की पक्तियों में उगाई जा रही गेहूं (*ट्रिटीकम ऐस्टिवम* लि०) फसल की सक्रिय बढ़वार अवस्थाओं में वातावरण की नमी और हवा के तापमान की दशाओं का अध्ययन करने के लिए आयोजित किया गया। 8 मी x 3 मी फासला छोड़कर लगाई वृक्ष पंक्तियों की ऊंचाई, वक्षोच्चता पर व्यास, छत्र की चौड़ाई और छत्र की लम्बाई अन्य फासले देकर लगी वृक्ष पक्तियों की तुलना में काफी अधिक रहे। वृक्षों के बीच छोड़े गए फासले का पोपलरों के नीचे उगाई जा रही गेहूं की फसल में वातावरण की नमी और हवा के तापमान पर सार्थक प्रभाव पड़ा। वातावरण की नमी वृक्षों की पंक्तियों के बीच छोड़े फासले के प्रत्यक्ष समनुपात में भी जबकि हवा के तापमान ने उनमें उससे उलटा (प्रतीत) सम्बन्ध दिखाया। फसल बढ़वार की संयुक्त होती अवधि (11.00 बजे) में हवा के तापमान को छोड़ संपूर्ण फसलोत्पादन अवधि के दौरान दोनों अणुजलवायु परिमापों में गेहूं की विभिन्न किस्मों में काफी अन्तर रहता पाया गया। फसल की किस्मों और वृक्षों के बीच छोड़े गए फासलों के दरम्यान होने वाले क्रिया प्रतिक्रिया प्रभाव पूरी गेहूं बढ़वार अवधि के दौरान इन दोनों परिमापों पर कोई खास ज्यादा प्रभाव नहीं डाल सके।

References

Carlett, J.E., C.K. Ong and C.R. Black (1987). Microclimatic modification in intercropping and alley cropping system. *Meteorology in Agroforestry* (W.S. Reifsnyder and T.O. Darnhofer, eds.). I.C.R.A.F. Nairobi, Kenya. pp. 419-430.

Chauhan, V.K. (2000). Evaluation of wheat and maize varieties under Poplar based Agroforestry System in Paonta-Doon Valley. *Ph.D. Thesis,* FRI (Deemed University), Dehra Dun.

Harsh, L.N. and J.C. Tewari (1993). Tree-crop interations in agroforestry practices. *Agroforestry for Rural Needs* (D.K. Khurana and P.K. Khosla, eds.). I.S.T.S., Nauni, Solan. pp. 535-541.

Khan, C.M.A. (1974) New adjustable decimal collapsible quadrat versus three old quadrats - an evaluation. *Journal of Range Management,* **27**: 71-75.

Ramakrishnan, Y.S. and A.S. Shastri (1977). Microclimate under *Acacia tortilis* plantation in C.A.Z.R.I. *Annual Proj. Rep*., Jodhpur. pp. 69-70.

Ramakrishnan, Y.S., A.S. Shastri and K.D. Muthana (1981). A note on the importance of radiant energy penetration in silvipastoral systems. *My Forest,* **17**: 1-3.

Rao, M.R., P.K.R. Nair and C.K. Ong (1998). Biophysical interactions in tropical agroforestry systems. *Agroforestry Systems*, **38** : 3-50.

Singh, S.P. and M.C. Mittal (1987). Growth of poplar plantations in Tarai Region of Uttar Pradesh. *Indian Forester*, **109**(10) : 755-761.

Sharma, A. (1989). Studies on biomass production and site amelioration under high density plantation. *M.Sc. Thesis*. Dr. Y.S. Parmar Univ. of Horti. & Forestry, Nauni, Solan.

Wel., L. and A.L. Jiang (1982). The influence of shelter-belts on temperature of wheat leaves. *Scientia Silvae Sinica,* **18**: 135-142.