SUMMARY
AND
CONCLUSION
Windbreak is a narrow wide barrier of living trees or shrubs planted and maintained for the protection inside of the farm. Using trees to reduce windspeed locally is important in both arable and livestock farming. Most research work on the values of trees for shelter has been carried out on the Great Plains of United States, The Canadian Paries, Russian steppes, Danish heathlands and Hungarian plains, where condition of soil, climate and cropping practices are sufficiently uniform over extensive areas to allow for generalization. The main beneficial effects of shelter are in increasing crop yields and reducing or preventing soil erosion.

In Haryana nearly 18,640 ha area in the districts of Sirsa, Hisar, Bhiwani, Mahendergarh and Rohtak are sandy wastelands of which about 80% is subjected to dune formation. Since a large number of habitations of arid and semi-arid region are threatened with moving sand and sand dunes, the immediate necessity to prevent erosion is to undertake tree plantation. The efforts for afforesting the dry areas have been insufficient during the past due to financial constraints and limited technology and choice of species. Afforestation along the road and canal side were started during 1950s in Haryana. Successful strip plantations of Dalbergia sissoo, Acacia nilotica, Albezia lebbek etc., were raised along canal and roads. In the early seventies, fast growing species like, Eucalyptus and
Populus, were raised on the farm boundaries and along railway tracts, canal and roads. At places, Eucalyptus, A. nilotica, A. tortilis, Dalbergia sissoo, Populus, etc., trees were grown with agricultural crops.

The beneficial effects of windbreak have convincingly been demonstrated in the temperate regions of the world but studies on the biological effects of windbreaks are relatively few in arid and semi-arid regions. Generally, it is assumed that the technology developed in the temperate region will provide the same benefits of shelter and protection to agricultural crops and livestock in tropics too. In many instances, the assumption has been proved to be wrong. In the present study, the effects of Dalbergia sissoo planted as windbreak were studied on the growth and productivity of cotton and wheat. In addition, the study include the effects of windbreak on evapotranspiration, nutrient status and physiology of the two crops.

The studies were conducted in the farmer's field of village Dhiranwas at Hisar district, situated at a height of 215.2 m above sea level at 29°10' N latitude and 75°46'E longitude. The maximum temperature rises upto 46°C in the summer and minimum comes down to 0°C in the winter. Maximum rainfall (73-79%) is received during the months of June to September. Occasional winter showers are also received from westerly depressions. The
relative humidity is low during summer months (50%) and high in the rainy and winter season (83-85%). The potential evapotranspiration during summers exceeds 12 mm/day and during winter it is as low as 1.3 mm/day. The site has supply of cannal water but during summers shortage of water is observed. The region is covered by Indo Gangetic alluvium.

An area having a windbreak of two rows of Dalbergia sissoo, was selected for the present study. The distance between rows of belt was 3 m and within the row trees were separated at a distance of 8 m. The trees planted in a staggered pattern were 18 years old with an average height of 17.68 m and mean diameter at breast height of 32.26 cm. The mean crown diameter was 7.63 m. The two windbreaks are involved running East to West and North to South, cutting at right angles to each other, virtually dividing the area into four big farms (named A, B, C and D). A farm without belt served as control (E farm).

To assess the effect of trees on annual crops, quadrat (2 x 2 m for cotton and 1 x 1 m for wheat crop) spaced at 18 m intervals at right angles to each belt, were taken. All the plants with the main axis being inside was taken as "in" regardless of their tops. The following parameters were studied in the above crops: Growth and Development: Above ground biomass: Photosynthesis:
Transpiration: Biochemical and soil and plant nutrients.
Tree growth was measured in terms of height, diameter at breast height.

The maximum temperature as recorded during month of May and June was $40\pm1^\circ C$ during three years of study. The mean minimum temperature for winter months (December and January) ranged between 4 to $9^\circ C$. Maximum night time temperature of 1.2 to 1.5$^\circ C$ was observed during the month of December. The relative humidity at study site was observed to be always very low. During summer months, it was observed to be minimum during all the three years of study and the mean ranged between 19-33%. The average wind velocity throughout the year was found to vary between 2.3 to 10.9 km/h. The prevailing wind direction was South-West and North-West, during months of May to November and December to April, respectively. Depending on the direction of wind, the four farms are characterised into protected, semi-protected and unprotected. For a period when the direction of wind was SW, farm A and C are semi-protected. B is protected while farms D is exposed to wind. Similarly, during the period when the direction is NW, farm A protected, B and D semi-protected and C is unprotected.

Windbreak reduces the wind speed and maximum wind reduction was at 2H, beyond which wind velocity increased as the distance from the belt increases. Tree belt was able to reduce the windspeed by 15 to 45% depending upon
season and wind speed. All the parameters showed an increasing trend as one moves away from tree belt and reached a peak value and then decline to a value almost equal to that obtained in control. The yield of seed cotton obtained in the farms (except for D) at 4H distance, was maximum. It was found to be 41.9, 37.1, 30.4 and 63.8% lower then that of control in the farms A, B, C and D, respectively in the year 1990 at 1H. Similarly, in 1991 the cotton yield was observed to be 34.9, 29.85, 30.04 and 54.6% lower at 1H when compared with control. The overall yield in A, B and C farms increased by 0.8, 4.7 and 10.8%, respectively; while in farm D it decreased by 10.4% when compared with control farm. Similarly, in case of wheat the yield (Average) in farm A was observed to be maximum (19.40 and 18.61 q/ha for 1991 and 1992, respectively) and minimum grain yield (15.33 and 16.02 q/ha for 1991 and 1992, respectively) was recorded in farm C. The percentage increase in grain yield was found to be 47.0, 31.0, 16.8 and 31.09 in 1991 and 29.0, 23.0, 11.87 and 22.48 in 1992 in the farms A, B, C and D, respectively.

Photosynthetically active radiations (PAR) in case of cotton showed maximum value of 1330.12 (at 5H), 1270.00 (at 4H), 1236.31 (at 6H) and 1310.12 μ mol/m²/s (at 6H) in A, B, C and D farms, respectively. Similarly, in wheat a maximum PAR of 1629.0 (at 7H), 1598.00 (at 3H), 1571.3 (at 5H) and 1686.00 μ mol/m²/s (at 4H) was recorded in farms.
A. B. C and D, respectively. All the parameters show the same trend i.e., the value was lower near the belt and increases away from belt after that it started decreasing. But in case of plant sugar and starch no consistent pattern was observed. In case of moisture and nutrient status of plant and soil, the percent moisture content were found decreasing at respective deistances, being highest near the tree belt.

Owing to wind reduction, a local or microclimate arises in the sheltered area. The effect of windbreak in protected region seems to be due to lower intensities of solar radiation and high moisture availability. The sheltered areas were not distinct climatologically from unsheltered areas. Windbreaks affect microclimate of sheltered zone primarily by intercepting solar radiation. The resulting shadows travel from West to East of the tree daily, and from North to South annually. As a result, the microclimate associated with a tree was locally heterogenous and extends well beyond the borders of the canopy zone. Further, due to reduction in wind, the microclimate near the ground was altered and, on balance, improved. When the wind and solar radiation were lessened, humidity tended to increase. Water losses through evaporation fall and moisture reserve in the soil increases. In general these small changes in the heat and moisture economics, are transmitted to the growing plants.
Both higher productivity (away from trees) and lower productivity (under tree canopy) in the sheltered area are seen. Increased productivity seems to be associated with high soil fertility, soil moisture and improved microclimate which ameliorates influence of shade in hot. Decreased productivity seems to be due to low solar radiation (i.e., tree shade effects) and competitive interactions between trees and crops. However, the ameliorative effects of windbreak in the canopy zone appeared to be more than the negative effects, caused due to competition between trees and crops and other effects due to woody component. These interaction indicate an improvement in positive effects such as increased soil fertility and better plant water relations. The productivity (of crops) under sheltered zone is much higher than unsheltered zone in the semi-arid regions. This assumes a greater significance as the present study suggests an improved conditions for agricultural crops in association with trees in semi-arid regions.