Discussion
CHAPTER V

DISCUSSION

A field experiment was conducted for two years (2000-02) at Research Farm of National Research Centre for Agroforestry, Jhansi to quantify the competitive effect of soil moisture, light and nutrients and to see the effect of management practices on minimize competition and maximize complementarity in tree-crop system. The results obtained during field experimentation have been discussed in this chapter along with support of field observations of elsewhere on similar type of research.

5.1 Effect of intercrops (blackgram and mustard) on growth of tree (*Albizia procera*)

The growth performance of pure tree was better to that tree-crop system during first year because mustard crop overlapped the trees and both tree and crop competed for aboveground growth resources from same level during first year. The results here were similar to the observation made with agricultural crops such as sugarcane, maize, arhar, jowar etc. interplanted with tree and their related cultivation practices do affect the trees in several ways and they compete with sapling for nutrients, water, light and space, particularly during first few years (Dwivedi, 1992). In another study Sharma (1988) also observed that several tree species interplanted with sugarcane, maize and jowar in Haryana and western Uttar Pradesh, the growth rate of saplings planted on the bund was less in comparison to those growing in open. However, the results are different from silvipasture in which intercropping grasses had no effect on the growth of *Azadirachta indica* and *Acacia nilotica* (Muthana et al., 1985). Contrary to this observation, the growth of *Acacia tortilis* was suppressed by *Cenchrus* species during the first three year but after that the trees attained better growth rates with grass (Shankarnarayana et al., 1987).

During second year, the growth of trees was some time better/similar in tree-crop system to that pure tree. *Albizia procera* is fast growing tree and their root systems are well developed after a year of planting. Under such situation the effect of intercrop on the trees is considerably reduced and slowly the trees become more dominant and their effect
on the agricultural crops become more relevant. In general, the growth performance of trees was obviously better in those treatments in which trees were growing normally and associated crop (mustard) received irrigation as per their requirement compared to other treatments (one irrigation provided to the associated crop at flowering) during both the years. This is probably due to *Albizia procera* benefited from the irrigation given to the mustard crop. The results are in conformity with those obtained with eucalyptus seedlings in which fertilizer and weeding given to the agricultural crop also benefited to the growth of eucalyptus seedling when compared to the eucalyptus monoculture (Couto and Gomes, 1995). Pruning of tree up to 70 per cent plant height and soil barrier did not show any influence on the growth of tree after one or two years after plantation. It was mainly due to the space available within the barrier was sufficient for the growth of tree and pruning up to 70 per cent plant height was able to maintain the growth of tree in early age. Similar views were also expressed by Roy and Deb Roy, 1986; Handa and Rai, 2001 in case of *Albizia amara, Albizia procera, Hardwickia binata* and *Anogeissus spp.* These species are able to tolerate even 70 to 75 per cent of the canopy removal.

5.2 Effect of tree on growth of intercrop (blackgram)

In general, germination in first row from the tree base was less compared to second, third and fourth rows from tree base after one year of tree plantation. However, in pruning (up to 70 per cent plant height) the germination was slightly higher than the tree was allowed to grow normally during both the years but the differences were not significant. Sharma *et al.* (2000) also stated that the reduction in plant population of wheat crop due to poplar at 0-3 m distances from tree line was 34.2 per cent over control and this reduction was less with increasing distances from tree line. Overall, the germination of crop in pure crop was higher as compared to tree-crop system irrespective of treatments and different rows from the tree base.

After one year of planting, the effect of tree on height of crop was observed only up to second row and this effect was more pronounced during second year. The plant height of crop was significantly higher in first and second row from tree base under pruning of tree up to 70 per cent plant height + irrigation of crop as per their requirement as
compared to other treatments. The plant height of crop was almost similar in third and fourth rows. In some cases plant height was better in third row and in some cases better in fourth row, which indicate that tree did effect the crop up to second row from tree base after one or two years of planting. Many other studies had also revealed that the level of effect on growth and yield of crop by tree component in tree-crop system under different level of stresses and caused by growth behaviour and age of tree (Ralhan et al., 1992; Puri and Sharma, 2002; Puri et al., 1994; Schroth, 1999).

The effect of tree on branching of crop indicated that number of branches plant$^{-1}$ was less in first row from tree base compared to second row irrespective of treatments. It was mainly due to the growth of tree was not so enough after two years of plantation to compete with crop beyond second row of crop. Effect of tree on crop was decreased with increasing distance from tree base. Among different treatments, the branching in crop under pruning of tree up to 70 per cent plant height was significantly higher in first year as compared to other treatments but the differences were significant during second year. Higher branching in this treatment was might be due to the pruning of tree up to 70 per cent plant height permitted more light to understorey crop as compared to naturally growing trees. The competitive effect of tree on crop was seen only up to first row and very little effect was noticed on second row during first and second year. Soil barrier had significant effect on branching of crop after a year of planting but the differences were not significant during second year. However in those treatments in which a soil barrier (GI sheet) was installed in between tree and crop, the associated crop was better in branching as compared to without soil barrier either trees were growing normally or pruned up to 70 per cent plant height. It indicated that soil barrier did not allow penetrating tree roots in crop area, which minimized the competitive effect for soil moisture and nutrients in between tree and crop.

5.3 Effect of tree on yield and yield attributes of intercrop (blackgram)

The effect of tree line on pod formation was more obvious on first row and in this row the pods were 4.06 to 9.44 per cent less as compared to second row of crop from tree base during 2001. This difference was higher (1.34 to 10.49 per cent) during 2002. Number
of pod increased gradually with increasing distances from tree base. This may be due to the fact that tree canopy during first and second year tree could not affect the penetration of light beyond the second row from tree base. Light availability is the most important limiting factor for the performance of under storey annual crops particularly where upper storey perennial from a dense over storey canopy (Miah et al., 1995). The effect of treatments was also significant on pod formation of crop in first to fourth rows during 2001 but during 2002, the differences in pod number were only significant in first and fourth row. Among all the treatments, pruning of tree up to 70 per cent plant height + irrigation as per requirement of crop and tree allowing to grow normally + irrigation as per requirement of crop were significantly better to contribute more pods plant\(^{-1}\) than other treatments but pruning of tree up to 70 per cent plant height + irrigation as per requirement of crop was overall superior than rest of the treatments during both the years. This was mainly due to the pruning of tree up to 70 per cent plant height had minimum competition for light with crop, in other words the intercrop intercepted more light in this treatment as compared to tree allow to grow normally. Another reason of higher pod formation in this treatment, one-irrigation was provided to the crop during pod formation which significantly contributed in higher pod formation. Number of pods per plant under tree-crop system was less as compared to that pure cropping with irrespective of treatments and different rows from tree base.

Tree did not affect the seed formation in crop either near by the tree base (first row from tree base) or away from the tree base (second, third and fourth rows from tree base). However seeds pod\(^{-1}\) were comparatively higher in pruning of tree up to 70 per cent plant height irrespective of soil barrier and irrigation, but differences were not significant during both the years. In tree-crop system seeds pod\(^{-1}\) were almost similar to that pure crop during both the years.

In tree-crop system the grain yield running meter\(^{-1}\) in first row from tree base was 2.47 to 9.32 per cent less than the yield obtained in second row. Like wise the yield of second row was 5.06 to 11.05 per cent less than the yield of third row from the tree base irrespective of treatments. However the treatments effect was not significant during first year. The lower grain yield in first row was might be due to the tree canopy which could
affect the availability of light up to first row only. But the canopy of tree was not so enough to affect the crop in third and fourth row. During second year, the effect of trees on grain yield in first row was more pronounced and it was 2.42 to 22.77 per cent less than the yield obtained in second row. Similarly, the grain yield in second row was 1.65 to 7.46 per cent less than the grain yield of third row irrespective of treatments. The significant effect of treatments was observed in first, third and fourth rows from the tree base. Khybri et al. (1988) also recorded the depressing effect of tree up to 3 m, which subsequently increased up to 5 m with advanced age of trees. However no adverse effect on crop was recorded beyond 5 m distance from trees. Several field observation were made by Khybri et al., 1992; Chauhan et al., 1995; Yadav et al., 1993; Sharma et al., 2000 indicated that distances of tree line from crop significantly affected the crop yield up to a distances of 4 to 6 m depending upon age and growth of tree but reduction in yield near by the tree base (0-3 m) was higher as compared to the away from tree base (4-6 m) in wheat, and mustard with various tree species. Increasing competition during second year was mainly due the more canopy development, which reduced light availability to the crop. The effect of tree on crop in initial year was more visible only up to first and second row of crop from tree base. If a quantitative effect of soil moisture, light and nutrients is calculated on grain yield of crop in first row only. It indicated that the grain yield of crop per running meter was 3.68 per cent higher in pruning of trees up to 70 per cent plant height than tree allowed to grow normally in during 2001. It means the availability of light in this treatment had contributed 3.68 per cent higher yield than tree allowed to grow normally. Several other studies also given similar observations in which they have stated that low light intensity is one of the important constraints for higher yield (Tanaka et al., 1964; Stansel et al., 1965; Vankateswarlu and Srinivas, 1978). In other hands, the grain yield was 10.82 per cent higher due to irrigation provided to the crop at pod formation stage as compared to moisture stress. It indicated that moisture is essentially had contributed to increase the grain yield, when rain was terminated before pod formation stage. In another situation, when the moisture and nutrients competition has been avoided by installing a soil barrier in between tree and crop, the grain yield in first row was 4.44 per cent higher than without barrier with irrespective of pruning and naturally growing trees. It means, if moisture and nutrient competition is avoided
between tree and crop the grain yield of crop certainly be increased, the amount may be less or more. Similar results were also found during the second year but the effect of moisture was nullified due to natural rain received during pod formation and maturity. Overall the grain yield running meter\(^{-1}\) in case of pure crop was 3.07 and 3.90 per cent higher than the yield received in tree-crop system irrespective of treatments during 2001 and 2002 respectively. Higher yield in pure crop was mainly due to the tree had competed for light, soil moisture and nutrients but the effect of tree during initial year was less.

Test weight of seed was maximum in pruning of tree up to 70 per cent plant height with irrigation as per requirement of the crop. The effect of treatments was significant in first row and fourth row only during 2001 and in second year the differences were not significant. No significant variation in treatment was mainly due to the moisture play an important role on seed size and during kharif season moisture was not a constraint during 2002 but during 2001 early termination of rain caused less test weight in all the treatment except those treatments, which received irrigation as per requirement of crop. The overall test weight of crop in tree-crop system was almost similar to that pure crop during both the years.

Among different treatments, the grain yield was maximum in pruning of tree up to 70 per cent plant height + irrigation given to the crop as per their requirement during both the years. In over all comparison, the pure crop yield was 6.58 and 20.71 per cent higher during 2001 and 2002, respectively compared to tree-crop system. Similar results were also obtained by Odhiambo et al., 1999 in which the maize yield was reduced in agroforestry treatments particularly close to the trees. For quantifying the effect of soil moisture, light and nutrients on grain yield of intercrop in tree-crop system, the grain yield of two years in tree-crop system was compared in different ways, like tree allowing to grow normally Vs pruning of tree up to 70 per cent plant height, tree allowing to grow normally + soil barrier Vs pruning of trees up to 70 per cent plant height + soil barrier, tree allowing to grow normally + irrigation as per requirement of crop Vs pruning of tree up to 70 per cent plant height + irrigation as per requirement of the crop and tree-crop system Vs pure crop. The results revealed that the grain yield of crop was 4.50 per cent
higher due to pruning than tree allowed to grow normally it indicates that the pruning facilitate more light than tree allowed to grow normally. Installing a soil barrier around the tree, contributed 3.10 per cent higher grain yield of crop either in pruning of trees up to 70 per cent plant height or tree allowed to grow normally. Impact of soil barrier was small of tree or either crop. Irrespective of root barriers, a high response to tree pruning suggested above ground competition for light dominated tree/crop interaction in agrisilviculture system in semi-arid region (Osman et al., 1998). The grain yield of crop was 2.17 per cent higher in case of pruning of trees up to 70 per cent plant height + irrigation as per requirement of crop than tree allow to growing normally + irrigation as per requirement of crop. It was mainly due to availability of moisture depress the detrimental effect of light. The similar results were also obtained during second year but differences in yield between the treatments were gone up to 24.30 per cent, which was higher than first year. Thus observations confirmed that tree suppressed crop yields from second year onwards when trees have established themselves well. The effect of moisture on grain yield was less during second year because the crop received rain during pod formation and maturity.

5.4 Effect of tree on growth of intercrop (mustard)

Germinated plant running meter\(^1\) did not vary significantly within the treatments during first year (2000-01). The similar results were also obtained during second year. However in third and fourth rows the differences were significant. The plant population near by the tree base (first row) indicates that after four months of plantation, tree (planted during July, 2000) did not exert any adverse effect on germination of crop either in first or in second row and so on. During second year also, the effect of tree was not obvious on the germination of crop. This was mainly due to fact that trees did not well established themselves and their root development was not so enough to compete for water and nutrients. Similarly the crown diameter was 0.46 to 1.26 m during this period, which could not affected much the light availability to the crop.

The maximum plant height was recorded in pruning of tree up to 70 per cent plant height irrespective of irrigation as per requirement of crop and soil barrier as compared to
tree allowed to grow normally. It indicates that after one year, the pruning of tree up to 70 per cent plant height facilitate more light interception to the crop as compared to tree allowing to grow normally. The effect of moisture was very much obvious on crop growth in those treatments in which crop received irrigation as per their requirement. Crop growth was comparatively less in those treatments in which only one irrigation was provided at flowering stage. Similar results were also obtained during 2001-02 in all treatments as well as in different rows from tree base. In general the plant height of crop was less in first row in most of the treatments during both the years. It indicates that the competitive effect of tree was only up to first row in initial years.

Branching in crop under first row was less as compared to second, third and fourth rows during both the years in all the treatments. The branches increase with increasing distances from tree base. The competitive effect of tree during second year increased simultaneously with growth of tree and the effect of tree on first row was more obvious, but this effect was not seen in third and fourth rows from tree base. Among different treatments, pruning of tree up to 70 per cent plant height + irrigation given as per requirement of crop recorded maximum branches during both the years followed by tree allow to growing normally + irrigation as per requirement of the crop. It indicated that under same amount of irrigation, the number of branches were more in pruning, it means pruning of tree compete less for light with crop, which ultimately reflect higher branching in crop. If the competition for soil moisture and nutrients are avoided by installing the soil barrier in pruning of tree up to 70 per cent plant height and tree allowed to grow normally. The effect of pruning of tree was still affective in increasing branching in crop besides soil barrier during both the years. Once again contribution of light is important or in another way the management (pruning) is also an important practice to minimize light competition. The effect of soil barrier on branching of crop was not obvious during first year but during second year, the branching in crop was at par higher than without soil barrier. In overall comparison of tree-crop system Vs pure crop under moisture stress (one irrigation given at flowering stage), number of branches in pure crop were almost similar to that intercrop with trees irrespective of treatments. Similarly, in case of no moisture stress situation, where crop received irrigation as per requirement,
number of branches in pure crop was apparently equal to that intercrop in tree-crop system.

5.5 Effect of tree on yield and yield attributes of intercrop (mustard)

The similar results were also obtained in siliquae plant\(^{-1}\) and seeds siliqua\(^{-1}\) to number of branches plant\(^{-1}\). However, tree allowed to grow normally + irrigation as per requirement of crop and pruning of tree up to 70 per cent plant height + irrigation as per requirement of the crop had higher siliquae plant\(^{-1}\) and seeds siliqua\(^{-1}\) as compared to rest of the treatments during both the years. The values of this character were higher during 2001-02 compared to 2000-01. Those treatments received irrigation as per requirement of crop, siliquae plant\(^{-1}\) and seeds siliqua\(^{-1}\) were increased besides pruning and tree allowed to grow normally during both the years. In overall comparison of tree-crop system with pure crop under both the situations (irrigation given as per requirement of crop and one irrigation at flowering), siliquae plant\(^{-1}\) and seeds siliqua\(^{-1}\) was higher in pure crop as compared to intercrop.

The grain yield running meter\(^{-1}\) in first, second, third and fourth rows from tree base was more or less similar to each other during first year. But during second year, the grain yield in first row was less than second, third and fourth rows in all the treatments. The effect of treatments on grain yield running meter\(^{-1}\) was not significant during first year, but the differences in grain yield were significant during second year. It indicated that from second year, the competition between tree and crop has started. The grain yield meter\(^{-1}\) of crop was 6.93 per cent less in tree allowed to grow normally as compared to pruning of tree up to 70 per cent plant height in first row of crop. Similarly the grain yield running meter\(^{-1}\) was about 7.16 per cent less in tree allowed to grow normally as compared to pruning of tree up to 70 per cent plant height + soil barrier. The higher yield in 70 per cent pruning might be due to the crop intercepted more light due to pruning, that induced the growth and yield attributes of crop. Similar results were also obtained in rest of the rows of crop. The influence of irrigation was more obvious on grain yield running meter\(^{-1}\) during both the years and due to irrigation as per their requirement the grain yield
was 18.53 and 16.16 per cent higher during 2000-01 and 2001-02 respectively than the crop received one-irrigation at flowering.

Overall, the grain yield of crop was similar to that pure crop either crop received one irrigation at flowering or as per requirement of crop during first year. But during second year the grain yield meter$^{-1}$ was less as compared to that pure crop. The similar results were also obtained in case of test weight of crop.

The grain yield of crop obtained under different treatments during first year was less as compared to second year. This was mainly due to the regular fog in December and January affected the grain filling in pods. The grain yield of crop did not vary significantly during first year but the differences were significant during second year. The significant variation in yield during second year in different treatment was mainly due to the fact that after establishing the tree, tree-crop interface begun and gradually their effect on grain yield is appeared. For quantifying the effect of growth resources on crop yield in tree-crop system, it will be ideal to compare the yield received in tree allowing to grow normally Vs pruning of tree up to 70 per cent plant height clearly showed that pruning reduced more availability of light to the crop and due to pruning the grain yield was 6.77 to 14.57 per cent increased. Similar effect of pruning was also seen in other treatments.

Overall crop yield received under pure crop was 9.45 and 15.95 per cent higher to that intercropped with tree in those treatments, in which only one-irrigation was given to crop. Similarly, crop yield under pure crop was also higher than the crop yield obtained in tree-crop system, in which crop received irrigation as per their requirement. The requirement of irrigation certainly reduced the moisture competition between tree and crop besides that it increases the nutrient uptake in the crop which ultimately helps to increase the yield of crop.

5.6 Weed density and dry matter accumulation

5.6.1 Weed density and dry matter accumulation under blackgram

During kharif season, the crop was infested with *Cyperus iria*, *Digera arvensis*, *Cynodon dactylon*, *Phyllanthus niruri*, *Echinochloa crusgalli* and *Commelina*
*benghalensis*. The weed density and dry matter of weeds m\(^{-2}\) were varied significantly among the different treatment during both the years but during second year dry weight of weeds m\(^{-2}\) at harvest was not significant. This was mainly due to the fact that after a month of sowing, crop cover was not so good, which could not fully smother the weed but after full growth of crop its canopy coverage was able to smother the weeds. Secondly after a year of planting, trees are also well established and they also had smothering effect on weed. The effect of shade was more severe to light demanding plants than for shade tolerant plants. This could be an avenue to suppress some light demanding weeds. A reduction of weeds due to the presence of trees has been reported from many ecological zones (Yamoh *et al.*, 1986; Jama *et al.*, 1991; Rippin, 1991 and Yadav *et al.*, 1993). Apart from shading, weed suppression is also determined by factors such as land-use history, weather and competitiveness of crop. The weeds dry weight and their count were significantly higher in those treatments, in which the tree was allowing to grow normally with irrespective of soil barrier or irrigation as per requirement of crop. In this case natural growth of tree creates hindrance in cultural operation and equipment used for cultivation can not approach up to the base of tree. In this way some spaces are left over around the tree without cultural operation which helps in survival of perennial weeds. In case of pure crop the values of weed count and dry weight m\(^{-2}\) were almost similar to that intercropped with trees.

### 5.6.2 Weed density and dry matter accumulation under mustard

In rabi crop, *Chenopodium album*, *Fumaria parvifolia*, *Anagallis arvensis*, *Melilotus alba*, *Melilotus parviflora*, *Vicia sativa*, *Cyperus rotundus* and *Cynodon dactylon* were common weeds occurred in the field. Infestation of weeds during first year was more as compared to second year however the weeds were almost similar in tree-crop system to that pure crop during both the years at 30 days after sowing. Weeds m\(^{-2}\) at harvest was higher, where irrigation provided to the crop as per their requirement irrespective of pruning of tree up to 70 per cent plant height and tree allowed to grow normally. Irrigation helps the crop for better yield but simultaneously it also help in better growth and dry matter yield of weeds presence in the field. Besides that in mustard senescence of leave occurred before harvesting of crop at that tree crop allow more light
to floor vegetation. Those weeds (Chenopodium spp., Anagallis spp., Spergula arvensis, Asphodelus spp.) came in later stages of crop, they were got benefit of light due to shading of leaves. The similar results were also obtained in case of dry weight of weeds at 30 days after sowing and at harvest.

5.7 Light interception

5.7.1 Light intercepted by an intercrop (blackgram) in tree-crop system

The light infiltrated through tree canopy is available to the under storey crops and determines its productivity. The multiple canopy layers in agroforestry system absorb more solar radiation and use it efficiently to produce higher biomass. The advantages of higher absorption of solar radiation in intercropping system can be successfully extended to agroforestry system. In agroforestry system total biomass production may be higher than pure cropping but the productivity of crops always depends upon the quantum of light available to crop in tree-crop system.

Light interception at 0.5, 1.0, 2.0, 3.0 and 4.0 m away from the tree base were varied significantly in tree allow to growing normally and pruning of tree up to 70 per cent plant height. Light intercepted by crop under tree-crop system at 0.5 m away from tree base was 21.15 to 23.56 per cent less in pruning of tree up to 70 per cent plant height and 37.52 to 42.60 per cent less in tree allow to grow normally as compared to pure crop. It indicated that 70 per cent pruning had transmitted more light as compared to tree allowed to grow normally. The similar observation also observed by Thakur and Singh (2002) in case of Morus alba, in which 75 per cent canopy removal allowed more light transmission as compared to 0, 25 and 50 per cent canopy removal. In another study, light intensity was minimum in A. auriculiformis under without pruning, but the intensity under went a sharp rise on pruning (Datta and Dhiman, 2001). Although several studies have already been proved that the light interception in tree-crop system is less as compared to open field (Hazra and Patil, 1986; Thakur and Singh, 2002; Behari et al., 1994; Basawaraju and Gururaja Rao, 2000). The light interception in crop was gradually increased with increasing distances from tree base in both the treatments. In tree-crop system the effect of tree on light interception was more visible at 0.5 m away from tree
base after two years of plantation as compared to 1.0, 2.0, 3.0 and 4.0 m away from tree base.

5.7.2 Light intercepted by an intercrop (mustard) in tree-crop system

The results and trend were similar to kharif crop. However the quantum of light intercepted by the crop during rabi season may be different. The light interception in crop was 7.10 to 42.25 and 6.02 to 36.69 per cent under pruning of tree up to 70 per cent plant height and tree allow to growing normally respectively at 0.5 m away from tree base. These values were significantly less as compared to light intercepted by the crop at 1.0, 2.0, 3.0 and 4.0 m away from tree base. The light interception was 4 per cent higher in pruning of tree up to 70 per cent plant height as compared to tree allowed to grow normally at 0.5 m away from tree base. In general, the light interception increased gradually with increasing distances from tree base. Overall the effect of tree on light availability to intercrop was seen up to first and second row in both the treatments (pruning of tree up to 70 per cent plant height and tree allowed to grow normally). In tree-crop system, light intercepted by the crop was less as compared to pure crop at 15, 30, 60, 90 DAS and at harvest respectively.

5.8 Effect on micro-climate in tree-crop system

5.8.1 Kharif season

5.8.1.1 Temperature

Below tree canopy temperature under tree allowed to grow normally at different dates after sowing was less as compared to pruning of trees up to 70 per cent plant height. It means in pruning the light transmission was comparatively higher, which induced higher temperature as compared to tree allowed to grow normally. In tree-crop system temperature was 4.86 and 8.81 per cent less below tree canopy as compared to open field at different dates after sowing. The microclimatic conditions to be more favourable below canopy of trees (Huxley, 1983; Corlett et al., 1989; Hazra and Patil, 1986; Ramkrishna et al., 1981). A similar finding was also reported in case of *Acacia nilotica*, the temperature
was 1 to 2°C was less below the canopy as compared to open canopy (Viswananth et al., 1998).

5.8.1.2 Humidity

Humidity under tree canopy was 25.81 to 30.55 per cent and 18.42 to 21.43 per cent higher in tree allowed to grow normally and pruning of tree up to 70 per cent plant height respectively than open field irrespective of different dates after sowing. A positive interaction, which is often attributed to agroforestry, is the amelioration of micro-climate (temperature, humidity and wind speed). The microclimatic effect due to shelterbelt plantation are well documented but in case of agrisilviculture or silvipasture system, higher relative humidity below tree canopy has been observed by Hazra and Patil, 1986; Ramkrishna and Sastri, 1977.

5.8.2 Rabi season

5.8.2.1 Temperature

Changing pattern in temperature due to tree in rabi season was almost similar to kharif. However the temperature in case of tree allowed to grow normally was 2.01 to 6.61 per cent less at different dates after sowing compared to open field during first year and these values were higher (7.73 to 16.95 per cent) during second year. Similarly in case of pruning of tree up to 70 per cent height, the temperature under tree canopy was 0.31 to 2.51 per cent less compared to open field at different dates after sowing.

5.8.2.2 Humidity

The humidity under tree canopy in both the treatments (tree allowed to grow normally and pruning of tree up to 70 per cent plant height) was higher than open field at different dates after sowing during both the years. Under tree canopy, the light does not reach directly and some part of light is only transmitted by the canopy, which low... the temperature as well as the evaporation.
5.9 Shade length of tree (*Albizia procera*)

5.9.1 Kharif season

Shade length is varying with time and months. Shade length and their area increased with increasing height and canopy of tree after a year of plantation, shade length was up to 2.76 meter from tree base and after two year it had gone up to 3.17 meter from tree base.

5.9.2 Rabi season

In rabi season, the shade of tree had gone up to 1.56 meter after a year of plantation and after two year the shade length was reached up to 2.90 meter from tree base. Observations in kharif and rabi indicated that shade length differ with different month of the year.

5.10 Soil moisture

Moisture content in soil at 0.5 m and 1.0 m was slightly less as compared to 2.0 m and 3.0 m away from tree base at 0-15 cm soil depth. Similar results were also found in case of 15-30 cm soil depth during both the years. A similar finding was also reported elsewhere in different studies (Malik and Sharma, 1990; Sanjay Kumar *et al.*, 2001; Pant and Singh, 1998; Bhaskar *et al.*, 1991). Among different treatments, the moisture content was less in those treatments in which crop received one irrigation at flowering as compared to crop received irrigation as per their requirement. In another condition, where tree and crop was separated by soil barrier, the moisture content at 0.5, 1.0, 2.0 and 3.0 m away from tree base was almost similar under 0-15 and 15-30 cm soil depth because the soil barrier did not allow the root to inter in crop area, which helped in minimizing the competition for moisture and nutrients.

5.11 Root length density and specific root length

Knowledge of the root distribution of trees is essential to understand the ecological niche of a tree species to design agroforestry system and its management to optimize the productivity of trees and crops in various agroforestry systems (Huxley, 1983; Von
Maydell, 1987; Toky et al., 1989). Root length density (cm root length / cm³ soil volume) and specific root length (m root length / g dry weight of root) after one and two years planting showed that soil barrier was fully able to restrict the movement of root. But in case of other treatments (trees allow to growing normally and pruning of tree up to 70 per cent plant height) the horizontal movement of roots after a year of planting was observed up to 1.0 m. Although the root length density was higher 0.5 m away from tree base and it decreased with subsequent increase in distances from tree base. Similarly, specific root length was less at 0.5 m away from tree base and it increased with increasing distances from tree base. Similar observations were also made by Ram Newaj et al., 2000; Ram Newaj et al., 2001; Toky et al., 1989. Many other workers (Toky and Bist, 1992; Dhyani et al., 1990, Odhiambo et al., 1999) had also reported that in general, the root density declines with vertical depth and distance from tree. The root length density and specific root length were less in pruning of trees up to 70 per cent plant height as compared to tree allowed to grow normally.

5.12 Pruned biomass

After a year of planting the pruned biomass (leave and twigs) of tree was 0.43 to 1.19 kg tree⁻¹ and it was two to three fold more after two years of plantation.

5.13 Changes in physico-chemical properties of soil

Changes in pH, electrical conductivity and organic carbon were very much nominal after two years as compared to initial value. However, the pH, electrical conductivity and organic carbon were higher at 0-15 cm soil depth as compared to 15-30 cm soil depth under different treatments. The values of these parameters at different distances from tree base were also similar to each other. After two years of experimentation, no definite trend was observed due to treatments at different distances from tree base under 0-15 and 15-30 cm soil depths. Similar results were also found in case of available nitrogen, phosphorus and potassium. The content of nitrogen, phosphorus and potassium in soil was less at 15-30 cm depth as compared to 0-15 cm depth.