CHAPTER - V

Intercropping of legumes with the non-legumes for fodder production

In animal nutrition feeding of green fodder is of special importance. The green fodder, when fed to the animals, supply vitamins and minerals apart from proteins, fiber, fat and carbohydrates. Higher productivity from animals is obtained by including fresh green fodder in their ration.

The green fodder denotes green foliage of the plant resulting due to vegetative growth. This includes soft stem portions along with the leaves. For this purpose the fodder crop are cultivated and harvested just before flowering. When harvested at this stage, the foliage is soft with minimum indigestible lignin content. The protein content in the leaves is high at this growth stage of the plant. It contains all nutrients in adequate quality. This green foliage harvested at a pre-flowering stage is more palatable and nutritious than that harvested after flowering.

Several plants species have been recommended for cultivation to obtain nutritious green fodder. These include annual or perennial species, short duration or long duration crops the plants belonging to family Leguminosae, Gramineae and other families.

The crops recommended for fodder production and found suitable for cultivation in this region include lucerne (a perennial legume), berseem (a
perennial short duration legumes), hybrid Napier grass (a perennial non-legume), maize, Sorghum, bajra, oat and barley etc. (annual short duration non-legumes), cowpea, Vigna, Dolichos, pea, etc. (annual short duration legumes). These crops are raised for providing animal feed in the form of the green fodder. While cultivating fodder crop emphasis is always given on its higher productivity per unit land area in a short period. This is usually done by selecting proper species for a particular season, sowing of the plants by proper method with slightly high seed rate than recommended for grain production, using suitable variety of the crop; proper irrigation, fertilizer, insect and pest management etc. If a suitable species of a particular variety is cultivated on good quality of soil in a proper season. It gives profuse vegetative growth and result in higher productivity. Fertilizer management plays an important role in increasing the productivity of fodder crops.

Among the three fertilizer elements nitrogen (N) fertilizer is most commonly used to increase the yields of non-leguminous fodder crops. Application of phosphorous (P), and to some extent potassium (K), with limited use of nitrogen is recommended for obtaining maximum green produce from leguminous fodder crops. In addition the use of compost, farm yard manure (FYM) and manure made from dung is also used. The use of biofertilizer which include Rhizobia, Azotobacter, blue green algae (BGA) and vermicompost is also recommended.
Though various tropes of fertilizer are suggested and available, more emphasis is being given on the use of chemical fertilizer for gaining higher productivity. Among these nitrogen is used in large quantity, particularly while cultivating the grasses, cereals and other non-legumes. Though fertilizer nitrogen increase the productivity, its use in excess is more times non-economical and undesirable. Continuous use of nitrogen slowly destroy the soil texture with increased salts. It excess use may result into the accumulation of toxic constituents like oxalates and nitrates in foliage. The use of organic fertilizer which includes compost and farm yard manures, as well as the employment and bio-fertilizers is not yet gained much popularity as it gives the result at a slow rate. It is, therefore suggested that more stress should be given on the use of organic and bio-fertilizer.

Crop rotation is an ancient practice in Indian agriculture. During crop rotation the cultivation of leguminous crop in kharif is followed by growing of non-leguminous crop in the rabi season particularly in rainfed areas. This practice provide nitrogen fixed by legume to the succeeding crop cultivated in rabi season. However, with the availability of irrigation facility the farmers cultivate crops without proper rotation, and use fertilizers for getting maximum yields. This slowly result into increase in the area of uncultivable lands which were fertile earlier.

The another method of increasing the productivity of land is mixed cropping or intercropping. In mixed cropping, two or more crops are cultivated as a mixture simultaneously on a piece of land. On the other hand
during intercropping, the two or more crops are cultivated simultaneously in rows with appropriate proportion of the component crops. While employing either mixed or intercropping system, normally a legume is used as a component crop with non-legume. Under such situation both component crops compete with each other for water and nutrient in the soil, space and the light. This results in higher productivity of both the crops and yield benefit. Apart from this the legume component supply fixed nitrogen to the non-legume component, while the later give shade, shelter and support to the leguminous crops. The simultaneously cultivation of two crops also decrease the growth of weeds. All these happening during the growth of component crops due to mixed cropping or intercropping results into higher productivity.

The increased production due to intercropping could be obtained with very limited use of fertilizer. Thus, apart from increasing the yield, intercropping protect the soil texture and prevent erosion by giving favourable canopy structure with full cover on the land. As mentioned in the first chapter, mixed cropping and intercropping were considered as ancient and primitive practices of agriculture. However, it has been established now that intercropping is the most ideal practice for increased yield through better exploitation of natural resources.

Investigations in this laboratory on the productivity of fodder in general and that of leaf protein (LP) in particular, were restricted to the sole cropping until 1980. After going through the literature on intercropping, it
was decided to undertake field trials with fodder crops by cultivating them in intercropping system. Kasture (1982) initiated experiments on intercropping by cultivating *Sorghum* or maize with either cowpea or *Dolichos*. The result obtained were encouraging and cultivation of *Sorghum* with cowpea was found beneficial in giving yield advantage (Kasture and Mungikar, 1981), cultivation of *Sorghum* and maize with either cowpea or *Dolichos* gave increased fodder yields (Kasture and Mungikar, 1984). Maize plant showed improvement in dry matter accumulation due to its cultivation with cowpea (Kasture and Mungikar, 1985). Reddy and Mungikar, (1985-86) showed very little influence of fertilizer nitrogen application to an intercropping system with maize and cowpea. In an experiment with *Sorghum* which was cultivated with either cowpea or *Dolichos* an improvement in leaf area index (LAI), Net assimilation rate (NAR) and leaf area duration (LAD) of *Sorghum* was observed which resulted into greater biomass production (Kasture et al., 1986). An experiment with lucerne and hybrid Napier grass, the two perennial fodder crops, gave significantly higher yields due to their simultaneous cultivation (Dakore and Mungikar, 1986). In one of the experiments, maize – *Dolichos* intercropping yielded more fodder than maize–cowpea (Kasture and Mungikar, 1986). During the field trials with maize – cowpea intercropping system, higher fodder yields were recorded due to their cultivation in equal proportion (Dakore and Mungikar, 1988). It was concluded by Mungikar, (1988) that an intercropping system makes better use of solar energy.
These results obtained in this laboratory and elsewhere by earlier workers tempted the author to undertake studies on intercropping to observe the advantages in doing so. For this purpose, three field trials were undertaken on the farm located in the Botanical garden. The main objective was to evaluate the performance of various fodder crops under sole and intercropping systems. The results are presented on the following pages in the form of tables, illustrations and discussion.

**EXPERIMENTAL**

**Agronomy**

All field trials were conducted on the research farm of Dr. Babasaheb Ambedkar Marathwada University Botanical Garden during 2004 – 2005. The land was prepared by ploughings and cross ploughings. It was then made good for sowing by applying farm yard manure (FYM) at a rate of 1200 kg / ha to undertake agronomic trials. A piece of land was divided into 15 plots of equal size, each bearing an area of 11.81 m². The sowing was done by hand either by broadcasting the seeds in some experiments and / or by drilling in row spaced 30.5 cm apart. Table 1 gives data on the crops taken during each experiment, sowing dates, date of harvesting, duration of the crops, amounts of fertilizer applied and net size of the plots harvested. Since the crops were to be harvested for vegetative phase of growth slightly higher seed rates were used to get abundant foliage.
A minimum use of fertilizer was made. The two fertilizers i.e. N and \( \text{P}_2\text{O}_5 \) were applied through urea and single super phosphate respectively. The fertilizers were applied in two or three equal split doses at an interval of 25 to 30 days. All crops were raised under irrigation and whenever necessary weeding was done by hand. As far as possible the use of insecticide and pesticide was avoided, except during the field trials undertaken in monsoon when the insecticides were sprayed to control aphides.

**Field techniques**

In all three experiments were conducted. The treatments offered for all experiments were replicated three times in randomised blocks.

Maize (*Zea mays* L.), *Dolichos (Lablab niger medicus Syn. Dolichos lablab* L.) were selected for experiment - I undertaken during June to August 2004. The two crops were cultivated as sole crops, and in addition maize + *Dolichos* were cultivated in intercropping system. In intercropping system, the two crops were sown in 2 : 1, 1:1 and 1 : 2 proportion. Maize and *Dolichos* were sown at a seed rate of 50 and 90 kg / ha respectively. The sowing was done on 24 June, 2004 and the green fodder was harvested on 8 August, 2004.

*Sorghum* and *Dolichos* were selected for experiment – II. The two crops were cultivated under sole cropping system, using the seed rate of 50 and 90 kg/ha respectively. The intercropping system contained simultaneous cultivation of these two crops in rows. Three intercropping
systems were adopted using replacement series technique, wherein the two crops were sown either in the proportion of 2:1, 1:1 and 1:2. There were thus five treatments, sole *Sorghum*, sole *Dolichos* and *Sorghum + Dolichos* in 2:1, 1:1 and 1:2 proportion. The crops were sown on 4 September, 2004 and green fodder was harvested on 30 October, 2004.

*Sorghum* and Gram were selected for experiment – III. The two crops were cultivated under sole cropping system, using the seed rate gram of 50 and 60 kg / ha respectively. The intercropping system contained simultaneous cultivation of these two crops in rows. Three intercropping system were adopted using replacement series technique, wherein the two crops were sown either in the proportion of 2:1, 1:1 or 1:2. Slightly higher fertilizer dose was given in comparison to that applied for experiment – I & II. Thus the five treatments were Sole *Sorghum*, Sole Gram and *Sorghum + Gram* in 2:1, 1:1 and 1:2 proportions. The crops were sown on 4 December, 2004 and green fodder was harvested of *Sorghum* on 8 February, 2005 and green fodder of gram was harvested on 8 March, 2005.

During all field trials, each treatment was replicated three times in randomised block design. As far as possible, the values of seed rates mentioned for sole cropping system decreased in mixed or intercropping system depending on the proportion of a particular crop in mixed or intercropping system. In order to ensure uniform population density and plant to plant spacing within a row, either extra seedlings were thinned after emergence or the gaps were filled with re-sowing shortly.
Sampling and analysis

The green foliage was harvested normally at a pre-flowering stage. The harvesting of the crops for fodder was usually done early in the morning with a steel cutter. The fresh fodder yield obtained per plot due to a single crop or the two crops under intercropping was recorded. The sample of green fodder were immediately brought into the laboratory, chopped 2 – 3 cm pieces, dried in oven at 95°C till constant weight, dry matter (DM) content was determined and dry samples were used for analysis.

Dry samples were ground to a fine powder. The N content was estimated by microKjeldahl method and crude protein was expressed as N x 6.25 as described in chapter III.

Calculations

The yield of green fodder, dry matter (DM) and crude protein (CP) were calculated from the weight of the foliage per unit area of ground, its dry matter and crude protein (N x 6.25) content.

Land equivalent ratio (LER) was worked out by determining the ratio of the yield of individual crop in a mixture to its yield as sole crop (Motha and De, 1980).

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LER = \frac{\text{Yield of the crop in intercropping system}}{\text{Yield of the crop in sole cropping system}}
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Below ground interaction between the component crops during intercropping

There has been a rapidly growing interest in intercropping as a potentially beneficial system of crop production. It has now well established that, if the component crops are properly selected the intercropping system gives yield advantage. When the intercropping system gives higher yields than sole cropping, the yield advantage is often attributed to more efficient use of environmental resources. This is mainly due to the complementary interaction between the component crops. The two component crops use natural resources differently and compliment each other resulting into higher biomass productivity. Observations recorded with a species which is cultivated alone and along with the component crop in an intercropping system, can indicate relative exploitation of the natural resources. The interaction between the two crops may be either below or above the ground.

The below ground relationship between the two component crops is related to their root system. The roots of the two component crops compete with each other for space, moisture and minerals. When the intercropping system comprises of a non-leguminous cereal crop as one component and leguminous crop as another, there is variation in the root system. The roots of cereal crop are not so deep while in the leguminous crop they are deep rooted, as a result of which the intercropping system can exploit underground resources more efficiently. In addition, it has been observed that the roots of many species secrete chemical compounds which may
support or inhibit the growth of surrounding plants. Under such situation the two components either compliment each other or result into the failure of either component. In other situation, the roots of one component may secrete nitrogen or other chemical compound which are beneficial for the growth of other crop resulting into increased productivity of both the crops (Bhuktar, 1995). This results favourable growth of both the crops and higher yields.

Attempts have been made during present study to observe the growth of the two component crops in an intercropping system when Dolichos was cultivated with either Sorghum or maize. The crops were cultivated in the pots and their growth was observed. In order to study the below ground interaction between crop species, vertical partition in the soil was employed to prevent it. The results obtained are presented in this chapter, which are mainly concerned with growth of the plants during initial stages.

Two experiments were conducted for the present study wherein a leguminous a crop Dolichos or Gram was cultivated with either Sorghum or maize. All experiments were undertaken in the pots with 25 cm diameter. The pots were filled with soil collected from the University Botanical garden after mixing it with farm yard manure (FYM). Each experiment was conducted with a set of twelve pots each. There were four treatments each replicated in three pots. Experiment I was undertaken with maize and Dolichos. In three pots, maize alone was sown. In the set of other three pots, Dolichos alone was sown. In the third set maize and Dolichos were
cultivated together in equal proportion. In set IV the soil in the pot was divided by a partition with steel sheet and the two crops were grown on either side to avoid underground competition.

Experiment– II was undertaken with Sorghum and Gram, the method for sowing were as per the Experiment– I with Maize and Dolichos.

The crops in all of the pots were allowed to grow for a period of 45 days. The plant population of 6 plants / pot was kept constant by removing the extra plants few days after sowing. In the pots, where a mixture of two crops were cultivated 3 plants of each species were allowed to grow. The plants were raised in the garden under irrigation and without the use of any fertilizer elements.

At the age of 45 days height of the plants and number of leaves per plant were recorded. The plants were separated from soil carefully and the length of the root was measured. In case of Dolichos, the number of nodules on the main and lateral roots were measured and recorded.

The above ground biomass or the shoot portion comparing the stem and leaves were separated and its yield per pot was recorded for each crop. The plants were dried in oven at 95°C for the determination of percent dry matter (DM). On the basis of the yield of foliage per pot and percent dry matter in the foliage, the dry matter (DM) produced per pot was calculated.

The dry samples obtained from each pot were ground to a fine powder and employed for the estimation of nitrogen (N) by microKjeldahl method as described in Chapter – III. Using the data on the yield of dry
matter per pot and N % of DM, the accumulation of nitrogen (N) per pot was calculated. The data on the yield of green foliage, dry matter (DM) and nitrogen (N) per pot from each crop under sole and intercropping system were calculated and compared. The data were statistically analysed following Panse and Sukhatm (1978).

RESULTS AND DISCUSSION

In all three field and two pot experiments were undertaken during present investigation while doing experiments in pots in the I set either maize or Dolichos alone were cultivated in the pots. Simultaneously both the plants were cultivated together in the same pot in 1:1 proportion. In some pots while cultivating the two crops simultaneously and together with each other a partition was imposed in the soil to avoid interaction / compilation among the roots of two crops. The experiments with maize and Dolichos were undertaken during 8 July, 2004 to 7 September, 2004 and with Sorghum and gram in a similar way was conducted during 27 December, 2004 to 19 March, 2005. Table 2 gives detailed account regarding sowing and harvesting dates of the crops cultivated in pots.

During the cultivation of maize and Dolichos in the pots, either alone or together, and with or without interaction of the root, observations on the growth of two component crops were recorded 61 days after sowing (DAS). When maize was cultivated alone in the pot it grew 77.8 cm high. The growth of maize was increased when it was growing with Dolichos as indicated by the height which increased to 125 cm. Slightly different trend
was recorded with *Dolichos* when cultivated alone. Height of the *Dolichos* plant was 40.1 cm which decreased to 37.1 cm due to its association with maize. A further decrease in the height of *Dolichos* plant to 30.8 cm was recorded when the interaction between root was prevented by partition of the soil. The results on height on the plant indicated more influence of above ground competition rather than between the roots below the ground level.

The number of leaves per maize plants were 6.3 which increased to 8.7 in association with *Dolichos* and to 7.7 when the root were prevented from interaction due to the partition. As with height of the plant the number of leaves per plant of *Dolichos* were 19.1 which decreased to 15.4 due to its association with maize. The data on height of the plant and number of leaves clearly indicated that when both crops were growing together, the growth of maize improved considerably while that of *Dolichos* was reduced to some extent.

There were 11.4 nodules / plant of *Dolichos* which increased to 13.8 when it was growing along with maize. Partition of the soil to avoid root interaction had no influence on nodulation.

The fresh and dry weights of maize significantly increased when they were growing with *Dolichos*, while the weights of *Dolichos* decreased while growing in association with maize. The N % of dry matter in maize foliage increased from 1.08 to 1.42 % when it was growing along with maize. The N content in maize, however, decreased to 0.82 % when the
roots of it were not allowed to interact with *Dolichos*. Similar results were expressed with *Dolichos* when N % dry matter was 2.00 % which increased to 2.50% in association with maize while remained constant even after growing along with maize due to the lack of root interaction. The result thus gave and clear cut indication that accumulation of nitrogen in *Dolichos* improves when it simultaneously grown with maize. This results in higher accumulation of nitrogen in maize foliage too. The total N content in the maize plant increased while that in *Dolichos* decreased when the two component crops were growing simultaneously in the same pot. The results obtained with maize and *Dolichos* which are presented in Table 3 and Fig. 1, thus indicated beneficial effect of intercropping particularly on the non-leguminous component crop i.e. maize.

Table 4 and Fig.2 gives an account on the effect on simultaneously cultivation of *Sorghum* and gram in the pots. As with earlier experiment, the two crops *Sorghum* and gram, were cultivated in pots either alone or together and their growth was major 81 days after sowing. The results obtained during this experiment were similar to those obtained during earlier experiment with maize and *Dolichos*. The height of *Sorghum* plant growing alone was 47.4 cm which increased to 70.2 cm while growing along with the plants of gram. However, the height of the gram plants remained unaffected due to its association with *Sorghum* and ranged from 27.5 to 30.2 cm. Association of *Sorghum* with gram had no effect on number of leaves per plant which fluctuated between 4.7 and 5.0. The
number of leaves / plant of gram, however, decreased from 6.8 to 3.3 due to its association with Sorghum. The fresh and dry weight of Sorghum decreased in association of gram while remained almost unchanged when the roots of it were not allowed to interact with gram due to partition. The weight of the plant in case of gram remained unaffected even when the plant was growing with Sorghum. The N % of dry matter in both the plants remained constant when they were growing either alone or simultaneously together. Partition of the soil to avoid root interaction decreased N % of dry matter in the foliage in both crops. As far as the amount of nitrogen per plant was concerned it decreased in both the plants due to togetherness. The decrease was more pronounced when partitioning was done in the soil to avoid root interaction.

The overall results obtained with Sorghum and gram indicated that when they were cultivated together there was improvement in morphological character but productivity and assimilation of dry matter decreased in both the crop due to allelopathy.

The data included in Tables 3 and 4 based on the experiments are undertaken in pots clearly indicated beneficial effects of growing leguminous and non-leguminous crop together. The results however indicated that the effect of above ground association was more effective than underground competitions between the roots of two component species. Though the pots experiments undertaken during the present investigations and these undertaken by Bhuktar (1995) with Sorghum +
cowpea, Maize + cowpea and bajra + cowpea does not give clear cut idea regarding yield advantage, it reveals the competitive relation between the two component crops (Bhuktar and Mungikar, 1998, 1999 and 2001).

In addition to the experiments in the pots, fields experiments were also undertaken with maize + Dolichos, Sorghum + Dolichos and Sorghum + gram combinations. The two component crops in each field experiment were sown in rows either alone or in ratios of 2:1, 1:1, 1:2. The experiments were planned in such a way to investigate the competitive relationship and yield advantages due to intercropping.

The first field trial was undertaken during June to August 2004 with maize and Dolichos. Table 5 and Fig. 3 illustrated in the form of histogram. Both plants grew well with favourable canopy structure and dark green foliage without any hazards from either insects, pests or pathogens. When the green foliage of maize and Dolichos were harvested, 61 days after sowing, it was soft and lush containing from 9.8 to 10.6 percent dry matter (DM). Slight decrease in dry matter was noticed when maize and Dolichos were growing in 1:1 proportion. The dry matter content of Dolichos ranged from 15.25 in intercropping system to 16.32 % when it was growing alone in sole cropping system. The N % of dry matter in maize was 1.49 % under sole cropping system which increased to 1.61 % while growing along with Dolichos. Similarly the N % of dry matter in Dolichos was 3.3 % which increased to 3.44 % due to intercropping. Intercropping of these two crops in 1:1 ratio however showed very little influence on nitrogen content of
The yields of green fodder, dry matter and crude protein significantly increased due to intercropping. Maize alone yielded 8166 kg / ha green fodder, 858 kg / ha dry matter and 78 kg / ha crude protein. The yields of all these components increased significantly to 12360, 1262 and 131 kg / ha respectively in the form of mixture of a two component crops in an intercropping system with 1:1 ratio of component crops. A careful observation on the yields and the values of LER clearly indicate yield advantage in case of maize while disadvantage in case of Dolichos, but higher total productivity due to intercropping was confirmed with the values of LER reaching upto 1.78 in case of green fodder, 1.58 in case of dry matter and 1.59 in case of crude protein. The overall results indicated suitability of intercropping maize and Dolichos showing field advantage, presented in Fig. 4 in the form of correlation and Fig. 5 in the form of LER.

The yield of green fodder was 3779 kg / ha with Sorghum while 1434 kg/ha with Dolichos data presented in Table 6 and Fig. 6 in the form of histogram. When these crops were cultivated in sole cropping system the yield of green fodder was more than Sorghum sole cropping system when the two crops cultivated in 2:1 proportion. Though the green fodder decreased in remaining two intercropping combination (i.e. 1:1 and 1:2 ratio) the yield advantage was clearly observed in the form of the values of LER. The total LER for green fodder was 1.32, 1.10 and 1.27 when the two component crops were cultivated in 2:1, 1:1 and 1:2 proportion respectively. Thus as far as the production of green fodder was considered
the cultivation of *Sorghum* and *Dolichos* in either 2:1 or 1:2 proportion was more beneficial. Similar types of results were obtained with the yield of dry matter and crude protein. *Sorghum* alone produced 782 and 58 kg/ha dry matter and crude protein respectively. While the values for *Dolichos* were 304 and 55 kg/ha respectively as experienced with the yield of green fodder. Increased total dry matter, productivity was experienced in an intercropping system comparising of *Sorghum* and *Dolichos* in 2:1 proportion in spite of low total dry matter production in the remaining two intercropping systems. The yield advantage was visible in the form of LER. The values of LER for the yield of dry matter were 1.37, 1.07 and 1.38 respectively, when the two crops were cultivated in 2:1, 1:2, 1:1 proportion.

Unlike yield of green fodder and dry matter the crude protein yield increased in all intercropping combinations in comparison to that obtained under sole cropping. The sole *Sorghum* and *Dolichos* yielded 58 and 55 kg/ha crude protein. The total crude protein yield in the three intercropping combination was between 60 to 78 kg/ha showing advantages in the yield of crude protein, which was also clear with values of LER. The maximum yield advantage in crude protein was experienced in *Sorghum + Dolichos* intercropping system in 1:2 ratio having value of LER of 1.39. The overall results on the yield of green fodder, dry matter and crude protein were significantly low with 1:1 and 1:2 combination while significantly higher for the yield of crude protein. Thus a significant increased in the total crude protein productivity can be achieved by cultivating *Sorghum* and *Dolichos*
in 1:2 ratio. A careful observations of the values of LER for individual component crop indicate yield advantage in both the species. The LER values thus indicated that the two component crops complimented each other in producing either green fodder, dry matter and crude protein particularly when they were grown in 2:1 or 1:2 proportion cultivating of *Sorghum* and *Dolichos* in 1:1 proportion was found to be less effective in spite of marginal yield advantage.

The competitive relationship between the component crops during three intercropping system for the productivity of green fodder is given in figure 7. The illustrations clearly indicated that there was an increased in total productivity of all the components due to intercropping. The relationship between the two component crops was of complementation type, while in some cases compensation was observed. In all the three intercropping combination the non-leguminous component crops shows more yield advantages in terms of LER values are given in figure 8, which indicated that all intercropping system showed yield advantage with the total LER exceeding 1.0. Furthermore it was observed that non-leguminous component crop dominated legumes. The overall results obtained during present investigation suggested yield advantage due to intercropping as was also experienced by earlier workers from this Department (Mungikar, 1999; Kasture and Mungikar, 1998). Cultivation of *Sorghum* and maize with either cowpea or *Dolichos* resulted in increased the fodder yields (Kasture and Mungikar, 1994). An improvement in dry matter accumulation in maize
due to its association with cowpea was observed by Kasture and Mungikar (1985). A very little influence of fertilizer application to intercropping system comprising of maize and cowpea was experienced by Reddy and Mungikar (1985-86). Similarly higher green biomass production was reported by Kasture et al., (1986) with Sorghum and cowpea. Dakore and Mungikar (1986) also experiences significantly higher yields of green fodder when the two perennial fodder crops lucerne and hybrid Napier grass were cultivated in an intercropping system. In one of the experiment cultivation of maize and cowpea in 1:1 proportion gave maximum yield advantage. Mungikar (1988) pointed out that an intercropping system makes better use of solar energy. Bhuktar and Mungikar (1998-99) while studying competitive relationship between bajra and cowpea, which were cultivated in an intercropping system, reported advantage in the yield. The competition between cowpea and Sorghum was also studied by Bhuktar and Mungikar (1997) by undertaking pots experiment and indicated that both crop complement each other, when cultivated simultaneously. Performance of maize and cowpea plant, when cultivated alone or in mixture was also evaluated by Bukhtar and Mungikar (2001). Basole and Mungikar (1996) gave an account of maize and Sorghum when cultivated with cowpea and highlighted their yield advantages. Intercropping of legumes crop with cereals for better use of land resources was advocated by Bhuktar and Mungikar (2000). More comprehensive account on intercropping and its advantages have been given by Bhuktar (1995) and Mungikar (1999).
The results obtained during the field trials with *Sorghum* and gram are presented in Table 7 and Fig. 9 illustrated in the form of histogram. The dry matter content of gram was 24.02% which slightly decreased due to its association with *Sorghum* in intercropping system. On the other hand the dry matter (DM) content of *Sorghum* increased from 20.67% to 25.63% due to its association with gram. The nitrogen content in the dry matter (DM) of both species increased when they were cultivated in intercropping system, thus showing increased accumulation of nitrogen in the foliage.

The yield of green fodder obtained from gram was 2124 kg/ha while that from *Sorghum* it was 8635 kg/ha. Intercropping of these crops gave significantly lower yields of total green fodder due to low productivity of gram in comparison to that of *Sorghum*. However, yield advantage was noticed in case of gram which suppressed the productivity of *Sorghum* to some extent. The values of LER calculated for green fodder yield indicated yield advantage when gram and *Sorghum* was cultivated in 2:1 ratio. Cultivation of these two crops showed yield disadvantage with the value of total LER as 0.82 when gram and *Sorghum* were cultivated in 1:2 proportion. Stability in the yield was observed even though the yield of *Sorghum* was reduced. The value of LER for green fodder thus indicated dominance of gram plants over *Sorghum* as was indicated by the values of LER.

When the data on the yield of dry matter considered at almost similar pattern was observed, wherein yield disadvantage was observed in gram +
Sorghum (2:1 proportion) and gram + Sorghum 1:2 proportion). The values of LER clearly indicated the dominance and gram over Sorghum presented in Fig. 10. The yields of crude protein, however, showed yield advantage in all intercropping systems. Sole cropping system with gram and Sorghum yielded 86 and 145 kg/ha crude protein respectively which increased to 155 kg/ha showing yield advantage with the value of total LER of 1.27. However, the increase in crude protein yield was statistically non significant. Gram + Sorghum in 2:1 and 1:1 proportion yielded 123 and 111 kg/ha crude protein respectively with the values of LER exceeding unity. The crude proteins yield was also suppressed to some extent when the two component crops were cultivated in 1:1 proportion. In the remaining two intercropping systems, gram indicated advantage in the yield and thus showed its dominants over Sorghum.

When gram was harvested for its pods and grains it was observed that the yield of total biomass in case of sole cropping was 2118 kg/ha data presented in Table 8. It decreased with its proportion in various intercropping combination. Similarly the yield of grains was 1266 kg/ha, which also decreased with the decrease in plant population in intercropping systems. The decrease in grain yield however, was not much less when the proportion of gram + Sorghum was 1:2. The weight of 100 grains raised from 18.32 to 19.01 gm when the grains were collected from intercropped gram, thus Sorghum facilitated grain filling in gram.
The overall results obtained during two pot experiment and there field trails during present investigation concluded that cultivation of legumes with cereals gives yield advantage, particularly that for fodder. The advantages in the yield during present study have been proved with values of LER. The illustration on competitive relationship also indicated yield advantages due to intercropping with both compensation as well as complementation type relationship. Thus it can be concluded that intercropping of suitable species including leguminous component crop is most suitable for increased fodder productivity with minimum or no use of chemical fertilizer. It has been well documented that the leguminous species fix atmospheric nitrogen and when there is a leguminous crop growing in association with tall non-legume component, the roots secret nitrogen which is useful for the non-leguminous component (Nicol, 1935; Virtanen et. al. 1937, Wilson and Burton 1938)