CHAPTER 5

DISCUSSION

5.1 The possibility of maize/ lablab intercropping

The findings from informal survey, discussions and participatory activities with key informants in Lanku and Tandi sites of Chitawon district Nepal, showed that, lablab can be introduced as companion species in an intercropping system with maize.

The incorporation of lablab in the cropping systems of Lanku site seems more advantageous. It is because farmers can utilize the usual fallow period of 2 to 2½ months after maize (mid July to September) in a common cropping pattern of maize-fallow- mustard/ wheat. Use of lablab as a fodder can be partly as green fodder and partly by making hay which can be presumed as prompt source of legumes that reduces the quantity of concentrates needed during dry season. In practice, farmers use dried maize as a source of feed materials from September to January which normally has low protein content. In such situation, lablab as a fodder could be used to balance the protein requirement of livestock since it has high protein content (16.03 to 19.09%).

The combination of cereal and legume, can be a potential feeding materials even from January to April provided, the acreage of intercropping is increased. Household labor availability will not be the constraint in cultivation of lablab as a component crop, since extra labor requirement will be only during sowing and harvesting. It was found that, farmers were highly responsive in lablab cultivation after knowing the intercropping practices and its possible advantages.

Situation in the Tandi site revealed different. It is because farmers follow intensive crop cultivation in the rice based cropping system. They may cultivate lablab during February, which is the normal time of maize sowing. But, in order to prepare field for rice cultivation, lablab must be cleaned up at around June. This untimely harvesting of lablab calls for preservation need of hay or silage to feed during dry season. Normally, fodder availability is not a problem in the rainy season (June to september). Hence, importance of lablab to them only exist if they can make necessary arrangement of preservation. To do this, besides other factors, availability of labor is most important. Generally, farmers are heavily involved for rice cultivation during these months. They can only trade off the need of labor for other works according to the level of fodder scarcity and livestock enterprises. Therefore, possibility of lablab introduction in the area largely depends on the degree of commercialization of livestock.

Based on these findings, it can be said that, there exists a positive attitudes of most of the farmers towards lablab cultivation that may help to improve productivity of cereal crops in addition to solving the problem of fodder scarcity if lablab could be cultivated without affecting the yield of main crop in the upland maize based as well as lowland rice based crop livestock mixed farming systems of Nepal.

5.2 Evaluation of component crops in intercropping systems

Grain and dry matter yield of mono maize was slightly more but not significantly higher ($P < 0.05$) than intercropped maize if lablab was not cut. In fact, yields of intercropped maize were found increased ($P < 0.05$) when cutting practice in lablab was performed at 40 DAS with either severity level of 30 or 20 cm cutting height from the base. This implies that, there was no suppressive effect of lablab to the intercropped maize in terms of dry matter and grain yield production when cutting lablab was not done. This was supported by the fact that, Leaf Area Index (LAI) of maize was similar between mono and intercropped maize throughout the growth period (Table 8). Further more, it can be said that, by the time maize accumulated maximum LAI (40 DAS), lablab was not established enough in comparison with maize either in terms of canopy development or making shading effect. When lablab grew vigorously, maize had crossed it's critical period of nutrients requirements. Ultimately, lablab could not make any significant suppressive effect to maize.

Similarly, plant arrangements in the intercropping systems, which caused less competition by lablab to maize for PAR during early growth period (until trailing started) could play some important role in order to have such result. Dallal (1974) adapted from Ofori and Stern (1987) suggested that in the maize/ pigeonpea system, maize yield was not affected in the alternate row arrangement, possibly due to improvement in the amount of light transmission. Such effect of plant arrangement may be applicable to have less suppressive effect of lablab on maize since lablab was sown in every other row of maize. However, reduction in yield of either components in a cereal legume intercropping have been reported by different researchers (Cordero and McColleum, 1979; Allen *et al.*, 1983; Misbahulmunir *et al.*, 1989).

Higher grain yields of intercropped maize while cutting lablab at 40 DAS could be related to the increment in the photosynthetic efficiency of maize that could have resulted higher yield. Such result is also supported by the lower yield of maize if cutting lablab was delayed by 60 DAS. Fisher *et al.*, (1983) suggested that, any events to reduce competition at around flowering in maize has a positive effect to the yield. Tolleaar *et al.*, (1988) observed that, maize yield in the absence of other limiting factor is determined by PAR, crop canopy and efficiency of plant for PAR absorption. On the other hand, lower grain yield of mono maize in comparison with intercropped maize with cutting lablab at 40 DAS, to some extent could be due to higher competition by weeds for the soil mineral nutrients.

Lablab, without any cutting practices showed increase in dry matter production with advancement in days in either cropping systems. Growth rate of lablab was higher especially after 100 DAS. Crop growth rate in monolablab was some 37 gm^{-2} d^{-1} compared to 27 gm^{-2} d^{-1} in intercropped lablab. Gardner *et al.*,(1985) reported that maximum short-term crop growth rates for alfalfa, sugar beat and sudan grass were 23, 31 and 51 gm^{-2} d^{-1} respectively. Similarly Loomis *et al.*,(1963) reported that crop growth rates for the C_3 plants range from 20 to 51 gm^{-2} d^{-1}. These data supports that under certain circumstances growth rate could be very high as in this experiment. However, actual causes for the higher growth rate of lablab are still unanswered. On the other hand dry matter production of lablab was reduced ($P < 0.05$) by introducing cutting management practices. At 130 DAS, in monocrop, some 20% reduction in dry matter accumulation was observed if cutting at 40 DAS in comparison with 42% in intercrop. Similarly, about 32% dry matter accumulation was reduced when cutting at 60 DAS in monocrop compared with 67% in intercrop. This result was also found to be associated with the LAI of lablab (Table 8). More reduction in dry matter of lablab in intercrop if cutting at 40 DAS in comparison with monocrop could be due to shading effect of maize on regrowth of lablab after cutting. This could be due to intensity of shading at the top of legume canopy as observed in cassava-soybean combination by Tsay (1985) adapted from Ofori and Stern (1987). Similarly, reduction might also be associated with the lower uptake of soil mineral nutrients by lablab after cutting in intercrop due to some stress effect.

Greater reduction in dry matter accumulation in intercrop if cutting at 60 DAS was observed. Which could be more due to shading effect of maize coupled with inactivation of lablab bud after cutting. Rao (1983), reported that, shading decreased photosynthesis of legume. In lablab, shading effect of upper leaves as such can make senescence to the lower leaves as plant height increased. It caused inactivation of auxiliary buds on lower stems which should have provided the regrowth. Such process could be more prominent in intercropped grown plants where further shading effects of maize provided lower availability of PAR coupled with less ability of recovery as well as uptake of soil nutrients which caused greater reduction in dry matter. Mislevy *et al.*, (1984) also observed such effect of bud inactivation in joint vetch. Eveas (1972) suggested that, the role of regrowth of a forage plant after defoliation is influenced by remaining leaf area on the stubble and amount of carbohydrate reserves in roots, crown and stubble. This all suggests that, the stress effect of cutting practices could be varied with growth stages, which may result slower growth rate of plants as well as lower amount of dry matter accumulation.

5.3 Nitrogen fixation in intercropping system

Proportion of fixation was found steadily increasing throughout the growth period at each sampling i.e., from V7 (30 DAS) to V48 (130 DAS) (Table 11). In this study, plants derived more proportion of it's nitrogen from fixation (P fix) in intercrop than in monocrop-grown lablab at every growth stages. Derivation of more proportion of it's nitrogen from fixation by intercrop grown legume was in the same line with the result reported by Rerkasem and Rerkasem (1988) in maize ricebean intercropping and by Pantollana (1992) in upland rice-ricebean intercropping. It can be argued that, amount of nitrogen that maize plant extracted more from soil nitrogen could be best possible due to result of more favorable environment to the maize plants coupled with higher ability to exploit soil nitrogen from the pool. Simultaneously, which could be accounted for intercrop lablab to depend on symbiotic nitrogen fixation. Similarly, the maintenance of nitrogen fixation activity during late vegetative growth was consistent when patterns of nodulation and accumulation of shoot nitrogen were taken into consideration in lablab (Figure 7, 8, 9).

It was found that, cutting practices reduced nitrogen fixation, if cutting was done at 40 DAS in either cropping systems. Which could be due to the lower rate of photosynthetic activities or the carbohydrate reserved (Ryle *et al.*, 1986) in plants after cutting. Similarly, during regrowth (at V36, V48), the rate of recovery of nitrogen fixation was related more to the re-establishment of plant photosynthetic capacity (Ryle *et al.*, 1986) in white clover, and in lablab in this study, which represents the overall recovery of nitrogen fixation of lablab when cutting practices were imposed in intercrop. Bethlenfalvay and Philips, 1977, adapted from Nambier *et al.*, (1983) reported that, reduced light in intercrop could affect nitrogen fixation by restricting photosynthesis of host shoots and so the energy supply of nodules. Depression in P fixation were also found to be associated with reduction in nodule numbers in either cropping systems. Interactive effect of cropping system and severity of cutting, resulted higher P fix in intercrop cutting at 20 cm height indicates that for the growth and recovery of buds and leaves, plant needed more nutrients which forced them for more P fixation.

Cutting at 60 DAS indicated similar trend of depression in P fixation as in 40 days in intercrop at V36 stage. Which supports the lower rate of growth and overall performance of lablab plants after cutting due to suppressive effect of maize that could have lead to the lower P fixation in lablab. Increment in P fixation after maize harvest also suggests the higher level of suppressive effect to lablab if cutting was delayed by 60 DAS. Such effect, however, in monocrop, if lablab was cut at 60 DAS was not observed. In which, P fixation was not depressed after cutting which could be best possibly due to early recovery of plant growth that needed higher rate of photosynthesis and dependency on fixed nitrogen probably due to insufficient soil nutrients to meet the needs of regrowth plants. More LAI of lablab (Table 8) after V36 stage was also associated with this result along with higher number of root nodulation (Figure 7). However, P fixation started decreasing after 100 days which could be due to intraspecific shading effect or the development of visible dense and overlapped crop canopy.

Amount of nitrogen fixation in lablab found tremendously increasing after V36 stage (100 DAS) until final harvesting (130 DAS). Similar result has been reported by Piha and Munus (1987) in field grown bean. High levels of nitrogen fixation in bean was found to be associated with late maturity and climbing habit (quoted from Peoples and Herridge, 1990). On the other hand, amount of nitrogen fixation was found to be affected by the cutting practices. However, in mono, cutting did not affect on cumulated N fixation when cut at 60 DAS at V36 stage. But at V48, it was declined by 26%. Unlike this, in intercrop, reduction was already begin by about 50% at V36, which increased up to 70% at V48. Increment in the reduction rate of N fixation from 50 to 70 also implies the severity of effect. This is with the same trend in dry matter accumulation as well as LAI. Wahua and Miller 1978, adapted from Ofori and Stern (1987) reported that shading by the cereal reduces both seed yield and nitrogen fixation potential of the companion legume in a sorghum-soybean intercrop system. Such effect could be applicable in this result. Along with these, plants also had to compete with weeds in order to have photosynthetic activities, resulting lower growth rate as well as nitrogen requirement. Similarly, reducing effect of cutting on nitrogen fixation have also been observed when cutting was done in 40 DAS. However, reducing effect was decreased from V36 (55% reduction) to V48 (43%) in intercrop. While, in monocrop, such trend was not observed. It could be argued that bud activation of lablab at early stage was quite high, which caused progressive growth rate after cutting. Such growth, which was observed high in monocrop, and low in intercrop that could be due to shading effect, which caused lower availability of PAR in intercrop-grown lablab plants.

Like wise, there appeared a interactive effect ($P < 0.05$) of cropping system and cutting days at V48 (130 DAS) stage which was not found at V36 stage (100 DAS). This also proved that reduction in nitrogen fixation is highly associated with the cutting days of lablab i.e. lower rate of reduction for the early cutting (40 DAS) and vice versa. Which further proves the significance of cutting lablab at 40 DAS.

5.4 Productivity of intercropping system

Intercropped maize and lablab yields, whether in terms of LER's for dry matter for the period of associative growth or ATER's for dry matter and protein yields all indicated a definite advantage of intercropping that could improve the productivity in an intensive cropping pattern compared with their monoculture yields. Which means, maize lablab intercropping system is advantageous to the grain and stover yield of maize and fodder yield of lablab in comparison with monoculture maize. Our data supports this propositions. Similar advantages in legume/ non legume intercrops have been observed by Ssekabembe (1984), Faris *et al.*, (1983), Allen *et al.*, (1983), Trenbath (1976), Hiebsch and McCollum (1987) and Rerkasem and Rerkasem (1988). The fact that, the dry matter and protein yields of both maize and lablab when intercropped, were generally LER and ATER value greater than 1 implies beneficial effects of intercropping for both species. In addition to the advantage in relative terms, intercropped maize without cutting lablab had also absolute advantage over monoculture maize by about 30% in terms of dry matter production. Cutting lablab in the intercrop, however, increased this advantage only about 23% and 18% when cut at 40 and 60 DAS respectively in comparison to monoculture. Therefore, with the cutting practice, farmers may partially solve the problem of fodder scarcity during dry months of the year since lablab stuff is considered one of the nutritious fodder to feed animals. Besides this, the gross economic analysis of the dry matter, grain yields and nitrogen yield show that maize/ lablab intercropping with cutting practice of lablab at 40 DAS is the most profitable cropping system considering their products into valuation. Which proves that, farmers can expect a higher economic return from the intercrop than the monoculture maize.

Horwith (1985) has proposed theory of companion plant compensation that caused intercropping advantageous, in which when biological or the physical factors affect the companion crops differently, compensation mechanism causes over yielding of the system as a whole. Cutting practice could have such mechanism in intercropping. Similarly, Willey (1979) hypothesized that, intercropping exhibited biological advantages over sole cropping when interspecific competition for growth resources was less than intraspecific competition. In this study, cutting lablab at 40 DAS could have helped to lessen the interspecific competition.

Nitrogen fixation, on the other hand, could be one important factor in the advantage of legume/nonlegume intercrops or pasture mixtures (Harper, 1977; Valis, 1978; Willey, 1979, adapted from Rerkasem and Rerkasem 1988). From this study, it is clearly indicated that, both maize and lablab contribute towards the observed intercrop advantage. Differential utilization of soil mineral nutrient sources by the two species may be responsible for the observed effects. Hiebsch and McCollum (1987) noted that, legume/ nonlegume intercrops may, under low-N regimes, utilize area and time more efficiently than sole crops because of the legumes ability to fix atmospheric nitrogen, which reduced the direct competition for the available nitrogen, causes intercropping advantageous. Results from this study indicated that, intercrop advantage, in terms of dry matter yield in lablab was positively correlated with the amount of nitrogen fixation in intercrop-grown plants i.e., more the nitrogen fixation, more dry matter yield.

Therefore, it can be hypothesized that such higher fixation of N by lablab could be stimulated due to uptake of mineral nitrogen by the maize. In the same way increase in nodule number in treatments cutting at 40 DAS at V36 and V48 stage in comparison with 60 days cutting also supports the proposition of dependency on fixation by 40 days cutting. This may also explain why depression of fixation was more by 60 days cutting (decline in ureide export) than 40 days cutting which could be resulted from low uptake of mineral nitrogen by maize. On the other hand, higher uptake of mineral nitrogen by maize when cut at 40 DAS could have forced lablab to be more dependent on nitrogen fixation. Such effect has been previously reported by Rerkasem *et al.*, (1988) on maize rice bean intercropping; Ofori and Stern, (1987) on maize/ cowpea intercrop; Faris *et al.*, (1983) on sorghum-pulse (cowpea or common bean) and Allen *et al.*, (1983) on corn, cowpea and soybean intercrop system.

In a maize lablab intercrop, the visibly strong canopy of lablab had shade the maize, practically that could be controlled through the cutting management of lablab during critical stages of maize development. Such practice ultimately provided maximum growth and yield of maize. Results of this study supports this propositions.

Maize lablab intercropping system proved to be a viable alternative as a source of food and fodder equally for a crop-livestock integrated mixed farming systems of subtropical as well as tropical area, which not only increased land use efficiency but also achieved highest net income to the farmers. However, the evaluation of the potential and limitations of maize legume intercropping systems and hence, the potential benefit of nitrogen fixation by the legume would greatly benefit from an understanding of how intercrops respond to varying levels of factors eg., light, water and other mineral nutrients (Rerkasem *et al.*, 1988) and cultivar used, management and environmental factors (Ezumah *et al.*, 1987). Besides this, management of soil fertility in the long run is also equally important in terms of utilizing the benefit of maize/lablab intercrop system. It is established fact that, Nepalese farmers do not use the inorganic source of nitrogenous as well as other fertilizer as sufficient as required to make balance in the source (soil). From this experiment it was observed that, fixation from the atmosphere contributed some 88% of the intercrop lablab nitrogen, which is a large dependence of lablab on atmospheric nitrogen, which could be due to more utilization of soil nitrogen by maize. In this situation, there could be a danger that, soil nitrogen may be depleted under such system if all of the lablab biomass is removed from the field. The attention to the management of lablab biomass is essential in order to maintain the long term productivity. For which, some portion of lablab biomass may be utilize as a green manure. Along with this, recycling of nutrients in the form of farm yard manure could be another alternative. For which, attention should be made to the better utilization of dung and manure in the field. The productivity of maize/lablab intercrop in the long run therefore, depends not only on technical aspect of intercropping, but also to the fate of soil in intercrop condition.