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Review article

A CRITICAL REVIEW ON NITROGEN MANAGEMENT IN SPECIALITY CORN UNDER *PONGAMIA* + MAIZE AGRI-SILVI SYSTEM

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Intercropping of agricultural crops with woody species is an age-old practice in traditional farming systems in the tropics. Food production is the major aim of subsistence farmers with most of their farmland being allocated to food crops rather than to trees and shrubs. Due to increasing population and scarcity of productive lands that cannot sustain intensive exploitation, one method that has been proposed to enhance the sustainability of agricultural production is the growing of trees in association with crops. Alley cropping is an agroforestry system in which food crops are grown in alleys formed by hedge rows of trees or shrubs and these hedge rows are kept pruned during the rainy season. The hedge rows are usually cut to a height of about 2 m when crops are sown and kept pruned to reduce competition with crops. Work done on alley cropping in *Pongamia pinnata* was less in India and other countries. Hence literature pertaining to tree crop competition studies in agri-silvi system was presented in this chapter. Moreover, it was unable to get sizeable literature related to speciality corn. In view of the paucity of adequate literature related to speciality corn, few citations with respect to grain corn were also presented in brief to know the general scientific idea.

The available literature related to the present study has been reviewed under the following heads.

1 Tree crop competition studies in agri-silviculture system.
2 Performance of arable crops in alley cropping system.
3 Performance of speciality corn under the influence of graded nitrogen levels.
4 Economic studies in agri-silviculture system.

1. Tree Crop Competition Studies in Agri-Silviculture System

Agroforestry experiments involving forestry tree species *Casuarina equisetifolia* and *Leucaena leucocephala* and arable crops sunflower, sesame and groundnut resulted in significant reduction in intercrop yields primarily due to reduced light interception (Srinivasan et al., 1990).

Yamoah (1991) opined that pole bean was most appropriate intercrop in six month old sesbania plantation in comparison to maize. On the other hand Tripathi and Hazra (1997) revealed that maize yields under *Hardwickia binata* were enhanced due to improved soil fertility, lower bulk density and pH. Likewise, Khadse and Bharad (1996) reported that *Hardwickia binata* canopy reduced the mean sunlight transmission on the castor crop grown in alleys. However, higher yield was recorded from central rows with reduction in yield towards the tree. Likewise, Rao et al. (2000) observed higher drymatter, crop growth rate, leaf area and leaf area index in groundnut under alley cropping with *Albizia* than in sole cropping. Similarly, in a study conducted at Jhansi on the tree-crop interaction in *Albizia procera* and black gram and mustard agrisilvi system it was noticed that there was significant reduction in the crop yield due to the limited availability of light to the crop (Newaj et al., 2003).

2. Performance of Arable Crops in Alley Cropping System

Studies conducted at CRIDA, Hyderabad on alley cropping with *Leucaena leucocephala* revealed significant reduction in crop yields of pigeonpea and castor (61-62%), sorghum (48%) and pearlmillet (30%).

This was primarily attributed to rooting pattern of agricultural crops affecting the nutrient and moisture relations (Singh et al., 1987). Likewise, Balasubramanian (1989) reported higher grain yields of pearl millet and sorghum in *Leucaena leucocephala* alley cropping.

Chamshama et al. (1994) reported that in an intercropping of maize with *Faidherbia albida,* the grain yield was 90 per cent of sole maize in the first year of normal rain and corresponding year being a dry year, intercropped maize yield was 64 per cent higher than sole maize yield. Vani (1995) conducted experiment in alley cropping with *Faidherbia albida* at Hyderabad the results revealed that plant height, dry matter production, crop growth rate, leaf area, leaf area index of castor were found significantly superior to sole crop of castor. Likewise, the work of Madhusudhan (1997) revealed that castor had significantly higher plant height, dry matter production, crop growth rate and leaf area index when alley cropped with *Leucaena leucocephala* than the values noticed in sole castor. The evaluation of maize production in an alley cropping system with *Calliandra calothyrsus* and *Erythrina fusa* and monoculture where trees were planted in rows of 6 m wide with spacings of 0.5, 1 and 2 m between trees and pruned twice yearly was indicated that maize crop yields in alley cropping were greater than in monoculture. (Jimenez et al., 1997)

Further, Bheemaiah et al. (1998) observed better performance of rainfed castor alley cropped with *Leucaena leucocephala* in terms of dry matter production and crop growth rate than the sole cropping of castor. Results of an experiment on growth and yield of maize alley cropped with *Leucaena leucocephala* and *Faidherbia albida* indicated that there was no gain in maize grain yield due to presence of *L. leucocephala* and *F. albida* (Chamshama et al., 1998)

Whereas, Bisaria et al. (1999) conducted an experiment at Jhansi to study the effects of stand density of *Hardwickia binata* on intercrops viz., soybean and mustard. Yields of intercrops were moderate but not more than the yields obtained under sole cropping.

Suresh and Rao (1999) reported that reduction of grain and fodder yields of sorghum were minimum to the extent of 12 to 40 % with the association of nitrogen fixing trees like *Faidherbia albida, Acacia ferruginea* and *Albizia lebbeck* as compared to sole sorghum.

Studies conducted on the performance of soybean under tree species viz., *Prunus domestica*, *Morus alba* and *Punica granatum* at Solan (HP), revealed that crop yield in close proximity to tree species was minimum and the yield increased with the increase in distance from the tree (Sharma and Chauhan, 2003). In a study on alley cropping of wheat with *Morus alba* hedge rows under rainfed conditions at Solan (HP) it was observed that adverse effect on photosynthesis, transpiration and water use efficiency of wheat was attributed to the shade effect of *Morus alba* (Thakur and Dutt, 2003).

Studies conducted on production potential of sorghum, cowpea, groundnut, dhaincha, moongbean and turmeric in alley cropping with poplar recorded significant reduction in the yield of all the test crops due to the decreased light availability to crops under poplar (Nandal and Hooda, 2005).

Performance of Specialty Corn under the Influence of Graded Nitrogen Levels:

Effect on Growth parameters

Baby corn

Thakur et al. (1997) studied the response of baby corn to different levels of nitrogen and found that growth parameters viz., plant height, leaf area and dry matter accumulation were increased with increasing levels of nitrogen application up to 150 kg N ha-1. Nitrogen fertilization had noticeable influence on crop growth and yield of baby corn. Significant increase in plant height was observed up to 120 kg N ha -1 (Sahoo and Panda, 1999). Thakur and Sharma (1999) reported that plant height of baby corn was found significantly increased up to 200 kg N ha-1.

A field experiment conducted during rainy season at Almora, envisaged that among three levels of N tried 120 kg N ha-1 resulted in maximum plant height of baby corn. (Pandey et al., 2000).

Sunder Singh (2001) revealed that in baby corn during summer season there was a significant increase in plant height with every increment dose of N up to 150 kg ha-1 where as during *kharif* season the significant difference in plant height was observed only up to 120 kg ha-1.

Sunder Singh (2001) reported that in baby corn, increasing nitrogen levels recorded significant increase in dry matter production in maize up to 150 kg ha-1 but it was comparable with 180 kg ha-1 both in *kharif* and summer seasons.

Bindhani *et al.* (2007) stated that in baby corn, application of 120 kg N ha-1 resulted in tallest plant with maximum dry matter yield and leaf area index, which were significantly higher than those at remaining lower levels of nitrogen.

Sweet corn

Nath *et al.* (2009) observed that in sweet corn the dry matter accumulation increased significantly by enhancing the fertility level up to 90 kg N + 45 kg P2O5 ha-1.

Jat et al. (2009) found that in sweet corn plant height was significantly increased with increase in level of fertilizer from 50 per cent (60:30:30 kg NPK ha-1) to 100 percent RDF (120:60:60 kg NPK ha-1). They also reported that application of 100 per cent RDF significantly produced more dry matter (137.95 g plant-1) than 75 and 50 per cent RDF.

Popcorn

Gokmen et al. (2001) reported that in pop corn the maximum plant height was observed with the highest dose of nitrogen *i.e.*, 250 kg ha-1 while lowest values were recorded at control level 0 or 50 kg N ha-1. Application of 90 kg N ha-1 in pop corn significantly improved dry matter per plant at harvest over 60 kg N ha-1. Further increase in fertilizer dose failed to get a significant improvement. (Choudhary and Singh, 2006).

Ashok Kumar (2009) found that each successive increment in nitrogen level from 0 to 120 kg ha-1 markedly improved plant height as well as dry weight plant-1 in pop corn at New Delhi.

Konuskan et al. (2010) reported positive effect of increased nitrogen application on plant height of popcorn and the highest value was obtained with 240 kg N ha-1.

Maize

Shanti et al. (1997) envisaged that in maize, among five levels of nitrogen tried, 160 kg N ha-1 resulted in maximum leaf area index and dry matter accumulation per plant.

Shanti et al. (1997) reported advancement of silking by 7.9 and 8.4 days, respectively due to 120 and 160 kg N ha-1 in comparison with the crop in no nitrogen treatment (control). Earlier appearance of silks (60.6 to 56.2 days) was also observed with increase in nitrogen level from 80 to 160 kg ha-1 by Muniswamy *et al.* (2007).

Increase in LAI (2.6 to 4.9) of maize with increase in nitrogen level from 0 to 240 kg ha-1 was also reported by Kumar and Bangarwa (1997) at Hisar during winter season in sandy loam soil. Similar response to increased level of nitrogen on LAI was reported by Shivay *et al.* (1999) from Pantnagar, Muniswamy *et al.* (2007) from Bangalore and Suryavanshi et al. (2008) from Parbhani.

Bangarwa and Gaur (1998) reported that increase in N dose from 40 to 120 kg ha-1 significantly increased the plant height from 132.16 to 139.84 cm in silty clay loam soils at Akola.

Bangarwa and Gaur (1998) reported significant response up to 120 kg nitrogen ha-1 in dry matter production of maize. Suryavanshi et al. (2008) also observed significant response of maize to N application up to 150 kg ha-1 and increased the dry matter production over 100 kg nitrogen ha-1.

On silty clay loam soils of Pantnagar (Tarai), significant increase in plant height and dry matter accumulation was recorded with each successive increase in the level of nitrogen application from 0 to 120 kg N ha-1 in maize (Shivay and Singh, 2000).

Mishra et al. (2001) reported that in eastern Uttar Pradesh, among the three levels of nitrogen tried viz., 0, 75, and 150 kg N ha-1, 150 kg N ha-1 recorded maximum leaf area index in winter maize.

Vadivel et al. (2001) observed that with increase in nitrogen levels from 0 to 60 kg N ha-1, the plant height, leaf area index and dry matter of maize increased significantly.

Mohamoud and Sharnappa (2002) recorded maximum leaf area index of maize crop with 150 kg N ha-1. The result of the experiment conducted by Muniswamy et al. (2007) at Bangalore during *kharif* season indicated that plant height of maize increased (151.3 to 175.2 cm) significantly with each increment of nitrogen from 80 to 160 kg ha-1.

Ashok Kumar et al. (2008) observed that in maize, growth parameters were found to be the highest with the application of 120 kg nitrogen through urea and 30 kg nitrogen through poultry manure per hectare.

Suryavanshi et al. (2008) reported that application of 150 kg nitrogen ha-1 was found significantly effective over 50 and 100 kg nitrogen ha-1 in increasing plant height of maize from 149.20 cm to 185.61 cm in black soil during *kharif* season at Parbhani.

Effect on Yield attributes:

Baby corn

Application of 120 kg N ha-1 resulted in the maximum weight of baby corn without husk compared to other levels of N tried viz., 0, 20, 40, 60, 80 and 100 kg N ha-1 (Sahoo and Panda, 1997).

Thakur et al. (1997) noticed increased number of baby corn cobs per plant with 200 kg N ha-1 compared to no nitrogen on alfisols of Bajura, Kullu valley, Himachal Pradesh.

Thakur et al. (1997) demonstrated that baby corn weight with and without husk was found increased significantly with successive increase in N levels up to 100 kg N ha-1.

Length of baby corn, weight of ear and number of ears per plant were found to be the highest with 120 kg N ha-1 (Sahoo and Panda, 1999).

Thakur and Sharma (1999) registered higher number of baby corn cobs per plant and length of baby corn with 200 kg N ha-1 as compared to 100 kg N ha-1.
Contrary to this, significant differences were not observed in the weight of cob when nitrogen was applied at 100, 150 and 200 kg ha-1 to baby corn. (Thakur and Sharma, 1999).
Pandey et al. (2000) reported that the number of baby corn cobs per plant and cob weight were highest with 120 kg N ha-1 than at 60 and 90 kg Nha-1 but did not observe any significant difference in the length of baby corn with increased levels of nitrogen from 60 to 120 kg N ha-1.
Bindhani et al. (2007) observed that in baby corn a significant increase in baby corns/plant, their fresh weight, length and girth were also recorded up to 120 kg N ha-1.
Singh et al. (2010) reported that significant increase in baby corn weight, cobs per plant, baby corn girth was observed with the application of 180 + 38.7 + 74.7 kg N+P+K ha-1 compared to 60 + 12.9 + 24.9 kg N + P + K ha-1.

Sweet corn

Raja (2001) reported that increase in nitrogen levels from 0 to 120 kg N ha-1 significantly increased the cob length as well as cob girth of sweet corn.
Sahoo and Mahapatra (2004) concluded that in an experiment conducted in sweet corn at Jashipur, increase in levels of nitrogen from 60 to 120 kg ha-1 increased the number of cobs per hectare, length and weight of cob.
Kar et al. (2006) recorded that increased nitrogen application from 20 kg N ha-1 to 80 Kg N ha-1 significantly increased the cob length from 14.6 cm to 17.5 cm and cob girth from 13.8 cm to 16.7 cm.
Nath et al. (2009) reported that in sweet corn an increase of 11.6% and 16.9% in cob length and cob girth were recorded when the fertility level was raised from 50 to 70 kg N ha-1 and an application of 110 kg N ha-1 accounted for significant increase (10.1%) over 70 kg N ha-1 in cob girth.

Popcorn

Gokmen et al. (2001) observed that in popcorn, the kernel number per ear increased by about 6% as nitrogen increased from zero to 250 kg N ha-1 and also stated that maximum cob length was obtained from 250 kg N ha-1.
Oktem and Oktem (2005) revealed that cob length increased from 16.42 cm at 150 kg N ha-1 to 20. 88 cm at 350 kg N ha-1. They also concluded that cob girth was increased with application of N up to 250 kg ha-1, beyond the level of 250 kg ha-1 there was no significant increase.
Ashok Kumar (2009) observed that in pop corn maximum values of yield attributes viz., cob girth, cob length, grains ear-1 and shelling percentage were recorded with the application of 120 kg N ha-1. Cob weight increased with increase in nitrogen application and the heaviest cobs were obtained at 240 kg N ha-1. (Konuskan et al., 2010).

Maize

Shanti et al. (1997) observed that application of 160 kg N ha-1 recorded the highest number of cobs per plant in maize which was however, statistically on par with that of 120 kg N ha-1 and significantly superior to other N levels (0, 40 and 80 kg N ha-1).
Application of 160 kg N ha-1 in maize significantly increased the number of cobs per plant (1.62 to 2.12) as compared to 80 kg N ha-1 (Muniswamy et al., 2007).
Ashok Kumar et al. (2008) revealed that in maize, highest values for all the yield parameters like number of cobs per plant, length of cob, no of grains per cob and test weight were obtained with the application of 30 kg N through poultry manure in addition to 120 kg N through urea.
Bhat et al. (2008) reported that maximum values for cobs per plant (1.46), grain rows per cob (16.13), grains per row (44.60), grains per cob (718.01), test weight (205 g) were obtained with nitrogen at 150 kg ha-1 supplied through urea and azotobacter followed by treatments with nitrogen at the same rate but through urea and poultry manure.

Effect on Cob/ Grain Yield:

Baby corn

Sahoo and Panda (1997) recorded the maximum baby corn yield with 120 kg N ha-1 both winter and wet seasons. Sahoo and Panda (1999) observed increased baby corn yield with increased levels of nitrogen from 80 to 160 kg ha-1 and the increase was more during winter than in wet season.
Thakur and Sharma (1999) found significant increase in baby corn yield with increase in applied nitrogen dose from 100 to 200 kg ha-1 in a field experiment carried out during rainy season at Bajaura.
Baby corn yield recorded with 120 kg N ha-1 was found to be significantly higher than that with 60 and 90 kg N ha-1 (Pandey et al., 2000). Application of 120 kg N ha-1 in baby corn resulted in the highest baby corn yield, which was 28.6, 52.2 and 178.7% higher than that of 80, 40 kg N ha-1 and the no nitrogen respectively. (Bindhani et al., 2007).
Significant increase in baby cob and corn yield were observed with the application of 180 kg N ha-1 compared to 60 kg N ha-1. (Singh et al., 2010).

Sweet corn

Kang et al. (1985) noticed that 100 kg N ha-1 was optimum for maximum cob yield of sweet corn and the increase in green cob yield beyond 120 kg N ha-1 was not appreciable.

Mullins et al. (1999) opined that application of 112 kg N ha-1 was sufficient for sweet corn, where as Akthar and Silva (1999) obtained maximum weight of green cobs with 150 kg N ha-1 which was on par with 120 kg N ha-1.

Raja (2001) revealed that application of increasing doses of nitrogen significantly increased the number of primes from 50,376 at control to 65,639 at 120 kg ha-1.

Sahoo and Mahapatra (2004) observed that increase in levels of nitrogen, increased green cob yield from 8.88 t ha-1 (60 kg ha-1) to 10.53 t ha-1 (180 kg ha-1).

Kar et al. (2006) noticed that green cob yield of sweet corn was significantly increased with increase in nitrogen from 0 to 80 kg ha-1.

Sahoo and Mahapatra (2007) reported that a plant population of 83,300 per hectare & fertility level of 120 kg N-1 ha with P2O5 and K2O at 26.2 kg ha-1 and 50 kg ha-1 respectively should be adopted to obtain the maximum green cob yield and net profit from sweet corn.

In a field experiment conducted during *Kharif* season at Pune, it was reported that application of 100 per cent RDF (120:60:60 kg NPK ha-1) recorded maximum cob yield (8.84 t ha-1). (Jat et al., 2009).

Popcorn

Choudhary and Singh (2006) reported that application of 90 + 45 kg N and P2O5 ha-1 in pop corn significantly improved grain yield over 60 + 30 kg N and P2O5 ha-1. Further increase in fertilizer dose failed to get a significant improvement. Ashok Kumar (2009) found that successive increase in levels of nitrogen from 0 to 120 kg ha-1 recorded markedly higher green cob yield amounting 119.6, 200.0 and 222.4 %. with application of 40, 80 and 120 ha-1 respectively over control.

Maize

Rao and Padmaja (1994) reported that yield of sweet corn, pop corn and hybrid maize increased significantly up to 150 kg N ha-1.

Kumar and Singh (2002) revealed that grain yield in Maize increased significantly with increasing levels of nitrogen (0 – 150kg ha-1) and highest was obtained at 150kg ha-1.

Effect on Stover Yield

Baby corn

Thakur and Sharma (1999) reported significant increase in green forage yield of baby corn with increase in nitrogen dose from 100 to 200 kg ha-1.

Sweet corn

Sahoo and Mahapatra (2007) reported that in sweet corn, application of 120 kg nitrogen ha-1 resulted in higher stover yield than with other nitrogen levels.

Popcorn

Significantly higher stover yield was obtained with increase in fertilizer dose from 60 + 30 kg N and P2O5 ha-1 to 90 + 45 kg N and P2O5 ha-1 and further increase did not result any significant response in pop corn. (Choudhary and Singh, 2006).

Increase in nitrogen levels in pop corn enhanced the green fodder yield to the tune of 97.6, 157.8 and 185.5 % with the application of 40, 80 and 120 kg ha-1 over control. (Ashok Kumar, 2009).

Maize

Gaur (1991) reported higher stover yield at 60 kg „N‟ ha-1. However. Venugopal and Shiva Shankar (1991) found that application of 160 kg N ha-1 gave significantly higher stover yield (7326 kg ha-1) as compared to no nitrogen (1817 kg ha-1) in maize.

Gaur et al. (1992) reported significantly higher stover yield due to 120 kg N ha-1at Udaipur during rabi season in vertisols. Another study made by Selvaraju and Iruthayaraj (1994) revealed that 175 kg N ha-1 increased the stover yield significantly over 75 kg N ha-1.

Kumpavat and Rathore (1995) reported maximum stover yield due to application of 120 kg ha-1. There was linear increase in stover yield due to increase in N level from 62.5 to 250 kg ha-1 (Kuruvila and Iruthayaraj, 1996).

Bangarwa and Gaur (1998) reported higher stover yield (48.72 q) at 120 kg N ha-1. Similar response to higher „N‟levels was reported by Ameta and Dhakar (2000), Kar et al. (2006) and Suryavanshi et al. (2008).

Effect on Nutrient Uptake

The nitrogen concentration (%) in grain and stover of maize at harvest was increased with increase in levels of nitrogen from 50 to 100 kg ha-1 (Roy and Thripathi, 1987).

Baskaran et al. (1992) revealed that the N-uptake by maize exhibited a positive trend with increased levels of nitrogen application at all stages of crop growth. Application of 202.5 kg N ha-1 recorded highest N-uptake by shoot and grain.

N-uptake by grain (64 to 89 kg ha-1) and stover (46 to 61 kg ha-1) increased significantly with increase in N-levels from 80 to 120 kg ha-1 (Gaur et al., 1992).

Increasing the nitrogen dose up to 90 kg ha-1 increased the nitrogen and phosphorus uptake by grain and fodder maize (Singh et al., 1992).

Najundappa et al. (1994) found that increased nitrogen uptake by grain was increased up to 150 kg nitrogen ha-1, which was found at par with 225 kg nitrogen ha-1.

Application of 175 kg N ha-1 significantly increased the N-uptake as compared to lower levels (Selvaraju and Iruthayaraj, 1994).

Singh et al. (2000) found significant increase in nitrogen uptake with successive increment of nitrogen up to 100 kg ha-1, beyond which the increase was only marginal up to 200 kg ha-1.

Kumaresan (2001) revealed that the application of 100 per cent recommended dose of nitrogen and phosphorus in maize resulted in significant increase of nitrogen and phosphorus uptake, but did not influence the potassium uptake compared to 50 per cent recommended dose of nitrogen and phosphorus or control .

Parmar and Sharma (2001) reported that the nitrogen uptake in maize increased to a considerable extent with nitrogen application up to 120 kg ha-1. Ashok Kumar (2008) also reported the similar findings in popcorn.

Sofi et al. (2004) observed that the highest uptake of nutrients in maize with the application of 160 kg nitrogen and 80 kg potassium ha-1.

Sutaliya and Singh (2005) recorded that uptake of nitrogen, phosphorus and potassium was distinctly higher with application of 180-90-60 kg nitrogen, phosphorus and potassium ha-1 than with 120-60-40 or 60-30-20 kg nitrogen, phosphorus and potassium ha-1.

Kar et al. (2006) revealed that uptake of N in grain and stover increased significantly with successive increase in nitrogen. It ranged between 20.41 kg in control to 91.11 kg ha-1 at 80 kg N application.

Application of 120-26.2-50 kg nitrogen, phosphorus and potassium ha-1 to sweet corn resulted in significant increase in nitrogen, phosphorus and potassium uptake compared to other levels tried (Sahoo and Mahapatra, 2007).

Bindhani et al. (2007) reported that the nitrogen content both in baby corn and green fodder increased significantly with increasing N levels up to 120 kg ha-1.

Nitrogen application also enhanced nitrogen uptake up to 120 kg ha-1 (Ashok Kumar, 2009).

Effect on Economics of Speciality corn:

Thakur and Sharma (1999) concluded that the application of nitrogen @ 150 and 200 kg ha-1 gave 29.2 and 37.6 per cent higher net returns, respectively over 100 kg N ha-1 and the net returns per rupee invested increased with increased levels of nitrogen application. However, this increase was maximum with increased nitrogen application from 100 to 200 kg ha-1. Pandey et al. (2000) found that application of 120 kg N ha-1 gave significantly higher net returns of 27.3 and 8.6 per cent over 60 and 90 kg N ha-1, respectively and the benefit : cost ratio was also found to be the highest with 120 kg N ha-1. Significant increase in net monetary returns (Rs 10,685) was recorded by Ameta and Dhakar (2000) with 150 kg N ha-1 over 60 kg N ha-1 (Rs 8,572) in maize. Sharma *et al.* (2000) reported that application of 120 kg nitrogen ha-1 resulted in higher net returns than with lower levels.

Sahoo and Mahapatra (2004) observed significant higher net profit (Rs 20,700 ha-1) due to 180 kg N ha-1 over 60 kg N ha-1 (Rs 15,300 ha-1). Kar *et al.* (2006) reported that application of nitrogen from 0 to 80 kg ha-1 gave significantly higher net returns (Rs 32,086 to Rs 61,532 ha-1) and benefit: cost ratio (1.73 to 3.76) of sweet corn during *kharif* season in sandy loam soils of Bhubaneshwar.

Bindhani et al. (2007) concluded that in baby corn net returns and benefit : cost ratio were highest with 120 kg N ha-1, which resulted in significant increase of 289.2, 69.8 and 39.15 per cent in net returns and 235.2, 57.7 and 34.1 per cent in benefit : cost ratio compared to that of the no nitrogen, 40 and 80 kg N ha-1 respectively.

Suryavanshi et al. (2008) reported significantly higher gross returns, net monetary returns and benefit: cost ratio with 150 kg nitrogen ha-1 as compared to either 50 and 100 kg nitrogen ha-1.

There was marked improvement in net returns with each successive increase in nitrogen level from 0 to 120 kg ha-1. The maximum net returns of Rs. 49.57 thousands ha-1 was noticed with 120 kg N ha-1, which was 560.9, 64.5 and 10.0 % higher over 0, 40 and 80 kg N ha-1. The net returns rupee-1 invested was also enhanced with higher nitrogen levels, but significant improvement was found up to 80 kg N ha-1 (Ashok Kumar, 2009).

Economic Studies in Agri-Silviculture System

Malviya and Patel (1989) reported from the experiment conducted at Saurashtra that crop yields of groundnut, greengram and blackgram with *Leucaena leucocephala* were remunerative when compared to their respective sole crops. Similarly, Singh et al. (1989) reported that gross returns were higher in alley cropped systems. Alley cropped sorghum yielded twice the income of sole sorghum whereas the alley cropped pigeonpea yielded almost seven times the income over the sole pigeonpea. Vani (1995) from the study conducted at Hyderabad reported that higher net returns and benefit-cost ratio obtained from castor alley cropped in *Faidherbia albida* than sole cropped castor. Subrahmanyam et al. (1996) reported that sunflower and castor gave higher monetary returns under intercropping in young plantations of *Dalbergia sisso* when compared to sole cropping situation.

Bheemaiah et al. (1998) observed that sunflower intercropped with guava + curry leaf showed higher gross returns, net returns and benefit cost ratio than sole cropped sunflower.

Sharma et al. (2010) conducted an experiment at Dharwad on shallow black soils to study the effect of integrated nutrient management on pigeonpea based intercropping system and revealed that application of 50% RDF + vermicompost @ 2.5 t ha-1 recorded significantly higher pigeonpea yield, gross returns and net returns over the other integrated nutrient management practices.

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