II - REVIEW OF LITERATURE

Various nutritional aspects and growth regulators have been recommended for growing of papaya crop which differs with environment, genotype and other factors. It is essential to review the literature pertaining to the present investigation which have been presented in this chapter in the following heads:

The earlier workers reported that use of growth regular, fertilizer application to papaya in Hawaii is that of Higgins and Holt (1914). According to the Kebby (1960) the critical stage for adequate supply of plant food to papaya are the early growth, blossoming and fruit setting period. De Gues (1967) reviewed that the fertilizer application for papaya and stated that papaya has rapid growing characters and need readily available plant food at all times in order to ensure good growth and high fruit yield. He also reported that the first objective of a well balanced fertilizer programme should be development of a full grown crown of healthy leaves. It is particularly desirable to keep the bottom leaves green as long as possible because the growth of plant, the flavour and sugar content of the fruits are directly related to the leaf surface and carbohydrate synthesis. Awada and Suehisa (1970) worked out the nutrients removal by papaya fruits and reported that the quality of nutrient removed was in decreasing order of N, K, Ca, Mg
and P. The quantity of N and K removed represents 50% and 38% of the total removal of all the nutrients, respectively Cunha and Haag (1980) worked out the growth curve in papaya in field conditions and found that there was continued increasing trend in dry matter accumulation irrespective of weather conditions.

2.1 Effect of N on the Growth :

Agnew (1948) in Hawaii observed that the papaya required an ample supply of nitrogen. Further, Agnew (1954) found that application of water soluble fertilizer with a high nitrogen content produced a marked improvement in growth. Application of N, Significantly improved the yield, although, no response was observed on growth of the tree at Sabour (Ray, 1952). Chandler (1958) reported that papaya responds to an exceptionally high, continuous nitrogen supply which should be at a higher level in comparison to other orchard species. Ochese et al. (1961) reported that the productivity of a papaya plant depends upon its being kept in a state of constant growth, hence, fertilizer should be applied at higher rates and at frequent intervals. De Gues (1967) observed that papaya responds well to an exceptionally high continuous nitrogen supply in view of its growth characters, confirming the findings of Tripathi (1961) that nitrogen application significantly increased plant growth. Samule and Cibes (1969) observed the deficiency symptoms
caused by lack of nutrient in papaya in sand culture and recorded the poorest growth in the treatment in which no N was given. According to Hussain (1970) trunk growth of papaya in the first year was proportional to the N application rates. Jauhari and Singh (1971) found that the maximum growth of papaya seedlings was obtained in response to the highest doses of N (140 g N/plant). Awada (1977) observed that an increase in N fertilization increased the stem girth at vegetative stage only. According to Colom Covas (1977) in Peurto Rico, plant received a total of 340.2 of a 13:13:20 of NPK commercial fertilizer attained a maximum plant height and stem circumferences. Purohit (1977) reported that plant height and trunk diameter was significantly influenced by N. Cibes and Giaztambide (1978) reported that lack of N markedly by depressed overall growth of papaya plant. Perez (1982) observed that plant height, number of stem nodes, trunk diameter, leaf fresh and dry weights increased with the increase in nitrogen application. Das et al. (1981) reported the best results in terms of plant growth by applying N (200g), per plant. Luna and cadas (1984) reported that N application increased the trunk diameter and plant height when applied to Solo variety of papaya. Sumule and Cibes (1969) reported that the treatment avoid of nitrogen resulted in poor growth than that of the treatment lacking in P in sand culture in green house. Jauhari and Singh (1971) obtained
maximum growth response to 140g N. Biswas et al. (1989) during the experiment on papaya recorded maximum plant height with higher level of N 350g / plant as compared to plant height recorded under control. Number of leaves and basal girth also showed the similar trend. Maximum number of leaves and girth were recorded under the treatment comprising highest levels of N as compared to that under control. According to Reddy et al. (1989), the plants received no N, most of the biomass accumulated in vegetative parts (stem, leaves and roots) whereas those received N, biomass accumulation in fruits was increased. Moreover, N application also induced early flowering. Rao et al. (1992) conducted an experiment on papaya and observed that plant height and girth were significantly influenced by nitrogen application to the extent of 65 percent and 78 percent, respectively.

Plant height and stem girth of papaya plant were significantly affected by nitrogen rates. There was no significant difference in stem girth between the plants supplied with nitrogen at varied level, but it was significantly higher with nitrogen application over no nitrogen application. The number of leaves produced by plants treated with different nitrogen doses were statistically at par. Nitrogen had no significant effect on growth (Wagh et al., 1994). Ghanta et al., (1995) found that application of nitrogen, significantly increased the height and girth of the papaya plant. Positive and significant
correlation was observed between plant height and yield per plant and also between girth and yield per plant. Patil et al. (1995) obtained maximum plant height with N (15g) per plant per month applied in the form of neem cake and urea (50 : 50). Trunk circumference was maximum with N (30 g) as neem cake per plant per month. Number of leaves produced during the initial 6 month was maximum with 30 g N per plant per month. Plant height at which first flower formed was maximum with 30g of N per plant per month and minimum with 30 g N per plant per month in papaya. Singh and Sharma (1996) found a significant increase in plant height and number of leaves with higher dose of nitrogen. Patil et al. (1997) noticed maximum tree growth (height and circumference) with 150g N per tree per month. Reduced leaf area and plant height was observed in potassium deficient media in seedlings of papaya cv. Tainung No. 2 (Pan et al., 1994). Rani and Sathiamoorthy (1997) observed that growth was greatly enhanced when inorganic fertilizers are substituted with 50 percent organic N and 50 to 70 percent organic P along with biofertilizers, in papaya cv. Co-6. Villasurda and Baluyut (1990) observed significant effect of fertilizer application on stem diameter of guava. It was greatest with urea (10.5 g / plant) or Ammonium sulphate (23.75 g / plant). Flowering was advanced by 15 days in treated plants as compared to that in control when urea (105 g) combined
with poultry manure (1589g) per plant were applied. They also recorded maximum N uptake by the plants when combined application of organic and inorganic fertilizers were done. Gubbuk et al. (1993) observed highest growth rate of stem and fingers with N (80 g / hill) in Dwarf Cavandish banana and N (320 g / hill) in Basrai. Nitrogen reduced the time required for fruit development in comparison to no nitrogen application. According to Ray and Yadav (1996) in case of banana (cv. Basrai) nutrition supplied only through inorganic fertilizer (NPK 200 g N + 50 g P + 200 g K per plant) produced shorter plant which took longer times to shoot out, whereas, nutrition provided by combination of 25 percent fertilizer not only produced taller plant but also shortened the time required for emergence of bunch. Pseudostem circumference was also thicker in the combination having FYM than those without FYM. Cruz et al., (2004) evaluated that the effect of nitrogen on production and partition of dry matter and the change of some leaf sugars in cv. Solo. They reported that the increasing nitrogen rates promoted plant growth and qualitative characters of papaya fruit crop.

2.1.2 Effect of N on yield and yield attributes:

Singh and Singh (1963) recorded improvement in yield by applying a 180g N / plant in papaya. Hussain (1970) reported that highest yield in the second year was obtained from plants received nitrogen (20 g per plant
per month). Jauhari and Singh (1971) recorded maximum yield with nitrogen (140 g) per plant. Rao and Shanmugavelu (1971) found promising results with 200 g N per plant in split doses. Gaillard (1972) found highest yield in response to 250 g / plant of nitrogen. He also stated that split application did not improve the yield.

Awada and Suehisa (1975) obtained maximum yield with nitrogen 150 g per plant at 12 weeks interval. Purohit (1977) reported that the fertilizer treatment nitrogen (250 g), per plant per year applied in six doses, gave the maximum yield of 186.6 t per ha. According to Colom-Covas (1977) papaya plants received a total of 340.2 g of 13 : 13 : 20 of NPK commercial fertilizers in six, bimonthly intervals attained maximum fruit yield. Awada and Long (1978) reported that an increase in nitrogen fertilizer increased the number of harvested fruit but did not affect the yield of marketable fruits. Randhawa and Subramanian (1978) obtained the maximum yield 180 g N / plant. Rao and Rao (1978) reported that nitrogen significantly influenced the fruit yield. The yield was higher than control with 150 g N / plant. Awada (1977) reported that yield, number and size of marketable fruits increased with increasing nitrogen fertilization with the recommended dose of nitrogen (0.5 lb per plant).
Das et al. (1981) observed that treatment received N, at the rates of 200 g per plant yielded 57.1 t/ha fruits compared with 23t per ha in the control. Perez and Reyes (1983) reported that number and weight of fruits borne on female and hermaphrodite trees increased linearly with increased nitrogen levels. Biswas et al. (1989) found that in case of papaya, application of N (N 350g, per plant) along with FYM (25kg) resulted in maximum number of fruits, fruit weight and fruit yield as compared to control. According to Reddy et al. (1989) NPK rates had a marked effect on nitrogen, phosphorus and potassium concentration in petiole. A highly significant correlation was obtained between the nitrogen concentration in petiole and yield of papaya. Higher rate of N induced early flowering and significantly increased the yield. The highest estimated fruit yield of 155.5 t/ha over a 24 months cropping period was obtained with N 260 g, per plant. As per the reports of Jayprakash et al. (1989) nitrogen application resulted in significant increase in number of fruits per plant and fruit yield compared with control. Higher yield 38.12 Kg per plant was obtained with 250 g N / plant. Lokhande and Moghe (1990) reported that the highest yield (32.84 Kg per plant) with fruits weighing 1.828 Kg/fruit, was obtained by application of nitrogen 200g per plant along with urea (1%) and boron (0.2%) spray per plant in papaya cv. Honey Dew. Rao et al. (1992) observed that average
fruit weight was least influenced by nitrogen doses. Werner and Campbell (1993) found that yield of papaya increased linearly with increased N application from 50 to 150 Kg per ha. According to Wagh et al. (1994) number of fruits per plant was significantly increased by nitrogen as compared to control. There was no statistical difference between intermediate and high nitrogen level application on first crop harvest fruits. Application of nitrogen 150 g per plant gave higher yield as compared to nitrogen 300g per plant. Significant increase in number of fruits per plant, fruit weight and yield/plant by the application of N, has been reported by Ghanta et al. (1995). They reported that application of nitrogen 200g per plant exhibited maximum fruit weight and number of fruits as compared to application of 100g and 400g nitrogen. Patil et al. (1995) obtained highest yield with 30g of N, per plant per month and lowest in control. Harjadi et al. (1995) noticed increase in total fruit weight per plant with the increase in nitrogen levels in papaya. Bertuzzi et al. (1996) found that increasing rates of applied N, significantly increased total fruit yield. Application of N 200g per plant resulted in the highest average yield. Singh and Sharma (1996) found significant increase in fruit yield with the application of nitrogen. Maximum fruit yield was recorded with application of nitrogen 250g per plant per year as compared to control. Patil et al. (1997) noticed highest fruit yield (70.2 Kg/tree) with
nitrogen 150g per tree per month. Lavania and Jain (1998) advocated that nitrogen application significantly increased the yield and yield contributing characters of papaya cv. Pant Papaya-1. They have reported that nitrogen (200g) per plant was the best dose for increasing fruit yield in papaya. Srivastava and Soni (1988) studied the quality and yield of grapes as influenced by applied NPK. They reported that increased nitrogen levels upto (300g) per vine increased the bunch weight, berry weight, size and the number of berries/bunch. Gomes et al. (1988) obtained highest average bunch weight (10.9Kg) in banana from the plants received NPK and least from the plant received no NPK. Wang et al. (1991) applied different rates of chemical fertilizer on grape cv. Kyo-Ho and observed that for most of the treatments, fruit yield was at par with or higher than control (NPK at 100, 100 and 200 Kg per ha). Arumugam et al. (1994) reported that nitrogen application to palmyrah significantly increased the yield of fruits and was found to improve the number of bunches as well as number of fruits per palm. In case of banana (cv. Basrai) higher yield was obtained with nitrogen rates than that of control (Ray and Yadav, 1996). In mandarin-orange application of nitrogen alone resulted in a significantly greater fruit yield per tree and in fruit weight (Upadhyay and Patiram, 1996).
2.1.3 Effect of N on fruit quality:

Hussain (1970) reported that total sugar and TSS were inversely related to nitrogen doses. Jauhari and Singh (1971) observed that increasing nitrogen applications decreased the T.S.S. of the fruit. Purohit (1977) found that application of nitrogen significantly increased the T.S.S., as compared to control. Biswas et al. (1989) found that application of the higher doses of nitrogen resulted in maximum fruit size, pulp thickness and T.S.S. On contrary, Reddy and Kohli (1989) reported that nitrogen had no effect on fruit TSS and number of fruits. However, Jayprakash et al. (1989) suggested that the fruit quality is not significantly affected by nitrogen application with the exception of total sugar content which increased with N application. Lokhande and Moghe (1990) stated that maximum T.S.S. was obtained by the application of N (200g) per plant along with urea (1 percent) and boron (0.2 percent) spray in cv. Honey Dew. Rao et al. (1992) observed that T.S.S. of fruit was slightly influenced by nitrogen application. Fruit quality in papaya was not influenced by nitrogen application rates as reported by Werner and Campbell (1993). A significant improvement in quality of fruits due to application of NPK was found by Ghanta et al. (1995). Maximum fruit T.S.S. and good colour of fruit was obtained with nitrogen (15g per plant per month) as ground nut cake and minimum T.S.S. was recorded
in control (Patil et al., 1995). Lavania and Jain (1998) reported that nitrogen application reduced the T.S.S. content of the fruit while it was increased significantly by potassium application. Nitrogen (200g) in combination with phosphorus (50g) and potassium (100g) per plant was the best dose for good quality of fruits in papaya cv. Pant Papaya-1. Srivastava and Soni (1988) studied the quality of grapes cv. Perlette as influenced by NPK. They further reported that increasing nitrogen application along with FYM (30Kg) increased the TSS content. Wang et al. (1991) during the experiment on grape cv. Kyo-Ho observed that most of the treatments (different types of organic manure with a chemical fertilizer) gave similar or better fruit quality as compared to control. Arumugam et al. (1994) observed that T.S.S. of neera was higher with the application of 50g N/plant than the control to palmyrah palm.

2.1.4 Effect on N on nitrogen content and uptake

Awada et al. (1975) found the N fertilization increased the concentration of nitrogen content (%) in fruits as compared to control in papaya. Cunha and Haag (1980) reported that level of N in papaya plant was 4.24% in standard solution and 3.6 percent in the deficient solution. Awada and Long (1977) worked out the relationship between nutrient content, nitrogen levels, nitrogen fertilization and yield of papaya. Nitrogen concentration and fruit
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2.1.5 Effect of N on the Sex-expression:

Rao and Rao (1978) observed that sex-expression did not appear to be influenced by the nutrients, although there was an indication of N promoting femaleness but the effect was non-significant. Sharma et al. (1994) reported that nitrogen had no significant influence on sex-expression of papaya.

2.2 Effect on growth regulators

2.2.1 Effect of Growth regulators on the growth

Ganta and Mitra (1998) reviewed that they sprayed twice at 30 days interval starting from 45 days after transplanting with TIBA (25 PPM and 50 PPM), GA₃ (25 ppm and 50 ppm), ethrel (200 ppm and 500 ppm) and MH. (200 ppm and 500 ppm) and highest plant height and internode length of papaya were increased by GA₃ and ethrel, respectively. Though the GA₃ and TIBA concentrations increased the girth and no. of leaves/plant in papaya. Morales et al. (1998) determined that GA₃ 30 ppm concentration showed positive increase in height of plant, no. of leaves, shoot girth and length of the internodes in papaya as compared to 0, 10 and 20 ppm GA₃. Kumar and Prasad (1998) noted that 50 ppm GA₃ promoted no. of leaves, height of plant and diameter of shoot as compared to control and 25 ppm GA₃ in the tune of papaya growth. Morales et al. (2000)
advocated that papaya growth was increased positively in the tune of shoot
height, leaf number, leaf area and shoot dry weight with the use of 30
ppm GA$_3$ concentration as compared to 0, 10 and 20 ppm.

2.2.2 Effect of growth regulators on the fruit-yield

Ghanta and Mitra (1998) observed that all the growth regulators
concentration produced marked increase in fruits number, fruit yield.
Individual fruit weight, fruit size (length and diameter), pulp and seed ratio
but decreased the no. of fruit / papaya. Highest fruit yield of 45.63 kg
per plant and 114.07 t/ha were recorded with 25 ppm GA$_3$. The maximum
fruit yield of 45.6 kg / plant and 114.1 t/ha were recorded from the treatment
with 25 ppm GA$_3$ as compared with control (28.2 kg / plant and 76.6 t
/ ha). Although GA$_3$ was also found effective in increasing fruit size of
papaya (Mitra et al. 2000). Shanmugavelu et al. (1973) advocated that 200
ppm GA$_3$ and 50 ppm TIBA increased fruit size and reduced the seed content
and enhanced the fruit yield t / ha in papaya. Further they have reported
that GA$_3$ (25 ppm and 50 ppm) showed increasing trend pertaining to fruit
observed that all the TIBA concentrations (50-200ppm) significantly control
the fruit drop in papaya (21.33 to 62.67%) except TIBA 200ppm (6.67%).
Bhattacharya and Rao (1977) reviewed that 70 ppm TIBA and 150 ppm
GA$_3$ concentrations increased fruit yield in papaya.
2.2.3 Effect of Growth Regulators on the Sex-expression

Ghanta and Mitra (1998) reviewed that 50 ppm GA₃ and 50 ppm TIBA caused significant increase in femaleness in papaya. Mitra et al. (2000) advocated that spray of 25 ppm GA₃ and TIBA at 45 and 75 days produced earlist flowering in (79.5 days) as compared with control (104.5 days). Obviously TIBA 50 ppm gave highest percentage of female flowers than that of other treatments (62.5%) followed by (60.0%) in papaya. Shunmugavelu et al. (1973) reviewed that 200 ppm GA₃ and TIBA 50 ppm reduced the staminate flowers and increased the female flowers in cv. Coorg Honey Dew of papaya and also increased hermaphrodite flowers. Singh (1973) conferred that TIBA (100, 200 and 300 ppm) had no effect on sex-expression in papaya. Bhattacharya and Rao (1982) reported that papaya seedlings were sprayed 5 times with three growth regulators at 30 days intervals starting 75 days after transplanting one month old seedlings. Flowering in papaya, was earliest (177.7 days from transplanting) with TIBA (50 to 200 ppm) however, flowering in the control accrued on the 189 days. Through TIBA 50 ppm showed higher percentage of femaleness as compared to other concentrations of TIBA in papaya. Vishwakarma et al. (2000) found that the concentrations of GA₃ (25, 50 and 100 ppm) had marked effect on the sex-expression and reviewed that 50 ppm GA₃ gave highest no. of female
flowers in papaya over their higher & lower concentration of GA$_3$. All the female flowers showed marked increase in flower size with 50 ppm GA$_3$ concentration.

2.2.4 Effect growth regulators on the fruit quality

Ghanta and Mitra (1998) reported that GA$_3$ 50 ppm gave highest TSS content (%), ascorbic acid, sugar; acid ratio of papaya fruits. The ethrel 200 ppm produced total carotene in papaya pulp. Mitra et al. (2000) recommended that 50 ppm, GA$_3$ noted superior than control, 25 ppm and 100 ppm from the pulp and peel ratio, T.S.S. (10%) and ascorbic acid point of view in papaya fruits. Shanmugavelu et al. (1973) recommended that the 25 and 50 ppm GA$_3$ increased the total and reducing sugars, fruit volume, pectin content, T.S.S. and carotene content (%) of papaya fruits. Bhattacharya and Rao (1981) applied TIBA at the rate of 50 to 200 ppm in papaya at the brown stigma stage and twice more at 15 days intervals. Ripening was shortest (141 days) in fruits of papaya treated with TIBA (100 ppm) while control took 153 days to ripen the fruits. TIBA had positive effect on the T.S.S., ascorbic acid and carotene content (%) of papaya fruits. Total sugar was highest (9.23%) in papaya fruits treated with TIBA at 100 ppm which was more than the control, and other TIDA concentrations. Vishwakarma et al. (2000) stated the GA$_3$ 50 ppm showed advantageous
effect on the length of the fruits, size of the fruits, pulp and peel ratio, no. of seeds, T.S.S. of fruits, ascorbic acid and carotene content of papaya fruits. Ramkrishana et al. (2002) evaluated that GA$_3$ at the rate of 150 ppm was more effective in reducing physiological weight loss, total loss, total soluble solids and total sugar content by maintaining fruit firmness in papaya. Further ripening parameters like colour and total carotenoid content were delayed, thereby, increasing the shelf life by four days more over the control in papaya fruits.

Kumar and prasad (1998) reported that the maximum total soluble solid content (10.5%), total sugar (8.74%), reducing sugar (7.15%), non reducing sugar (1.59%), vitamin A (2450 I.U. / 100mg) and vitamin C (ascorbic acid) content (58.50mg / 100 g) were recorded with the treatment of 50 ppm GA$_3$ in papaya fruits. Bhattacharya and Rao (1977) reported that TIBA (50 to 200 ppm) significantly decreased papain yield from 80-100 days old fruits of papaya.

2.2.5 Effect of Growth regulators on the nutrient content and uptake

Kumar and Prasad (1998) reveals that 50 ppm GA$_3$ produced highest nutrient content in fruit of papaya as compared to control, 25 ppm and 100 ppm GA$_3$. They also reported that various growth regulators promoted nitrogen content (%) in fruits and uptake of nitrogen through fruits as compared to control.