Discussion
V. DISCUSSION

The productivity and quality of a crop mainly depends on its genetic potential and its interaction with the environmental conditions in addition to its response to fertigation and exogenous application of growth substances. Balanced use of nutrients is known to result in the overall improvement of any crop in terms of growth, yield and quality. An interruption in the supply of plant nutrients even for a short period will have a negative effect on yield and quality. Many times, a portion of the recommended nutrients applied to the soil for taking up by the plant, go waste. Moreover, the amount of nutrients taken up also depends on the form of nutrients applied. It has also been observed that in many commercial flowers, the response of a crop to growth regulators were significant in achieving desirable characters.

Hence, studies were conducted during 2010 to 2012 to know the Effect of different levels of fertigation and growth regulators on growth, yield and quality of rose cultivars under polyhouse condition. Irrespective of the seasons the results of which are discussed hereunder.

5.1 Growth attributes

Growth is more important for a crop as the factors that are imposed on the crop in the form of treatments are reflected in its growth.

5.1.1 Plant height and Internodal length

Increased concentration of gibberellic acid combined with 120 percent of recommended dose of fertilizers as fertigation significantly increased the internodal length and in turn plant height respectively. When varieties were compared, it was found that Grand Gala showed a tendency of vigorous growth. The same results were depicted when factors like varieties, growth regulators and levels of fertigation were
interacted each other. The results obtained were in accordance with (Palai et al., 2002) who noticed increased plant height with the application of 400:300:200ppm NPK per plant per week in rose cv. Montezuma, Suganya et al, 2007 and (Qasim et al., 2008) who stated that NPK at 500 ml applied at 2 days interval in rose was optimum for vegetative growth. However humic acid reduced the plant height drastically in all the varieties. These results are in accordance with the findings (Meybodi et al., 2012) who stated that, an increase in humic acid concentration caused a reduction in the height of the plants.

The increment in plant height with the application of GA is primarily due to cell division and cell elongation resulting in increase in internodal distance and number of internodes there by the mean plant height was increased. The steep increase in plant height with GA was also in conformity with Bankar and Mukhopadhyay (1982) who found that GA$_3$ at 100 to 250 ppm increased the stem length and internodal length in rose Cv. Queen Elizabeth. Padmapriya and Chezhiyan (2003) studied morphological characters of 4 cultivars of chrysanthemum as influenced by GA$_3$ and reported that plant height was increased drastically with increase in concentration of GA$_3$. These results are in accordance with the findings of Gowda (1980) in rose Cv. Super Star, Gowda (1988) in rose Cv. American Heritage, Sadanand et al. (2000) in rose Cv. First Red, Ramesh and Singh (2003) in Carnation.

### 5.1.2 Number of primary branches per plant

Grand Gala produced plants with maximum number of branches as compared to other varieties. The productivity of the crop depends primarily on the framework and cultural operations. This could be the reason why varieties differed significantly with each other with respect to number of primary branches produced. However, fertigation with 120 percent of recommended dose (4.93 and 5.32) and Gibberellic acid at 300...
ppm (4.70 & 5.00) concentration produced significantly higher number of primary branches per plant. While, the interactions V₄F₂ (5.9 & 5.98), G₂F₂ (5.48 & 5.93) and V₄G₂ (5.21) also maintained the same trend in producing significantly higher branches. This could probably due to application of optimum level of nutrients in a readily available form. Similar views were expressed by Anwar et al. (1999) who studied the effect of N, K fertilizers on vegetative growth of Rose, Vidhya Sankar and Bhattacharjee (2000) who obtained increased number of basal shoots with optimum level of nitrogen in roses and (Qasim et al., 2008) who stated that NPK at 500 ml applied at 2 days interval in rose was optimum for vegetative growth.

Increase in the number of branches per plant as a result of GA₃ application can be explained in the light of the fact that GA₃ interacts with auxins thus reducing the apical dominance and thereby results in the increased number of axillary branches. Similar results have been reported by Prabhat Kumar et al. (2003) in China Aster.

5.1.3 Days taken for emergence and harvesting of first flower bud

While var. First Red flowered early; the flowering was delayed considerably in var. Noblesse, Gold Strike and Grand Gala. Application of 120 per cent of the recommended dosage and GA₃ (300 ppm) also resulted in early flowering. These were reflected in the interaction between var. First Red and 120 per cent of the recommended dosage and between GA₃ (300 ppm) and 120 per cent of the recommended dosage of fertigation. The results obtained although gave an indication that the above mentioned character is depending on the variety, influence of level of fertigation (120%) and their interaction reflected in the results. Earliness in flowering and harvesting could be attributed to quick availability and optimum level of nutrients, also may be due to production of more number of leaves. Gopinath (2001) in carnation,

Similarly earliness in flowering and harvesting could be attributed to the fact that, GA$_3$ increased the cell division and cell elongation influencing floral morphogenesis. Hence, rendering early maturity in plants and also could be due to quick availability of optimum level of nutrients. Further, GA also increases the activity of IAA oxidase enzyme which is responsible for the degradation of auxin, thus inducing early flowering and harvesting (Padmapriya and Chezhiyan, 2003).

5.1.4 Number of leaves per plant

Higher number of leaves per plant was recorded in variety Grand Gala (259.83 & 235.02), GA$_3$ 300 ppm (206.86 & 205.08) and fertigation with 120 per cent (206.86 & 230.88). The same was reflected in the interaction between var. Grand Gala and GA$_3$ 300 ppm, var. Grand Gala and 120 per cent fertigation and between GA$_3$ 300 ppm and 120 per cent fertigation. This gave an indication that application of 120 per cent of recommended dose of fertilizer rather than full dose that too as soil application would result in obtaining maximum number of leaves per plant. The results depicted the view that optimum dose in easily available form would benefit the growth of leaves. The results are in accordance with Ashok and Rangaswamy (1999) who obtained maximum number of leaves per rose stalk with water soluble fertilizers at optimum dose.

Meanwhile, more leaves appeared by application of GA attributed to increased shoot length, more nodes as well as the physiological role played by GA in increasing the area of photosynthesis to produce more carbohydrate. These results are in conformity with the results of Nanjan and Muthuswamy (1975) who noted increase in number of leaves with
increased shoot length by the application of GA$_3$ at 300 ppm in Edward rose.

5.1.5 Plant spread

Regarding the spread of plant there is a direct relationship between dose of fertilizers and GA concentration. Increase in spread due to GA in combination with fertigation is attributed to increase in cell division and cell enlargement. So, results revealed that variety Grand Gala (884.03 cm$^2$ & 494.68 cm$^2$), fertigation with 120 per cent recommended dose (687.49 cm$^2$ & 414.06 cm$^2$), Gibberellic acid at 300 ppm (624.01 cm$^2$ & 404.29 cm$^2$) and their interactions like V$_4$F$_2$ (606.24 cm$^2$), V$_4$G$_2$ (599.67 cm$^2$) and G$_2$F$_1$ (494.76 cm$^2$) in turn produced plants of wider spread. Reddy (1978) in aster and (Prashant et al., 2006) in rose reported similar results, which are in agreement with the present findings.

5.1.6 Leaf Area

The leaf area differed significantly among the varieties, levels of fertigation and with the concentration of applied growth regulators. However variety Grand Gala recorded leaves of maximum area, while treatment with 120 per cent fertigation and GA$_3$ at 300 ppm found to be significantly effective in inducing leaves of larger area. The same results were depicted when var. Grand Gala interacted with 300 ppm GA$_3$ and 120 per cent fertigation.

Increased leaf area by increased dose of fertigation is mainly due to the presence of K$_2$O. The K$_2$O promotes the photosynthesis activity which leads to more nitrogen metabolism and synthesis of protein thereby increase in the leaf area occurred. Similar results were obtained by Haripriya et al. (2004) who studied the effect of fertilizers on growth and quality of rose (Rosa centifolia). Whereas, gibberellic acid increases leaf area by triggering the photosynthesis activity to produce more
carbohydrates. These findings are in conformity with the results of Nanjan and Muthuswamy (1975) who noted increase in number of leaves with increased shoot length by the application of GA$_3$ at 30 ppm in Edward rose.

**5.2 Yield attributes**

Yield of a crop is the ultimatum of what all is done to the crop to achieve the same. Yield depends on the growth of the crop and the conditions prevailed before and during the cropping period.

Higher cumulative number of cut flowers per plant and per square metre was found to be associated with var. Noblesse (14.47, 12.66 and 115.77, 101.33), var. Grand Gala (13.57, 12.65 and 108.63, 101.23), GA$_3$ 300 ppm (13.32, 12.80 and 106.58, 102.42) and 120 per cent of recommended dose of fertilizers (14.21, 14.01 and 113.68, 112.10) respectively. The same treatment effect was depicted in the interaction combinations V$_2$G$_2$ (14.94 and 119.56), V$_2$F$_2$ (15.94 and 127.54), V$_2$F$_1$ (14.83 and 118.68), V$_4$F$_2$ (14.64 and 117.13) and G$_1$F$_2$ (14.29 and 114.34), G$_2$F$_2$ (14.44 and 115.54), G$_3$F$_2$ (13.70 and 107.55) respectively.

The results revealed that application of 120 per cent of recommended dose in water soluble form produced higher yield in var. Noblesse and Grand Gala. The enhancement in flower producing vegetative sinks such as basal and side shoots (cut flower stalks) might be due to quicker and ready availability of nutrients at optimum level (120 per cent) when compared to others (80 per cent fertigation and 100 per cent soil application). Similarly application of water soluble fertilizers increased the flower yield as reported by Ashok *et al.* (1999), Thakur *et al.* (2003), Barbosa *et al.* (2007), Qasim *et al.* (2008) in roses. The increased productivity of 120 per cent may also be due to more number of basal and side shoots, but 80 per cent was found to be superior as

The yield of cut flowers by application of GA was substantially more due to appearance of more number of longer and vigorous shoots having more leaves resulted into larger and attractive flowers. These finding are in accordance with the studies of Nanjan and Muthuswamy (1975) who recorded maximum flower yield with GA$_3$ at 200 ppm in Edward rose, EL-Shafie et al. (1980) with GA$_3$ 250 ppm in Queen Elizabeth and Baccara roses, Bankar and Mukhopadhyay (1982) with GA$_3$ at 100, 250 ppm in Queen Elizabeth roses, Gowda (1985) with GA 200 ppm in rose cv. Super Star, Kewete and Sable (1997) in rose cv. Paradise, Sadanand et al. (2000) in rose cv. First Red, Kotre et al. 2003 in China aster and Abadi, 2010 in rose.

5.3 quality attributes

Quality is a measure of superiority of the produce in consideration. It depends on the environmental factors, the treatments imposed and the management since the beginning of crop production.

5.3.1 Length and girth of cut flower stalk

Application of 120 per cent (59.76 cm, 55.60 cm and 0.72 cm, 1.00 cm) of recommended dose as fertigation and GA$_3$ 300 ppm (59.76 cm, 55.60 cm and 0.71 cm, 0.89 cm) resulted in longer length and girth of cut flower stalk was depicted in significantly higher values obtained in var. Grand Gala (62.03 cm, 61.27 cm and 0.69 cm, 0.93 cm). The same results were reflected in the interaction between var. Grand Gala and 120 per cent fertigation and between GA$_3$ 300 ppm and 120 per cent fertigation. Many workers recorded an increase in the length of cut flower stalk (Johnson, 1978); Mikio et al (1996), Uma and Gowda, (1987) in
roses and Pimple et al. (2006) in gerbera with increase in the dosage of fertilizers.

Increase in stalk length and girth due to application of GA confirmed the findings of Sarhan and Sayed (1993) in Antirrhinum, Venkatesh Reddy and Nagarajaiah (1986) and Arun et al., (1999) in roses. The role of GA in increasing the plant height during early stage may be acceleration in mitotic activity and subsequent cell division and cell elongation resulting in stem extension. These findings are in line with those of Prabhat Kumar et al. (2003) in China aster and Jyothi et al. (1995) in Chrysanthemum, Dheknet et al. (2000) in carnation, Hashemabadi and Zarchini, (2010) in rose.

5.3.2 Length and diameter of flower bud

Similar trend as that of the length and girth of cut flowers stalks was seen with regard to length and diameter of flower bud. Eventhough, fertigation with 120 per cent RDF (3.86 cm, 3.51 cm and 3.18 cm, 3.13 cm) and GA₃ 300 ppm (3.28 cm, 3.09 cm and 3.08 cm, 2.98 cm) induced buds of maximum length and diameter but var. Grand Gala (5.05 cm, 3.40 cm and 3.07 cm, 3.17 cm) responded significantly. But varied interaction response was observed. However, interaction between V₄G₂ (5.28 cm), V₄F₂ (5.55 cm), G₁F₂ (3.50 cm) and G₂F₂ (3.50 cm) recorded lengthy buds. While interaction between V₄F₂ (3.3 cm & 3.32 cm), V₃F₂ (3.31 cm & 3.20 cm), G₄F₂ (3.29 cm) and G₂F₂ (3.17 cm) recorded buds of higher diameter.

Increasing the supply of fertilizers to rose plant improved the length of flower bud as observed by Krishna (1999) and Nagaraju et al. (2003). The above results were in accordance with the findings of Arun et al. (1999), Sadanand et al. (2000) and Nagarajuna et al. (2003), observed higher bud length in gerbera and rose, respectively grown under low cost
polyhouse. These results are also comparable with the findings of Dhekney et al. (2000), Chakradhar et al. (2003) where they observed the highest bud conditions which were attributed to the genetic response of the cultivars to the treatments.

5.3.3 Number of petals per flower

Higher number of petals per flower to be associated with var. Grand Gala (39.95) and Noblesse (42.32), GA$_3$ 300 ppm (39.17) and GA$_3$ 200 ppm (38.72) which were on par with each other and fertigation with 120 per cent recommended dose of fertilizers (38.23 & 39.14) recorded significantly higher number of petals per flower. Any of the interactions did not show much significant difference between them. The results were in accordance with Qasim et al., (2008) who noticed maximum number of petals per flower in rose with the application of 500 and 250 ml of NPK at 2, 4 and 6 days interval.

In general, it has been brought out by the results that application of higher dose of fertilizers in water soluble form would result in obtaining longer length and higher girth of stalk, longer and thicker flower buds. This has given room for thinking that when fertilizers are applied in excess of the recommended dosage, after the utilization of nutrients at the required level for better growth and yield of any crop, the part left out might have been used for producing the quality flowers that too when used in water soluble form as there would be negligible amount of wastage in such a form.

More number of petals per flower with GA might be due to high levels of endogenous gibberellins and auxins which contributed to the development of flower, more production of carbohydrate associated with existence of more leaf number and area per flowering shoot. Similar results regarding the number of petals were noted by Gowda (1998) who
observed increased number of petals per flower in rose cv. American Heritage with GA, Chakradhar (2002) in rose cultivar Gladiator and Horibe et al., 2010 in rose.

As far as number of petals per flower is concerned, results of interaction among factors, varieties, growth regulators and fertigation depicted that fertigation and growth regulator levels did not influence the varieties, thus giving way for the thought that it is more a varietal characteristic.

Based on the quality attributes it was observed that 120 per cent of recommended dose of nutrients in water soluble form resulted in better quality in terms of length and girth of stalk, length and thickness of flower bud and number of petals per flower as compared to 80 per cent and 100 per cent of recommended dosage. This takes anchorage form the lowest number of basal shoots recorded per plant, which received 120 per cent of recommended dose. The quantity of nutrients available over and above the optimum dose might have enhanced the quality of result of cut rose flowers.

5.3.4 Weight of flower

Application of 120 per cent (5.55 g & 5.41 g) of recommended dose as fertigation and GA3 300 ppm (5.04 g & 4.94 g) resulted in flowers of maximum weight and var. Grand Gala (5.81 g & 5.66 g) responded significantly. The similar results were reflected in the interaction V4G2 (6.06 g), V4G1 (5.97 g), V4F2 (6.39 g), G2F2 (5.54 g) and G1F2 (5.51 g).

Increase in weight of flower by higher dose of fertigation may be due to the role of K2O in plants which includes cation transport across membrane, water economy, energy metabolism and enzyme activity and consequently stimulates vegetative growth and decreases translocation of photosynthates into storage organs which resulted in increased in weight
of flowers. Similar results were reported by Larikl, *et al* (1999) who studied the effect of N and K fertilization on quality, yield of Zinnia and observed maximum weight with application of optimum dose of N and K.

Increased weight of flower in relation to application of gibberellic acid may be due to production of larger flowers containing more number of petals, which in turn resulted from increased levels of gibberellins and auxins in plant and more biomass producing area. These findings are in conformity with the results obtained by Singh *et al*. (1991) who noticed significantly increased flower weight in African marigold with GA₃ 400 ppm. Dehale *et al*. (1993) also found increased weight of flowers with GA₃ 100 ppm in Chrysanthemum, similar increase in flower weight was reported by Tiwari *et al*. (2002) and Abadi (2010) in rose.

### 5.3.5 Neck length and diameter

These are the varietal characters and will have very slow response to the external factors. However, it was found that var. Grand Gala produced flowers of lengthy neck and having thicker diameter. Same results were noticed with 120 per cent fertigation and 300 ppm gibberellic acid. The results of the present investigation confirmed the earlier result of Nanjan and Muthuswamy (1978), Banker and Mukhopadhyay (1982) and Dhekney *et al*. (2000) who have also reported increased neck length due to GA spray.

### 5.4 Vase life attributes

Pose harvest behavior of a cut flower not only depends on post harvest factor but also on pre-harvest factors. Vase life is one such post harvest trait.

Water soluble fertilizers with 120 per cent of recommended dose and humic acid influenced the cut flowers to take up and loose higher
amount of water and experience longer vase life. Due to uptake and loss of maximum water in the vase, var. Grand Gala exhibited longer days in vase compared to other varieties. This effect was reflected in the interaction between varieties, humic acid and 120 per cent fertigation as well.

Variety Grand Gala observed to be a more hardy variety when compared with other var. like First Red, Noblesse and Gold Strike, owing to its ability to withstand pest and diseases incidence. Moreover, var. Grand Gala produced significantly higher number of leaves and petals. This may probably due to the influence exerted by 120 per cent of recommended dose of fertilizers as fertigation reflected in the results obtained. Similar views were expressed by Ashok et al. (2000) and Barman et al. (2003) in roses.

Eventhough gibberellic acid found to be a better growth regulator as compared to humic acid with respect to vegetative characters, but as vase life is considered humic acid and its interactions are significantly superior. This may be due to the fact that, humic acid induced thicker flower shoots at harvest as compared to gibberellic acid. Therefore, the additional energy may be supported the flowers in the vase for extended vase life. The same views were expressed by (Keshavarzi and Chamani, 2012) in lily flowers.

5.4 Economics

The economics of cultivation of exotic rose var. Grand Gala influenced under different levels of fertigation under cost effective greenhouse revealed that application of water soluble fertilizers at 120 per cent of recommended dose was not only highly productive but also profitable with a net profit of Rs. 11570 and benefit: cost ratio of 1.65.
This may be attributed due to production of maximum number of quality flowers by utilizing optimum level of nutrients.

Eventhough gibberellic acid induced vigorous growth and maximum number of flowers, it failed to give maximum benefit cost ratio due to its high cost as compared to humic acid. Therefore, humic acid at 0.4 per cent recorded maximum benefit: cost ratio of Rs. 2.17.

**Future line of work**

1. Many more international export oriented rose varieties could be tried under cost effective greenhouses with the concept of integrated nutrient management.

2. Pruning coupled with fertigation and biostimulant studies could be taken up further.

3. Further studies can be carried out using humic acid at different concentrations in different varieties