The use of different growing media and GA$_3$ concentration for improving the germination of seeds has been known from a long time. However, poor growth and development of seedlings restricts the availability of healthy planting material on large scale. Therefore it is highly essential to accelerate the rate of seed germination and growth by treating the seed with growth substances to obtain high germination percentage and good size of seedling within a short period. The present experiment titled "Effect of growing media and GA$_3$ on seed germination and seedling growth of acid lime (Citrus aurantifolia Swingle) cv. Kagzi lime" was undertaken during the year 2016 at Madhhdadi Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, with two factors having five different proportions of media and four different concentration of GA$_3$. The results presented in the preceding chapter indicated many significant variations in the different characters, due to the effect of media and different concentration of GA$_3$. In this chapter, it is contemplated to these variations with possible explanation and available evidences and literature. For brevity the entire discussion has been divided into following sub heads.

5.1. SEED GERMINATION PARAMETERS

5.2. SEEDLING GROWTH PARAMETERS

5.1 SEED GERMINATION PARAMETERS

Result presented in Table 4.1.1, 4.1.2, 4.1.3, 4.1.4 and 4.1.5 clearly showed that the different growing media and different concentration of GA$_3$ were significantly affected the seed germination parameters viz., days required for initiation of germination, germination (%), germination span (days), seedling vigour (cm) and germination index of acid lime seeds and interaction effect of different growing media and different concentration of GA$_3$ on seed germination parameters were also found significant. The data regarding polyembryony (%) is presented in table 4.1.6. The results clearly indicate that the effect of growing media and GA$_3$ concentrations were found non-significant.
5.1.1 Effect of media on seed germination parameters

Regarding different media under study, the medium consisting of M₃, Soil + Vermicompost + Cocopeat (1 : 1 : 1) recorded the minimum days required to seed germination (16.83). The maximum germination percentage (76.56 %) was found in treatment M₃, Soil + Vermicompost + Cocopeat (1 : 1 : 1) and it was at par with the treatments M₄ (73.49 %). The minimum germination span (6.74 days) was also found in treatment M₃, Soil + Vermicompost + Cocopeat (1 : 1 : 1). The maximum seedling vigour (1538 cm) was found in treatment M₃, Soil + Vermicompost + Cocopeat (1 : 1 : 1). The maximum germination index (2.97) was found in same treatment M₃, Soil + Vermicompost + Cocopeat (1 : 1 : 1).

The increasing seed germination parameters might be due to beneficial effect of medium combination in improving physical, biological and chemical properties of media. Soil provides natural support to plant, cocopeat given warm condition, high water holding capacity, vermicompost as a source of organic manure provided better nutrition to the germinating seedlings (Hartmann and Kester, 1997). The well decomposed compost may preserve soil humidity, increase nutrients the cell turgidity, cell elongation and increase respiration at optimum level. Organic matter may also improve nutrient availability and improve phosphorus absorption (Karama and Manwan, 1990). All these factors are favorable for seed germination and ultimate by increase seed germination per cent. The similar results reported by Chopade et al. (1999) and Parmar et al. (2015) in custard apple, Abhilasha (2012) and Parsana and Ray (2013) in mango, Anjanawe et al. (2013), Kumawat et al. (2013) and Bhardwaj (2008) in papaya, Bisla et al., (1984) in ber and Govind and Chandra (1993) in Khasi mandarin, Biradar et al., (2001) in neem and Yadav et al. (2012) in acid lime.

5.1.2 Effect of gibbrellic acid (GA₃) on seed germination parameters

The results pertaining to seed germination parameters were also significantly influenced by varying GA₃ concentration. The minimum days required for seed germination (15.05) was noted with the treatment GA₃ @ 200 ppm concentration. The same treatment GA₃ 200 ppm had given highest germination percentage (73.08 %) and it was at par with G₃ (71.65 %) and G₂ (72.29 %). The treatment GA₃ 200 ppm was found minimum germination span (9.28 days). The same treatment GA₃ 200 ppm
was found highest seedling vigour (1358 cm) and found highest germination index (2.76).

The increasing seed germination parameters might be due to the involvement of GA$_3$ in the activation of cytological enzymes along with increase in cell wall plasticity and better water absorption. GA$_3$ acts as a directly on embryo relieving them from dormancy through promoting protein synthesis and elongation of coleoptiles and leaves and also helps in the production of ethylene. This ethylene invokes the synthesis of hydrolases, especially amylase, which favours the seed germination (Stewart and Freebairn, 1969). GA$_3$ stimulates seed germination by formation of α-amylase enzymes which converts insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks as suggested by Gillard and Walton (1973). Similar findings on germination enhancement in papaya due to GA$_3$ treatment was reported by Veerugavathatham et al. (1980), Anburani and Shakila (2010), Meena and Jain (2005) in papaya, Rajamanickam et al. (2002) in aonla and Harshavardhan and Rajasekhar (2012) in Jackfruit, Patil et al. (2012) and Gupta (1989) in Rangpur lime, Ghosh and Sen (1988) in ber, Farooqui et al. (1991) in sapota, Govind and Chandra (1993) in khasi mandarin.

5.2. EFFECT ON SEEDLING GROWTH PARAMETERS

In this research study, result presented in Table 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5, 4.2.6, 4.2.7, 4.2.8, 4.2.9, 4.2.10, 4.2.11, 4.2.12 and 4.2.13 clearly showed that the different growing media and different concentration of GA$_3$ were significantly affected the seedling growth parameters of acid lime seedling viz., plant height (cm), stem girth (mm), number of leaves, leaf area (cm$^2$), number of roots, root length (cm), fresh weight of shoot (g), dry weight of shoot (g), fresh weight of root (g), dry weight of root (g) and root-shoot ratio, survival (%) and mortality (%).

5.2.1 Effect of media on seedling growth parameters

Among the media treatment M$_3$- Soil + Vermicompost + Cocopeat (1 : 1 :1) was found maximum plant height of seedlings of acid lime (8.93 cm, 17.89 cm and 33.44 cm), stem girth of seedlings (0.80 mm, 0.95 mm and 1.16 mm), number of leaves (11.67, 21.06 and 29.78), leaf area (3.65 cm$^2$, 5.12 cm$^2$ and 6.74 cm$^2$), number of roots (20.14), root length (13.10 cm), fresh weight of shoot (11.70 g), dry weight
Discussion

of shoot (3.40 g), fresh weight of root (2.46 g), dry weight of root (0.59 g), root-shoot ratio (0.64), minimum mortality percentage (24.02 %) and maximum survival percentage (75.99 %).

The increasing seedling growth parameters might be due to combined application of soil, vermicompost, compost and cocopeat showed significant effect on seedling growth parameters probably due to the synergistic combination of different media in improving the physical conditions of the media and nutritional factors. The conducive effect of media composition on water holding capacity, porosity, soil aeration and supplying substantial amount of nutrient specially nitrogen and micro nutrients for good seedling growth and root growth over soil alone (Chopade et al. 1999) in custard apple. Increase in number of leaves might be mainly due to corresponding increase in plant height (Govind and Chandra, 1993) in Khasi mandarin. The beneficial effect of media on number of roots, root length and root-shoot ratio might be due to improved soil structure, porosity, water holding capacity, activity of useful soil micro fauna and flora, maintained soil temperature and improved soil health and nutrient status of media (Hartmann and Kester, 1997). The findings of this experiment are in close conformity of Kumawat et al. (2013) and Anjanawe et al. (2013) in papaya, Baghel et al. (2004) in phalsa. The leaves of seedling raised in this media (M₃), also has due to presence of nitrogen in vermicompost and cocopeat which might certainly improved the photosynthetic rate, dry matter production. Therefore, the medium with vermicompost and cocopeat is more suitable than vermicompost alone because of the better physical properties and enhanced nutrient level. The results of study are in close agreement with the findings of Wong and Lee (2000) in phial pitcher plant (Nepenthes ampullaria), Kumar and Arora (2007) in peach, Pio, et al., (2007) in pears, Lopes, et al., (2007) in passion fruit, Li et al., (2008) in Phoebe chekiangensis and Venkatesh et al., (2009) in saru (Casuarina equisetifolia).

5.2.2 Effect of GA₃ on seedling growth parameters

Among the different concentrations of GA₃ 200 ppm was found maximum plant height of seedlings of acid lime (8.30 cm, 16.26 cm and 30.98 cm), stem girth of seedlings (0.66 mm, 0.83 mm and 1.06 mm), number of leaves (10.43, 19.45 and 28.14), leaf area (3.17 cm², 4.83 cm² and 6.27 cm²), number of roots
Discussion

(17.61), root length (11.95 cm), fresh weight of shoot (10.44 g), dry weight of shoot (3.25 g), fresh weight of root (2.32 g), dry weight of root (0.41 g), root-shoot ratio (0.59), minimum mortality percentage (28.08 %) and maximum survival percentage (71.92 %).

The increase in seedling height with GA}_3 treatments was due to the fact that this hormone increased osmotic uptake of nutrients, causing cell elongation and thus increased height of the plant and stem girth also increased due to greater cell division and elongation at the stem portion (Sen et al., 1990). The increase in number of leaves and leaf area might be due to activity of GA}_3 at the apical meristem resulting in more synthesis of nucleoprotein responsible for increasing leaf initiation and area. The number of roots, root length and root-shoot ratio increasing due to GA}_3 treatment might have resulted into increased production of photosynthates and their translocation through phloem to the root zone might be responsible for increasing the root length (Vachhani et al., 2014). The seeds treated with GA}_3 might be accelerates the translocation and assimilation of auxins, reasons for better root growth and vegetative characters are due to overall assimilation and redistribution of materials with in plants enhance the growth attributes. Moreover, GA}_3 also induced the activity of gluconeogenic enzymes during early stages of seed germination and vigour characteristics that are reflect in terms of increase in root length. These results are in close agreement with Anburani and Shakila (2010) in papaya; Pampanna and Sulikeri (1999) in sapota; Manekar (2011) in aonla and Vasantha et al. (2014) in tamarind. Whereas, increase in fresh and dry weight of stem and leaves were due to fact that GA}_3 improves the rate of photosynthesis and cause greater accumulation of photosynthates in papaya (Chacko and Singh 1991). Such effect is in accordance with the finding of Parmar et al. (2015) in custard apple, Anburani and Shakila (2010), Meena and Jain (2005) and Babu et al. (2010) in papaya, Prajapati (2013) in jackfruit, Dabhi (2000), Gholap et al. (2000), Rajamanickam et al. (2002), Manekar et al. (2011) in aonla; Pandey (1992) in Khasi Mandarin; Krishnan and Kulasekaran (1984) in ber and Nimbalkar et al. (2012) in karonda.
5.2.3 INTERACTION EFFECT OF MEDIA AND GA$_3$ ON SEEDLING GROWTH PARAMETERS

The interaction effect between different media and GA$_3$ concentrations on seedling growth parameters was found significant. Among the different combinations of media and GA$_3$ concentrations i.e. Soil + Vermicompost + Cocopeat (1 : 1 : 1) with GA$_3$ 200 ppm was found maximum plant height of seedlings of acid lime (9.79 cm, 18.60 cm and 34.41 cm), stem girth of seedlings (0.84 mm, 0.98 mm and 1.19 mm), number of leaves (12.00, 21.50 and 30.04), leaf area (3.80 cm$^2$, 4.80 cm$^2$ and 6.90 cm$^2$), fresh weight of shoot (12.05 g) and dry weight of shoot (3.43 g), fresh weight of root (2.78 g) and dry weight of root (0.64 g) and survival percentage (76.77 %).

The increase in height of seedling with pre-sowing treatments may be due to removal of sarcotesta which induce seed dormancy and reduces the nutrient and water uptake so, minimize the overall growth of the plant. A maximum plant height, plant girth and inter node length were also recorded by Rajwar et al. (2007) in ber. The more plant height, stem diameter and number of leaves observed in M$_3$G$_4$ have occurred due to cell division and cell elongation, which in turn would have increased the internodal length and overall vegetative growth as suggested by Chaudhary and Charawar (1982) on rangpur lime. These types of results were previously noted by Anjanawe et al. (2013) and Kumawat et al. (2013) in papaya, also.