SUMMARY AND CONCLUSIONS
It is well known that the cultivation of *Curcuma* species since remote past is done by rhizomes because the seeds (and sometimes even the fruits) are not formed in the plants. Furthermore, the main target everywhere has been to obtain the maximum amount of rhizomes which are used for various purposes. Therefore, no much and serious attempts were made to know why seeds and fruits are not formed in several species of *Curcuma* and how can they be produced in the plants. Fruits and seeds were also not available in the market and even research institutes. Therefore, it was not possible to initiate any investigation on raising the seedlings and studying their growing behaviour. Therefore, in the present thesis it was planned to observe the effect of three growth regulators on the growth and development of four *Curcuma* species. The first hormone selected was GA₃ (Gibberellic Acid) which has been found to be successful by some scientists to initiate flowering and/or fruiting in a few rhizomatous or tuberous species like yam (*Dioscorea alata* and *D. rotundata* etc.) and *Colocasia esculenta* (Mozie, 1987; Rao *et al.* 1989). It acts as a florigen and also increases the rhizome production. Therefore, it was expected that some success may be achieved by this hormone in getting fruits and/or seeds.
Another growth regulator selected for the present study was NAA (Naphthalene Acetic Acid) which has been found to promote growth in *Curcuma zedoaria* and *C. domestica* (*C. longa*) during tissue culture (Yasuda et al. 1988). During field trials also it showed enhancement in number and size of leaves per plant as well as the size of plant itself. Therefore, it was thought to use this growth promoter because if the photosynthetic area of plants could be increased, growth in other parameters could also be obtained.

IBA (Indole Butyric Acid) is a well known rooting hormone. Its influence in the enhancement of roots and rhizomes have been apparent in several species like *Zingiber officinale* (Babu et al. 1992). Roots increase the absorption machinery of the plants and help in the growth by providing water and dissolved nutrients to the plant body. Therefore, IBA was also selected to be tested for its growth accelerating substance in the four selected *Curcuma* species.

The field work was done in the Botanical Garden of Dr. H.S. Gour University, Sagar during 1998-1999. The soil of the experimental field was clay-loam having pH 7.20 to 7.35. Average annual rainfall received was 1774.41 mm.

The hormonal treatments comprised of four *Curcuma* species (*C. amada*, *C. angustifolia*, *C. aromatic* and *C. caesia*) as the main-plot treatments and three growth regulators (GA$_3$, NAA, IBA each @ 20, 50 and 100 ppm) and control (water only) total 10 sub plot treatments making in all forty treatment combinations.
For sowing, rhizomes were cut in such a way that each piece has at least one lateral bud (eye). The fresh weight of such pieces varied from 3.86 to 4.72 g in different species. These rhizome pieces were dipped in 20, 50 and 100 ppm solutions of each growth regulator separately for eight hours and then sown in the field beds at about 5 cm depth as per layout plan, on July 15, 1998 at 40 cm x 25 cm planting geometry.

An uniform fertilizer dose of NPK was given in each bed after soil working. The beds were mulched with green leaves immediately after planting. The beds were irrigated daily in the beginning and at 2 day intervals after 30 days till the harvest. The fungicides Endosulfan and Diathane-M-45 were sprayed twice at 40 and 90 days stages to protect Curcuma plants from fungal diseases. Sprouting was recorded daily till 30 days to calculate the sprouting capacity and other related parameters like Sprouting Velocity Index (SVI) and Sprouting Vigour (SV) etc. Plant length, leaf size, number of leaves per plant and number of flowers in spike were recorded from standing plants. But, for determining the fresh weight of rhizomes, 5 plants from each treatment were dug out after 60, 120 and 180 days. Last digging of Curcuma plants was done on 16 February 1999 (after 210 days), when the leaves turned yellow and began to dry.

The salient findings based on the observations are summarized below :-
There was a definite and significant enhancement in the sprouting capacity of all the four *Curcuma* species at thirty day stage due to the influence of growth regulators. As compared to 81.80% sprouting in the rhizomes of *C. aromatica* in control, 100 ppm GA$_3$ increased it to 92.5%. Other two growth regulators also showed the enhancement of the same magnitude. Similarly, hormonal concentration from 20 to 100 ppm exhibited a straight rise in the sprouting capacity of rhizomes of all the four *Curcuma* species.

Other parameters of sprouting like Sprouting Velocity Index (SVI), Sprouting Vigour (SV) and Sprouting Energy (SE) followed the same trend as they are somewhat different expressions of the sprouting capacity. But, plant mortality was reduced to about 7% from about 18% in all the four species. Such a reduction resulted in better plant-percent (93.3%) as compared to the control (81.66% in *C. aromatica*). Higher concentration (100 ppm) of GA$_3$, IBA and NAA was found to be more effective in protecting the life of the young plantlets.

Average plant length after 30 days of sowing ranged from 2.6 to 3.0 cm without any treatment of growth regulators but after the dipping treatment with GA$_3$, NAA and IBA, it increased to 4.00 to 8.5 cm. Maximum influence was observed in *C. aromatica* and minimum in *C. amada*. Similarly, average number of leaves per plant was 2, in plants without any hormonal treatment but increased to 3.0 to 3.62 by various growth promoting substances. Highest number of leaves per plant was produced by GA$_3$ at 100 ppm.
Considerable increase in the plant size was recorded after 60 days due to the influence of growth regulators (5.06 to 23.95 cm). In fact, plant length, number of leaves per plant and length and width of leaves went on increasing even upto 180 days. But, no flowers could be produced in *C. angustifolia* by any of the three growth regulators. In *C. aromatica*, some success was recorded by GA₃ in this aspect when a small spike with two rudimentary flowers developed. However, there was no flower initiation in control as well as NAA, IBA treated rhizome-raised plantlets. In *C. amada*, the number of flowers per spike remained the same (2) in control as well as in hormone treated plants whereas, in *C. caesia*, number of flower per spike increased from 2 to 3 by 100 ppm NAA and 4 by 100 ppm GA₃. It was realised that instead of soaking the seed rhizomes in hormonal solutions, foliar spray would have been more effective and if its frequency would have been every month, probably fully developed flowers would have been obtained.

Production of rhizomes per plant at the time of harvest (210 days) indicated that *C. aromatica* is most responsive for the growth regulators because maximum yield of rhizomes was recorded in it (113.5 g per plant in NAA treated plants as compared to 52.40 g in control). On the contrary, *C. amada*, exhibited least yield of rhizomes (99.60 g per plant as compared to 49.67 g in control). When the yield was calculated per bed, it varied from 2.38 to 4.78 kg per bed in *C. amada*, 2.46 to 5.22 kg in *C. angustifolia*, 2.51 to 5.44 kg in *C. aromatica* and 2.41 to 4.88 kg in *C. caesia*. 
Benefit: Cost ratio determined for each species suggested that cultivation of *C. aromatica* is more beneficial for the growers than any of the other three species. Maximum B : C ratio of 8.20 : 1 recorded in 100 ppm NAA treated plants of *C. aromatica* led to the conclusion that maximum profit can be earned by cultivating this species along with a treatment of 100 ppm NAA.

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