CONCLUSION

Swertia chirayita (Roxb. ex Fleming) Karst., Family Gentianaceae, is among the several medicinal plant species growing in the Himalayan region. Despite its medicinal properties and use in the herbal industry, *S. chirayita* could not get much attention on conservation and cultivation, particularly in areas near its natural population. Therefore, the plant is still collected from the wild to meet industrial demand. This, alongwith other factors like habitat destruction, uprooting of the whole plant before seed setting, certain negative features of the plant itself, like prolonged stage of vegetative growth, monocarpic senescence etc, it is now on the verge of extinction and is categorized under Critically Endangered medicinal herb. All parts of the plant from roots to the inflorescence are used as medicine for various ailments like diarrhea, cough, all types of fevers, anaemia, gastropathy, dyspepsia, burning of the body and pain in the joints and skin diseases etc. It tastes bitter from root to tip.

In this investigation, a detailed study was carried out on some physiological and biochemical aspects of the plant, but emphasis was laid on analyzing the negative yield attributing characters of the plant and improvement of crop yield. Three plant growth promoters, *viz.*, Gibberellins (GA_3), Indole Acetic Acid (IAA) and Kinetin (Kin) and three growth retardants, *viz.*, Maleic Hydrazide (MH), Alar (SADH) and Abscissic Acid (ABA) were applied at three different stages of plant, *viz.*, rosette stage, sapling stage and pre-flowering stage. Two different concentrations of 100µg/ml and 200µg/ml of the Plant Growth Regulators were used; except for Abscissic Acid of which the concentration used was 10µg/ml and 15µg/ml. The chemical-induced changes on growth, metabolism and yield were analysed at different developmental stages of the plant.

Foliar treatment at rosette stage: 135-240 days old plants were treated by PGRs with two different concentrations for three consecutive days. The results revealed that they failed to induce any permanent effect on modification of growth, metabolism and yield of chirata plant.

- It was observed that all the PGRs used, irrespective of their concentrations, increased the level of all the macromolecules analysed upto the sapling stage and

in certain cases upto pre-flowering stage, and gradually declined as the plant age progressed.

- It was found that the activity of catalase was suppressed at the sapling stage whereas that of peroxidase, RNase, α-amylase and IAA-oxidase was found to be enhanced significantly by the promoters used, especially GA_3. But this effect was transitory and was not seen to last beyond pre-flowering stage.
- It was noted that the level of bitter principle compounds remained more or less equal in all the treated plants at different developmental stages.
- Compared to control, all the PGRs used, especially GA_3, significantly increased the physiological parameters analysed. However, the internodal distance was shown to decrease with retardants.
- Yield parameters were found to increase, especially with GA_3.

Biochemical, physiological and yield data at five different stages showed that there was a transient effect of PGRs on growth and metabolism. At initial stage, *i.e.,* at sapling stage enhancement of macromolecules and acceleration of enzyme activities was significantly effective, which gradually became insignificant with the plant age. Thus, foliar treatment at rosette stage could only render a transient effect on the growth and metabolism of chirata and such changes were not reflected in yield attributes to a significant extent.

Foliar treatment at sapling stage: Foliar application with PGRs at the sapling stage (245-320–days old plants) caused significant effects on macromolecules content in leaves which were reflected on growth, metabolism and yield of the plant.

- It was observed that promoters resulted in significant increase of biochemical parameters analysed till pre-flowering stage. With the onset of fruiting stage, the level decreased. With the retardants the decrease in chlorophyll level and protein was observed from the initial sapling stage of treatment upto the senile stage.
- It was found that all the PGRs used enhanced the activities of catalase, peroxidase, IAA-oxidase and RNase till pre-flowering stage. α-amylase activity was found to decrease. Insignificant effects of PGRs were observed on advancement of the plant age.
- It was noted that the content of bitter principle increased with the application of PGRs, particularly GA_3.

- It was observed that the promoters have a positive influence on the physiological parameters which increased significantly with all the promoters used. GA_3, in particular, seemed to have marked influence.The effect of retardants was found to be lesser than that of the promoters. Stem circumference, number of leaves, nodes, branches increased markedly with all the retardants used, particularly MH. On the contrary, the internodal distance decreased.
- Yield parameters, likewise, increased significantly with the chemicals at sapling stage in comparison to control, especially GA_3.

Plant growth promoters increased the macromolecule content in leaves at the initial observation period of sapling stage, whereas, the retardants caused significant reduction of these biochemical parameters in initial stage. With the progress in plant age, further enhancement was noted with the promoters in all the parameters. Likewise, the retardants also exhibited a trend of effect with reduction in biochemical levels. But it was observed that after pre-flowering stage there was no significant effects on growth and metabolism. PGRs showed a tendency towards deferring senescence of chirata plants but among all the treatments, only GA_3 (100µg/ml) showed a significant senescence deferral effect. Again a marked increase in yield parameters was revealed in GA_3 and IAA treated plants.

Thus, unlike rosette treatment, effect of foliar treatment with PGRs at sapling stage was found to persist till senile stage and changes of the growth and biochemical parameters were associated with substantial increase of yield components at least in treatments with GA_3 and IAA.

Foliar treatment at pre-flowering stage: Foliar application with PGRs at the pre-flowering stage of 325-360–days old plants caused insignificant effects on macromolecules content in leaves of chirata plant.

- It was observed that application of PGRs decreased all the macromolecule content analysed. The change, if noticed, was insignificant.
- It was found that all the PGRs suppressed the enzyme activity.
- There were no significant effects of PGRs on bitter principle content in different parts of chirata plant.
- It was observed that there was not much difference between the treated plants and control as regards the physiological parameters. The change, if noticed, was transitiory.

- Yield data similarly did not show noteworthy difference as compared to control.

It was observed that all the treated plants were similar in yield attributes to the plants taken as control and hence nullified the growth and maturation effects of PGRs at later stages of plant.

Hence, it can be observed that increased crop yield by the PGRs can be substantiated from the enhanced plant potential as evident from the biochemical analyses of this investigation. Foliar treatment with the PGRs at the sapling stage, with more marked and vigorous vegetative growth and increase in yield, was found more effective than the treatment done at rosette and pre-flowering stages. Treatment at pre-flowering stage was found to have an insignificant change in biochemical, growth as well as yield parameters.

Out of all the growth promoters used, GA_3 seemed to be the most effective, especially at a concentration of 100µg/ml. On the other hand, all the growth retardants used seemed to have similar effects on the growth, development and yield of chirata plant. Hence, the application of GA_3 was found to be the most effective and out of three stages of treatment, sapling stage was found to be the most beneficial.

Thus it is concluded that selective concentrations of some plant growth substances (especially, GA_3) might be used with a view to increasing yield of chirata plant; selection of the optimum stage of the chemical treatment and exploitation of the imposed higher vigour through hormonal manipulation at a critical stage of plant growth are the important determinants for obtaining the most covetable result. These findings can be utilised to introduce *Swertia chirayita* as a commercially cultivated plant. This, in turn, will help in the conservation of the plant in its natural habitat, which will further help in upliftment of the local economy.