Drought is one of the most common environmental stresses that affects growth and development of plants through alterations in metabolism and gene expression (Leopold, 1990). The maintenance of water potential during drought period can be achieved by osmotic adjustment. Plants have evolved two major mechanisms for accomplishing this: drought stress tolerance and avoidance (Touchette et al., 2007). Avoidance depends primarily on adaptations in root and shoot architecture and morphology, whereas tolerance appears to involve the accumulation of compounds that may protect the cells from damage at low water potential, such as osmolytes, chaperones, proteinase inhibitors and proton ATPases (Save et al., 1993; Touchette, 2006). As a primary response reactive oxygen species (ROS) are generated on exposure to drought stress. The ROS are highly toxic and can interact with the antioxidant system thereby, interfere with various metabolic pathways (Yadav et al., 2010). The ROS can oxidize biological macromolecules such as lipids, proteins and nucleic acids (Sudo et al., 2008). Thus accumulation of ROS and free radicals leads to imbalance in antioxidant defence system resulting in oxidative stress. However, plants have adopted several stress protective strategies to combat such adverse stressed conditions. ROS are also scavenged via antioxidant defence system comprising enzymatic and non-enzymatic components.

The demand for food is expected to keep on increasing due to an ever-increasing world population. Up till now agriculture kept pace with the demand for food by using techniques that are far from sustainable such as using pesticides, fertilizers, extensive irrigation and transforming more and more land into agricultural land. In addition, agriculture is responsible for about 70% of the global water usage, a resource expected to become scarce due to climate changes (UN, 2009) and about 50% of all yield losses are caused by abiotic stresses, from which drought stress probably is the most important one. Expanding cultivation and utilization of ‘underutilized’ crops can contribute essentially to upgrade well being and nourishment, wage generation and biological sustainability.
Chapter-5

Summary and Conclusion

Fagopyrum esculentum Moench, is one of the vital unattended crops cultivated in the high altitude temperate zones of the North West Himalayan region. Due to the less economic output and cultivation constraints the crop is at the verge of extinction, though it is of high medicinal and nutritive value (Shah, 2013). The plant is selected for present study to analyze the effects of different levels of drought stress on morpho-physiological and biochemical characteristics.

The effects of drought stress induced by polyethylene glycol (PEG 6000) on germination (%) and morphological parameters of seedling (shoot and root length; fresh and dry weight) were studied. Seeds of F. esculentum were subjected to drought stress for fifteen days by using six different concentrations of PEG (15, 20, 25, 30, 35 and 40%) under laboratory conditions. Seeds of F. esculentum were also sown in nursery beds and with the appearance of first leaf; seedlings were transferred to ceramic pots filled with mixture of soil and sand. Drought stress was imposed by watering while weighing method was used to control water potential to meet the experimental requirements. Different water potentials (-0.01, -0.02, -0.03, -0.04, -0.05, -0.06 and -0.07 MPa) were achieved after 15 days of transplanting the seedlings to pots. Response of morpho-physiological and biochemical characteristics to drought stress was studied in leaves and roots of F. esculentum at an interval of 30, 45, 60 and 75 days of plant growth.

The present study on effect of different levels of drought stress on morpho-physiological and biochemical characteristics of seedling and plant of F. esculentum over period of time had revealed the following important observations:

1. A significant increase in germination percentage was recorded at lower PEG concentration. Shoot and root length; fresh and dry weight of seedling decreased with increase in PEG concentration. But at lower PEG concentration root length increased significantly.

2. Increase in the intensity and duration of drought stress was accompanied by a significant reduction in plant height, number of leaves, fresh and dry weight; and
relative water content of plant. The root length increased as drought stress increased from mild to moderate level and then decreased at severe drought stress.

3. A significant increase in the level of carbohydrate, total protein, total free amino acids and proline content was recorded in plants subjected to different levels of drought stress.

4. The sodium content was elevated with increase in the concentration level and period of drought stress, whereas, an inverse relationship was observed between drought stress and potassium content.

5. Drought stress showed significant alterations in contents of total chlorophyll, chlorophyll ‘a’ and chlorophyll ‘b’.

6. Analysis of enzymatic antioxidants revealed a significant increase in the activity of superoxide dismutase, catalase, peroxidase, ascorbate peroxidase, glutathione peroxidase and glutathione-s-transferase under the influence of drought stress over period of time.

7. Non-enzymatic antioxidants such as ascorbic acid, tocopherol, phenol, flavonoid, rutin and malondialdehyde were found to accumulate significantly with an increase in the level and duration of drought stress.

8. Capability of plant to scavenge free radicals (DPPH and ABTS) was observed significantly high under severe drought stress conditions.

From the present study it can be concluded that drought stress reduced plant growth, which consequently reduced biomass production, however the content of osmolytes was increased. The results of present study revealed that reduction in relative water content in comparison to control was not much, therefore, *F. esculentum* can be considered as drought tolerant. An increase in enzymatic, non-enzymatic antioxidants and radical scavenging activity was observed, which indicate that *F. esculentum* has the ability to scavenge the reactive oxygen species (ROS) and can be grown successfully under stressful conditions. From the obtained results and taking into account that rutin is the main component that defines the quality of *F. esculentum*, increased under drought stress...
conditions suggesting that domestication and cultivation of this species in water scarce areas is economically and medicinally beneficial.

The present study of the effect of the drought stress on the growth of the *Fagopyrum esculentum* Moench made it possible to reveal the existence of various adaptation mechanisms to this constraint. It would be interesting to continue this work by studying behavior of drought tolerant common buckwheat plant in field conditions. A thorough study on mechanism of tolerance to drought cannot be under consideration without a molecular approach.