Summary and Conclusions

Panicum miliaceum L., commonly known as "Common" or "proso millet", is one of the minor cereal crops in India, with total area approximately 450 thousand hectares under cultivation. It is a relatively short duration (90 days) emergency or quick season irrigated crop with low moisture requirement. The grain after hulling make a nutritious and palatable cereal for unleavened bread or cooked. It has ability to tolerate and survive under conditions of continuous or intermittent drought that results from low and uncertain rainfall. It adapts to low fertile loosened sandy soils and favours good growth on slopes of hilly tracts.

In the past 20 years considerable progress has been made in *Sorghum* and *Pearl millet* in ceiling to yield by commercial use of hybrids and by incorporating resistance to major diseases and pests. However, very little attention has been paid to minor millets like common or proso millet, finger millet, foxtail millet, little millet and kodo millet. This is especially true from the point of view of research. Now it is universally accepted that understanding the physiology of crop species should be an essential prerequisite for any ambitious breeding programme. However, very little is known about physiology of this crop. Hence, in the present investigation preliminary physiological studies have been carried out.

An attempt is made to study the growth and development of this crop under well-irrigated field conditions as well as drought conditions. An attempt has also been made to correlate this with biochemical changes taking place in the plant. For this the changes in some organic and inorganic constituents have also been investigated. An attempt is also made to study the stomatal behaviour in this plant during drought conditions.

Senescence marks one of the important events in the life cycle of a plant. In many crop plants like rice, wheat and soybean it has been fairly well established that senescent leaves can serve as source and can supply nutrients to the young developing organs. It is thought worthwhile to see whether similar situation prevails in prosomillet also. For this, biochemical changes during senescence of leaves have also been attempted.

The significant findings of the present investigation can be listed as follows :

(1) The plant height increases rapidly from 15 days after sowing till the heading stage while leaf area increases considerably from active titlering stage and reaches its maximum just before heading stage.

(2) The first tiller appears after 15 days (4 to 7 leaf stage) and the active tillering occurs 45 days after

sowing. After 60 days, tillering ceases probably due to competition for light and nutrients. High concentration of nitrogen and potassium during vegetative stage probably favours the active tillering.

(3) Uptake of nitrogen, phosphorus, potassium and calcium is high during tillering and panicle initiation stage (45-days), similarly carbohydrates and nitrogen contents are also enough during this stage.

(4) Rate of dry and fresh matter production is slow at the early stages of growth but is remarkable from the highest tiller number to grain filling stage (75 days). The total nitrogen, soluble sugars, crude starch and phosphorus content in the mature leaves during this stage well correlate to the above process.

(5) Relative growth rate (RGR) and Net assimilation rate (NAR) reach at their maximum value during heading stage when 3rd and 4thleaf area is maximum.

(6) High content of nitrogen, phosphorus and calcium in the leaves during 45 to 75 days probably favours the emergence and rapid growth of ears. The Leaf area ratio (LAR) is also maximum during third period which correlates well with NAR also contributing to grain filling process.

(7) Based on these changes, whole growth span of proso millet can be devided into the following three phases from the view of dry matter production.

I. From sowing to maximum tiller number stage : Preparatory period in which plant is established for active dry matter production.

II From maximum tiller mumber stage to heading stage : Active stage of dry matter production.

III From heading to harvesting state : Accumulation of assimilatory products.

(8) The organic acid content of leaf as revealed by TAN values steadily increases as the growth proceeds and riches its highest value just before heading stage. This may be in response to continuous cation accumulation and increased respiratory rate. The organic acid level also increased during drought condition which may be an adaptive features to water stress.

(9) Both reducing and total sugar contents increase as growth proceeds and the maximum being during grain filling stage. Starch content in stem is maximum during heading stage. During drought conditions the level of both reducing and total sugars increases. The continuous fall of reducing sugars in stem and leaves is only observed during severe drought conditions. The accumulation of sugars probably help in osmotic

adjustment. During senescence of leaves there is continuous degradation of starch resulting in increase in concentration of both reducing and total sugars. This may also be due to the reduced rate of photosynthesis.

(10) The nitrogen in all three parts of proso millet plant increases up to heading stage and there is a fall at grain filling stage which can be attributed to the translocation of this nutrient to the developing seeds. Nitrogen content in root and stem increases but slightly decrease in the leaves of water stressed plants. This increase probably contributes to the synthesis of aminoacids like proline. Significant decrease in nitrogen content in senescent leaves may be due translocation of this nutrient from the older leaves.

(11) The accumulation of polyphenols in flag and mature leaves during panicle initiation and ripening stage possibly play a role in emergence of ear which account for increasing the number of seeds and grain weight. Water deficits in plants too causes to increase polyphenols. This may be due to the enhanced secondary metabolism during drought conditions.

(12) Chlorophyll content in flag and mature leaves is maximum during panicle initiation stage. This might reflect vigorous photosynthesis. During water deficit conditions chlorophyll content decreases considerably. However, 16 days water stressed leaves retain about 65-75% chlorophylls, which may be considered as a drought resistant feature of this plant.

During aging of leaves much loss of chlorophylls will undoubtedly hamper the photosynthetic efficiency of the plant.

(13) Proline content of both flag and mature leaves is high during vegetative and grain filling stage. During drought conditions proso millet plant accumulates proline in all three organs significantly which may play a key role in stress recovery. Proline level decreases during senescence of the leaves which indicates that this important amino acid may be translocated to other developing parts of the plant.

(14) The phosphorus content is maximum at heading stage and root contains always the higher phosphorus than those of leaves. It indicates that proso millet has got a good capacity of phosphorus uptake. Water deficit slightly increases the phosphorus uptake by the plant. This may be due to less disturbances in phosphorus related activities and an adaptive feature in stress recovery. Decrease in phosphorus level in senescent leaves indicates that this mobile element is translocated from the senescent leaves to the young developing parts of the plant.

(15) Potassium and Sodium content is more in vegetative stage, thereafter it slowly decreases along the age of the plant. However, stem is exception, where potassium remains accumulated even at the ripening stage. This indicates that probably stem acts as a buffer for potassium accumulation and its

translocation. Water deficit causes the accumulation of potassium and sodium in all three parts of plant which may be accounted for osmotic adjustment.

(16) The calcium content of all plant parts is high during vegetative stage and thereafter it decreases towards maturity. Calcium content of root and stem drops down with advancement of growth of proso millet and is continuously accumulated in mature leaves. This indicates that calcium uptake is a passive process. Higher accumulation of calcium in flag and mature leaves may play a role in drought resistance.

(17) The magnesium content is high during vegetative stage. In later stages it falls down which is quite significant in root followed by stem; and it accumulates in the leaves during grain filling and ripening stage. This may be due to further translocation of magnesium from clum to developing grains. During water deficit condition the magnesium content decreases in stem and root but increases in leaves. It may be translocated to leaves to reduce the loss in lipid chloroplast and may take active part in retention of chlorophylls.

(18) Iron content continuously decreases in stem and leaves up to grain filling stage and increases further in the leaves at maturity. However, iron content of root continuously

increases as growth proceeds but falls down after heading stage. During water deficit iron accumudates in all the three parts of plant, due to negative influence of water stress on iron translocation. Iron content slightly increases in the senescent leaves which may influence the enzymatic activities.

(19) Silicon in all parts of the plant accumulates during heading stage. The silicon content at maturity in proso millet leaves is quite appreciable which may render the plant to be resistant to diseases. During drought conditions silicon is decreased considerably in the leaves but in case of stem it increases. Reduction of silicon content is also observed in the senescent leaves.

In conclusion it can be said that there are considerable changes in the pattern of inorganic and organic constituents during different growth phases of proso millet plant and leaf senescence. The metabolism of proso millet plant is also influenced by environmental factors like availability of water. Like other crops proso millet also possesses good ability of nutrient uptake and translocation of essential nutrients during senescence. Accumulation of proline, organic acids, potassium and sodium under water stress are suggestive of adaptive ecological nature of proso millet plant.