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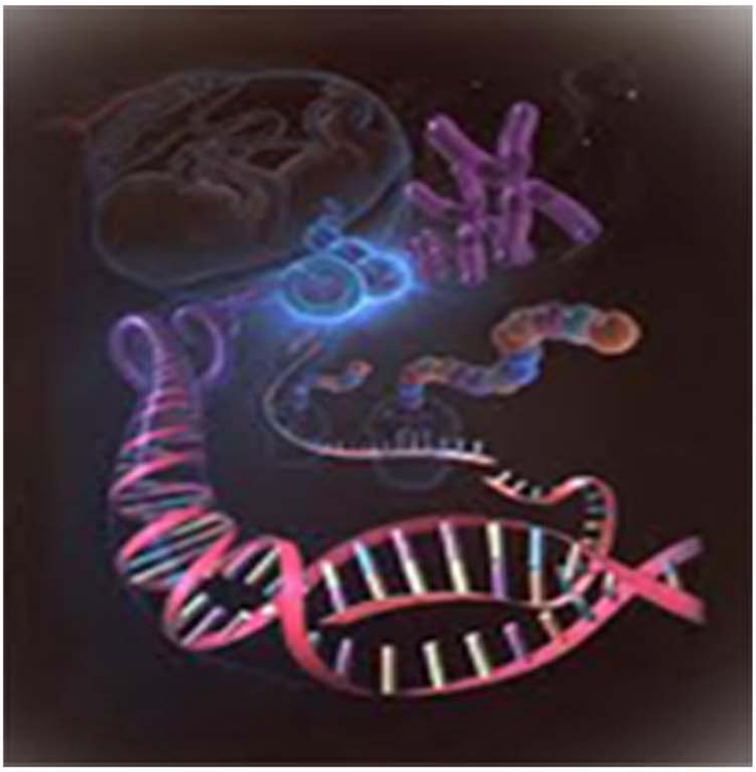

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Review Article

ABIOTIC STRESS RESPONSE IN *VIGNA RADIATA* L. (MUNGBEAN)

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Vigna radiata L. (Mungbean) commonly known as green gram is one of the important legume native to India, highly rich in proteins, vitamin and minerals and is generally consumed as sprouts or in dry form. It has high concentration of thymine, niacin and ascorbic acid. It requires low input and has wider adaptability to grow in short duration (90-120 days). They acquire 80 million hectares of land worldwide. Drought and salinity are the main constraint for its productivity. This types of stress are induced which explains the intense investigation carried out to understand the tolerance mechanism under stressed conditions. Stress effect metabolism of plant which leads to tremendous change in physiological and biochemical parameter. However, the appropriate screening techniques are insufficient to study the stress tolerance is developed by Mungbean. To increase the productivity of Mungbean it is essential to make them drought and salinity resistance. On these aspects, limited information is available. The main objective of this review is to summarize the work done on the response of *Vigna radiata* for abiotic stress.

Keywords: *Vigna radiata* L., Drought stress, Salinity stress, Biochemical parameters

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is one of the most valuable and popular crops of the world. It is also known as green gram or golden gram mainly cultivated in India and others Asian countries. It is highly consumed in sproutsor dry seed form because of its high protein content (Khattak *et al*., 2001). Presence of negligible amount of carbohydrates (4-6 g) and other important vitamins (A, B, C and E) in it makes it popular among vegetarians. Mungbean has a major impact on immunity; its regular diet can enhance the immune power. Germinated seeds of Mungbean contain anti-carcinogenic, antibacterial and antifungal properties which neutralize the toxicity. Since, it is an important ingredient in several protein supplements and nutraceutical formulations (Mehta, 2012). Therefore, it can be used for the welfare of human beings. It has a fantastic property to fix the atmospheric nitrogen by forming symbiotic relation with *Rhizobium* bacteria which also beneficial for the crop succeeding (Ali, 1992). Therefore, it also enhances the productivity of soil

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which promotes the cropping system (Abrol *et al.,* 1997 and Weinberger, 2003).

Water and salt stress are the main environmental factors which act as major constraints for Mungbean. Stress changes the growth pattern by affecting the major physical and biochemical parameters. Mungbean is highly sensitive to these stresses, mainly it effect the root production compared to shoot. Against very little amount of saline water can induce high response of Mungbean. Since, pre-treatment with saline water should be done to generate stress tolerance in *Vigna radiata* (Saha *et al*., 2010). Stress tolerance is necessary to develop in Mungbean so that it can withstand in adverse conditions to increase productivity and yield of the grain. High stress condition can offer an opening to a number of insect-pests and several disease conditions which result in the loss of productivity and quality of the Mungbean (Singh and Singh, 2011). The main objective of this review is to emphasize the work done on *Vigna radiata* during last three decades in response to abiotic stress.

DROUGHT STRESS

Drought is a worldwide problem. Basic metabolism is mainly affected by water stress which controls the growth, yield and quality of a crop (Hsiao and Acevedo, 1974, Begg and Tuener, 1976). Water deficit can change the growth pattern of the grain which inhibits the cell elongation and enlargement. This decreases the productivity of Mungbean and disturbs normal turgor pressure. It may loss the cell turgidity. The effects of drought stress can seen by measuring root and shoot ratio which increases during stress conditions. As well as index area of leaf is decreases whereas increased cell thickness, lignifications and cutinization amounts are noticed. This grain is reported to more susceptible to drought than many other grain legumes (Pandey *et al*., 1984). Therefore, this affects the productivity of a crop, mainly during spring and summer climate. Due to of its short life span it mostly escape drought climate conditions. During flowering period, Mungbean crop is more sensitive to water deficit. It determines that drought stress act as a constraint during flowering period which may cause instability and low productivity of *Vigna radiata.* There are various stress factor which act as an inhibitor to reduce vegetative growth, pod set, flower initiation in the Mungbean (Morton *et al.,* 1982).

Stress tolerance can be easily identified by a means of osmoregulation (Morgan 1984). It can be also measure by calculating the dry weight of roots and shoots after treating them with water deficit conditions. As the water supply is very less or negligible, the vegetative growth will differ from the normal. Effect of water stress can be seen in length variation in replicates of the same species. We can identify the growth of germinated seeds and their root length or we can also measure the weight of seeds to distinguish the productivity between replicates. It is a method which doesn't require high efforts but provides an idea that stresses disrupt which parameters such as cellular homeostasis and biochemical metabolism.

WATERLOGGING STRESS

Excess of water can also create an impact on the growth of Mungbean. It mainly affects the dry weight of roots. Roots are the main part of the crops which extract the water content of the soil and provide a good growth to the plant. Due the presence of excess moisture, roots lost their property and the productivity of plant decreases. This results in the increase of leaf dry matter. It is seen that during the high stress conditions the dry weight of the leaves get doubles of it normal and declined in leaf index area. Whereas, there is no effect is seen on flower color parameters (Musgrave M E and Vanhoy M A, 1989). There are other factors too on which water logging shows it effect by decreasing them such as chlorophyll content, flower partitioning, pod setting, photosynthesis rate, number of nodules, membrane stability index, crop growth rate, root dry weight, quality and yield of the crop. High reduction is shown in sensitive genotype and their selection is must. It can identified by their slow recovering rate in photosynthesis and physiological traits while in stress resistance genotype has high rate of photosynthesis and physiological traits during recovery period (Kumar *et al.,* 2012). Selection is required to identify the stress tolerance in germinated seed for the advancement of the crop and to increase the yield of the legume grain. Response of the mungbean for waterlogging stress is found by the carbon budgets between shoot and root (Vanhoy *et al.,* 1989). Identification of the tolerant cultivars and for selection of various tolerances has been made at AVRDC (Tickoo *et al.,* 2006).

SALINITY STRESS

Salt is one of the most predominant factor affects the growth of the crop in a large area of land worldwide. During a serve held by Nutritive Management Service in 2008 it is reported that 6.5% of the total land of the world is affected by salinity stress which is around 831 M ha of land (Hasanuzzaman and Fujita). Salinity is not the alone cause which decrease the quality of the crop there are major forms or other factors which heighten the salt stress in environment which can be natural or induced by humans. Naturally it occurs when breakdown of rocks takes place which contains high content of calcium, chlorine, sodium, Magnesium and sulphate. Anthropogenic activities which includes industry, agriculture, transportation, mining, construction, deforestation and habitations has a great impact in increasing the salinity of the soil which direct influence the vegetative growth of the plants. It disrupts the ecological balance of the soil (Munns, 2005; Garg and Manchanda, 2008).

The dissolved form of increase salt concentration is given to the germinating seeds of the Mungbean in replicates. After that the yield of the germinated is measure to identify the stress tolerated seeds. It show a drastic effect on the roots compared than shoot. During salinity conditions the length of the root, branches and number of root hairs are decreases. Wahid (2004) is reported that salt stress causes chlorosis, necrosis and reduced the chlorophyll content in the plant. Since, they appear in brown in salinity conditions. Whereas, the activities like catechol peroxidase and superoxide dismutase are increased under salt stress in the root and shoot. Biosynthesis of the polyamine is also affect by an increase amount of salt concentration in Mungbean grain (Friedman *et al.,* 2006). Yield of a plant is related to each and every aspect of it. If salt stress affects physiological pathways, biochemical metabolism and morphologically the yield of the plant will get abnormal.

To analysis the stress tolerance different concentration of dissolved salt is provided to the germinating seeds of the Mungbean. Predominantly different concentrations of NaCl (0, 60, 120, 180, 240, 320 mM) are provided. The glycinebetaine and proline content in the root and shoot is seen high under stress conditions. By measuring the concentration of proline and glycinebetaine it can be identified whether seeds are able to withstand in high salt or not (Misra and Gupta, 2006). Enzymes like y-glutamyl kinase and Pyrroline-5-carboxylate reductase are responsible for the synthesis of glycinebetaine and proline while an enzyme which facilitates the conversion of proline to glutamate is proline oxidase which reduces the level of proline. During salt condition decreases proline oxidases increases the proline levels due to the absence of calcium in roots and shoots (Misra and Gupta, 2006).

Different doses of salt (NaCl) concentration are given to three species of *Vigna radiata* (T 44, SML 66, Sarif) and results were observed after 15 days. The increased salt conditions were decreases seedling growth, germination percentage, relative growth rate and photosynthetic pigments (Arulbalanchandran *et al.,* 2009). In the response of salt many metabolite solutes concentration increased in roots and shoots of the Mungbean such as proline, reducing sugar, starch, proteins. Whereas, an enzyme called peroxidase have high level of it as salt concentration is increases respectively than control. Stress executed by NaCl was overwhelmed by pretreatment with salt concentration which modifies antioxidant enzyme activities; reduce malondialdehyde and H_2O_2 content so that accumulation of osmolytes (proline) increases (Saha *et al.,* 2010). In this way, plants of mungbean adapt the formula to survive even in salt stress.

Pailwal and Maliwal (1980) state that mungbean can resist to a particular level of salt at the germinating stage a mungbean plant can tolerate 6 m mhos/cm. Whereas, a mungbean plant can tolerate 9-18 m mhos/cm salinity. Another study is done on blackgram and cowpea seeds of different cultivars. The blackgram and cowpea are the grams in which chlorophyll pigment is extensively decreased or lost due to high salinity conditions present in the environment. However, cowpea has more compatible solutes than blackgram which controls the osmosis and endure cytoplasmic viscosity; this signifies that cowpea is more tolerant than blackgram. To enlighten the yield and growth of mungbean under salinity seeds are inoculated with L-TRP and *Rhizobium* is used as complement (Zahir *et al.,* 2010). Delayed and decreased germination is observed in the mungbean with an increases salt concentration. Salt stress is varied with cultivar is noticed, it decreases seedling height of mungbean seeds. No effect is observed in some of the concurrences of *Vigna radiata* when cultivated on extremely alkaline (pH >8.5) calcareous soils (Lawn *et al.,* 1988).

Gulati and Jaiwal (1994) examined accumulation of ions in cellular and response of whole plant against different salt concentration. Whole plants were cultivated in sand with Hoagland's nutrient solution addition with 0-350 mol/m-3 of NaCl. After 7 days from the same seed callus culture were initiated and grown in improved PC-L 2 medium (Phillips and Collins, 1979) which has the same level of salt as in Hoagland's solution. Hence, same tolerance power was observed in the whole plants and the seeds which demonstrated that salt stress is regulated at cellular level (Gulati and Jaiwal, 1995). The conclusion was that the major osmoregulants were sugar and ions of resistance lines of *Vigna radiata* Misra and Dwivedi (1995) stated that salt resistance and salt sensitive *Vigna radiata* can grow in high salinity and low salinity conditions respectively. During salinity the glucose is metabolized by pentose phosphate pathway in salt resistance mungbean. Mainly it is observed that in mungbean cultivar 'T 44' the proline and glycinebetaine levels are increased under stress conditions.

There are three distinct partial cDNAs (pVr-PLC 1, pVr-PLC 1 and pVr-PLC 3) in mungbean were identified which are present in putative phosphoinositol-specific phospholipase C encoded forms (Kim *et al.,* 2014). These genes exhibit inimitable patterns of expression and are trancriptionally active. The pVr-PLC 3 mRNA level was found to be less during normal growth and induced during high salinity and drought stresses. Whereas, the pVr-PLC 1 and pVr-PLC 2 mRNA levels were constitutively show its expression to varying degrees in all mungbean varieties.

The work of selection isolation was initiated by Kumar and Sharma (1989) in callus culture of germinating seeds. Clones were selected by viewing their growth and productivity behavior. Many characters such as free proline, potassium and sodium ions concentration are compared with sensitive callus when mungbean seeds are grown under stress as well as normal media. Under stress conditions the selected calli has capacity to grow. On comparing with wild types the selected calli are more capable of carrying high content of free proline and other ions.

OTHER STRESSES

Environment factors, temperature, pH of the soils are some of the other stress which influence the vegetative growth and yield rate of the Mungbean. A continued rainy period at maturation frequently results in poor seed quality due to fungal infestation, sprouting of seeds within pods and discoloration of seeds. Pre-mature sprouting is a serious problem in mungbean in the tropics (Fernandez and Shanmugasundaram, 1988).

Temperature is one of the minor aspects which alter the yield of mungbean plant. Over a range of environments the cultivation of mungbean is differ which has a great impact of temperature. Therefore, it is needed to develop photo-period and temperature insensitive varieties. It can progressively delay (30 to 40 days) in flowering during the extent in photoperiod. Kumari and Varma (1983) reported that high temperature (>40) has direct contact on consequently formation of pods and flower maintenance. Generally low temperature causes delay in photoperiod and high temperature will hastens flowering. Khattak *et al.* (2006) reported that there will be no effect on the pods and buds during high temperature and humidity fluctuations. In India the incurable heat stress predominantly in summer and spring mungbean is a severe problem. During this drastic loss in yield of mungbean is noticed due to the pollen inviability, high shedding of flowers which results in no fertilization. In hisar the field experiments done by Singh *et al.* (1991) with mungbean cultivar 'K' during summer season of 1989. A linear response is shown by leaf, flower and pod growth with increasing heat units which initiated at 140,630 and 725° C respectively. Through it the tolerance level of mungbean are generated under high stress.

During the process of pre-harvest sprouting under salt stress some changes are observed in features of mungbean are found such as bulky pod wall, elevated cuticular wax content present in pod wall, small pod beak and angle and decreased rate of moisture absorption by pod wall (Naidu *et al*., 1996). During the change of atmosphere the hardening of seeds may be useful which can contribute to stress tolerance. The seed hardening is mostly seen under stress which declines itself on storage. The transient hardening of seeds during harvesting is found to be administrated by a dominant gene Hd1Hd1 (Singh *et al*., 1983).

Mostly it is seen that the genotype of mungbean are prone to shattering. During their reproductive phase mungbean plants were found to be covered with flowers and mature pods due to of it uncertain flowering habit. Pods are specially selected by hands to save them from shattering. Singh and Sharma (1984) observed that the 'Plant Moong-1' is has its own resistance power against shattering. It can delay its harvesting by 7-10 days.

The more stable yields are seen in mungbean which has long life span due to the presence of more reproductive flushes. It has more flowering and mature pods for long duration (Chowdhury and Haque, 1977). However, these cultivars are more prone to shattering, sprouting and lodging, it would require additional pickings. Tolerance is measured by measuring the dry weight of the whole plant, plant length and root length of the mungbean plant (Duong *et al*., 1988).

CONCLUSION AND FUTURE ASPECTS

Due to of its short life span Mungbean has a wide range of soils and environments for its refinement. It has a unique quality by which it can easily grow anywhere on the land easily. Due to its high popularity it is an income source for the farmers. Due to its sensitivity towards temperature, water deficit, waterlogging and salinity it's not gaining the lands. Therefore it is an immediate need to improve its sensitive nature for abiotic stress by offering same change in its genotype or by adaptation.

It can be done by incorporating an abiotic stress tolerated gene in their genotype to increases the quality and yield of the Mungbean. For identification screening tools can be used for evaluation of germplasm and breeding materials. Some important traits have been identified by RFLP markers linked genes which has resistance to abiotic stresses. This shows the importance of markers for identifies the tolerance in the Mungbean and there are many markers which are available for this work. Through conventional breeding it is not possible to improve the root features which can be imperatively done by using marker assisted selection. This can be done by tissue culture techniques by incorporating the highly resistance genotype of wild relatives of Mungbean into cultivated genotypes. This can be done by hybridization.

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