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Efficiency of Seed Bio-Priming Technique for Drought Management in Mungbean

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ABSTRACT

Drought stress is considered a severe treat to crop production as it adversely affects the morpho-physiological, biochemical and molecular functions of plants especially in short duration crops like mungbean. Water stress during the growth phase (called terminal drought) has become a threat to mungbean productivity. To reduce stress, "biopriming" has emerged as a new agricultural and sustainable technology. Biopriming is a coating process or treatment with PGPR, which is good at hydration control and improves pre-germination preparation without the appearance of radicles. Biopriming significantly increased Mungbam yield and composition and modulated the activity of antioxidants (superoxide dismutase, catalase, peroxidase, ascorbic acid and all phenolics) by 8 - 12% under normal and drought conditions. Seed application will increase the germination capacity of mung bean production and the plant will eventually tolerate drought stress.

Keywords Biopriming, Drought, Nutrients uptake, Mung bean.

INTRODUCTION

Mungbean (*Vigna radiata* L.) Mungbean is a tropical plant, it is a pulse crop used as a cereal crop based human diet and provide a rich source of energy in terms of lysine and protein (Kumar and Sharma 2009). The crop plays an important role in enhancing the soil fertility by nitrogen fixation due to the presences of nodules in roots (Figueiredo *et al.* 2008). The plants which are grown in natural environment getting many stresses like water as drought or flooding salinity, ozone and UV radiation (Sangakkaran *et al*. 2000) global climatic change abiotic stress become a significant and unavoidable drastic factor in the agriculture sector for crop production (Kohler *et al.* 2008). The grains are developed in restricted due to decrease in photosynthesis, accelerated leaf senescence and limited source-sink relationships under terminal drought stress conditions (Duvnjak *et al.* 2023). Mungbean has a well-developed root system. The posterior roots are numerous, thin and nodular. The stems are branched and sometimes curled at the top. Young stems are purple or green, mature stems are grayish yellow or brown. It can be divided into upright reed type, semi-trailer type and trailed type. The leaves are oval or broad-ovate, the

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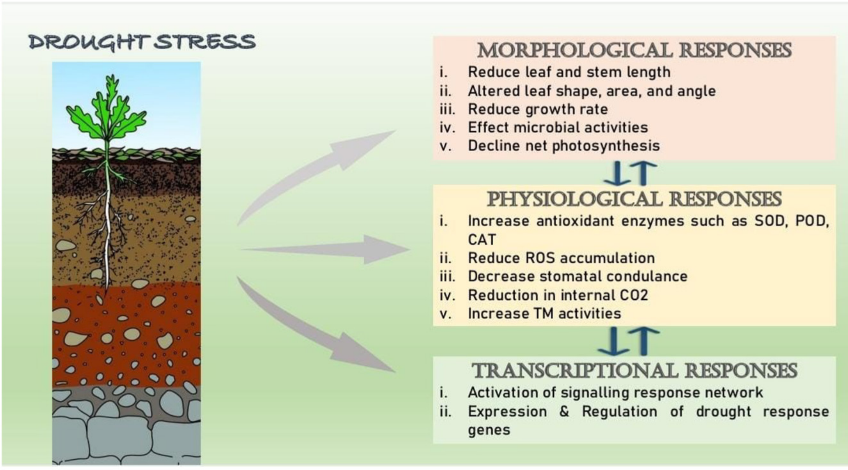

Fig. 1. Plant response under drought stress.

cotyledons die after emergence and three leaves are formed on two leaves. The leaves are 6-12 cm long and 5-10 cm wide. The panicles bloom with yellow flowers born in the leaf axils and leaves, each pedicel containing 10-25 self-pollinating flowers. Fruits are thin cylindrical or flat cylindrical capsules, usually 30-50 per plant. The pods are 5-10 cm long and 0.4-0.6 cm wide and have 12-14 segmented seeds. Seed colors and presence or absence of a rough layer are used to distinguish different types of mungbean. It is consumed as whole seed or split cooking, flour, or as sprouts, thus, forms an important source of dietary protein. Mungbean sprouts are rich in thiamine, niacin and ascorbic acid. The potential yield of beans is between 2.5-3.0 tonnes/ha, but the average for beans is staggering; only 0.5 tonnes/ha. Low productivity is due to abiotic and biotic constraints, poor crop management, and farmers' lack of access to quality seeds from improved varieties. (Pratap *et al.* 2019). Major biotic factors include diseases like yellow mosaic, anthracnose, powdery mildew, dry root rot, cercospora leaf spot (CLS), tan spot, halo blight and insect-pests especially whitefly, bruchids, aphids, thrips and pod borers (Pandey *et al.* 2018).

Adverse effects of drought on plant physiology and yield

Mungbean is a sensitive to drought stress at all the crop growth stages, which hampers the crop yield. Farooq *et al.* (2014) drought is the most limiting aspects for sustainable agriculture in minimizing the crop yield. The crop requires irrigation during the growing stages like flowering and graining severely hampers the grain productivity (Farooq *et al.* 2014). However, it is more sensitive at the reproductive stage, which represents a series of events from anthesis to maturity (Fig. 1). Drought stress witnessed during any of these critical stages leads to severe yield reduction (Duvnjak *et al.* 2023).

In the natural environment, plants may experience various stresses that affect their growth and development (Hasanuzzaman *et al.* 2012), some metabolic changes and changes in genes that enable the plant to survive in these conditions (Fig. 1). Depression related stress, known as the most limiting factor in agriculture, can greatly affect crop quality and yield.

Mechanisms to alleviate drought tolerances

Drought can be referred to as a metrological period without significant rainfall and it is one of the major abiotic stresses that contributes to a huge reduction tin crop yield throughout the world (Farooq *et al.* 2014). Plant shows a broad range of physiological, morphological, and biochemical changes such as reduced photosynthic accumulation, gene expression. Although water deficiency due to rainfall is often

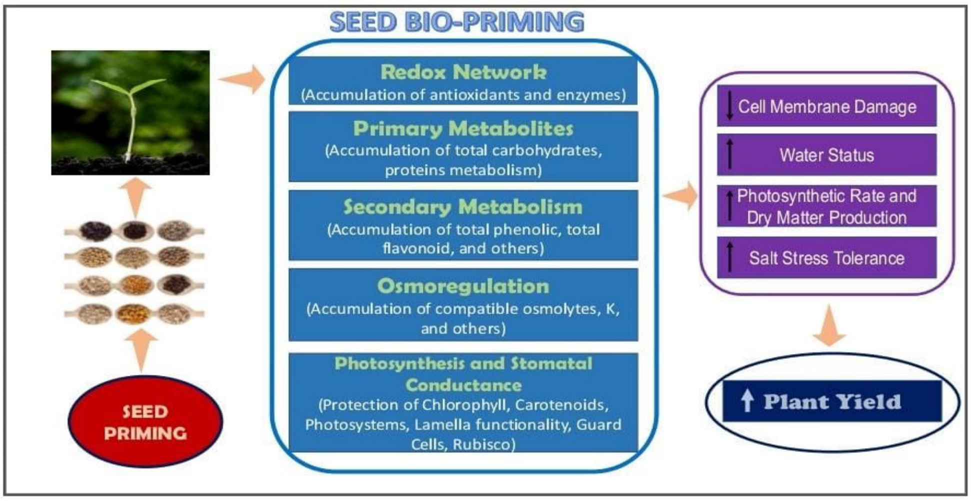

Fig. 2. Role of seed bio priming for abiotic stress alleviation.

the main stressor of depression (Rashid *et al.* 2004). Global climate change often leads to severe droughts in many parts of the world. In addition to drought stress, it is thought to be caused by insufficient water in the soybean plant (Maxton *et al.* 2017a, b).

Drought stress causes ROS production, which disrupts the balance between ROS production and ROS scavenging systems, and its accumulation depends on the intensity and duration of water stress and varies between species (Farooq *et al.* 2014). It affects the growth and yield of the crop. The negative effect of water stress on plants is the decrease in fresh and dry biomass. Plant responses to water stress are diverse and may include various defense mechanisms or physiological changes. These responses usually do not cause much damage to plants, provided that normal conditions return soon. Long periods of stress lead to more dangerous and permanent injuries and even the death of plants. Long term responses include repressed shoot growth, metabolic adaptations, limited transpiration area, kernel abortion and senescence (Kaur and Asthir 2017).

Nutritional enrichment of soil

Adding nutrients to soil by 8 ways they are: 1.Banana skins, 2. Egg shells, 3. Epsom salts, 4.Wood ashes, 5.Manures, 6. Expired animal feed, 7. Coffees and 8. Composting.

Addition of epsom salt

Epsom salt is a great way to get your plants in tip top shape. Those that are magnesium-deficient or have other problems caused by soil deficiencies will benefit from this amazing substance.

It can either be sprinkled on the ground when planting seedlings, mixed with water. Manure fertilizing your garden with animal faeces may sound sketchy, but it is a great way to fertilize. Ideally we should compost the manure so that it will not burn any plants. Never use dog or cat poop as they can contain communicable diseases such as toxoplasmosis and roundworms, and you do not want that on your plants.

Addition of composting

Compost is an organic matter that turns into a nutrient-packed fertilizer that can be from ingredients like apple cores, stale bread and vegetable peels or leaves and grass clippings to give plants what they need in order grow healthier. Compost should not be confused with fertilizer. Compost enriches the soil, itself, while adding nutrients to your plants so they can grow better and flourish in perfect conditions. To ensure that concerned plants receive the best care

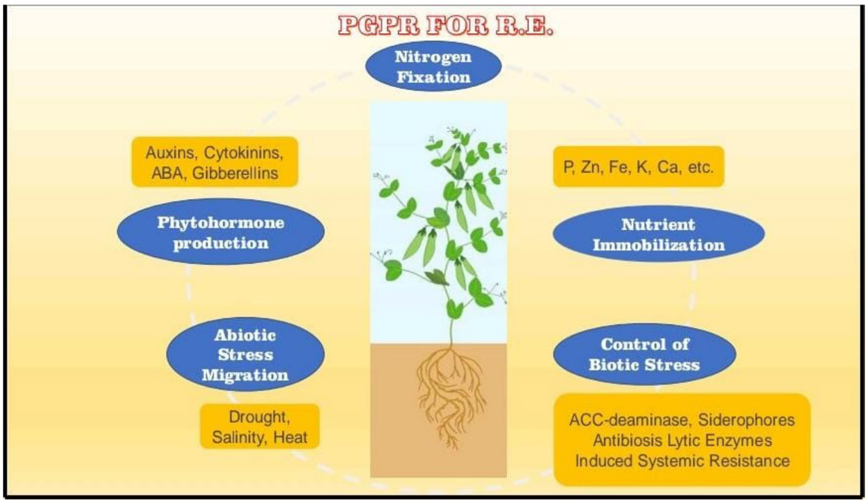

Fig. 3. PGPR mediated phytohormonal modulation and nutrient acquisition.

and survive in an environment with low quality soil, it must be enriched.

PGPR mitigated biopriming : An agroecological approach for inducing drought stress tolerance

Biopriming is a process in which plant seeds are treated with beneficial microorganisms, such as fungi or bacteria to improve their ability to germinate and grow under stress conditions (Mahmood *et al.* 2016, Maxton *et al.* 2017c, 2018a). Biopriming is a coating process or seed treatment with beneficial PGPR under controlled hydration. Priming seeds activated the faster inhibition and metabolic processes related to the initiation of germination (Fig. 2) (Nawaz *et al.* 2017).

The microorganisms colonize the seed surface and protect it from pathogens and stress factors, leading to improved seedling emergence and better plant growth. The microorganisms can help plants to better absorb nutrients such as nitrogen and phosphorus. The germination process of treated seeds is better compared to untreated seeds, resulting in more and uniform growth (Ahmad *et al.* 2013). Seed biopriming is considered a low-cost yet environmentally friendly technology that is effective in promoting growth, inducing long-term stress and achieving desired crop yields. The application of beneficial bacteria in seeds to stimulate plant production while maintaining environmental balance is called biopriming or seed treatment.

PGPR mechanisms for drought tolerances

The role of PGPR in nutrient management, biocontrol, plant growth and development is well known. These rhizosphere bacteria aid plant growth and development through various mechanisms (Glick *et al.* 2007, Saharan and Nehra 2011). Osmotic stress affects plant growth, development and soil microbial activity. There are various mechanisms of osmotic stress tolerance mediated by rhizosphere microbes in crops (Fig. 3) (Nawaz *et al.* 2017, Maxton *et al.* 2018b). These processes, which include changes in root structure, phytohormone activity, osmolyte accumulation, antioxidant protection, and soil bacteria, are widely used in agricultural processes due to their ability to promote plant growth, abiotic stress resistance, and plant diseases (Fig. 4) (Sahraran and Nehra 2011). Plant growth-promoting rhizosphere bacteria can influence plant growth through different direct and indirect mechanisms (Glick 1995). PGPR, as well as ACC, directly affect the growth of plants by fixing atmospheric nitrogen, soluble phosphates, and secreting hormones such as IAA, GAs, and Kinetin besides ACC (1-Aminocyclopropane-1- carboxylic acid) deaminase production (Glick *et al.* 1999, Maxton *et al.* 2018b), which helps in regulation of ethylene. Induced systemic resistance (ISR), antibiosis, competition for nutrients, parasit-

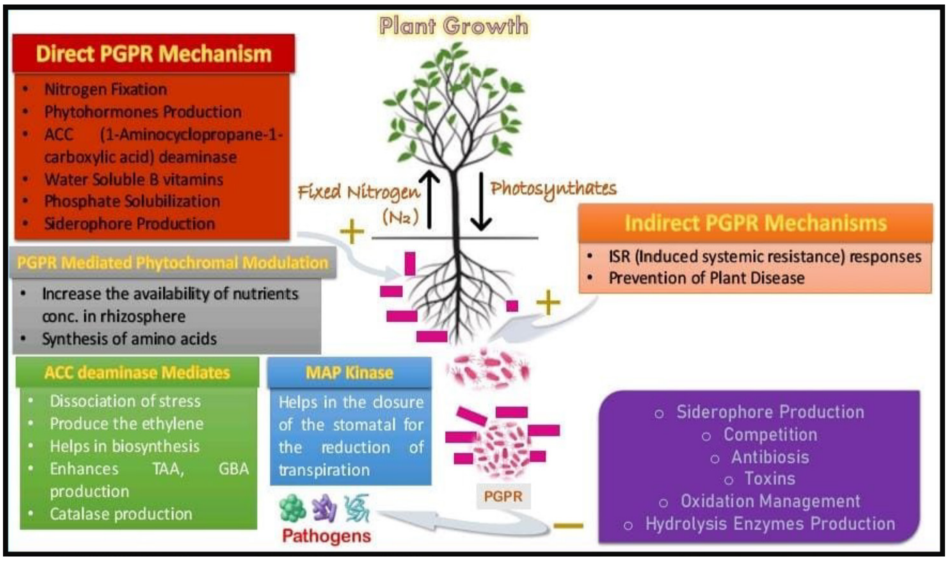

Fig. 4. Direct and indirect mechanisms adopted by PGPR to alleviate abiotic Stress.

ism, production of metabolites (hydrogen cyanide, siderophores) suppressive to deleterious rhizobacteria are some of the mechanisms that indirectly benefit plant growth. According to Vessey (2003) a variety of soil organisms that develop in plant rhizospheres but can grow in, on, or around plant tissues and promote plant growth through a variety of mechanisms known collectively as PGPR. Gray and Smith (2005) recently showed that the size of the PGPR relationship depends on the proximity of the organism to the root and the relationship between the relationship. These bacteria play an important role in the growth of plants by producing phytohormones, exopolysaccharides (EPS) and other metabolites by increasing nutrient availability in the rhizosphere and protecting plants from abiotic stress (Maxton *et al.* 2017 a, c). However, the bacterial response to stress varies depending on the duration, intensity, developmental stage and plant type of stress. Water stress directly affects soil systems in many ways, including stress on organisms (Karunakaran *et al.* 2013). Under drought conditions, soil microbes adjust their osmotic conditions and try to maintain their health.

Osmolyte accumulation.

Phytohormonal modulation.

Exopolysercide production.

Enzyme production or antioxidants or Ros enzymes Sodium potassium pump regulation.

IAA production.

PGPR : A sustainable green gram alternative for mitigating drought stress.

Osmolyte accumulation (OA)

In plant cells results in a decrease of the cell osmotic potential and thus in maintenance of water absorption and cell turgor pressure, which might contribute to sustaining physiological processes viz,. stomatal opening, photosynthesis, and expansion growth. Ex: Glycine betaine, Mannitol, Proline.

Exopolysaccharides production

Exopolysaccharides (EPS) are organic macromolecule, synthesized by various microbes using different carbon sources during fermentation process and are secreted outside the cell wall or as slime or into the extra cellular medium as jelly like material.

Phytohormonal modulation

Phytohormone modulation depends on the spatiotemporal distribution and activity of positive and negative regulators. Genetically encoded phytohormone signaling manipulators are important signals that can shift the balance by altering expression and/or genetic modification. For example: Auxin, ethylene, gibberellin (Maxton *et al.* 2017b,c).

Antioxidants enzymes

Antioxidant enzymes are produced by the cell during times of oxidative stress. An antioxidant is a chemical that inhibits the oxidation of another molecule. Antioxidant enzymes are enzymes that behave like antioxidants. They are called endogenous antioxidants since they are produced internally. Ex: Glutathione, Superoxide dismutase.

Reactive oxygen species

ROS are products produced by plants during various metabolic reactions such as photosynthesis and respiration. Oxidative stress occurs when there is an imbalance in ROS production and antioxidant defenses. ROS production leads to the production of anti-inflammatory drugs that rapidly damage cells. For example: Polyphenols.

Indole-3-acetic acid (IAA, 3-IAA)

It is the most abundant plant chemical of auxins. It is the best-known auxin and has been the subject of extensive research by herbalists. IAA is an indole derivative with a carboxymethyl substituent. It is colorless and soluble in polar organic solvents. Direct and indirect mechanisms work with PGPR to reduce abiotic stress. When it comes to seed priming, the application of indole-3- acetic acid (IAA) in combination with PGPR can have synergistic effects on seed germination. The exogenous application of IAA during seed priming can promote root elongation, enhance nutrient uptake, and improve overall seedling vigor. PGPR strains can facilitate the production of endogenous IAA in plants, which further promotes root development and nutrient assimilation. The combined application of IAA and PGPR for seed priming can lead to improved seedling emergence, enhanced root growth, increased nutrient acquisition, and ultimately, better crop establishment. However, it's important to note that the effectiveness of seed priming treatments can vary depending on the specific plant species, environmental conditions, and the formulation/concentration of IAA and PGPR used (Maxton *et al*. 2017c, 2018a).

CONCLUSION

PGPR has received particular attention for its ability to increase productivity, sustainability. It helps in root nodule formation and helps cell growth, cell elongation, cell formation. Bio-priming helps in mung bean in sustainable for agronomic approaches and for enhancing morpho-physiological growth and productivity. While there is substantial evidence supporting the positive effects of PGPR biopriming on plant drought tolerance, it's important to note that the effectiveness of this strategy may vary depending on the specific plant species, PGPR strains used, environmental conditions, and other factors. Further research is needed to optimize the selection and application of PGPR for different crop types and drought scenarios.

Future prospects

Bio-priming is a new technique of seed treatment that integrates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) of disease control. Compared with the control, bio-priming increased the seed yield of mungbean by 8–12% under normal as well as drought stress. Bio-priming also improved the nutrient uptake behaviour followed by Si- and hydro-priming treatments under terminal drought stress. It is recently used as an alternative method for controlling many seed- and soil-borne pathogens. Drought is an impact in reducing the crop growth. To mitigate the drought stress condition," Bio-priming has emerged as a newly agronomic and sustainable technique in improving the mungbean production.

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