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Research Article

POTASSIUM: AMELIORATE THE ADVERSE EFFECT OF CLIMATE CHANGE AND DROUGHT

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A R T I C L E I N F O

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A B S T R A C T

Research work of the past years on climatic policy in India lead to the conclusion that a gradual warming, reduction of the precipitation and a larger variability in the weather extremities are to be expected in India in the long run impacting vegetation and socio-agronomic growth negatively. The rise in temperature is also playing havoc with India's rainfall which is significant for India's agriculture sector on which billions are dependent. The report noted that the summer monsoon precipitation (June to September) over India has declined by more than six percent from 1951 to 2018, with notable decrease over the Indo-Gangetic Plains and the Western Ghats. It stressed that the overall decrease of seasonal summer monsoon rainfall during the last 6–7 decades has led to an increased inclination for droughts over India. Approximately 72% of cultivated land in India is rain fed largely due to inadequate precipitation and erratic rainfall resulting in reduced crop. In the post green revolution period, water stress problem is a major concern affecting the agriculture production. To increase the present yield level understanding various physiological process which are negatively affected due to drought condition is a matter of great concern. Poor monsoon and extended dry condition during critical growth period have a devasting influences on the crop performance. The production of the cereals and pulses could not be increased per unit area because even today 60-70% of the crops are grown under rain fed condition. High yields under such conditions need extra supply of nitrogen. Potassium, being a major plant nutrient which influences the water economy and crop growth through its effects on water uptake, root growth, maintenance of turgor, transpiration andstomatal regulation. Moreover, adequate potassium nutrition helps in increasing crop tolerance to water stress and promote root growth and results in better uptake of nutrients and water.

INTRODUCTION

India's average temperature has already increased by around 0.7 degree Celsius during the 1901–2018 period due to greenhouse gas emissions and by the end of 2100 it is expected to rise by approximately 4.4 degree Celsius (relative to 1976–2005 average, in the worst-case scenario), warns the first-ever climate change assessment report by the Indian government.

"Both the frequency and spatial extent of droughts have increased significantly during 1951–2018. In particular, areas over central India, southwest coast, southern peninsula and north-eastern India have experienced more than two droughts per decade, on average, during this period. The area affected by drought has also increased by more than1.3 percent per decade over the same period. The report by the Union Ministry of Earth Sciences observed that the impact of climate change on the availability of freshwater is a critical area of concern for India and the growing propensity for droughts and floods because of changing rainfall patterns caused by climate change would be "detrimental to surface and groundwater recharge, posing threats to the country's water security. Likewise, the country's food security may be placed under progressively greater pressure due to rising temperatures, heat extremes, floods, droughts and increasing year-to-year rainfall variability that can disrupt rain-fed agricultural food production and adversely impact crop yield," the report warned. Presently, the higher damages caused by draught are due to the rising summer temperature. The reducing tendency of the autumn and winter precipitation is smaller, about 14-15%, but still significant, since consequently less water is stored by the soil. The adaptation of plants to water stress is based mainly on osmoregulation, the plant enriches the osmotically highly-effective materials in the cell. The increase of the osmotic concentration causes anincreased water absorption, and a consequent increase in turgor. As soon as the potassium supply falls below a certain threshold, a closing of the stomata follows. Among nutrients, potassium has and especially favorable influence on the water management of plants. The promotion of water uptake and the inhibition of water release enable a certain adjustment to weather extremities.

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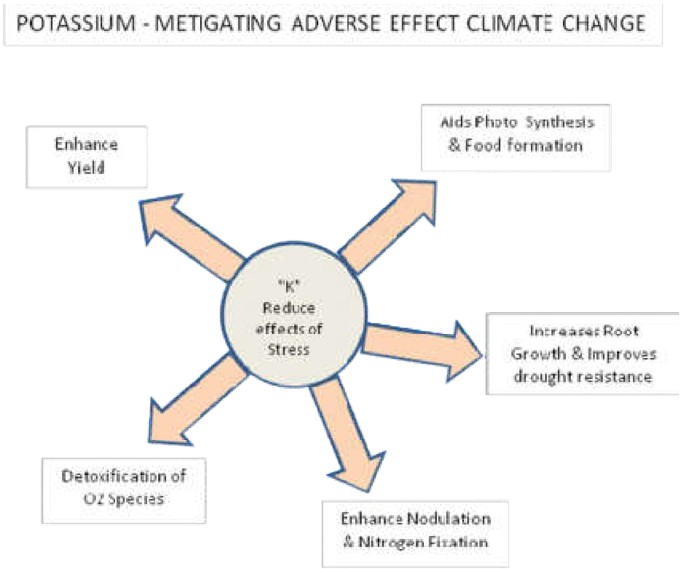

Potassium (K) is an essential nutrient for plant growth. It's classified as a macronutrient because plants take up large quantities of K during their life cycle. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. Potassium participates in many fundamental physiological and metabolic processes in plants, such as osmotic homeostasis and photosynthetic CO_2 fixation. Concentrations of K+ in the cytosol are maintained in a narrow range, around 100 mM, which is optimal for the function of cytosolic enzymes. The production of ATP can regulate the rate of photosynthesis. Potassium also helps regulate the opening and closing of the stomata, which regulates the exchange of water vapor, oxygen and carbon dioxide. If K is deficient or not supplied in adequate amounts, it stunts plant growth and reduces yield.

Potassium: Aids in photosynthesis and food formation

Water stress is a multidimensional stress which affects plants at various levels of their organization and development. During water stress, the concentration of solutes inside the solutes inside the plant cells rises, and therefore water potential drops. This in turn destabilized the cellular membrane and disrupts photosynthesis. Drought stress significantly reduced chlorophyll content in arid legumes (Garg *et al*.2005) The loss of chlorophyll-protein with concomitant decreases in photosynthetic rate during water stress has been attributed to increase in oxidative enzymes and decrease in scavenging enzymes like catalase and peroxidase that protect chloroplast pigments against oxidative breakdown(Levitt,1980) .Increased application of K has been shown to enhance photosynthesis rate, plant growth, yield and drought resistance in different crops under water stress conditions.

Potassium: Increases root growth and improve drought resistance

The retardation in plant growth under water stress is attributed to reduced accumulation of dry biomass due to inhibition of physiological processes (Singh *et al*.2000). Potassium, being a major plant nutrient which influence the water economy and crop growth through its effect on water uptake ,root growth, maintenance of turgor transpiration and stomatal regulation (Nelson 1980).Moreover, adequate nutrition helps in increasing crop tolerance to water stress and promote root growth and results in uptake of nutrients and water (Polizotto,1986 and Umar *et al*.1990). Potassium is the cation present in the plants in concentration is ranging from 50-150mM in the liquid parts, the cytoplasm and the vacuole (Leigh and Wyn jones,1984). The concentration of K+ in the cytoplasm is usually constant about 50mM. (Leigh, 2001) while the concentration in the vacuole may vary quite substantially. Kafkafi (1990) have suggested that accumulation of K+ by plants before initiation of stress is not luxury but rather an insurance strategy to allow the plant survive a sudden environmental abiotic stress. Soil moisture influence K+ uptake by plants by affecting root growth rate and the rate of K+ diffusion in soil towards the root.

Potassium: Help in Nodulation and Nitrogen fixation

Soil moisture deficiency has a pronounced effect on N2-fixation, nodule initiation, growth and activity are all sensitive to water stress. (Albrecht *et al*.1994). Limitation of water has been shown to impede capacity of plants to utilize inorganic nitrogen (Greenwood, 1976) that may be due to diminished absorption of nitrogen from soil and its adverse effect on the enzymes of nitrate and ammonia assimilation.

The response of nodulation and N2 fixation to water stress depends on the growth stage of the plants. It was found that water stress imposed during vegetative growth was more detrimental to nodulation and nitrogen fixation than that imposed during the reproductive stage. (Pena-cabriales and Castellanos 1993). Nodulation, nitrogen activity and dry matter yield increased with incremental K+ supplied plants. Nitrate reductase activity (NRA) has been found to be positively correlated with the crop productivity (Croy1967, Eilrich1968) and inversely with moisture stress. Garg *et al.* (1998) studied the influence of water stress on some enzymes of nitrogen metabolism. They reported that water-stress, irrespective of growth stage, significantly decreased the activity of NR, GS and GOGAT in all the genotypes, but the reduction was maximum in stress sensitive genotypes. Nitrate reductase activity increased in K+ treated plants.

Potassium role in Detoxification of O2 species

Water stress generally triggers many metabolic changes and results in synthesis and or accumulation of various plant metabolites. when CO2 fixation is limited because of stomata closure caused by water deficit, the rate of active oxygen formation increases in chloroplasts because an excess of excitation energy that is not dissipated by the protective mechanism is used to form reactive oxygen species(ROS) such as H2O2, superoxide (O2) hydroxyl radicals(OH°)and singlet oxygen (.O2)(Asada and Tkahashi1987.)

Enhanced antioxidant enzyme activities increased resistance to environmental stresses. (Bor *et al.* 2003).We observed a gradual increase in Peroxidase and Catalase activity at 45 DAS and then a gradually decline while in KCl and KNO3 treated plants Peroxidase and Catalase activities did not show significant increase because relatively less ROS accumulates in plants.

Plants overcome the ROS mediated stress responses either by preventing the accumulation of ROS or by effectively eliminating the ROS thus formed. The gamma- amino butyrate (GABA) shunt prevents the accumulation of ROS and has been implicated in plant defence against environmental stress (Bouche *et al.* 2003). Elimination of ROS is achieved by antioxidant compounds such as ascorbic acid, glutathione, thioredoxin and carotenoids and by ROS scavenging enzymes (eg. Super oxide dismutase, glutathione peroxidase, Glutathione reductase & catalase. K+ is predominant in accumulating solute during drought and significantly contributed to osmotic adjustment.

Potassium increases yield in cereals and pulses

Drought significantly constrains higher yield and yield stability in rain fed rice (Sibounheuang *et al.*2001) the grain yield usually decreased with the increase in water stress irrespective of cultivars (Moinuddin *et al.*, 2005), albeit, the magnitude of variation among them was large and consistent.

Yield improvements due to K application in number of crops have been reported (Sharma *et al.*1992, Umar *et al.*1993). Yield ability is determined by a proper balance between the source (photosynthetic organ) and sink (Fruits) capacities. Sugar are the most abundant organic compounds, they are radially accessible and energetically inexpensive source of osmotic. Greater reduction in sugar was observed in stress conditions. The translocation of soluble sugars from source was faster under rainfed condition as comparable to irrigated condition which was associated with early maturity and reduced grain-filling period. Sugar content increased due to foliar application of KCl& KNO_3 treated plants at some extent.

Drought tolerant varieties did not show any reduction in grain yield under stress conditions, while, the susceptible suffered around 50% reduction in grain yield as compared to the tolerant types (Natarajan and Rane, 2000)

Severe drought in the reproductions, mainly caused by an increase in the percentage of unfilled grains and also in grain weight (Wopereies *et al.* 1996). In consonance, Sharma *et al.*2003) and Chandra *et al.* (2005) reported similar results under mild or severely stressed environments. Further, Pradhan *et al.* (2003, 2006) corroborated the views of above workers by suggesting the decrease in yield attributing characters with decrease in yield attributing characters with decrease in irrigation regime.

Though moisture was the limiting factor but this could be overcome to a certain extent by potassium application in all the situation (Mengel and Brunschweig 1972) have also reported the significance of potassium under dry conditions. Similarly Rama Rao (1986) also observed favourable effects of potassium on pearl-millet yield under moisture stress situations. Yield improvement due to potassium application in number of crops have been reported (Sharma *et al.* 1992, Umar *et al.* 1993). Mengel and Kirkby (1980) suggested that under low soil moisture, K- application may result in yield improvement. Lahiri (1980) found increase shoot and seed yield with increasing K- levels, even under acute soil moisture deficit in moth bean, mung bean and cluster bean. Singh *et al* (1997) reported favorable effects of potassium applications on chickpea yield under water stress at various developmental stages.

Vignamungo: No. Of Pods/plant & Seed weight gm/100 seeds in black gram under water stress (amount) and also treated with KCl or KNO3.

Amount of water	No. of pods/plant			Weight of gm/100 seed		
(ml)	Without treatment	With KCl	With KNO3	without treatment	With KCl	With KNO3
Control	43±0.10*	45±0.10*	48±0.08*	4.0±0.40*	3.89±0.30*	4.12±0.37*
50	30±0.09	35±0.04	37±0.06	2.56±0.32	3.08±0.32	3.42±0.03
100	33±0.04	38±0.13	41±0.08	2.7±0.36	3.28±0.33	3.8±0.65
200	35±0.04	42±0.04	44±0.03	2.88±0.44	3.5±0.43	3.86±0.44
400	34±0.13	39±0.04	42±0.13	2.78±0.75	3.35±0.80	3.81±0.67

*Mean±Standard deviation (N=3)

The result of the present investigation indicates that water stress (duration and amount of water supplied) has adverse effect on the various morphological, physiological and biological parameters and yield on the test plant *Vignamungo*. Applied K mitigates the adverse effects of water stress in Black gram by favourably influencing internal tissue moisture photosynthetic rate and nitrogen metabolism.KNO3 have better impact on mitigating stress than KCl because interaction of N and K during formative phases and seed-filling stages give higher yield. The extent of change in any plant process mainly depends on the severity and duration of water stress and also on the stage of plant development when the water stress has occurred.

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