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Water Stress in Crop plants, Implications for Sustainable Agriculture: Current and Future Prospects

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Abstract: Shortage of water is one of the major threats crop production is facing today. Implications of Water stress can influence all plant processes on agriculture are predicted to increase under changing climatic conditions. This article describes impacts of water stress on crop production, and why water stress mitigation and management are vital for sustainable agricultural production under water scarce conditions. Plants respond to water stress through physiological and biochemical mechanisms depending on intensity, duration and frequency of stress conditions. Reduced water potential and stomatal closure lead to disturbed water flow and ultimately limiting photosynthetic capacity and growth and development of crop plants. It then reviews the effects of water stress on crop growth, yield, and quality are discussed. The article also discusses the potential implications of water stress for sustainable agriculture, including the need for improved water management, the development of drought-tolerant crop varieties, and the use of water-saving irrigation technologies. Stomatal regulation, osmotic and hormonal adjustment, morphological adaptations are key players. Future research efforts need to focus on the use of modern techniques to develop effective strategies to mitigate the impacts of water stress to ensure sustainable crop production and food security under rapidly changing climatic conditions..

Keywords: Agriculture; Drought; Plant growth; Seed germination; Plant hormones

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1. Introduction

Climatic change is multifaceted and often characterized by anomalies in the intensity, duration, and frequency of extreme weather events, changes in trends of precipitation, temperature, and other climatic parameters (Ncama et al., 2022). These anomalies will lead to conditions in which the performance of plants is compromised and cause a significant negative impact on crop yield (Francini and Sebastiani, 2019).

Soil provides a wide range of important ecosystem services, to meet the necessities of all living organisms (Fossey et al., 2022; Jónsson and Davíðsdóttir, 2016; Pereira, et al., 2018). It is responsible for providing facilities, meals, firewood, basic support, and balance resources, used to reduce the effect of runoff on the

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topsoil to control flooding, purification of nutrients and impurities, used carbon sequestration (Adhikari and Hartemink, 2016; Dominati et al., 2014; Hyun et al., 2022). Soil serves as a natural medium for plant growth and provides water, food and support for plants (Lal, 2016). Healthy soil must provide additional environmental amenities, for example, a diverse range of nutrients, a better bacteriological community, and a range (Baveye et al., 2016). Various ecological features including climatic conditions, topography, soil properties (soil texture and structure, organic matter contents), water quality, and availability have a direct impact on the productivity of the agricultural system. A healthy soil will be more resilient to changing climatic conditions (Lehmann et al., 2020; Mirzabaev et al., 2019; Olsson et al., 2019). Soil lacking features suitable for performing these ecological services leading to a reduction in soil capacity to produce optimum yield is generally termed degraded soils (Eswaran et al., 2001).

Plants are grown for food purposes in the open environment and experience multiple abiotic stresses during their life cycle. These stresses adversely affect plant performance, development, yield and quality of produce. Plants undergo a series of morphological, functional, natural and molecular variations in their quest to overcome abiotic stresses (Munns and Millar, 2023; Zhang et al., 2022). Much effort has been done to investigate the adaptation of food crops to various abiotic stresses, like temperature, drought, and salinity etc, (Wang et al., 2016; Anjum et al., 2017). However, judging plant responses to a combination of stresses to enhance plant adaptation to field conditions is limited (Pandey et al., 2015). In many regions of the world, most crops are susceptible to temperature anomalies (Wang et al., 2016), smaller increase in temperature can result in drought vulnerability of crops (Beck et al., 2007; Li et al., 2021).

Moreover, drought combined with other stresses, e.g., simultaneous drought and cold stress affect plant processes, hormonal imbalance, altered enzymatic activity, and ultimately reduces plant productivity, (Agurla et al., 2018; Chen et al., 2021; Guo et al., 2021). Generally, low temperature and drought stress cause several similar impacts on plants e.g., stomata regulation, foliage growth and hormonal imbalance. However, changes in physical properties caused by low temperature and drought are quite different (Deng et al., 2012; Guo et al., 2021; Zandalinas and Mittler, 2022). The combined effects of cold and drought on plants are not yet well understood, and it is not known whether plant reactions to them are exclusive or mutual. Plants may exhibit common molecular and physiological responses on exhibit cold and drought, some may be definite to a stated stress element (Sewelam et al., 2014).

Drought is a phenomenon that occurs due to environmental changes, and it can reduce crop productivity by influencing their physiological process (Breda et al., 2006; Dikshit et al., 2022; Raposo et al., 2023). Dehydration occurs when the soil is exposed to a water-deficit condition and this condition is called drought stress. Drought not only occurs with a minimum amount of water in the soil but it can also cause by the presence of high salt concentrations in the root zone area which reduces the amount of water and nutrient availability to plants. In simple words, a factor in which plants face water shortage is called drought (Osakabe et al., 2014). Lack of H2O in plant life can be caused by the unavailability of H2O content in the leaves and a decrease in turgor pressure, closure of stomata, and reduced cell growth and expansion (Farooq et al., 2009a). This stress can cause a reduction in plants growth by affecting physical and biotic features (Li et al., 2011).

Furthermore, plants are not the only ones that suffer from water deficits during drought, but even when reduced climatic conditions can cause turgor impairment at the cellular level (Janska et al., 2009; Yadav, 2010). Plants often experience drought and heat stress that decrease the production of crops all around the world. The united impact of mutually high temperature and drought on the production of many crops is sturdier than single stress effects (Dreesen et al., 2012; Rollins et al., 2013). Similarly, lack of water for crop production can cause plants to wilt which results in reduced crop yields (Vadez et al., 2011a; Vadez et al., 2012). Moreover, such factors are mostly due to low rainfall and lack of water in the soil. Precipitation extremes and prolonged absence of rain may enhance the possibility of drought (Trenberth, 2011; Vadez et al., 2011b).

2. Effects of Drought on Crop Plants

2.1. Effect on water content

Drought stress significantly affects plant performance due to reduced availability and uptake of water and nutrients, leading to lower crop yields with compromised quality (Table 1) (Elias et al., 2019; Shiade et al., 2023). Effect of drought on crops can vary depending on crop growth stages (Table 2).

Table 1. Drought-induced yield Reduction in different crops

Crop Species	Yield Loss (%)	References
Grain crops		
Maize (*Zea mays* L.)	63–87	(Kamara et al., 2003)
Wheat (*Triticum aestivum* L.)	57	(Balla et al., 2011)
Rice (*Oryza Sativa* L.)	53–92	(Lafitte et al., 2007)
Leguminous crops		
Chickpea (*Cicer Arietinum* L.)	45–69	(Nayyar et al., 2006)
Soybean (*Glycine Max* L.)	46–71	(Samarah et al., 2006)
Oilseed crop		
Sunflower (*Helianthus Annuus* L.)	60	(MazaheryLaghab et al., 2003)

Dehydration is a serious problem in plants and has a significant influence on the consumption of plant essential nutrients by roots and their translocation through root water to shoots. Minimum uptake of nutrients such as iron, calcium, magnesium, sodium, etc. leads to intervention in intake of nutrients and their exclusion procedures, and also decreased rate of plant transpiration process (Garg, 2003; McWilliams, 2003). Another consequence is that plant species and their genotypes might differ in reciprocating mineral consumption below drought conditions.

Generally, sodium content can rise by the influence of humidity disturbance, phosphorous content is reduced by the influence of humidity and there is no ultimate influence on potassium (Garg, 2003). Basically, the necessities for water and plant nutrients are almost inextricably linked, fertilizer application may increase crop productivity in using accessible water. This shows an important correlation between the deficiency of soil humidity and nutrient accessibility. Productivity can be significantly enhanced by the rising effectiveness of plant nutrients under unfavorable humidity conditions (Garg, 2003). It has been observed that the sodium and potassium content of Gossypium species was affected by drought (McWilliams, 2003). Potassium is an essential macronutrient, vital for several physiological processes in plants including drought tolerance. Potassium is critical for the improvement of water use efficiency, root growth, osmotic adjustment, and increased antioxidant activity (da Silva et al., 2021; Turcios et al., 2021; Zahoor et al., 2017).

2.2. Effect of Drought on Photosynthesis

One of the major impacts of low water content on plants is photosynthesis inhibition, resulting in reduced enlargement of leaves, malfunction of the photosynthetic implements, early degradation and related decrease in construction food (Wahid and Rasul, 2005). When stomatal and non-stomatal limits for photosynthesis are compared, the former may be considerably smaller. This suggests that all factors except carbon dioxide discharges are affected. One of the main problems caused by the effects of drought is the termination of leaf stomata, which limits the exclusion of carbon dioxide from the leaves. In this situation, the insufficient accessibility of CO2 can possibly enhance sensitivity to plant photodamage (Cornic and Massacci, 1996).

Table 2. Crop yield reduction due to drought at different crop growth stages

Crops	Development Stage	Yield Reduction (%)	References
Cicer arietinum (Chickpea)	Reproduction	60-11	(Ogbonnaya et al., 2003)
Oryza sativa (Rice)	Reproductive (Light stress)	53-92	(Lafitte et al., 2007)
Hordeum vulgare (Barley)	Seed filling	49-57	(Samarah 2005)
Oryza sativa (Rice)	Grain filling (Intense stress)	60	(Basnayake et al., 2006)
Zea mays (Maize)	Grain filling	79-81	(Monneveux et al., 2005)
Glycine max (Soybean)	Reproductive	46-71	(Samarah et al., 2006)
Brassica napus (Canola)	Reproductive	30	(Sinaki et al., 2007)
Phaseolus vulgaris (Beans)	Reproductive	58-87	(Martínez et al., 2007)
Vigna unguiculata (Cowpea)	Reproductive	60-11	(Ogbonnaya et al., 2003)
Helianthus (Sunflower)	Reproductive	60	(Mazahery-Laghab et al., 2003)
Zea mays (Maize)	Reproductive	32-92	(Atteya et al., 2003)
Oryza *sativa* (Rice)	Reproductive	24-84	(Venuprasad et al., 2007)
Cajanus cajan (Pigeonpea)	Reproductive	40-55	(Nam et al., 2001)

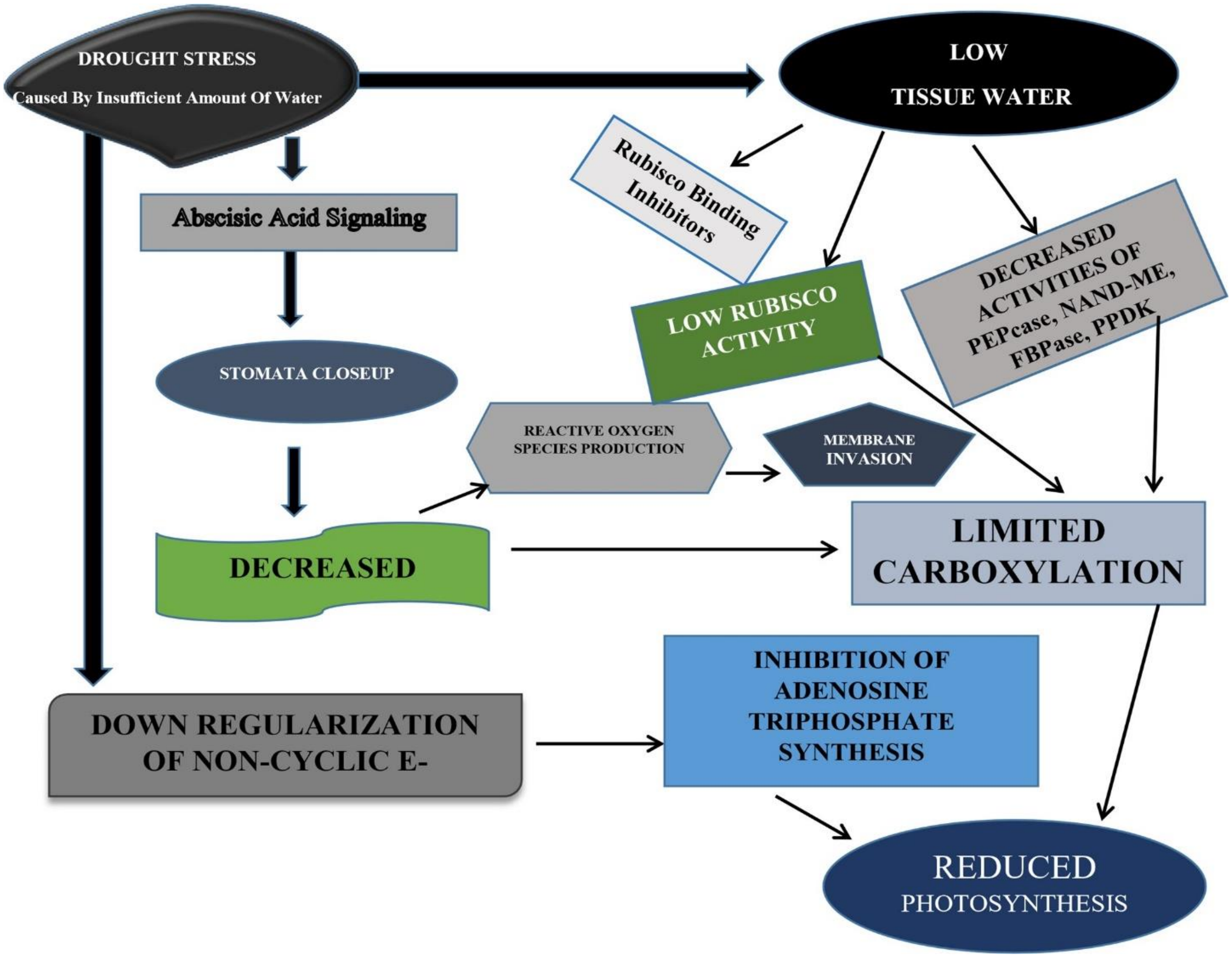

Fig 1. Schematic representation of effect of drought stress on photosynthesis (Farooq et al., 2009a)

Fig. 1 Photosynthesis decreased under low water potential or drought stress. Actionable processes that cause photosynthesis to decrease under stress. Drought stress inhibits the stabilization of reactive oxygen species and the formation of antioxidant defenses, leading to the addition of reactive oxygen species, reactive oxygen species (ROS) can cause oxidative stress that results in damage and dysfunction of cell components. When the water content in plant roots is low, it initiates the process of stomatal closure; this in turn reduces the amount of carbon dioxide that plants need to complete their life cycle. Carbon dioxide reduction not only directly decreases the carboxylate process (A process by which one 5-carbon molecule is converted into RUBP, into two three-carbon molecules, two 3-PGAs), but also leads more electrons to shape reactive oxygen species (ROS). Intense drought inhibits photosynthesis because of the reduced activity of several enzymes. When the water content of plant leaf tissue is very low, the activity of plant Rubisco binding inhibitors increases. Additionally, noncyclic electron transportation is down-regulated to meet the reduced demands for NADPH production and thus ATP synthesis is reduced. ROS: reactive oxygen species.

The influence of drought conditions in plants can induce some specific changes in the plants chlorophyll a, chlorophyll b, xanthophylls, and carotenoid pigments and mechanisms (Anjum et al., 2003), and harm to the photosynthetic capacity of leaves (Fu and Huang, 2001), also, when plants are stressed, morphological processes such as the Calvin cycle or C3 cycle are disrupted, which allow plants to make their foods by using light reaction products of photosynthesis such as nicotinamide adenine dinucleotide phosphate hydrogen (NADPH) and adenosine triphosphate (ATP) to produce organic products (Monakhova and Chernyadev, 2002). One more significant factor that results in reduced crop productivity and the capabilities of under-stress plants to produce their foods by using sunlight, water, and carbon dioxide is due to the failure of stability in the production of reactive oxygen species (ROS) and antioxidant defenses (Fu and Huang, 2001; Reddy et al., 2004), which result in the addition of reactive oxygen species which produce oxidative anxiety in lipids membrane, further cellular mechanisms and proteins (Fig. 1).

3. Plant Hormones in Regulating Drought Stress Response

Plants regulate growth, development, and other processes, through diverse signaling compounds i.e., phytohormones (Ngou et al.,2 022; Zheng et al., 2023). Moreover, phytohormones are also key in regulating responses under abiotic stresses including drought (Askari-Khorasgani et al., 2021; Hussain et al., 2014; Waadt et al., 2022). Hormonal crosstalk in plants during abiotic stress signaling is the key to understanding responses and mechanisms involved and plant survival (Table 3) (Jan et al., 2019; Kim et al., 2022; Salvi et al., 2021).

3.1. Auxin

Auxin is vital in chemical messengers that coordinate cellular activities and is involved in several growth processes and stress responses in plants (Shi et al., 2014; Verma et al., 2022). Auxins are involved in plant physiological processes like cell expansion, division, division and differentiation. Auxins also trigger the initiation of plant roots, apical domination, arrangement of leaves on plants and their relationship with one another and stimuli responses of plants. Various auxin genes such as Aux/IAA, GH3 and SAUR play important roles in various plant processes. They are essential in plant height or plant maturity, are essential in plant appearance and can also increase plant productivity. Furthermore, these genes are considered a vital part of plants which are essential for cell enlargement and progression evolution (Asgher et al., 2015). Auxin is considered to play an important function in arbitrating and ameliorating resistance to noninfectious stresses (extreme temperature and humidity and nutrient abnormalities), like scarcity conditions, which are mentioned in various experiment reviews (Kazan, 2013). The most common plant hormone, indole-3-acetic acid, a hormone belonging to the auxin class, was the first to be identified (Hamayun et al., 2021). The Indole 3-acetic acid (IAA) plant hormone is derived from tryptophan and has tryptophan-like properties. Due to variations in gene expression, the growth and progress of auxin-mediated is also controlled. Several experiments have shown that various changes in the metabolism, synthesis, activity of modules, and transport occur when plants are facing drought and further stresses (Ljung, 2013).

Reduction in Indole 3-acetic acid levels induced under stresses promotes the levels of abscisic acid in plants to stimulate productivity changes with the help of auxins. This was reported by Jung et al., (2015) that some auxin-coding genes were stimulated or energetic in rice cultivars under drought conditions to enhance crop tolerance. Presence of YUC6 in Solanum tuberosum (potato) cultivars and populus (poplar) plants increases growth or productivity by increasing auxin, which in turn increases drought tolerance and phenotypes (Ke et al., 2015). The presence of auxin hormone can improve root branching and significantly encourage tobacco seeds to withstand the effects of drought (Wang et al., 2018).

Table 3. Function of different plants phytohormones below the influence of drought

Hormones	Functions in Plants	References
Cytokinins	Formation of female gametes and embryos	(Wu et al., 2016)
Cytokinins	Growth of plant parts and the flowering stage	(Liang et al., 2016)
Cytokinins	Photomorphogenesis and leaf senescence	(Ha et al., 2012)
Auxin	Root branching	(Kim et al., 2013)
Auxin	Involved in cell division, cell elongation, apical dominance, phyllotaxis and tropic responses	(Kim et al., 2013)
Salicylic acid	Progressive responses against elevated temperature stress	(Munne-Bosch and Penuelas, 2003)
Salicylic acid	Stomatal closure	(Dempsey et al., 2011)
Salicylic acid	Defense responses	(Miura et al., 2013)
Abscisic acid	Photosynthetic activity, stomatal regulation, root growth, and germination	(Seo and Koshiba, 2011)
Abscisic acid	Stomatal closure, gene upregulation and compatible osmolyte synthesis	(Shi et al., 2018)

Similarly, tomato cultivars can increase their tolerance to drought stress because auxin response factors (ARFs) attachments directly to the proponent of auxin-responsive genes making them imitation tolerant to stimulation or suppression (Bouzroud et al., 2018). Also, auxin response factors (ARFs) are responsible for regulating various genes such as WRKY108715, MYB14, DREB4, and bZIP 107 to enhance tolerance and alleviate drought stress in Trifolium (Zhang et al., 2020). Similarly, plant phytohormones are also responsible for resistance to drought stress by binding with auxin. E.g. auxin can also manage several members of the ACS (1-aminocycloprop ne-1-carboxylate synthase) gene family, which is the rate-limiting factor enzyme in ethylene biosynthesis. This collaboration in plants is responsible for increasing resistance of tolerance in plants against drought pressure (Colebrook et al., 2014).

3.2. Cytokinins

Cytokinins play an important role in various plant processes to maintain or enhance plant growth by reducing the effect of drought stress by enhancing the process of photosynthesis. Drought resistance can be enhanced by exogenous application and through modification of cytokinin synthesis (Hussain et al., 2021; Hnatuszko-Konka et al., 2021; Rivero et al., 2007). Cytokines are the most important hormones in plants that promote cell division and play an important role in cell growth and cytokinins. Cytokinins are known to be important for plant growth and drought resistance, which can reduce the effects of drought on plants through tolerance (Salvi et al., 2021). As cytokinins are phytohormones with both beneficial and detrimental effects on drought pressure (Li et al., 2016). Improvement or deterioration in cytokine levels is totally dependent on drought duration and intensity (Zwack and Rashotte, 2015). A trait that helps plants survive drought or water deficit stress can be enhanced. Transgene expression can also be promoted by cytokinin in transgenic plants. The transgenic plants exhibited drought tolerance in late senescence by limiting drought-induced leaf senescence. Adverse impacts of cytokinin application on drought tolerance have also been reported in plants (Hamayun et al., 2021).

Cytokinins are beneficial in plant tissue culture procedures and play a vital role in plant growth, e.g., plants flowering stage and different plant parts. Moreover, cytokinins are important in plant improvement and progress of different gametes and embryogenesis. Cytokines also contribute to various plant processes such as plant seed germination, flower improvement, and shoot apical meristem improvement, vascular improvement, leaf senescence, and photomorphogenesis. It can also promote drought resistance of plants (Mao et al., 2020). Furthermore, the transcription of cytokinin biosynthetic genes can be regulated by many phytohormones and macro-nutrients. In Thallus cress, cell division can rise with the help of cytokinin by the opponent auxin. The expression of ATIPT5 and OPT7 can be stimulated by auxins, while the expression of AtIPT7, AtIPT3, AtIPT1 and AtIPT5 in the shoot meristem can be disturbed by cytokinins (Ismail H.M. et al., 2020). The total number of cytokinin-related genes of Thale cress plants was particularly more effected and transgenic lines of Thale cress with low cytokinin points showed progressively enhanced to tolerate the situations of drought (Nishiyama et al., 2011).

3.3. Abscisic Acid

Abscisic acid (ABA) is an important plant hormone that plays an important role in enhancing plant tolerance to abiotic stresses (De Ollas et al., 2013; Hussain et al., 2014). ABA is important in various plant processes like osmotic pressure in tissues and cells, stomata closure and gene regulation (Sarkar et al., 2023; Xu et al., 2022). Furthermore, various stages of ABA in plant tissues are generally useful in altering various plant processes such as reducing water loss through transpiration or stomatal closure which reduces plant water loss under drought stress. Abscisic acid is an important hormone in plants that stimulates plant physiological functions under drought stress and climatic anomalies. For example, in the relationship between root and shoot growth, ABA has been shown to suppress growth through the effect of high-water levels in the root zone. However, below the influence of drought stress common stage of ABA is vital in viviparous5 or viviparous14 mutant plant root development. Moreover, favorable condition of ABA in plants is essential in root growth, especially leaf enlargement under adequate water supply (LeNoble et al., 2004).

ABA plays an important role in plants under drought stress because it is a signaling hormone. Many proteins have been reported that constitute the ABA-signaling pathway. Signaling pathways of ABA are important in appearance of drought responses. As ABA plays a key role in plants, they are also important in the transmission of signals or messages within the plant body to maintain plant structure and physiological function through ABA receptors. In the subcellular condition. However, it has been shown that under favorable or desirable conditions, ABA was evident at low concentrations in plants (Parveen et al., 2021).

3.4. Salicylic Acid

Plant growth under abiotic stresses is reduced (González-Villagra et al., 2022; Naz et al., 2022). Drought stress is a harmful condition in plants by affects various plant processes due to the limited availability of water in plant roots. It is a common problem in high-temperature regions or arid and semi-arid regions because of low rainfall and high rate of evaporation (Lisar et al., 2012). Plants can ameliorate the effects of drought stress by regulating hormones. Salicylic acid is a plant hormone and plays a key role in plants. It is this favorable combination that can enhance plant tolerance to many climatic stresses by regulating morphological characteristics. It can help in the regulation of different plant functions including photosynthesis, stomatal closure, antioxidant defenses and transpiration (Nazar et al., 2015).

Salicylic acid is clearly a stress signal molecule that is essential in plant abiotic stress tolerance (Li et al., 2013). Salicylic acid is a vital phytohormone and plays a significant role in the regulation of plant growth. In plants, it can improve growth by regulating various functions under the influence of drought (Farooq et al., 2009a). In plants, it is vital in plants different processes like ion uptake, movement of solute in the plant body, plant transpiration processes, plants photosynthesis processes and protein synthesis (Ullah et al., 2012). Application of salicylic acid can increase antioxidant responses in date palm (*Phoenix dactylifera*) plants which results in increased drought tolerance in plants under drought stress (Dihazi et al., 2003).

Salicylic acid in plants can decrease the impacts of drought on relative leaf water content and is responsible for enhancing the soluble protein synthesis in wheat (Khan et al., 2012). Similarly, salicylic acid can be produced by two pathways i.e. isochorismate and phenylpropanoid pathways. These two pathways require a chemical namely shikimate to produce these pathways (isochorismate and phenylpropanoid) (Fig.2). In various plants isochorismate pathway is considered the best way to produce SA (De Ollas et al., 2013).

4. Effect on Yield Crop

Crop production is essentially a composite combination of dissimilar plant physical characteristics. Most of the plant processes are adversely affected by drought stress. Drought has negative impacts on crop growth which is basically due to the intensity of the stress and the crop development phase. The effects of drought stress have informed productivity declines in the most important crop grounds. Prior-flowering drought in plants decreased flowering time, although post-flowering drought decreased grain yields (EstradaCampuzano et al., 2008). There are four main enzymes to control grain size and density in grains namely ADP (Adenosine Diphosphate Glucose Pyrophosphorylase), starch synthesis, branching enzyme and Sucrose synthase (Taiz and Zeiger, 2006).

Because of drought, a significant reduction in the activities of various enzymes has been observed; hence drought stress has adverse effects on the productivity of various major cereal crops (wheat, maize and rice) (Ahmadi and Baker, 2001). Due to the effects of drought, there is a marked reduction in plant growth and this reduction in plants can be due to various factors such as weak leaf flagellum leading to inadequate grain growth (Rucker et al., 1995), increased rate of photosynthesis which Increases the water requirements of plants (Flexas et al., 2004a) or reduce the intake of nutrients and the process of cell separation or division (Farooq et al., 2009b). Under drought stress, the corn crop begins to shed its pollen at the full height stage, as a result, production is noticeably reduced (Anjum et al., 2011). In addition, under drought stress a major decline in cotton production and termination of small-shaped mature fruits was noted (Pettigrew, 2004). A prominent decline in barley yield has been noted in the influence of drought stress (Samarah, 2005). The reduction in crop productivity under the effects of drought in different field crops (Tables 1 and 2).

5. Conclusion

A growing world population and rapidly reducing resources have created a serious problem for farmers around the world. Drought, which is a serious problem for farmers all over the world, will increase in the coming days due to climate change and in the future, it will emerge as a serious problem that will damage more and more crops. Similarly, scientists on the other hand are experimenting with drought-tolerant crops to maximize crop yield. In this review, we will look at how plants use their different phytohormones to cope with drought stress. Such as abscisic acid, auxin, cytokinin and salicylic acid. These phytohormones trigger tolerance to drought stress via the regulation of various morphological, physiological, biochemical and molecular processes. Morphological and physiological processes include changes in leaf structure, root development and stomatal control. A biochemical procedure comprises adjusting the levels of phytohormones. Molecular procedures comprise phytohormone-mediated signals, which in turn activate various transcription factors that cause the expression of genes essential for plant survival under drought stress.

However, all the mechanisms by which plants tolerate drought by activating their hormones are not well understood and we need more studies to understand them. Also, scientists have not understood the crosstalk between phytohormones against drought stress. Because crosstalk is so complex, the underlying mechanisms are also unknown and require further study. On the other hand, various scientists are trying to understand the mechanism of drought stress tolerance of plants using exogenous phytohormones. Furthermore, drought stress in plants is reduced by the utilization of the plant microbiome. Plant microbes are known to produce different genes that reduce the effects of drought on plants and help different plants tolerate the effects of drought stress. In the future, different drought-tolerant species of crops will be developed to reduce the effects of drought. Maximum mulching is required to maintain soil moisture. It is important to reduce evaporation rates by using different cover crops. As climate change is increasing annually, drought stress will be a serious problem in the coming days. Therefore, seed varieties should be developed which can withstand maximum stress.

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Author's Contribution: ZA, MA and GA perceived the idea, performed experiment and collected data. JH and TM analyzed the data and draw figure. SH and MAB wrote and reviewed the manuscript. All authors read and approved the final draft of manuscript.

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