Common Beans and Abiotic Stress Challenges

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors AJL, MNK and AG designed the study. Authors ZAD, AMI, BAL and AA wrote the protocol and wrote the first draft of the manuscript. Author FUR and MHK managed the analyses of the study. Authors GA, FN and AF managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Legumes are well recognized for their nutritional and health benefits as well as for their impact in the sustainability of agricultural systems. The threatening scenario imposed by climate change highlights the need for concerted research approaches in order to develop crops that are able to cope with environmental stresses, while increasing yield and quality. Common bean (Phaseolus vulgaris L.) plays a significant role in human diets around the world, especially in developing countries and particularly in Asian Sub continent. It is very rich in protein, dietary fiber, vitamins, and minerals. Common beans face major production challenge in the form of various abiotic stresses like drought, cold temperature and salinity. Abiotic stresses play a major role in determining overall returns and also affects the differential distribution of the plant species across different types of environments. These stresses hamper production potential of beans and result in declining of final harvests. These traits are very complex in their expression behavior and their per se inheritance from one generation to next one. Abiotic stress resilience is most of the times governed by polygenic nature of inheritance and often conditioned by multiple factor interacting mechanisms right from physiological, biochemical and genetical processes. Enough has to be

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1. INTRODUCTION

Common bean (Phaseolus vulgaris L.) is among the most important food legume grown throughout the globe. These beans belong to family Fabaceae produces one of the best pods with protein packed gentle seeds. This crop is consumed principally for its dry (mature) beans, shell beans (seeds at physiological maturity), and green pods directly for culinary consumption. Common beans account for 15% of the protein and 30% of the caloric requirement to the world’s population and represents 50% of the grain legume consumed worldwide [1]. Dry beans are regarded as an important functional food containing high levels of chemically diverse components (phenols, resistance starch, fructooligosaccharides) providing support against oxidative stress, diabetes, cardiovascular diseases, metabolic syndrome and many types of cancer [2]. Worldwide, some 26 million metric tons of dry beans are produced annually, over an area of 33 million hectares [3]. Common beans plays a major role in global diets, especially in developing countries [4] with highly beneficial health effects and has been linked to preventative effects against diseases such as cancer, diabetes, and heart disease [5]. Common beans are encountered by various biotic and abiotic stresses. The hostile physical or chemical factors including low or high temperature, deficient or excessive water, high salinity, heavy metals, and ultraviolet (UV) radiation among others are included in abiotic stresses faced by the plants. These stresses, collectively referred to as abiotic stresses, are posing a severe threat to agriculture and the ecosystem, accounting for great crop yield loss [6,7]. Abiotic stresses have a negative impact on plants always, limiting their growth, production potential and even survival [8]. Cultivated common bean generally susceptible to many abiotic stresses, including water limitation (or drought stress), which affects >60% of dry bean production worldwide [9].

1.1 Abiotic Stresses

Physiologically, Abiotic stress resistance is a very complex trait, is typically subject to large environmental fluctuations and has been less well studied than biotic challenges resistance in common bean [10]. Further the effects of these stresses individually or collectively vary through interaction of variable response of underlying processes. Therefore, little is known regarding genetics of resilience to abiotic stresses when compared to biotic resistance. Plant response to one stress may be conditioned by the presence or absence of other stresses and cumulative effects can be of immense magnitude. For example, poor soil profile properties and inadequate soil fertility results in poor and stunted root growth thereby limiting the real potential of a particular plant to resilience to drought and final yields ultimately. Abiotic stress resilience is mostly governed by polygenic nature of inheritance and often conditioned by multiple factor interacting mechanisms right from physiological, biochemical and genetical processes. All the factors summed up together hinders unravelling of abiotic stress resistance both at genetic and physiological level. Various abiotic stress faced by beans throughout its life cycle prevailing across crop niches are discussed below.

1.2 Moisture Stress

Water is one of the most essential components for any crop production system and although its distribution is uneven with respect to crop stage and its frequency. However, due to non-execution of effective water management practices it became a scarce natural resource for raising crops. With the progress of water scarcity in any region, effective strategies like lifesaving irrigation and balancing irrigation at some growth stage without hampering crop yields by improving water productivity must be encouraged. Water stress is the major factor challenging crop production globally Jones & Corlett, [11]. Crop productivity will be challenged in future by climatic transitional changes Man et al [12]. Common beans in general are susceptible to drought challenges and moisture stress which in turn hastens precocity and maturity compromising yield losses owing to
reduced seed weight *per se*. as reported by Molina, [13]. There is a differential response by common beans to moisture stress challenge and impact of the stress is revealed by the severity of stress and stage of crop growth Boutraa, [14]. A study was conducted by Admasu et al. 2019 which revealed that when stress was imposed at initial and late stage of plant development, the effect was low because the plants were already well developed, and they could modify themselves to cope with stress compared to the case when stress was imposed at development and mid-season stages. It was concluded that for maximum grain yield and above ground dry biomass yield, moisture stress at development and mid-season stage must be avoided.

In order to improve water utilization and productivity scheduling irrigation at different growth stages is practiced to encourage water saving without effecting yields. Enough has to be explored regarding effect severity and crop stage susceptibility against drought or moisture stress and to optimize the severity of stress to be put on in the field. Hence framing and forecasting irrigation scheduling module for different crop stages is essential for effective water management and better economic gains. Common beans like other crop plants, is adversely effected by all kinds of stresses particularly water stress hampering it in general development and production returns [15]. Drought significantly reduced leaf area (by ~50%), harvest index (by ~60%), yield (by ~70%), seed weight (by ~25%) and enriched carbon isotope abundance ($\delta^{13}$C) in the seed. Within the soluble leaf fraction, drought significantly decreased the concentration of mineral nutrients and amino acids, whereas no negative effect on the concentration of nutrients and amino acids was detected within the seed [16].

A study conducted by Farooq et al. [17] showed the impacts of drought stress on legumes during the grain filling stage. They reported that drought is harmful in certain developmental stages, including the generation and function of reproductive organs and reported a 27–87% yield reduction. Moisture stress occurs when the water in a plant cell is reduced to less than normal levels. This can occur because of a lack of water in the plant's root zone, higher rates of transpiration than the rate of moisture uptake by the roots, for example, because of an inability to absorb water due to a high salt content in the soil water or loss of roots due to transplantation. Moisture stress is more strongly related to water potential than it is to water content [18,19,20]. Moisture stress also has an effect on stomatal openings of a plant, mainly causing a closure in stomata as to reduce the amount of carbon dioxide assimilation [21]. Closing of the stomata also slows the rate of transpiration, which limits water loss and helps to prevent the wilting effects of moisture stress [22]. Severity of water stress has a great impact on the physiological and biochemical process of plants [23]. Plant responses to water stress are usually screened on the level of selected physiological parameters such as water potential, relative water content, stomatal reactions, photosynthesis, or osmotic adjustment which have been proven to be good indicators of drought in several studies [24]. Other effects of moisture stress in plants leads to break down of RNA, DNA and proteins, inhibition of synthesis and translocation of growth regulators, hydrolysis of carbohydrates and proteins leading to increase in soluble sugars and nitrogen compounds and affects germination, cell expansion, cell division, growth of leaves, stems, fruits and root development. The duration of crop in general is increased when the stress occurs before flowering and decreased when occurs after flowering.

1.3 Cold Stress

Cold stress, including chilling (0–15°C) and freezing (< 0°C), is an abiotic stress that adversely affects the growth and agricultural productivity of plants [25,26]. Chilling stress usually restricts plant growth and development, and has several major effects on plant cells. First, chilling stress affects membrane rigidification in plant cells, which is considered to be the primary event that triggers downstream cold-stress responses in plants [27]. Second, chilling stress disturbs the stability of proteins or protein complexes and reduces the activities of enzymes such as ROS scavenging enzymes. Various phenotypic symptoms in response to cold stress include poor germination, stunted seedlings, yellowing of leaves (chlorosis), reduced leaf expansion and wilting, and may lead to death of tissue (necrosis). Cold stress also severely hampers the reproductive development of plants. The major negative effect of cold stress is that it induces severe membrane damage. This damage is largely due to the acute dehydration associated with freezing during cold stress. Cold impacts crop growers all over the world in every single country. ROS stands for reactive oxygen species. ROS plays a large role...
1.4 Heat and Drought Stress

Crops respond differently to environmental stresses such as drought. Improving genetic resistance of crops to drought has been a major challenge for plant breeders. Crop resistance to drought has been attributed to different mechanisms leading to different response types [30]. When temperatures start creeping above 85 degrees, you’re not the only one who’s stressed. Most plants suffer when the weather turns hot enough for a certain period of time. It causes irreversible damage by way of plant function or development. This isn’t merely droopy leaves in the heat of the afternoon; its things like stunted growth, leaf drop, leaf scald, failure to flower, or failure to produce seeds. Heat stress can occur from high daytime temperatures, high nighttime temperatures, or high soil temperatures, and is the collective result of the intensity of the heat, the duration of exposure, and the rate of increase in temperature. The increased concentration of CO2 and other greenhouse gasses in atmosphere is causing a future climate with higher temperatures and dramatic changes in rainfall patterns [31]. In addition to rising mean annual temperatures, the frequency, duration, and severity of periods with exceptionally high temperatures are also increasing [32,33]. HS events with a trend of high frequency and extremity have already been reported in different parts of the world [34,35,36]. Thus, plants in the future will be exposed to both higher mean temperatures, and likely more extreme heat stress. Extreme heat stress can reduce plant photosynthetic and transpiration efficiencies and negatively impact plant root development, which collectively can negatively impact yield.

Native acclimatization by large germplasm sets evaluated offers a distinct advantage with respect to drought resilience [37]. The plant expression of drought resilience is associated the genetics or breeding value of the parents in the given environment as revealed by the studies on Mexican highlands and in Colombia by White et al. [38]. Bean production is highly hampered because of drought induced stress in most tropical and subtropical countries as perceived the production recovery data. 60% of the bean growing areas in most of African continent and central America suffer from frequent periodic drought stress [39]. Most of the target traits associated to drought resistance include root architecture properties, fluid conductivity and mobilization and reserve carbohydrate storage and absorption efficiency [40]. Most of the scientists particularly breeders and physiologists are inherently focused on photosynthesize mobilization from source leaves to sink viz seeds and pods in exigency conditions like drought [41]. These photosynthesize-mobilizing traits include pod partitioning index, pod harvest index and in general harvest indices [40] which will aid in selection for drought-resilient beans [42]. As per findings of Asfaw and Blair [43]; Mukeshimana et al. [44] Durango race of beans and tepary bean are good sources of drought resistance which can be introgressed best adopted cultivars. Two major QTLs on Pv01 and Pv02 for seed yield in various abiotic stresses and drought tolerance conditions were identified by Trapp et al. [45] Further QTL in populations with Durango genetic background revealed drought resilience as analyzed by Briñez et al. [46]. Quantitative inheritance nature and impact of environment on various drought specific traits makes bean improvement programme complex activity [47]. Schneider et al. [48], identified specific QTLs for drought using Random Amplified Polymorphic DNA markers wherein improvement to the extent of 11 per cent in drought viz-a-viz 8 per cent under normal conditions using five markers. Blair et al. [49], and Mukeshimana et al [44] reported Genotype by environment interactions affecting QTLs related to drought. Phenotypic variation expressed by QTLs to the proportion of 37 per
cent for SPAD leaf chlorophyll and pod partitioning index traits was reported by Asfaw et al. [50] revealing importance of QTL identification for remobilization traits and photosynthetic acquisition. The identified trait specific promising QTLs can prove to be essential aids for MAS in any breeding programme for hastening indirect selection for target traits in large set of lines.

1.5 Salinity Stress

Soil salinity is one of the most important global problems that negatively affects crop productivity. Salinity is one of the most serious factors limiting the productivity of agricultural crops, with adverse effects on germination, plant vigour and crop yield [51]. Salinity impairs plant growth and development via water stress, cytotoxicity due to excessive uptake of ions such as sodium (Na⁺) and chloride (Cl⁻), and nutritional imbalance. Additionally, salinity is typically accompanied by oxidative stress due to generation of reactive oxygen species (ROS) [52,53,54]. High salinity affects plants in several ways: water stress, ion toxicity, nutritional disorders, oxidative stress, alteration of metabolic processes, membrane disorganization, reduction of cell division and expansion, genotoxicity [55,56]. Together, these effects reduce plant growth, development and survival. Leaf expansion is drastically reduced under exposure to salinity caused purely due salinity induced water stress. The osmotic effects of salinity stress can be observed immediately after salt application and are believed to continue for the duration of exposure, resulting in inhibited cell expansion and cell division, as well as stomatal closure [57,55]. Plants experience ionic stress leading to senescence of adult leaves prematurely on long term exposure of salinity and thus a reduction in the net photosynthetic area available to support continued growth [58]. The effect of salt on the physiological reaction in young bean plants was studied. The plants were grown in pots as hydroponic cultures in half-strength Hoagland nutrient solution under controlled conditions in a climatic room. The plants were treated for 7 days with NaCl and Na₂SO₄ (concentration 100 mM), starting at the appearance of the first trifoliate leaf unfolded. The salts were added to the nutrient solution. It was established that the equimolar concentrations of both salt types caused stress in the young bean plants, which found expression in the suppression of growth, photosynthesis activity and caused changes in stomata status (conductivity, number and size). The transpiration and the cell water potential in salt-treated plants were reduced (Kaymakanova et al. 2009). Revealing the genetic structures of Beans genotypes, as well as screening for salt stress and other stress factors, storage in gene banks, and inclusion in breeding programs should be among research priorities considering global climate predictions. Crossing among genotypes with differential salinity resilience is necessary to increase genetic diversity, overcome genetic bottlenecking, or specifically create a new gene pool for salt stress breeding research globally.

1.6 Aluminum Resistance

Roots are the first bearer to several abiotic stress factors: Infertile soil conditions, drought several toxicity viz. Aluminum toxicity. In common bean great variability exists for root traits [59], and matching the root system with the environment will be a research challenge for the future. For different soil environments different root systems will be required: shallow roots to maximize P acquisition in a P-poor soil [60]; deep roots for water acquisition under drought; greater numbers of root tips for calcium absorption; exudation of organic acids act as a defense mechanism against aluminum toxicity or as a mechanism of P acquisition. Our most intensive work on root systems in recent years has been for Al resistance, and we refer to this work as illustrative of both variability in root traits, and of difficulties of working with roots.

Common bean is considered to be relatively sensitive to Al as compared to other crops in general. The major site of Al perception and response is the root apex [61], and the distal part of the transition zone (1-2 mm) is the most Al-sensitive apical root zone. However, in contrast to maize (Zea mays L.), in common bean, Al applied to the elongation zone of the root apex contributed to the overall inhibition of root elongation [62]. Common bean is also known to differ from cereals through a lag phase in expression of Al resistance mechanisms after exposure to Al [62]. Common bean exhibits a typical pattern II type of response to Al treatment, characterized by a delay of several hours in an Al-induced exudation of organic acids, particularly citrate [63]. The most recent phase of our work on Al resistance initiated with a field evaluation of a collection of Phaseolus coccineus, or runner bean. In contrast to common bean which evolved in a sub-humid environment, this species originated in a moist, highland environment on volcanic soils with
potential for Al toxicity. Runner bean is a perennial plant that forms tuberous roots as a survival mechanism, and thus partitions considerable biomass to roots. An un replicated field evaluation on an Al toxic soil revealed accessions with substantially better vegetative vigor than common bean [64]. Resistance of runner bean roots to Al was confirmed in greenhouse tests, in both Al-toxic soil and in nutrient solution with Al (20 μM). Interspecific crosses were created to introduce the Al resistance of G35346, an Al-resistant runner bean, into SER 16, a drought resistant common bean line. Recombinant inbred lines (RIL) were developed from the first backcross to SER 16. Ninety-six RIL were evaluated intensively for shoot biomass and leaf area, total root length, and root diameter in soil tubes; and inhibition of primary root length in nutrient solution; among other traits. The RILs were also evaluated for yield potential in the field under Al toxicity, under drought, and without stress. Experience with breeding for resistance to drought and Al toxicity may illustrate a dilemma in the breeding for better root systems. Given the importance of roots in confronting abiotic stress, one expects that root vigor should favor better yield. However, by stimulating more partitioning of photosynthates to roots, better yield may not necessarily result. A breeder may be altering the overall pattern of partitioning between vegetative and reproductive structures to the detriment of yield. Instead of more root biomass, we may need to breed for more efficient roots that use the same biomass to best advantage, for example, through longer root hairs, through thinner roots and greater specific root length, through greater organic acid exudation, etc [60], while maintaining or improving partitioning to grain. These are important research issues that must form part of the strategy for fitting the right root system to each production environment.

1.7 Low Phosphorus Stress

Significant bean yield losses have been observed in the tropics are due to the low availability of soil Phosphorus [65]. In world about 50% of bean growing regions are affected by low soil P [66]. African bean growing areas of about three million hectare could suffer from low P stress [67]. Lots of progress has been made in developing phosphorus stress tolerant cultivars with better P acquisition efficiency, by improving higher total root length, root surface, and shallow root angle under low P [68]. One of the key mechanism recognized which increases access to P is greater topsoil foraging results out from root architectural, morphological, and anatomical traits [69]. Shallow root growth angle of seminal/axial roots increases the topsoil foraging and provides greater acquisition efficiency of P from low P soils. Beebe et al. [70] reported that greater the photosynthetic remobilization to the grain higher are the yield even under low P availability. The Bean Program by CIAT reported bean genotype G21212 and other breeding lines for drought tolerance and also gave better yield than poor performing lines under low soil P conditions [71]. Root QTLs associated with P acquisition in low soil P environments were reported by Beebe et al. [72], which are related with root parameters like total and specific root length. QTLs associated with P use efficiency were also reported by Cichy et al. [73]. QTL studies for P deficiency tolerance have also been conducted with other inter-genepool crosses [68] and within Andean genotype populations [73]. Liao et al. [74] studied mechanisms of tolerance to low soil fertility both in terms of root architecture and higher root hair density.

1.8 Low Nitrogen Stress

Low soil N effects Bean production in various regions [67]. Generally beans cultivated in nutrient and moisture-limited soils, tend to show diminished nodulation activity [75]. For SNF significant amount of genetic variability exists in both, host-plant and rhizobium strains in, which allows breeders to find cultivars with improved SNF ability [76,77]. According to Miranda and Bliss [78]; total N concentration in seeds could be used as selection criterion to screen advanced breeding lines for genetic variability in SNF . Harvest index and biological yield are also used as indirect measures for genetic improvement of SNF ability in bean [79]. Farid et al. [80] reported that selection of bean lines for their high SNF capacity could be done in both CBB susceptible and CBB-resistant genotypes. Their work suggests that selection for SNF capacity in CBB resistant lines of CB may have negative influence on the degree of rhizobial infection.

1.9 Breeding Objectives for Abiotic Stress Tolerance in Common Bean

Key traits linked to drought resistance are phenology, root size and depth, root hydraulic conductivity, carbohydrate reserve storage and mobilization, and water absorption efficiency [40]. Breeders and Physiologists specifically focus on
improving the traits related to photosynthetic mobilization from vegetative parts of the plant to the pods and seeds under drought conditions [41]. Beebe et al. [40] studied photosynthetic-mobilizing traits which includes pod harvest index (PHI), pod partitioning index (PPI), and harvest index (HI) and these may be used to select drought-adapted beans [81,41,82]. Sources for drought resistance have been found in the Durango race and in tepary bean [43,44].

A number of drought-resistant genotypes have also been identified in Africa [50,44]. A study revealed that based on the drought stress indices which includes drought tolerance index (DTI), Harvest Index (HI) SMC 162, DAB 602, SSIN 1128, DAB 378, DAB 362 and SMR 101 had performed better than other tested genotypes. Also, the results showed that genotypes DAB 582, SRC 59, DAB 602, SSIN 1240, SMC 24, SMR 101 and DAB 362 were drought tolerant with lower and high value of the DSI and YSI respectively. Therefore, the later genotypes can be used in the future breeding programs as the parent for drought tolerance and also can used as a new varieties by farmers (Mblu et al. 2019). Breeding is complex for better adaptation to drought as it includes several traits for resistance mechanisms, and the traits are quantitative inheritance and are highly influenced by the environment [47]. Schneider et al. [48] used MAS for improving drought resistance and identified QTLs for drought using Random Amplified Polymorphic DNA (RAPD) markers. GxE interactions affecting drought QTL are reported by Asfaw et al. [49], Asfaw and Blair [49] and Mukeshimana et al. [44]. Asfaw et al. [49] reported that the phenotypic variation explained by QTLs is up to 37% for SPAD leaf chlorophyll and pod partitioning index traits. The above study signifies the importance of QTL detection for photosynthetic acquisition and remobilization traits. From the above studies the identified QTLs can be used for MAS in bean breeding programme to select indirectly for drought tolerance traits that are difficult to screen in large populations.

Study by Rainey and Griffiths [83]; De Ron et al. 2016 says High temperature (HT) stress is a major bean production constraint. Day temperature greater than 30°C day and/or night temperature greater than 20°C causes significant reduction in yield, compromises quality and limits adaptation to environment. The major consequence of high temperature is inhibition of pollen fertility which results in flower drop. This causes remarkable reduction in seed setting and seed quality. Porch and Jahn [84] discussed about researchers who have identified heat-tolerant CB genotypes from diverse gene pools, some of them maintain pollen viability even in 5°C higher night temperatures compared to temperatures that are normally considered to be limiting (>18°C at night). Development of HT varieties under adverse environments would also increase resilience for the future global climate change threats [85].

Production of common bean is affected by low temperatures due to cold sensitivity, which limits its production during early season. Differences among genotypes for tolerance to suboptimal temperatures were reported by Dickson and Boettger [86]. The unifoliolate and the first trifoliolate leaf stages were the most sensitive to freezing temperatures in common beans [87]. Their estimated temperature to cause 50% mortality was −3.25°C, although regrowth after survival was limited, allows only few to maturity. Interspecific introgression of portions of the tepary bean genome into common beans is a promising method for increasing tolerance to extreme temperatures in common beans [88].

1.10 Mechanisms to Mitigate the Abiotic Stresses by Common Beans

Drought tolerance in beans is a complex character, involving a multigenic regulation, and depending on the environment and on several morpho-physiological characteristics [89]. Traits related to deep root system, biomass accumulation, stored biomass translocation to the seed and harvest index have been indicated as important contributors to the stability of grain yield under water deficit [44]. Regarding the physiological characteristics, photosynthetic efficiency, chlorophyll content, stomatal conductance, transpiration rate, leaf temperature and leaf water potential have been linked to drought tolerance in common bean [40]. In addition to the morpho-physiological characteristics, the accumulation of solutes has also been reported as a relevant trait related to the drought adaptation mechanism [90]. Many plants accumulate osmoprotective solutes in response to the imposition of abiotic stresses that cause cellular dehydration. Among the osmolytes are amino acids, sugars, alcohols and quaternary ammonium compounds, produced to stabilize proteins and membranes, and to reduce the osmotic potential of membranes, preventing intracellular dehydration [90]. In addition, the accumulation of solutes such as proline and
glycine has been described as a crucial source of drought response for some species [91].

Cold stress exposure causes various physiochemical disturbances, leading to growth inhibition. Cold stress response is perceived by plants through a signal transduction that leads to the activation of transcription factors and cold-responsive genes. Such transcription factors and genes control the damage due to cold stress and help in providing tolerance to plants. Temperature stress changes the structure, catalytic properties and function of enzymes [92] and membrane metabolite transporters. Interestingly, regulatory mechanisms of plants become active and function to restore normal metabolite levels, and most importantly, metabolic fluxes [93]. Secondly, the modifications of metabolism in response to temperature stress are mainly linked to enhanced tolerance mechanisms. Many metabolites thought to have important properties that could contribute to induce stress tolerance have long been linked to stress responses [94]. Particular interest has been focused on metabolites that can function as osmolytes. Osmolytes are involved in the regulation of cellular water relations and reduce cellular dehydration.

Plants are described as being heat tolerant if they are able to maintain the capacity to grow and produce economic yields at high temperatures [95]. Some heat tolerant crops maintain photosynthesis under elevated temperatures by maintaining stomatal conductance [96]. Keeping the stomata open at elevated temperatures sustains diffusion of CO2 into the leaves and enhances transpirational cooling [96]. Plants that are able to maintain stomatal conductance at high temperatures are therefore better able to regulate their temperature [97]. Leaf cooling is an important heat avoidance mechanism in common bean.

In response to excess salt concentration, plants develop various physiological and biochemical mechanisms for their survival. Ion homeostasis, ion transport and uptake, and compartmentalization are the primary defense responses and also biosynthesis of osmoprotectants and compatible solutes, activation of antioxidant enzyme also play role in combating salt stress challenges. Regulation of gene expression in salinity stress includes a wide array of mechanisms that are used by plants to up regulate or down regulate (increase or decrease) the production of specific gene products (protein or RNA). Various mechanisms of gene regulation have been identified during the central dogma, from transcriptional initiation, to RNA processing, and to the post translational modification of a protein.

2. CONCLUSIONS

It is always important for the development of promising bean cultivars, researchers need to continue to their quest to gain knowledge about the biotic and abiotic challenges of economic importance of beans in respective production areas. Mutual efforts of identification, preserving and sharing vital sources of resistance to the important stresses. Similarly we have strengthening our understanding hereditary mechanisms for purposeful product development. It is always important to develop robust phenotyping screening platforms for screening and identification of promising lines against various stresses. There is a need of encouraging interdisciplinary efforts for product versatility and integrate genetic engineering relevant for gaining a better understanding of prevailing resistance mechanisms and also to integrate marker aided breeding to compliment classical breeding efforts. Employing all above approaches for common bean breeding programme is definitely going to unravel the genetic mechanism and will lead to trait specific product development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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