**DRY SUB-HUMID REGIONS**

About 47% of the total area on Earth constitute of dry and sub-humid lands. About two billion people (or 35% of the world's population) live in dry and sub-humid regions. Encompass around 44% of the agricultural systems around the globe. 90% population of these regions is inhabited by developing countries. At least 99% of the land area in the following countries (Botswana, Burkina Faso, Iraq, Kazakhstan, the Republic of Moldova, and Turkmenistan) is categorized as dry and sub-humid regions. The biodiversity of dry and sub-humid lands is well adapted to the severe environments characterized by **irregular rainfall patterns** leading to **drought** and **flood periods**, as well as, in many cases, high temperatures and. Many of the crops grown around the world, including wheat, barley, and olives, originated in dry and sub-humid regions. The alleviation of salinity in these regions is necessary to ensure better crop production and plants growth. (Convention & Diversity, 2020)

Sub-humid regions are characterized by dry cold winters and wet hot summers. These climatic characteristics of sub-humid regions influence the growth of microorganisms differently. The temperature, moisture, salt content, and presence of other chemicals in the soil, together with the number and variety of plants present there, all have an impact on the variety and abundance of bacteria that can be found in dry sub-humid soils. These regions receive inconsistent rainfall during summer monsoon season which either results in floods or drought. Both floods and droughts have different impacts on the survival of these PGPM. Soil pH fluctuates under humid or dry climate conditions. The high rainfall in the humid region dramatically lowers soil pH. Because the growth and reproduction of the soil microorganisms, predominantly bacteria and fungi, are reduced in acidic soil, the majority of microbial functions, such as the breakdown of organic matter and the cycling of nutrients, are also reduced. So in acidic soils, plant growth promoting microorganisms are not much successful. Under certain circumstances, including salinity stress, they are able to manufacture the crucial bacterial enzyme ACC deaminase, which can successfully manage the stress. (Nath Yadav, 2017) A research was carried out to study growth of *Oryza sativa* (rice) under salinity stress to determine the impact of bacteria that promote salt-tolerant plant growth. Results showed that *Lysinibacillus sp.* (BPC2) and *Pseudomonas aeruginosa* (PRR1 and PHL3) significantly improved paddy seedling growth under salinity stress. Study revealed that these both bacterial strains can survive in flooded soils because rice is grown in wet fields and in turn can also promote plant growth under salinity stress.(Kumar et al., 2017)

In dry regions where plants experience drought, *Acinetobacter sp., Alcaligenes faecalis, Bacillus cereus* strains were found to be most successfully surviving in drought. Their traits that include; Antagonistic activities, Exoenzymatic activities, Indol Acetic Acid (IAA) production, Salt tolerance, Temperature tolerance, Volatile hydrogen cyanide (HCN) production support their survival in such harsh dry climates.(Bonatelli et al., 2021) In a study, metagenomic analysis was utilised to examine the rhizosphere of the bioenergy crop J. curcas, which has evolved to grow in environments with high temperatures and salt stress. The findings suggested that uncultured archaea *Crenarchaeota* and *Euryarchaeota* had a role in J. curcas' adaptation to stressful situations by showing significant abundances.(Lacava et al., 2022) *Pseudomonas fluorescens* an endophytic bacterium, has been found to increase the expression of 105 genes by a factor of two in Arabidopsis. These genes are involved in a variety of processes that are positively correlated with stress tolerance. In wheat with PGPR inoculation under drought stress, dehydrin proteins have also been observed to be increased. Whereas under biotic and abiotic stress, it has also been observed that "Pathogenesis related proteins" (PRs) and "small heat shock proteins" (sHSPs) are expressed. So we can again relate the survival of this bacteria in extreme conditions and their efficiency of salinity alleviation in soils of these regions.(Zia et al., 2021)

Selection of cold tolerant PGPR has a possibility of being a salinity stress alleviation tool during cold winters of dry regions. A study for nodulating bacteria that can survive at relatively low temperatures and that can function as a beneficial component of bio-fertilizers was proved successful. Four different PGPR isolates were examined in vitro for their potential advantageous traits, such as low temperature survival, phosphate solubilizing ability, auxin production activity, and antibiotic resistance. The findings demonstrated that, in comparison to all other strains, the PGPR strain PR-12-12 displayed much higher physiological activity. The PR-12-12 strain was shown to have increased growth at low temperatures, PGP activity, and antibiotic tolerance against nalidixic acid and ciprofloxacin. Therefore, the PR-12-12 strain can be used as effective bio-fertilizers for low-temperature crop production in sub-humid regions. So the above mentioned PGPR, because of its cold stress tolerance can also be successful in alleviation of salinity during winter season of these dry sub- humid regions. (Kumar Meena et al., 2015)

Overall, PGPMs have evolved multiple mechanisms to survive in saline soils in sub-humid areas, including salt tolerance mechanisms, symbiotic associations, biofilm formation, antioxidant production, nutrient acquisition, and genetic adaptations. These beneficial microorganisms can play a critical role in enhancing plant growth and promoting sustainable agriculture in saline-affected regions. Proper selection and application of suitable PGPMs, along with appropriate soil and water management practices, can greatly enhance the success of using PGPMs for plant growth promotion in saline soils in dry and sub-humid regions.

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