Review Article

An overview on *Amaranthuscruentus* L.- an alternative source of crop, its economical uses and the associated beneficial microbes

ABSTRACT

Amaranthus cruentus L.is a medicinally important locally available tropical plant belonging to the family Amaranthaceae. Now a days, this plant is designated as 'Alternative source of crop' or 'Pseudocereal' having various nutritional properties (Protein, carbohydrate, fatty acid, Vitamins, Minerals). Moreover, this plant has various medicinal properties also i.e. antioxidant, antihypertensive, antidiabetic, immune stimulation, anthelmintic, hepatoprotective, antimalarial etc. This plant has Worldwide distribution and short growing period of time. It is also regarded as Fodder crop and other industrial uses. The microbes associated with this plant help to protect the host plants from both pathogenic microorganisms and adverse climatic conditions by secreting different types of bioactive secondary metabolites i.e. phenolics, flavonoids, terpenoids, terpenes, tannins, alkaloids, quinones, anthocyanin, saponin, steroids and promote growth and development of the plant. Some unique features of this plant are also descried here. This review intends to expand the understanding of taxonomic characteristics of this plant, economic uses, associated beneficial microbes and their application for sustainability of this alternative source of crop.

Keywords*: Amaranthus cruentus, alternative source of crop, secondary metabolites, microbes.*

1.INTRODUCTION

Amaranthuscruentus is a tropical, endemic, invasive, short lived perennial herbaceous plant in Africa and South America (Grestaetal., 2020). Nevertheless, now this plant is distributed all over the world and contains approximately 70 species (Grestaetal., 2020). It is cultivated mainly in tropical and temperate region (Letchamoetal., 2017). This species has greater variability (Ma etal., 2021; Gins et al., 2024). Phenotypic plasticity, Introgression and hybridization are profoundly observed in this species (Grestaetal., 2020;Prajitha&Thoppil**,**2018**;** Jimohetal**.,** 2022;Amosovaetal., 2024**)**. To protect from pathogenic microorganism, this plant has some advanced physiological features (Jimohetal**.,** 2022**)**. In Africa, this plant is recognized as source of food and constructive and traditional medicine (Letchamoetal., 2017). Now a days, food scarcity is a major problem and food security is necessary to protect the future generations. So, this plant is used as 'Alternative source of crop' and also considered as 'Pseudocereals' (Fletcher,2015; Mburu, 2011; Grestaetal., 2020). Moreover, this plant is cultivated for using both the Grains and leaves in Africa and Asia (Hoidal et al., 2019). It has various medicinal principles i.e. antioxidant, anti-diabetic, anti-inflammatory properties, antihypertensive properties, stimulation of immune system, anthelmintic properties (Toraneetal., 2017) etc. This plant harbor endophytic and others microflora. Endophytic microbes secrete active secondary metabolites i.e. phenolics, flavonoids, terpenoids, terpenes, tannins, alkaloids, quinones, anthocyanin, saponin, steroid etc. These metabolites are potential agents for antimicrobial, anticancerous and many other therapeutic properties which are beneficial to protect the host plant from both biotic and abiotic stresses (Mousavi&Karami,2022**).** This plant is an example of C4 photosynthetic ones (Achiganetal., 2014, Gins etal., 2024) and reported as high-water using efficiency (WUE) **(**Wolosik&Markowska,2019**)** and grow in any types of soil i.e. acidic, alkaline, saline or nutrient-poor soil (Park etal., 2014). This species is highly resistant to drought (Grestaetal., 2020; Achiganetal., 2014) and salinity(Gins et al., 2024;Emam et al., 2024) heat, oxidative stress (Jimohetal**.,** 2022**)**. and UV radiation also(Castrillón& Frier, 2016 and;Omami& Hammes, 2006). It has very good nutritional properties as it contains vitamins, proteins (Lysine, Tryptophan), unsaturated fatty acid, minerals, tocopherols and tocotrienol etc. and essential antioxidant properties **(**Wolosik&Markowska,2019**)**. Light or temperature (20 -35℃) and combination of light and temperature promote higher growth and germination **(**Wolosik&Markowska,2019**)**. Its short growing period give expectancy and provide a source of employment to the farmers **(**Makinde &Ojeniyi, 2010**)**. According to genomic studies, *A. cruentus* contains 17 chromosomes **(**Sammour&Mitra,2012**)**. Previous report shows that it is hybridized easily **(**Lanta**&**Ondrej,2003**)**. In South Africa, it is considered as potential alternative cereal having minerals, phytochemicals (Manyeloetal., 2022). Several species of *Amaranthus* have a role in CO_2 sequestration (Jimoh etal., 2022; Malik etal., 2023). This is short day plant and flowering takes place in 44 days and harvested in 102 days **(**Ogwu**,**2020**)**. Microbes present

in the plant significantly help the host to increase growth, protect from both biotic and abiotic stresses and also stimulate the medicinal activities without causing any disturbance or damage. In this review, taxonomic characteristics, secondary metabolites, economic importance of this plant and lastly the microbes (PGPR, PGPF, fungal and bacterial Endophytes and Mycorrhizae) associated with this plant and how they promote the plant growth is discussed here.

2.TAXONMIC DESCRIPTION OF AMARANTHUS CRUENTUS L.

2.1Taxonomic classification: (Wolosik&Markowska,2019)

Kingdom: Plantae

Subkingdom: Tracheobionta

Subdivision: Spermatophyta

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Caryophyllidae

Order: Caryophyllales

Family: Amaranthaceae

Genus: *Amaranthus*

Species: *Amaranthuscruentus* L.

2.2Habit:

This plant is herbaceous, tropical and belongs to the family Amaranthaceae. The common name of the plant is red or blood amaranth. In Bengali, it is popularly known as 'Lal note sak'. It reproduces by seeds and have very short (4-6 weeks) growth period (Wolosik&Markowska,2019).

2.3Root: one dominant large tap root, soft, 6-7 cm long (Wolosik&Markowska,2019;Mukuwapasi et al., 2024).

2.4Stem: straight, branched, thick, ribbed, 60-65 cm in height, reddish in colour, surface minutely haired (Wolosik&Markowska,2019).

2.5Leaves: simple, reddish, 5-7.5 cm length and 2.1-4.2 cm breadth, margin entire, spiral arrangement, shape ovoid, exstipulate, leaf surface hairy. Petiolate, petiole 0.5 to 1 cm long, leaf apex retuse(Wolosik&Markowska,2019; Mukuwapasi et al., 2024).

2.6Inflorescence: Numerous concentrated spikes, axillary arrangement, ended with racemes and spikes. More than 50 cm long, reddish or pinkish colour. Branches are 40-45 cm long, perpendicular with numerous laterals. Monoecious bearing both male and female flower (Wolosik&Markowska,2019).

2.7Flower: Numerous unisexual flowers are greenish and form a terminal spike (Wolosik&Markowska,2019).

2.8Seeds: This plant produces thousands of seeds which are round or lenticular, dark brown or shiny. Campylotropus ovule (Wolosik&Markowska,2019). Endosperm present in the micropylar region (Wolosik&Markowska,2019).

Dissected parts of the plant under the simple microscope is represented in figure 1.

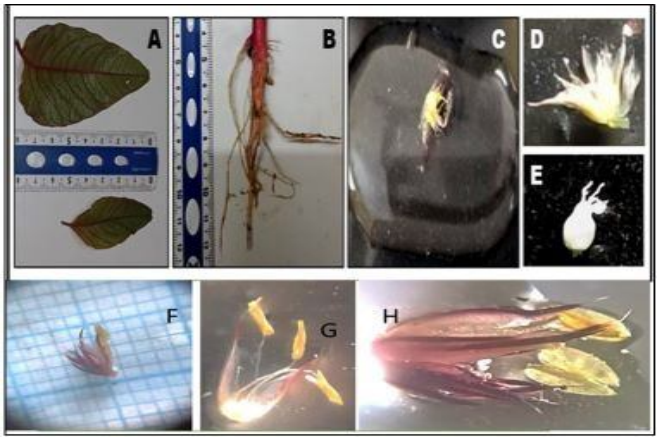

Figure1. *Morphological characters of Amaranthus cruentus* (where A, B, C, D, E, F, G, H represent dorsal and ventral surface of the leaf, root morphology, Dissection of female flower, male flower)

3.ECONOMICAL USES

3.1Food: *Amaranthuscruentus* is a leafy vegetable (Toraneetal., 2017;Mukuwapasiet al., 2024)and useful food supplement for human. This vegetable is similar to the well-known Barley, Wheat and Bazra crop for its nutritional properties and contain high amount of amino acids. So, this plant is considered as 'Alternative Source of Crop' or 'Pseudocereal' (Fletcher 2015; Mburu etal., 2011) and it protects the disease Malnutrition or Undernutrition. It has essential nutritional properties i.e. amino acid glutamine (Motta etal., 2019) proteins (Lysine and Tryptophan), vitamins, essential minerals, saturated and unsaturated fatty acid (Grestaetal., 2020), tocopherol, tocotrienol etc. and also contain high amount of fiber(Ali 2021) . Powdery dry leaves are used in sauces during the dry weather **(**Aderibigbeetal**.,** 2022**;** Toraneetal**.,** 2017**)**. In Nigeria, leaves are mixed with the condiments to prepare the soups (Mepba&Banigo, 2007; Ali, 2021). Boiled leaves are mixed with groundnut flower and consumed as relish (Ali ,2021). Leaves are consumed as spinach or green vegetable (Dhellotetal., 2006). Mixture of boiled leaves and groundnut sauce are prepared for salad in West Africa and Mozambique **(**KauffmanandWeber,1990**)**. Seeds are also used as nutritious food which enriched in minerals, vitamins and proteins (Emam et al., 2024;Mukuwapasi et al., 2024).

3.2Fodder: This plant is used not only for food but also as fodder. It has been planted as leafy vegetables for cattle, rabbit, pigs and chicken food across many countries. Dietary fiber present in the plant have positive impact on animal gut by improving behavior on digestive tract (Manyeloetal., 2022; Alegbejo 2013).

3.3Cosmetics Industry: Amaranth oil contains high amount of unsaturated fatty acid, tocopherols, Squalene which act as hair and skin conditioner (Baraniak&Kania**-**Dobrowolska2022**)**. This seed oil also cures aging effect, wounds, skin diseases and moistening the skin. It is efficiently used as strong antioxidant and photoprotector in herbal medicine industry (Baraniak&Kania**-**Dobrowolska,2022**)**.

It is also used as lubricant in computer industry (Achiganetal., 2014).

3.4Dye: In some countries, this plant is cultivated or grown only for making different dyes (Toraneetal., 2017) Dried plant is burnt for the preparation of potash in Benin countries (Toraneetal., 2017). Plants are used to extract red dye or coloring corn-based foods in South Western United states **(**Allemann,2016**).**

3.5Ornamental value: *A. cruentus* is cultivated as an ornamental plant in some countries (Toran*eetal*., 2017) specially in Nigeria (Ogwu, 2020; Mukuwapasi et al., 2024) valued for its feather-like flowering plumules and also have aesthetic value also (Hricovaetal., 2016). And sometimes it used as 'potherb' (Das & das, 2016). The *A. cruentus* isgreatly valued as ornamental because of its bright colour flowers(Amosovaetal., 2024).

3.6Medicinal properties: It has various medicinal properties i.e. antioxidant (Osei et al., 2023), anti-inflammatory properties, antihypertensive properties stimulation of immune system, cardioprotective, antidiabetic, antimalarial, hepatoprotective **(**Peter&Gandhi,2017**)**, anthelmintic (Toraneetal., 2017), antiandrogenic (Alegbejo, 2013) etc. Bioactive secondary metabolites and protein hydrosylates present in the plant are potential anticancerous, antimicrobial agents (Ramkissonetal., 2020). According to report of Azab 2020, the cooked leaves of the plant have laxative properties. Seeds have some medicinal properties also i.e. hypocholesterolemic effect. Ethanolic leaf extract have protective effect such as restoring RBC, WBC and hemoglobin levels in blood (Azab, 2020). So, it is used in Anemia treatment. *A. cruentus* extract administrated to rats receive Cyclophosphamide which is an immunosuppressant to treat nephritis and arthritis and also used in Chemotherapy in combination with other drugs (Pandey etal., 2016). For infants, treatment of constipation, roots of this plant is boiled with honey and feed it (Aderibigbeetal., 2022) Its water extract is used for the treatment of limb pain and as expellant of tapeworm also for wound dressing and tumors (Aderibigbe*etal*., 2022). This leafy vegetable is also important for lactating women to treat kidney complaints, constipation, anemia etc. (Toraneetal., 2017; Aderibigbeetal., 2022; Achiganetal., 2014) Presence of high amount of fiber reduces cholesterol levels as well as risk of cardiovascular diseases (Jimoh *etal*., 2022) and inhibits the intake of starchy food decreases the chances of diabetes **(**Adeleke**&**Babalola,2021**)**. Prevention of diuretic and hypertension problem is revealed by potassium content (George, 2015). Oils or fats decreases the lipid content of blood and chances of coronary diseases have been reduced **(**Chatepa&Masamba,2020**)** Decoction of leaves is utilized as sore throat, ulcers and extraction of inflorescence swallowing by women for relieving from periodic pain (Ali etal., 2021). Ethanolic leaf extract of mixture of *Amaranthuscruentus* and *Cleomegynandra* have blood glucose lowering effect (Siwale ,2018).

4.BIOACTIVE SECONDARY METABOLITES PRESENT IN THE PLANT

A number of different bioactive secondary metabolite present in the plant is graphically represented in Figure 2 **(**Peter&Gandhi,2017**)**. which helps to promote plant growth and protect from pathogens. These metabolites also possess antioxidant, biochemical and pharmacological properties and beneficial for human health (Omale & Okafor,2008).

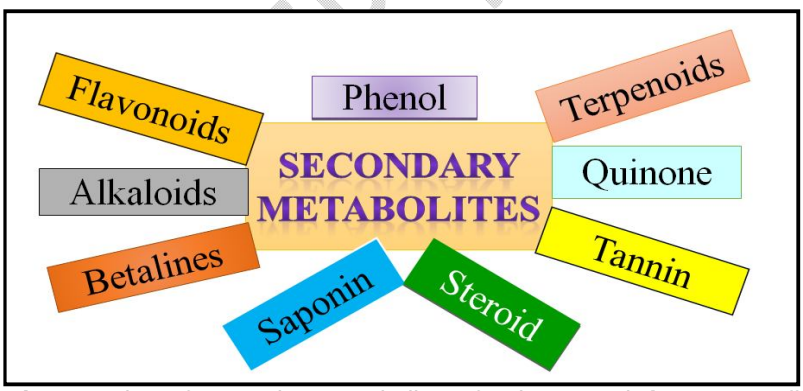

Figure2. Lists of Secondary Metabolites of red Amaranth **(**Peter**&**Gandhi,2017**)**

4.1Betalines: Betacyanin (red violet pigment) and Betaxanthin (yellow pigment) present in different parts (root, stem, leaf, flower) of the plant (Castrillón&Frier, 2016), water soluble vacuolar pigment used in Folk medicine and also as anticancerous, anti-inflammatory and cardiovascular agent (Nana etal., 2012).

4.2Phenolics: Anthocyanin produce excessive radicles which surpass the physiological antioxidant properties (Alvarez etal.,2010). Salicyclic, cinnamic, ferulic, p-coumaric, gallic, sinapic acids are also present **(**Peter**&**Gandhi,2017**;**Castrillón& Frier, 2016). Premature grain of this plant contains a huge

amount of phenolic acids i.e., ferulic acid, caffeic acid, galic acid, p-coumaric acid and anthocyanin) than mature grain (Manyeloetal., 2022, Osei et al., 2023). It has been reported that phenolics have beneficial role in antioxidative property serving as the free radical scavengers and lower the heart diseases and inflammation **(**Omale&Okafor,2008**;** Iwuagwuetal**.,** 2019**)**. Biosynthetic pathway of phenolics is diagrammatically represented in figure 3(Buchanon, 2015).

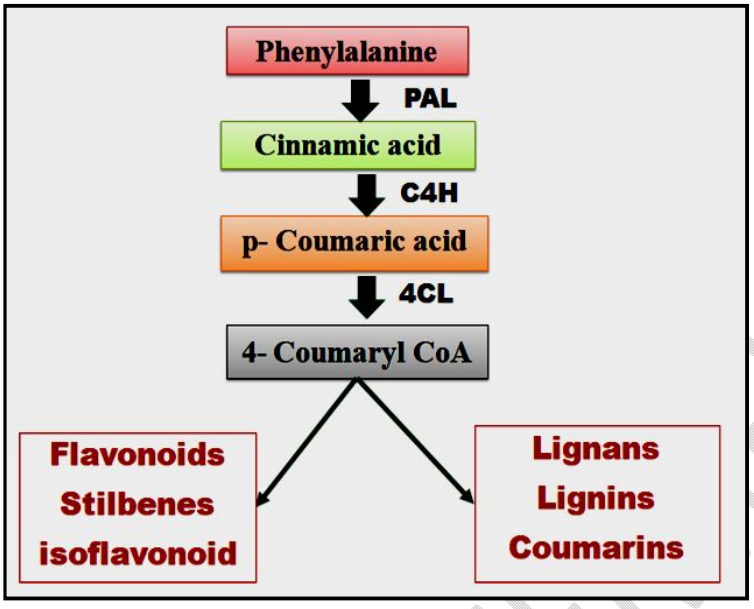

Figure3. Overview of Phenylpropanoid pathway PAL- Phenylalanine ammonia lyase, C4H- Cinnamate-4- hydroxylase, 4CL- Coumarate CoA ligase. adapted from Buchanon (2015).

4.3Flavonoids: Rutin is one of most important flavonoids reported to have various beneficial effects on human and protective effect on memory disfunction (Koda etal., 2009). Quercetin is also reported. It serves as antimicrobial agent and showing potential antioxidant property (Castrillón&Frier, 2016) and reduce the oxidation level of triglyceride, cholesterol, low density lipoprotein (Erdtmanetal., 2007).

4.4Terpenoids: Terpenoid showing antimicrobial, antifungal, antiparasitic, antiviral, anticancerous, antispasmodic, antiallergic, anti-inflammatory, immunomodulatory properties (Rabi&Bishayee,2009).

4.5Alkaloids: It is one of the important metabolites in living organisms help in development of the plant and served as useful repellant for any pathogen or parasite and possesses antimicrobial properties **(**Usunomena&Ngozi,2016;Cherian&Sheela,2016**).**

4.6Quinones: According to the result of phytochemical screening, ethanolic extract contains flavonoid, phenoilcs and quinones which are used in glucose tolerance test i.e., antihyperglycemia (Nofianti,2015**)**.

4.7Saponin: It limits the growth of cancerous cells and has beneficial effects on antiinflammation (Prohp&Onoagbe,2012**;** Rao&Sung,1995) and stimulate release of insulin and lower blood glucose level (Siwale, 2018).

4.8Steroid: Steroid is present at vegetative and flowering stage which protect from harmful effects of microbial pathogens and also have anti-inflammatory and anti-aging properties (Okunlolaetal., 2017). Amaranth grain and leaf extract contain high amount of Squalene **(**He**&**Corke,2003**)**.

4.9Tannin: It has been reported to possess potential antiviral (Cheng& Lin, 2002) and anticancerous activity (Narayanan etal., 1999).

5.BENEFICIAL MICROBIAL ASSOCIATION

5.1Endophytes: Numerous studies have shown that symbiotic (mostly Endophytic) fungi enhance abiotic stress tolerance mainly water deficit i.e. Drought and protect the host plant from critical environmental condition and plant survive (Rodriguezetal**.,** 2009**;** Singhetal**.,** 2011**)**. Endophytic microbes reside within living plant tissues and can interact with roots, stem and leaves without causing symptoms of diseases in their host plants (Schulz& Boyle, 2006). The endophyte infected plants express a range of adaptations to biotic stress (Morelietal., 2020) and abiotic stresses mainly drought tolerance. Some previous reports demonstrated that many grass species showed vegetative growth improvement in the presence of their fungal symbionts and these endophytic fungi enlarge plant fitness by the discharge of plant growth advancing secondary metabolites (Priti etal., 2009; Hardoimetal., 2015). Endophytes have both the horizontal and vertical mode of transmission (Frank *etal*., 2017). Endophytic microbes are mainly bacteria and fungi and some reports revealed that it may be algae also (Rit et al., 2023). Fungal endophytes mainly belong to the Ascomycetes, Zygomycetes and Deuteromycetes group and Basidiomycetous fungi is rarely reported **(**Rajamanikyametal.,2017;Stoneetal., 2000). Endophytes showing mutualistic behaviour i.e., it receives nutrition and shelter from host plant and give the competitive ability to the host **(**Rajamanikyametal.,2017). After isolation, pure culture and characterization of each specific endophyte, Maximum individual possessing antibiotics, anticancerous, antimycotics and immunosuppressant property (Alvin etal., 2014). Treatment of various types of endophytes upon *Amaranthus* plant showing enhancement of growth due to discharge of different plant growth regulator i.e. IAA, GA etc and increased SAR by decreasing diseases by direct antagonistic behaviour (Uppala etal*.,* 2010). Fungi Isolated from Phyllosphere and Rhizosphere of *A*. *cruentus* (Cladosporium, *Talaromyces*, *Gibberella*, *Penecillum*, *Alternaria*, *Trichoderma*, *Rhizopus*, *Fusarium*) increase the soil quality of the plant and plants health and produce antibiotic compound against pathogens (Puszetal., 2015). According to Uppala etal*.,* 2010, several bacterial endophytes promotes biometrics of Amaranth. Some endophytic bacteria isolated from plant roots and promote plant growth, survival and protect from biotic stress **(**Enebe**&**Babalola**,** 2018**)**. Endophyte protects the host plant from oxidative damage by producing ROS scavenging enzymes i.e. Superoxide dismutase (SOD), Glutathione peroxidase (GR) etc. (Choudhury etal., 2023). It was reported in Red Amaranth that the application of an endophytic strain *Sphingomonaspanaciterrae*not only increases the morphological parameter i.e., root length, shoot length, leaf number etc. of the host plant but also increase the chlorophyll and mineral content of the plant(Sultana et al., 2024).

Endophytic fungi are isolated(Shilpa**&**Shikha, 2015**)** from different partsof the plant *A*. *cruentus* is represented in figure 4.

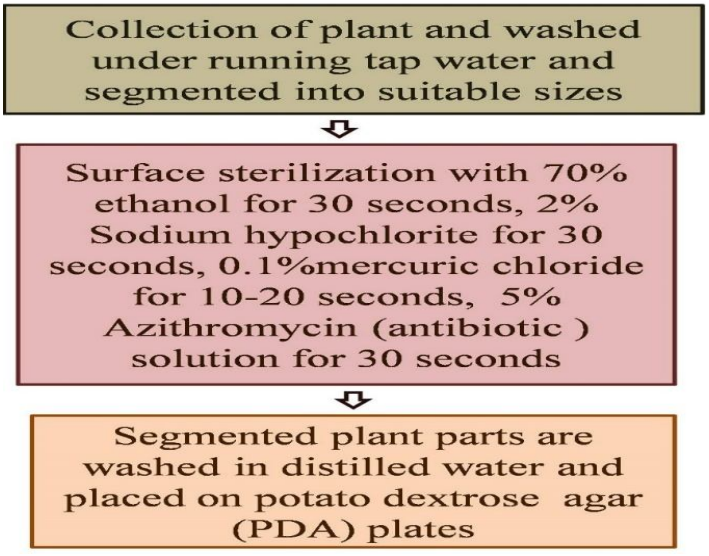

Figure4. Isolation of Endophyte from *A. cruentus* (Shilpa& Shikha, 2015)

The plates containing pure culture of the isolates are represented in figure 5.

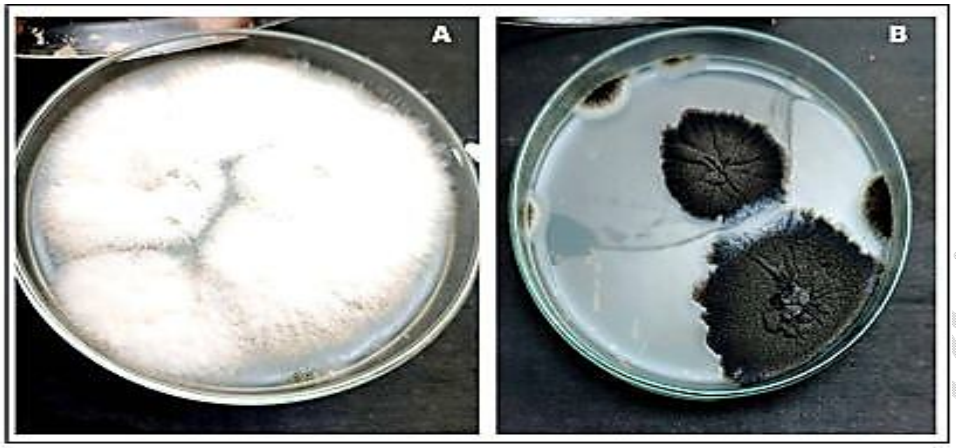

Figure5. Fungal isolates after pure culture

According to standard protocol, leaf tissues of red Amaranth were dissolved in organic solution and used to detect endophytes under microscope after staining with Trypan blue.

5.2 PGPR and PGPF: Plant Growth Promoting Rhizobacteria (PGPR) are a group of bacteria that enhance phytoremediation **(**Muthukumar et al., 2017). It colonizes plant root surface efficiently and promote plant growth. PGPR may facilitate plant growth either by promoting the acquisition of nutritional resources such as Nitrogen, Phosphorus or Iron, preventing or decreasing the damage to plants by pathogenic organisms (mainly fungi and bacteria) or by directly stimulating plant growth by either providing plant hormones such as Auxin, Cytokinin or GA or lowering plant ethylene levels through the action of the enzymes 1 amino-cyclopropane 1 carboxylic acid deaminase (ACC)(del Carmen Orozco-Mosqueda etal., 2020) . Other mechanisms involved i.e. solubilization of minerals, production of siderophores, increases in leaf area, chlorophyll and soluble protein content. These can also produce antioxidant, enzymes to protect plants from environmental stresses that lead to generation of ROS which cause cell damage. Rhizobacteria may reduce the level of disease by synthesizing hydrolytic enzymes, antibiotics, introduction of systemic acquired resistance (SAR) and competition for nutrients and niches (Sindhu & Sharma, 2019). PGPR significantly decrease the use of chemical fertilizer, pesticides, insecticide and herbicides in modern agricultural practices. PGPR *Pseudomaonas sp*., isolated from rhizosphere soil improve plant growth and crop production and survival of *Amaranthus* species and protect from pathogen attack(Enebe& Babalola, 2018;Ikhajiagbeetal., 2021). They have the ability to produce siderophore, hydrogen cyanide (HCN) and phosphate solubilization property (Sagar etal.,2018).

Plant Growth Promoting Fungi (PGPF) maintain plant growth through the generation of a number of significant enzymes like ACCD (1-aminocyclopropane-1-carboxylate deaminase), urease, catalase etc, phosphate solubilization, siderophores and IAA production, antagonism to pathogens and resistant to antibiotics and take a crucial role in plant growth. PGPF are non-pathogenic, soil borne fungi enhance plant growth and survival **(**HyAKuMAcHi,1994; Debashisetal., 2020). It also enhances soil fertility, productivity, nutrient uptake and Defence mechanism (Yapaetal., 2022). It triggers induced systemic resistance (ISR) against pathogenic microorganism by modifying cell wall accumulating callose, phenol, lignin (Yapaetal., 2022). Different PGPR and PGPF strains when combined and applied to soil of Amaranth, then morphological parameters i.e., shoot height, root height, fresh weight all are increased and induced SAR (Debashisetal., 2020).

5.3 VAM: Mycorrhiza (VAM) is the symbiotic association between higher plants and fungi(Giovannini etal., 2020). The fungus grows internally inside the root cortical cells where they form specialized structures called vesicles and arbuscules(Holland& Roth, 2023). Vesicles are swollen, sac like, unbranched, modified structures of the fungal hyphae. The major function is the storage of reserve

food whereas arbuscules are branched, finger like projected hyphal modifications of the endomycorrhiza and the major function is the absorption of food nutrients and water from the host cytoplasm (Holland &Roth, 2023). VAM efficiently extend plant roots making the uptake of water much more efficient, better mineral nutrition especially Phosphate, alteration in root architecture, modification of some physiological and enzymatic activities, induction of the plant hormones ABA **(**Fengetal.,2020). VAM inoculation increases stomatal conductance under drought condition. The VAM fungi are obligatory biotrophs in nature (Giovannini etal., 2020) and also act as bioprotectants against pathogen and toxic stresses. Application of VAM as fertilizer to the Amaranth plant significantly increase the shoot diameter, root length, leaf number etc. (Dada etal., 2017). According to the study of Safeena &Sasmina, 2018, AM (*Glomus fasiculatum*) were inoculated into the pesticide treated soil of *A. cruentus*, the result revealed that growth of the plant is increased and pesticide toxicity in the soil is decreased and soil-microbe growth are not inhibited. Report ofKalaikandhanetal.,2012, revealed that when VAM (*Glomus hoi*) is inoculated in soil of *A. cruentus*, heavy metal concentration of soil is reduced because of the VAM fungi having capacity to sequester it in their mycelia and make the soil less toxic.

6.DISCUSSION

In this review, we discussed mainly the beneficial features and also the exceptional features of this plant *A. cruentus* (Red Amaranth). It distributed all over the world and can grow any type of soils. This C4 photosynthetic plant can tolerate adverse climatic conditions. Short growing period are very advantageous for agriculture and farmers are also benefitted. As India and most of the countries are suffered from Malnutrition, this Red Amaranth provide high amount of nutrition (amino acid, carbohydrate, fatty acid, vitamins, minerals, fibres, antioxidant). Financial expenditure of the maintenance of this plant is comparatively low. Food quality is more important to prevent malnutrition than food quantity (Okunlolaetal., 2024). Major food crops are deficient in proper nutrient. By consuming these crops, many peoples are susceptible to diseases. This Red Amaranth is considered as 'Alternative source of Crop' or 'Pseudocereal'. It contains high percentage of nutritional compounds, bioactive secondary metabolites and medicinal properties (Manyeloetal., 2022). This plant is not only used for human food but also very efficient Fodder crop. This leafy vegetable is rich source of dietary fibre which helps in digestion of animals. In some countries, it, regarded as 'Ornamental' and also used in dye and cosmetic industry. Bioactive secondary metabolites (Phenolics, Flavonoids, Terpenoids, Saponins, Alkaloids, Quinone, Tannin) present in this plant prevent the entry of pathogenic microorganisms and have several medicinal activities i.e. antioxidant, anti-inflammatory, immunomodulatory etc. (Peter**&**Gandhi,2017**)**). Fungi isolated from this plant secret antibiotic compounds and protect plant from abiotic stresses (Pusz etal., 2015). PGPF are non-pathogenic soil borne fungi enhance nutrient uptake and soil quality of the plant have different antagonistic mechanisms (Debashisetal., 2020). VAM have the capacity to decrease the heavy metal toxicity and devasting effect of pesticides of the soil (**(**Kalaikandhanetal.,2012). Microbes and microbial inoculants application as biofertilizers and biocontrol agent is an indispensable component in organic farming practices. Improved understanding of 'mycorrhizosphere' interactions play pivotal role in order to preserve crop yield stability under an increasingly unstable climate change.

7.CONCLUSION

This plant has huge role in food, fodder, dye, cosmetic and medicinal industry. Secondary metabolites extracted from this plant possesses important role in pharmacy. Microbes are a noble and consistent source of unique natural medicines with a high level of biodiversity and may also yield several pharmaceutically important compounds. This symbiotic association at the molecular and genetic levels will be helpful for enhancing secondary metabolite production and can be an active area for future investigations. In recent years, there have been a large number of studies, both in the laboratory and in the field, that have provided information about the use of plant- associated microbes to the benefit of plant growth and development. Bacteria, fungi, mycorrhiza provide resistance to plants against various environmental (abiotic) stresses. In the recent time, we are hopefully determined that the purposeful use of microorganisms will be commenced on to replace the use of energy-intensive and often pollution causing chemicals in agricultural practices. Application of microbes and microbial inoculants as biofertilizers and biocontrol agent is an integral component in organic farming practices. Lastly, improved understanding of 'mycorrhizosphere' interactions is crucial in order to preserve crop yield stability under an increasingly unstable climate change. To think about the food scarcity of our near future, we should protect this plant as a Crop for alternative source

and try to increase the production of the plant by using the associated microbes and secondary metabolites extracted from this plant.

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