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Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 13
Issue: 06

Res. Jr. of Agril. Sci. (2022) 13: 1709–1713

CARAS

Res. Jr. of Agril. Sci. (Nov-Dec 2022)
13(6): 1709–1713

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

www.rjas.org

Full Length Research Article

Enhancement of Plant Growth and Water-Holding Capacity by Using Moringa Gum and Coco Peat-Based Substrates with Arka Microbial Consortium

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Received: 26 Aug 2022 | Revised accepted: 17 Oct 2022 | Published online: 14 Nov 2022

ABSTRACT

Moringa gum is one of the natural sources of rich carbohydrate polymers. These polysaccharide exudates are widely used in food, pharmaceutical and biomedical applications. The current study focused on the application of these gums in the agricultural sector. In our study, Moringa gums were used in the agricultural field as a natural resource in various experimental setups such as Moringa gum powder (MGP) + (MCS), (MGP) + (MS), + (MC), and soil combinations. We introduce to the field an idea of a Moringa gum-based hydrogel combination in various concentrations from the standpoint of high-water absorption, excellent retention capacity, effective controlled release, and especially allowing the soil beneficial microbiota growth. The experimental setup showed valuable results in Water Holding Capacity (WHC) with increased plant growth. However, this treatment induced a significant improvement in crop yield and soil condition.

***Key words*:** Soil condition, Moringa gum, AMC, MGP, WHC

Each year, the agricultural field faces surging crop loss due to the uncertainty of the frequency and pattern of rainfall in arid areas. Climate change has exacerbated the problem of water scarcity. Besides various traditional methods employed for efficient water usage in agriculture, there is always an urge for new perspectives. One of the strategies is to use water reservoirs to receive and conserve limited irrigation or rainwater for a longer period. Due to their water absorption properties, hydrogel products are widely explored for water retention in agriculture. Generally, the soil is the ultimate media or substrate for plant growth. That medium should provide better conditions for the plant, such as water supply, water holding capacity, nutrient supply, and suitable aeration [1]. Cocopeat is cheaply available in tropical and subtropical regions and widely used in the agriculture field, especially in ornamental pots and other horticulture species [2].

Biopolymers and polysaccharides in the form of gums and resins are obtained from living sources. Natural gums with the ability to absorb and retain a large amount of water are gaining importance in agriculture. Currently, soil-friendly products are applied to enhance soil fertility as well as better the growth of plants. Nowadays natural polymer-based hydrogels are flourishing due to their biodegradability, non-toxicity of the base component, and sustainability [3]. Water-absorbing gels commonly undergo swelling at different phases. The outside of the gel initially comes into contact with water molecules and gets wet due to hydrophilic groups on the gel surface [4]. Second, water molecules enter polymer matrices via micropores, causing the gel's molecular volume to expand [5]. Finally, the water osmotic pressure and the binding force of the molecular matrix reached equilibrium, resulting in the most severe water absorbency [6]. However, the polymer hydrophilic groups successfully bind salt component particles by a mechanism related to complexation [7].

Moringa oleifera (family Moringaceae) is a wild plant that grows in many tropical and subtropical areas. The *M. oleifera* tree's stem exudes a gum known as *M. oleifera* gum (MOG), which is initially white but transforms to brownish black and reddish brown upon exposure. When dipped in water, it produces an extremely sticky solution. [8] It contains the sugars d-galactose, d-mannose, d-glucoronic acid, d-xylose, l-arabinose, and l-rhamnose [9]. *M. oleifera* contains minerals, nutrients, and antioxidants that are nontoxic and useful to human health in all of its parts [10-11]. In India, MOG is usually known as Sajna gum. The *M. oleifera* plant is used in a variety of applications, including fertilizer (seed cake), blue dye (wood) [12], foliar nutrient (juice expressed from the leaves), green manure (from leaves), honey (flower nectar), medicine (all plant parts), gum (from tree trunks), honey and sugar cane juice clarifiers (powdered seeds), and water purification (powdered seeds). The Moringa plant is an exceptionally nutritious tree with a variety of potential uses [13-14]. Chemical fertilizers are one of the challenges that human societies currently face due to the pollution they cause; thus, using

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biological fertilizers can minimize the quantity of chemical fertilizers used and aid in agricultural sustainability [15-17]. The current study was examined efficiency of cocopeat soil with a natural gum biofertilizer combination for crop yield-enhancing properties and increased productivity in a low-cost and soil-friendly environment.

MATERIALS AND METHODS

Moringa gums are collected from January 2020 to January 2021 at Kannamadai Ayyanar forest, Tiruvannamalai, Tamil Nadu, India. Collected exudates were dried at room temperature & grinded fine to powder and kept in labelled plastic containers for further analysis. The Cocopeat were purchased from Williams Enterprises, Coimbatore, Tamil Nadu, India. AMC was purchased from Greentech Fertilizer Corporation, K. V. Nandal, Tiruvannamalai, Tamil Nadu, India.

Physicochemical analysis

The MCS, MS and MC and control soils were analyzed for the physiochemical properties such as Water Holding Capacity (WHC) Total moisture content, Nitrogen and crude protein, pH determination, Viscosity and Solubility were investigated flowed by [18-21]. The WHC percentage of different experimental setups was calculated individually using the given formula adapted from (add the reference where which the formula has taken).

$$\text{Percentage WHC} = \frac{\text{Volume of water retained by soil } (V_1 - V_2)}{\text{Weight of sample (w)}} \times 100$$

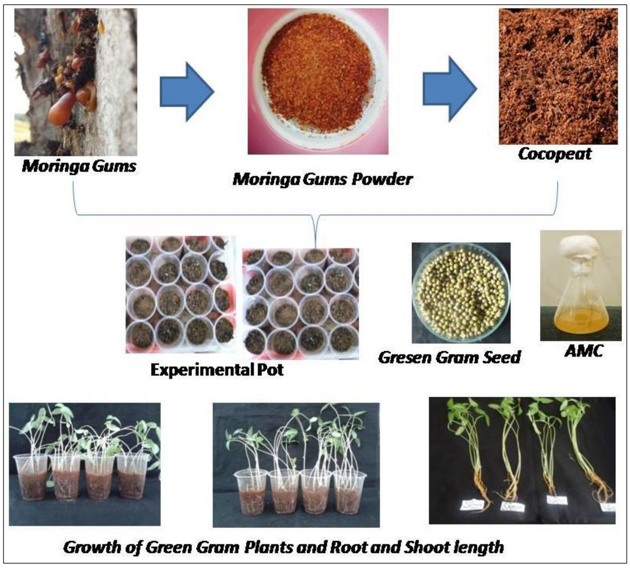

Fig 1 Overall experimental design of the study

Experimental design

The dried MGP were taken and applied in a different experimental setup such as:

Group 1: MGP + Coco peat + Soil - (MCS) (1:1:1 Conc.)
Group 2: MGP + Soil (MS) (1:1 Concentration)
Group 3: Soil + Coco peat (SC) (1:1 Concentration)
Group 4: Soil

The mixed soils were transferred to the pots, and Arka Microbial Consortium (AMC) treated plants and control pots were separately planted with the green grams and examined for the plant growth parameters (Fig 1) [22].

RESULTS AND DISCUSSION

Moringa olifera is a fast-growing tree known for its Horseradish tree, Ben oil, and Drumstick [23]. It is believed to have originated in Africa's Western and Sub-Himalayan regions, India, Asia, and Pakistan [24], and has since expanded to Central America, Cambodia, the Caribbean Islands, the Philippines, and North and South America [25]. Moringa gums are also used as a food veggie and to cure disease and infection in traditional Indian medicine [26]. The gum released from the stem is originally white in colour, but with prolonged exposure, it becomes reddish brown or brownish black. These polysaccharides represent the availability of biodegradable polymers that have no negative impact on natural resources such as humans or the environment.

In this experiment, 52 gms of dry-weight *M. Olifera* gum was collected in Tiruvannamalai, Tamil Nadu, India, from the Arunachala Hills. The gum collected in nature was brownish-red and hardened. Gum exudates were examined for solubility in various solvents and distilled water at room temperature. The gum exudates showed solubilization and swelling of gum components in cold and hot water and were insoluble in acetone, chloroform, and ethanol solvents (Table 1). The pH of the gum exudates was noted as 5.7. Protein, fat, and minerals including calcium and potassium are found in gum exudates. *Moringa olifer* has been used for a variety of purposes since ancient times due to its nutritional composition, which includes proteins, calcium, potassium, and vitamins such as A and C, all of which are necessary for human consumption. Distinct forms of nutrition have different roles in the treatment of human diseases and disorders. This contains calcium, which helps to prevent osteoporosis and strengthens the teeth, and potassium, which is required for the brain and nerve cells to function properly [27].

Table 1. Physiochemical characteristics of MGP

Parameters	Observation
Solubility	
Cold water	Soluble
Hot water	Soluble
Acetone	In soluble
Chloroform	In soluble
Ethanol	In soluble
Appearance	
Colour	Brownish black
pH	5.7
Nutrient	
Calcium	+
Potassium	+
Proteins	+
Nitrogen	+
Fat	+

The majority of gum exudates contain complex mixtures of polysaccharides and terpenes, which affect their properties and significantly reduce their solubility. The presence of insoluble cell wall components is another major factor that decreases the solubility of gum exudates [28]. However, Moringa gum's varied solubility could be attributed to complex linkages between polysaccharides and other components, or to trapped polysaccharide mixtures in the cell wall matrix, which are progressively released under optimal pH and solvent conditions [29].

Soil water-holding capacity is essentially determined by: I the number of pores and pore-size distribution of soils; and (ii) soil specific surface area. Total pore space expands as aggregation grows. Furthermore, when bulk density decreases, the pore-size distribution changes and the relative number of tiny pores rises, particularly in coarse-textured soils. Soil "holds" water accessible for crop use, resisting gravity's pull. This is one of the most important physical facts in agriculture. If the earth could not contain water, if water could flow downward with gravity like in a river or canal, we would have to irrigate continually or hope for rain every two or three days. There would be no reason to pre-irrigate. And no such thing as dry-land farming would exist. Soil texture and organic matter are important factors in determining soil water retention capacity [30]. (Fig 2) expresses the water-holding capacity of experimental pots. In this, the MCS combination setup showed high water holding capacity (35%), the MS and Sc combination setups showed 20% and 18% of water holding capacity, and the soil showed very low water holding capacity.

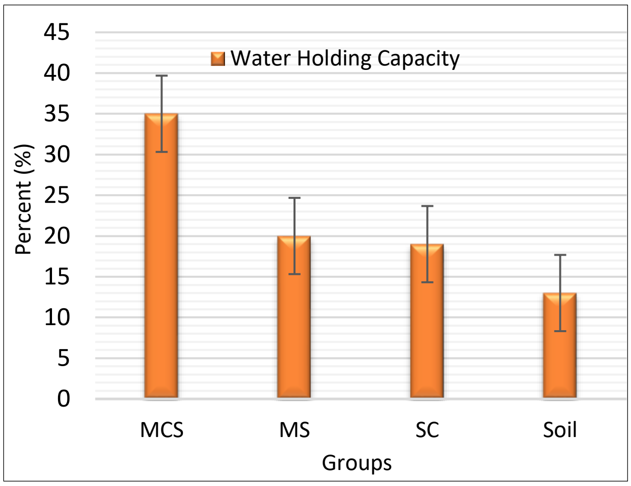

Fig 2 Water holding capacity of experimental pots

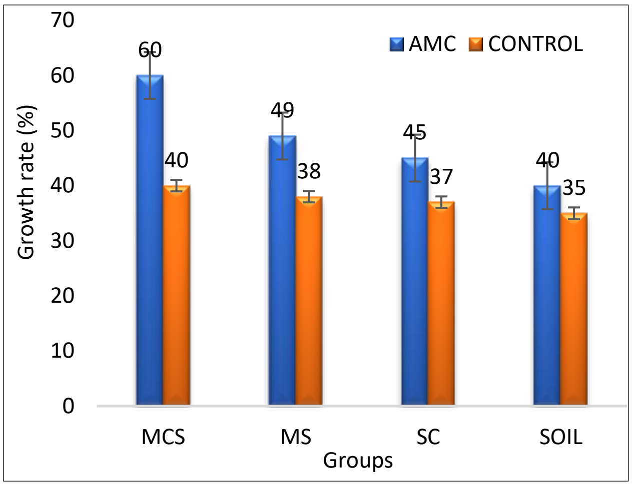

Fig 3 Comparative analysis of plant growth rate in AMC and control

The main constraint on agricultural production in the tropics is a deficiency of soil nutrients caused by land degradation, which affects plant development, nutrient content, and uptake. Low levels of nitrogen, phosphorus, and organic carbon were observed in the soil used for the experiment and the finding corroborates with the earlier results [31]. Therefore, a sustainable method of improving the nutritional status of the soil should be employed to enhance the growth and nutrient content of the plant.

In the present study, Arka Microbial Consortium (AMC) treated plants and control pots were separately planted with the green grams and examined for the plant growth parameters (Fig 3). Comparative analysis of plant growth rate in AMC and control. In this experiment, MCS Group plant showed high growth rate upto 60%. MC and SC Group showed 49% and 45% of growth rates (Table 2). Express comparison of plant growth parameters. In this study, there were AMC-treated and not-treated groups shoot and root lengths were measured. The highest root length of 7.9 Cm was noted in the group of MCS, and the MS group showed 7.5 cm. The Highest shoot length was recorded in the MCS 15.1 cm, and the SC group showed 14.5 cm [32].

Table 2 Comparison of plant growth parameters (cm)

		MCS	MS	SC	Soil
Control	Shoot length (cm)	15.1 ± [0.11	14.1 ± 0.12	14.5 ± 0.11	13.1 ± 0.12
	Root length (cm)	7.1 ± 0.3	6.9 ± 0.33	6.1 ± 0.12	5.9 ± 0.23
AMC	Shoot length (cm)	16 ± 0.6	14.9 ± 0.4	14.5 ± 0.33	14 ± 0.11
	Root length (cm)	7.9 ± 0.11	7.5 ± 0.1	7.1 ± 0.12	7 ± 0.33

Similarly, several experiments were carried. The outcomes of the experiments clearly indicated that application with a mixture of bioagents gave the best results in increasing plant height (cm/plant). *Ps. fluorescence*, T.S (fertilizer) and *Azotobacter* sp. whereas, these treatments recorded 91.92, 86.00, 85.58 and 80.50 cm/plant respectively. While, *T. harzianum* and *B. subtilis*, showed moderate effect in increasing plant height (cm/plant) these treatments recorded 79.00 and 78.00 cm/plant compared with the control in both seasons 2017 and 2018. Also, mixture treatment gave the highest values of fresh weight (g/plant) recorded 18.21 respectively. While treatments with T.S fertilizer, *Azotobacter* sp. (AZ14), *B. subtilis*, *P. fluorescence* and *T. harzianum* showed the moderate effect in increasing of fresh weight (g/plant) whereas, recorded 13.71, 12.12, 11.76, 10.70 and 10.32 g/plant as compared with the control. The experimental outcomes proved that biofertilization is alternative method for fertilization of most plants [33]. Nevertheless, the biofertilization minimize the addition of inorganic chemical fertilizers and reduced the hazard effects of chemical fertilizers on human health and environment.

CONCLUSION

Recently Moringa gum has been getting a lot of attention due to its various useful properties and attracted various industries from food, biotechnology, and pharmaceutical to biomedical. Since it is a bio-based material can be used in environmentally friendly perspectives. This study data resulted in the combinational effect of MCS can be a better alternative to a variety of chemical fertilizers that are being used and are a vivid danger to the agricultural field and soil. And for the translational field of this work, Arka Microbial Consortium (AMC)-treated plants were taken. Arka Microbial Consortium (AMC) is a career-based product containing synergistic effects of microbes as a single formulation including N fixing, P, Zn solubilizing and plant growth promoting microbes. In addition to AMC, MCS promotes the plant growth rate and water holding capacity (WHC) of soil better. In near future this can be used in such a way as plant growth and soil fertility promoting formulation to increase crop production in agriculture, crop producing and ornamental industries. All the experiments have been carried out in pots and small experimental areas. Further studies have to be carried out and initiatives to be started for further steps to be on a large scale.

Acknowledgement

The authors acknowledge the facilities offered by the higher authorities.

Declarations and statements

The author claims that there is no conflict of interest in this work.

Contribution of the authors

The authors mentioned in this article carried out this study, and the authors accept any responsibilities resulting from claims relating to this work and its contents.

Availability of data and materials

The data used to support the findings of this investigation are available upon request from the corresponding author.

Funding

This research received no funding.

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