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Comparative Potential of Rhizobial Species on Wheat Productivity and Soil Status

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Abstract. Crop yields and soil fertility are affected by plant-microorganism interactions. For this purpose, green house experiment was conducted in the University of Sa1ahaddin- Erbi1 from 2021 to 2022, to study the foliage application effect of three species of rhizobial bacteria on durum wheat *Triticum durum* L. cultivar (Akassad) quality and availability of soil nutrient contents. For this experiment, completley randomized design, (CRD) with three replicates was utilized. Rhizobial inoculation in durum wheat significantly affected leaf nitrogen (N), phosphoruse (P), Potassium (K), and iron (Fe) contents, leaf protein and carbohydrate contents, yield components and soi1 nutrient contents. While the application of *Rhizibium sp.* (Mung bean) significantly increased leaf N and protein contents, grain number.plant^{-1} and total nitrogen (Total N%) contents of soil over control. Whereas application of *Rhizobium sp.* (Phaseo1us), increased leaf K and Fe contents, weight of 1000 grains, available phosphorusus (Avail P) and available potassium (Avail K) soil contents, compared to control. However, application of *Rhizobium sp.* (Faba bean) significantly increased total N, avail P and avail K contents of soil. Over all, these rhizobia can be used for preparation of effective biofertilizer to enhance crop growth.

Keywords. Durum wheat, Rhizobial bacteria, Soil state.

1. Introduction

Improving agricultural crop productivity, particularly cereals such as wheat, is relevant and extremely important [1]. One of the most widely grown field crops is wheat. As a source of carbohydrates, vegetable-based protein, minerals, B vitamins, and fibre, it is essential to human nutrition. [2]. The most important wheat species are *Triticum aestivum* L. for bread, followed by *Triticum durum* L. for making pasta and last1y *Triticum* comactum L.; a wheat soft type that is used for making flours, cakes and cookies, [3]. Wheat is Iraq's main cereal crop and its main food, predominantly in the north, which has a total cropland. Due to the world's growing population, and rising prices, its average and total production are not increasing to meet Iraq's growing demand [4]. To ensure food security and environmental protection, the world must increase crop yields by better using water and fertilizer. Mineral fertilizer overuse may pollute soil, water, and air. Plant growth-promoting rhizobacteria (PGPR) inoculation may reduce environmental damage from chemical fertilizers. [5]. In general, rhizobial application is the biologica1 way to replace the use of mineral fertilizers and pesticides in agricu1ture practices [6].

Biofertilizer also known microbial inoculants are the substance that either solid or liquid substances contains beneficia1 microbes that have participated in different functions for promoting plant growth. Biofertilizer are environment friendly, inexpensive, and reasonable source that have potential role,, in the plant growth promotion[7]. Many microbiologists of soi1 have been concentrating on manipulation in cereals rhizosphere microbes, but many researchers have found that rhizobial bacteria can act as plant growth of promoting rhizobacteria (PGPR). Species of *Rhizobium* impacted the crop ontogeny by root / endophytic colonization, forming some plant growth regulators, effective rhizobial responsible for 1egume symbiotic N fixation, may improve the cereal grains quality. A rhizobial soil bacteria enhances cerea1s and non-legume plants growth, according to literatures. [8]. This study sought to find the best and healthiest way to increase wheat yields as wheat plants are the main source of food for human beings and animals in Iraq. We used various species of rhizobia1 bacteria by foliar application to achieve this goal.

2. Materials and Methods

2.1. Rhizobial Isolation and Purification from Different Legume Crops

Rhizobium spp. is isolated on Yeast, Extract Mannitol Agar, (Y.M.A.). Plants of faba bean, phaseolus and mung bean at nodulation stage are uprooted. For soil particles removal, tap water was utilized to wash the roots of each used plants. Each crop plant's healthy nodules and undamaging nodules from roots were collected. Healthy nodules are soaked for 4-5 minutes in ethanol (95%). Then nodules were washed by sterilizing distilled water. After that, nodules surface are disinfected with HgCl2 (0.1%), washed with sterile distilled water, punctured with a needle or crushed with sterilized forceps, and the juice is streaked on YMA media in Petri plates. Finally, the media was incubated for forty eight to seventy two hours. After two days, the pro1ific colonies appear on the plate.[7].

2.2. Inoculum Preparation

To prepare the inoculum, the chosen rhizobia isolates were grown in a conica1 f1ask(250mL) with YEM broth(100 mL) in an orbital shaking incubator at 28 ± 1C0 for three days. To attain uniform cell density (108 – 109 CFU mL^{-1}), an optica1 density of 0.5 recorded, at a wave1ength (535nm) was gained by dilution.

2.3. Experimental Description

Pot experiment was conducted during November 25, 2021 to April 18, 2022 in Salahadddin University-Erbi1. Durum wheat (*Triticum durum*) was used for this work, the experiments were carreid out using plastic pots, According to [9] the experimental soil was sterilized after sieving by using formalin 40%. Experimental separated seeds were sterilised by ethano1(95%) for thirty seconds and washed at least eight times with sterile distiled H_2O. [10]. Four seeds for each experimental pot were sown and later thinned to 3 plants. Four rhizobial inoculum levels were tested (Contro1, *Rhizobium sp.* (Faba bean), *Rhizobium sp.* (Mung bean), and *Rhizobium sp.* (Phaseolus). Wheat plants were sprayed with inoculum using a manual sprayer after thirty days from sowing. Foliar spraying was repeated on 3 subsequent days.

2.4. Statistical Analysis

Data were subjected to statistical analysis following completely randomized design (CRD) and differences among the treatments means were compared by the Least Significant Differences (L.S.D.). SPSS statistics package, version 20 was used for data analysis.

2.5. Data Collection

An electrical grinder ground dried leaves during flowering. After adding 10 ml of Hydrogen peroxide and 10 ml of concentrated Sulfuric acid, 0.3g of ground samples were heated. By using Kjeldahl method the total nitrogen (Total N) was calculated, while, total phosphorus and total potassium were determined by using spectrophotometer method and f1ame-photometer method respectively [11]. Otherwise, by multip1ying the rate of tota1 N by5.75, the total of protein contents were measured [12]. Further, the method of Anthron [13] was uti1ized to calculate the total soluble of carbohydrate. For estimates parameters related to yield components, the plants at harvest were cut at soil surface from each pot, and then grain was separated from straw to estimate spike number.plant-1, grain number.p1ant^{-1} and weight of l000 grains. After harvesting, one gram of the dried soil was used to calculate total nitrogen, available phosphorus, available potassium and available iron [11].

3. Results and Discussion

3.1. Effects of Rhizobial Foliar Application on some Biochemical Contents of Leaves

Table 1 show how foliar application of different rhizobial bacteria affected leaf nutrient content. Potassium and iron leaf contents increased significantly with mentioned treatments. Compared to control, *Rhizobium sp.* (Phaseolus) treatment had the highest potassium and iron values. However, *Rhizobium sp.* (Mung bean) significantly increased nitrogen and leaf protein contents. This results partially agreed with those obtained by [7] concerning wheat plants. Rhizobial bacteria improved wheat, cotton and maize growth by mobilizing more nutrients, and increasing NPK uptake, this may either be due to the ability of rhizobial inoculums to act as PGPR, and solubilize and mobilize nutrients from organic and inorganic sources according to Adnan et al [14]. Also, Qureshi et al [15] found that rhizobia benefit legume plants but also cereals and non-legume plants without producing nodules such as rice, maize, wheat by increasing nutrient availability, releasing of growth hormone, siderophores production and enhancing root morphology.

Table 1. Effects of rhizobial foliar application on some biochemical contents of leaves.

Treatments	N (mg.kg^{-1})	P (mg.kg^{-1})	K (mg.kg^{-1})	Fe (mg.kg^{-1})	Protein (mg.g^{-1})	Carbohydrate (mg.g^{-1})
Control	41997.42	2304.21	7063	102.9	239.38	290.42
Rhizobium sp.(Faba bean)	40277.92	2321.26	9396.65	130.98	229.58	330.51
Rhizobium sp.(Mungbean)	44813.3	2348.23	9847.79	130.79	255.43	292.79
Rhizobium sp.(Phaseolus)	41166.91	2357.07	10126.09	137.79	234.65	310.03
L.S.D.(0.0l)	2457.67	n.s.	456.8	15.82	14.01	n.s.

3.2. Effects of Rhizobial Foliar Application on some Yield Components

Data in table (2) indicated that, foliar *Rhizobium sp.* (Mung bean) application increased grain number.plant^{-1} compared to the control treatment. While, foliar application of *Rhizobium sp.* (Phaseolus) was significantly improved weight of l000 grains. This result partially agreed with those obtained by Mehboob et al [16] concerning maize plants. Rhizobial bacteria may increase yield components due to one or more growth-enhancing mechanisms that produce organic acids, vitamins, enzymes, and exopolysacccharides in the rhizosphere. [17]. [18] found that plant-microbe interaction affects soil biochemical processes that affect plant growth and yield, such as nutrient availability and uptake. Also, *Rhizobium species* stimulate plant growth by producing phytohoromones, siderophores, cyanide, killing pathogens with lytic enzymes and antibiotics, increasing macro and micro-elements mobilization like phosphate so1ubalization [19].

Table 2. Effects of rhizobial foliar application on some yield components.

Treatments	Spike number.plant^{-1}	Spikelet number.plant^{-1}	Grain number.plant^{-1}	Weight of l000 grain (g)
Control	3	18	70	54.79
Rhizobium sp. (Faba bean)	4.67	19.33	86.33	59.2
Rhizobium sp. (Mungbean)	4.17	18.67	81.67	63.04
Rhizobium sp. (Phaseolus)	5	18.67	89.5	58.45
L.S.D.(0.05)	n.s.	n.s.	19.19	5.42

3.3. Effects of Rhizobial Foliar Application on some Mineral Nutrient Contents in soil

Table 3 shows how foliar application of different rhizobial bacteria species affected soil nutrient availability. Foliar rhizobial treatments caused significant increases of all nutrient contents except

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available iron contents which non-significantly increased. The highest values of available phosphorusus content (10.05ppm) and available potassium content (86.18ppm) were recorded with *Rhizobium sp.* (Phaseolus) treatment as compared with control, while the highest value of total nitrogen (1.336%) was gained by foliar applying of *Rhizobium sp.* (Mung bean). This result partially agreed with those obtained by [5] concerning wheat plants. While, this result agreed with those finding by Jangir et al [20], they concluded that the soil's nutrient availability improved with rhizobial bacteria. Soil microbes decompose organic matter and transform and cycle nutrients, which maintain crop productivity and soil physical and chemical quality, which may explain rhizobial bacteria's positive effect on soil nutrient contents [21]. El-Azab and El-Dewiny [22] concluded that the biofertilizeres play several roles for activates the beneficia1 bacteria and improve the fertility of soil by increasing the plant nutrient requirements.

Table 3. Effects of rhizobial foliar application on some mineral nutrient contents in soil.

Treatments	Total N%	Available P(ppm)	Available K(ppm)	Available Fe(ppm)
Control	0.706	4.217	60.106	2.06
Rhizobium sp. (Faba bean)	1.336	9.255	80.538	4.055
Rhizobium sp. (Mungbean)	1.327	9.233	82.749	3.81
Rhizobium sp. (Phaseolus)	1.247	10.05	86.18	3.925
L.S.D.(0.0l)	0.41	2.81	11.14	n.s.

Conclusion

The present study confirmed the positive impact of various species of rhizobia1 legume bacteria on wheat growth and soil nutrient availability. Growth of wheat and nutrient availability of soil were significant1y improved by differnt species of rhizobial foliar app1ication. Among the species of Rhizobium tested, Rhizobium sp. (phaseolus)) performed better than all other species in improving the wheat growth and availability of nutrient contents of soil followed by Rhizobium sp. (Mungbean) and Rhizobium sp. (Faba bean).

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