

Evaluation of *Rhizobium* strains on Urdbean productivity

Abstract

Totally seven *Rhizobium* isolates were obtained from four AICRP centres viz., Kalaburagi (GUR5 & GUR8), Akola (WUR 12-1), Vamban (VUC) and Pantnagar (A-3, P-5 & PUR 34) along with the local best *Rhizobium* BMBS 47 were used for the experiment. Urdbean seeds were treated with the *Rhizobium* isolates and sown. Observations were recorded at 45th DAS to assess their effect on plant growth parameters viz., number of nodules / plants, root length, shoot length, nodule dry weight and yield parameters were recorded during harvest. Among the *Rhizobium* isolates VUC (Vamban) recorded a greater number of nodules / plant (30 / plant) and nodule dry weight (0.038 g/plant) which is significantly higher than other isolates. The same isolate recorded the highest root length (13.50 cm). The treatments T₉ recorded the maximum shoot length of 27.26 cm. Crop was harvested at 65 DAS and yield parameters viz., number of pods per plant, plant dry weight and yield were recorded and tabulated (Table 2). Among the different *Rhizobium* isolates, VUC (Vamban) performed better and recorded the higher values for yield parameters. The highest yield of 1162 kg/ha was recorded by T₅ which received VUC through seed treatment followed by T₆ treatment A-3 (Pantnagar) which recorded 1077.6 kg/ha of seed yield.

Introduction

Nitrogen (N) is the macro-nutrient that is required in the largest amount for plant growth, development, and yield ([Good, 2018](#)). Its deficiency in the soils adversely impacts the overall agricultural productivity. A quick method to supply N to plants is *via* synthetic industrial production of reactive N-fertilizers to maintain higher crop yields in highly agricultural intensification systems ([Allen, 2008](#); [Good, 2018](#)). However, in low-input production systems, such as in many smallholder farms in Africa, food production is hampered by the use of little or no N ([Masso et al., 2017](#); [Bindraban et al., 2020](#)). Other impediments to high crop yields in sub-Saharan Africa (SSA) are the inherent low N status of soils, a high nutrient depletion rate (which is exacerbated by crop removals), and non-replenishment ([Manyong et al., 2001](#); [Jemo et al., 2015](#); [Bado and Bationo, 2018](#)). Increasing events of drought associated with uncertainties in climate change are also observed in many areas of West African regions, which will also likely aggravate the yield gaps, specifically for legume crops that are often grown toward the end of the rainy season ([Cernay et al., 2016](#); [van Loon et al., 2018](#); [Defrance et al., 2020](#); [Paliwal et al., 2020](#)). Therefore, exploration of alternatives to synthetic N sources and fertilization, such as the

natural biological N₂ fixation (BNF), is paramount to increasing crop yields in smallholder farms, particularly in Ghana.

Unlike most non-legumes, legume crops establish a beneficial root association with bacteria in the α - and β -proteobacteria groups, where rhizobia (Rh_z) convert abundant N₂ present in the atmosphere into usable N *via* specialized plant structures called “nodules” ([Udvardi and Poole, 2013](#); [Basu and Kumar, 2020](#)). Through this process, legumes satisfy their N demand and that of other non-legume plants when grown in rotation or association. This process contributes to the agricultural sustainability of production systems for the benefit of millions of smallholder farmers ([Giller, 2001](#); [Desbrosses and Stougaard, 2011](#); [Franke et al., 2018](#); [Ulzen et al., 2018](#); [Adjei-Nsiah et al., 2019](#)). However, various abiotic and biotic stress factors, such as drought ([Jemo et al., 2017](#)), low phosphorus (P) availability ([Suliman and Tran, 2015](#)), non-competitive Rh_z strains, and diseases ([Jiménez-Guerrero et al., 2021](#)), may affect the BNF process and limit legume productivity ([van Loon et al., 2018](#)).

Seed inoculation with effective *Rhizobium* at sowing is a recommended agronomic practice for pulse production technology. The soil contains many types of microorganisms such as bacteria, actinomycetes, fungi, and algae. These soil microorganisms are important because they affect the soil's physical, chemical, and biological properties through different processes ([Datta et al., 2015](#)). Among the soil bacteria, there is a unique group called rhizobia that has a beneficial effect on the growth of legumes. Rhizobia are soil-inhabiting bacteria that form the root nodules where symbiotic biological nitrogen fixation takes place. In root nodules, the nitrogen-fixing rhizobia exist as irregular cells called bacteroids which are often club and Y-shaped whereas regular rod-shaped when they are living freely in the soil ([Datta et al., 2015](#); [Bahati 2015](#)). Different groups of Rhizobia genera include *Rhizobium*, *Bradyrhizobium*, *Sinorhizobium*, *Mesorhizobium*, *Allorhizobium*, and *Azorhizobium*, which can form symbiotic associations with different legumes ([Sessitsch et al., 2002](#)). The formation of root nodules ([Nyaguthii, 2017](#)) in symbiotic legumes involves complex molecular signaling between the legume host and the rhizobial microsymbiont ([Jaiswal et al., 2021](#)). *Sinorhizobium* consists of all fast-growing acid-producing rhizobia while *Bradyrhizobium* contains the slow-growing alkali-producing rhizobia ([Nyaguthii, 2017](#)). Nowadays, global agricultural production increased considerably. But due to the global human population increase, the demand for higher crop production has also increased substantially. Because of this, to achieve higher agriculture yields, farmers have adopted the extensive application of chemical fertilizers and pesticides, which causes soil degradation and a decrease in soil fertility ([Díaz Valle A. et al., 2019](#)). Inoculants are products composed of living microorganisms capable of benefiting the development of different plant species. Rhizobia are the first microorganisms used as inoculants. Currently, the use of

inoculants is widespread and indicated in agriculture, mainly for legumes such as soybeans, common beans, faba beans, and cowpea, but the production of inoculants for other legumes and non-legumes has to be increased to obtain the greater yield (Emanoel et al., 2020). *Rhizobium* inoculants are selected strains of beneficial soil microorganisms cultured in a laboratory and packed in with or without a carrier. They are host-specific, low-cost, and an environmentally friendly source of nitrogen. Rhizobia inoculants coated on legume seeds before planting enhances the growth, yield of legume crops, and provide nitrogen and organic carbon for subsequent or associated crops. Seeds coated with rhizobia inoculants are not exposed to chemical nitrogen fertilizer. The coated seeds must be planted in moist soil as soon as possible. (Daniel, 2019). The present paper highlights the *Rhizobium* sp. effect on nodulation and productivity in urdbean under field conditions.

Materials and methods

To assess the performance of *Rhizobium* strains at various locations, a trial was laid out with *Rhizobium* strains received from various AICRP centres. The experimental details are mentioned below.

The field experiments were conducted during kharif 2022 in red sandy loam soil of pH 7.3 and low in organic C, and available N and medium in available N and P. The ten treatments consisted of inoculation with different *Rhizobium* strains (T1- BMBS 47 (Coimbatore), T2-GUR 5 (Kalaburagi), T3-GUR8 (Kalaburagi), T4-WUR 12-1 (Akola), T5-VUC (Vamban) T6-A-3 (Pantnagar) T7-P-5 (Pantnagar), T8-PUR 34 (Pantnagar Ch. strain), T9- N as per RDF, T10-uninoculated control were tested following Randomized Block Design in three replicates in plot of 4.0 x 3.0m size. Urdbean seeds (VBN8) were treated with the required inoculants (200g/10 kg seeds) at the time of sowing and crop was raised as per the recommended agronomic practices.

Totally seven *Rhizobium* isolates were obtained from four AICRP centres viz., Kalaburagi (GUR5 & GUR8), Akola (WUR 12-1), Vamban (VUC) and Pantnagar (A-3, P-5 & PUR 34) along with the local best *Rhizobium* BMBS 47 were used for the experiment. Urdbean seeds were treated with the *Rhizobium* isolates and sown. Observations were recorded at 45th DAS to assess their effect on plant growth parameters viz., number of nodules / plants, root length, shoot length, nodule dry weight and yield parameters were recorded during harvest.



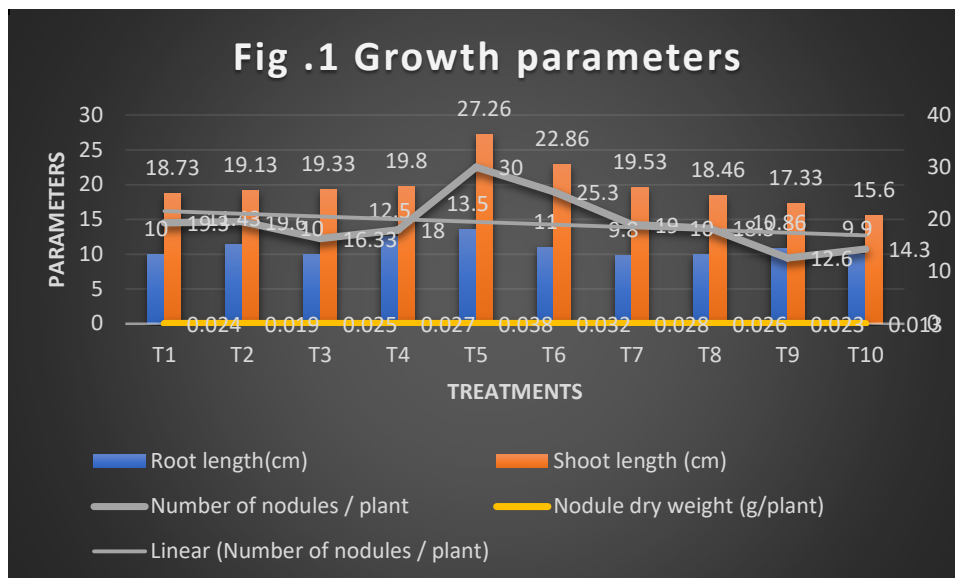
Image .1 Experimental field

Results and discussion

The plant growth parameters viz., root length, shoot length, number of nodules / plant and nodules dry weight (g/plant) were observed after vegetative growth and the results were tabulated in Table1& Fig.1.

Table 1. Multilocation testing of *Rhizobium* strains for Urd bean – Plant growth parameters

Treatments	Root length(cm)	Shoot length (cm)	Number of nodules / plant	Nodule dry weight (g/plant)
T1	10.00	18.73	19.30	0.024
T2	11.43	19.13	19.60	0.019
T3	10.00	19.33	16.33	0.025
T4	12.50	19.80	18.00	0.027
T5	13.50	27.26	30.00	0.038
T6	11.00	22.86	25.30	0.032
T7	9.80	19.53	19.00	0.028
T8	10.00	18.46	18.30	0.026
T9	10.86	17.33	12.60	0.023
T10	9.90	15.60	14.30	0.013
SE (D)	0.64	0.90	2.23	0.002
CD (0.05%)	1.35	1.88	4.68	0.003

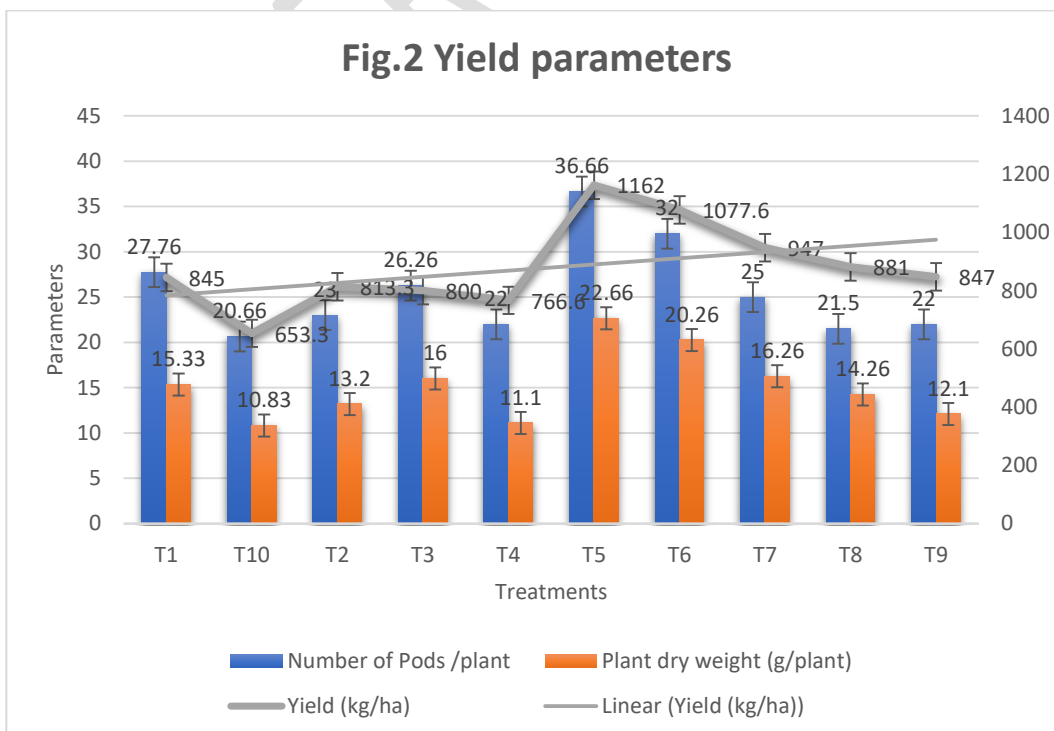


The above table concluded the findings in which among the *Rhizobium* isolates VUC (Vamban) recorded a greater number of nodules / plant (30 / plant) and nodule dry weight (0.038 g/plant) which is significantly higher than other isolates. The same isolate recorded the highest root length (13.50 cm). The treatments T₉ recorded the maximum shoot length of 27.26 cm. The findings corroborated with the findings of Jinwen et al., 2016 indicated that the seeds treating with *Rhizobium* significantly increases root length, nodule number on a plant root, and plant biomass. Native rhizobial inoculation significantly affects the shoot dry weight of cowpea, this improvement is because rhizobia increase plant growth and improve the plant biomass by providing nitrogen through symbiotic fixation. Inoculated common beans have a higher shoot dry weight compared to the control indicating that inoculation with native isolates improves the growth of plants (Erana et al., 2020). Also compared with the findings of Mfilinge et al., 2014 and concluded that *Rhizobium* inoculation significantly affects the growth and yield components like number of pod bearing branches per plant, number of pods per plant, number of seeds per pod, and 1000-seed weight. The study on the effects of *Rhizobium* inoculation in *Vigna mungo* and *Vigna radiata* shows that inoculated plants possess improved height, fresh weight, number of roots, nodules, number of leaves, shoots, pods, length of pods, seed weight, over the uninoculated control. Tairo and Ndakidemi (2013) on soybean found that plant height for field experiment increases with rhizobium inoculation for the entire interval of the soybean growth

Crop was harvested at 65 DAS and yield parameters viz., number of pods per plant, plant dry weight and yield were recorded and tabulated (Table 2: Fig.2). Among the different *Rhizobium* isolates, VUC (Vamban) performed better and recorded the higher values for yield parameters. The highest yield of 1162 kg/ha was recorded by T₅ which received VUC through seed treatment followed by T₆ treatment A-3 (Pantnagar) which recorded 1077.6 kg/ha of seed yield. The above results agreed with the findings of Asante et al., 2020, indicated that the

Table 2. Multilocation testing of *Rhizobium* strains for Urd bean – Yield parameters

Treatments	Number of pods /plant	Plant dry weight (g/plant)	Yield (kg/ha)
T1	27.76	15.33	845.00
T2	23.00	13.20	813.30
T3	26.26	16.00	800.00
T4	22.00	11.10	766.60
T5	36.66	22.66	1162.00
T6	32.00	20.26	1077.60
T7	25.00	16.26	947.00
T8	21.50	14.26	881.00
T9	22.00	12.10	847.00
T10	20.66	10.83	653.30
SE (D)	3.74	2.01	54.12
CD (0.05%)	7.86	4.23	113.70



inoculation of legumes with rhizobia triggers plant growth, development, and yield and it is used as a substitute for mineral nitrogen fertilizer which is often costly. However, the rhizobium is host-specific as certain species can only infect specific legumes. Inoculation of soybean seed with a mixture of bradyrhizobia strains increases nodulation and total plant nitrogen. Several researchers have found that inoculation of soybean seeds before planting results in increases in nodulation, percentage N, plant growth, seed yield, and yield components compared to uninoculated control (Miriko 2015). Growth and yield of leguminous crops can be triggered by rhizobial inoculation directly by producing various metabolites/substances such as plant hormones, ACC deaminase enzymes, LCOs, siderophores, lumichrome, riboflavin, etc., and or by fixing as well as solubilizing and increasing the uptake of mineral nutrients (Naveed et al., 2015). Inoculated soybean plants show improvement in nodulation, growth, and yield (Zerihun and Lijalem, 2020).

Conclusion

Biological nitrogen fixation is a better alternative N source, through the use of rhizobia inoculants. It is a nonpolluting and more cost-effective way to improve soil fertility. The application of rhizobial inoculants in legume production has great economic, environmental, and ecological benefits. Increasing and spreading the role of biofertilizers such as rhizobium can decrease the use of chemical fertilizers and decline adverse environmental effects. Therefore, the use of *Rhizobium* inoculants for improvement in nitrogen fixation and productivity of grain legumes is so advisable since inoculants are cost-effective and eco-friendly.

Compliance with ethical standards:

Ethical Issues: None

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