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# The Impact of *Bradyrhizobium*, Farmyard Manure and Inorganic Nitrogen on Growth and Yield of Guar

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**Abstract** A field experiment was conducted for two consecutive seasons to study the effect of *Bradyrhizobium* inoculation, farmyard manure (FYM), nitrogen (urea) and inoculation plus farmyard manure on growth and yield of guar crop. Four *Bradyrhizobium* strains were used to inoculate guar seeds (USDA3089, USDA3385, USDA3386 and ENRRI 16A) and two levels of farmyard manure, i.e. 5 (FYM1) and 10 (FYM2) ton $ha^{-1}$. Results indicated that combining *Bradyrhizobium* inoculation with FYM significantly increased plant height, shoot dry weight, pod dry weight, yield and phosphorus (P) percentages compare to the control and *Bradyrhizobium* inoculation. However, *Bradyrhizobium* inoculation significantly increased plant height, shoot dry weight and pod dry weight compare with the control. Sole FYM2 treatment significantly increased shoot dry weight, pod dry weight, plant height, seed yield and seed P percent compare with the control and *Bradyrhizobium* inoculation. Urea application showed similar results to that of FYM2 except that urea had no significant effect on seed P percent. In conclusion, combined application of FYM and *Bradyrhizobium* inoculation could be a useful practice in sustaining the growth and yield of guar.

***Keywords:*** *Bradyrhizobium, guar, farmyard manure, inoculation, urea*

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## 1. Introduction

Guar (Cyamopsis tetragonoloba L. Taub) is a branched summer annual legume which is considered indigenous to Pakistan and India, from where it has been introduced to the United States and other parts of the world [1]. Guar belongs to the family *Fabaceae* (*Leguminosae*) and its common names include guar, are siam bean, guaru, gwarar, gavar and cluster beans [2,3]. Guar is a drought tolerant crop well adapted to arid and semi arid climates [4]. It grows under a wide range of soils, but grows best in fertile, medium textured and sandy loam soils with good structure and well drained sub soils [5]. It is tolerant of both salinity and alkalinity [6]. The primary importance of guar is the commercial value of its seed gum (Galactomannan gum) [2], this gum has a wide variety of food and non – food uses [1]. Guar gum is one of the most economical viscosity builders because of its capacity to give high levels of viscosity useful in industries like tobacco, petroleum, mining, textile, cosmetics, oils, pharmaceuticals and food industries [1,7], being rich in protein (26–32%) [2], guar can be used for animal feed production [8].

The beneficial effect of *rhizobial* inoculation on yield and quality of guar has been reported. Sprent et al. [9] stated that guar belongs to the cowpea cross-inoculation group. *Bradyrhizobium* strains are well-known root nodule forming bacteria that fix atmospheric nitrogen in symbiosis with guar [10,11] and significantly improved fresh and dry weight of shoot, roots and pods, number of pods and nodules per plant in addition to yield [12]. Moreover, inoculation increased the protein, decreased fiber, and improved seed quality [11,12].

Furthermore, application of farmyard manures receives great attention and recognition from scientists to improve crops yield. The content of nutrients in farmyard manure encourages use it as a fertilizer. Moreover, it has been shown that application of farmyard manure improves physical, chemical and biological properties of the soil [13, 14]. Application of farmyard manure are very important for countries like Sudan with a predominantly low-input agricultural systems of production, since chemical fertilizers, if available, may not be economically affordable. Moreover, most of Sudan's soils are characterized by low organic matter and low N content [15].

Large amount of farmyard manure are produced every year from the cattle farms in Sudan. Farmyard manure consists of three main groups of components, bedding or litter, solid excreta of the animals and liquid excreta or urine. The nature and relative concentration of these components vary greatly in different manures, depending on the animals and the methods of their feeding and handling as well as feed quality [16]. Since the various components of the manure also differ considerably in chemical composition, it is natural to expect that the decomposition of different manures should vary. Plant residues used for bedding purposes are usually high in carbohydrates, especially in cellulose, and low in nitrogen and nutrient elements. Urine is high in nitrogen and minerals and has very little, of any carbohydrates. Solid excreta contain considerable amounts of proteins, and thus tend to give a more balanced medium for the growth of microorganism.

In the present study the objective was to evaluate inoculation with different *Bradyrhizobium* strains on growth and yield of guar crop during two cultivation seasons at two cases with and without farmyard manure application, and compare the effect with urea and sole farmyard manure.

# 2. Material and Methods

## 2.1. Soil and Site

The experiments were carried out at the experimental farm of the Agricultural Research Corporation at the Gezira Research Station, Wad Medani, Sudan, (latitude 14.4º N longitude 33.5º E and altitude 405 meter above sea level). The locality is in the arid zone with hot summer and short rainy season (July- September). It has a great seasonal variation both in rainfall and temperature. The total average annual rainfall is about 280 mm which varies in inter site distribution (Wad Medani Metrological station). The soil of the experimental area is classified as "find smectitic isohypethemic, Typic Chromusterts, Elremaitab series [17]. Chemical and physical characteristics of the soil are shown in Table 1. The fractions of sand, silt and clay was analyzed according to the method described by Kettler et al. [18]. Total nitrogen (N) in the soil was determined using Kjeldahl method according to Bradstreet [19]. Organic carbon (C) was determined using Walkley and Black [20] method modified by Gaudette et al. [21]. Phosphorus (P) percentage was determined according to Jackson [22]. Potassium (K) was determined according to Chapman and Pratt [23]. The water holding capacity was determined using the method described by Forster [24]. Soil pH was determined at a soil-to-water ratio of 1:2 according to Mclean [25] method. Soil bulk density was measured according to Chan [26]. Soil electrical conductivity (ECe) was measured using the method described by Rhoades [27].

**Table 1. Chemical and physical characteristics of the soil used for cultivating guar**

| **Parameters** | **Values** |
|---|---|
| **Physical properties** | |
| Clay (%) | 62 |
| Silt (%) | 15 |
| Sand (%) | 23 |
| Water-holding capacity (%) | 29 |
| Bulk density (g $cm^{-3}$) | 1.9 |
| Electrical conductivity (ECe, ds $m^{-1}$) | 1.5 |
| **Chemical properties** | |
| $pH_{paste}$ | 8.1 |
| Total N (%) | 0.03 |
| Organic C (%) | 0.4 |
| P (g $kg^{-1}$ dw) | 0.04 |
| K (g $kg^{-1}$ dw) | 0.4 |

## 2.2. Cattle Manure

Cattle manures were taken from dairy farm located in Agricultural Research Corporation of Wad Medani - Sudan. Chemical characteristics of farmyard manure are shown in Table 2. The pH was determined according to Mclean [25] method. Total N in the manure was determined using Kjeldahl method described by Bradstreet [19]. P was determined according to Jackson [22]. Soluble K, Mg, Ca and Na determined according to Chapman and Pratt [23]. Organic C was determined according to Walkley and Black [20] method modified by Gaudette et al. [21].

**Table 2. Chemical characteristics of farmyard manures used for cultivating guar plant in both seasons**

| Parameters | First season | Second season |
|---|---|---|
| pH | 7.2 | 6.8 |
| Tot N (%) | 2.36 | 2.51 |
| Org. C (%) | 14.4 | 14 |
| C/N | 6:1 | 5.6:1 |
| Tot P (%) | 0.46 | 0.47 |
| Tot K (%) | 4.6 | 4.5 |
| Tot Mg (%) | 5.9 | 3.0 |
| Tot Ca (%) | 7.3 | 10.1 |
| Tot Na (%) | 0.03 | 0.12 |

## 2.3. Source of the Strains

Four *Bradyrhizobium* strains were collected and used in the presented study. Three strains were brought from the United States Department of Agriculture (USDA). Those were USDA 3089, USDA 3385 and USDA 3386 [10]. The fourth strain was an isolate named ENRRI 16A supplied by the Environment and Natural Resources Institute (ENRRI), Khartoum, Sudan. ENRRI 16A is local strain which has been used and mentioned in several studies [11,12].

## 2.4. Experiment Setup

The experiment was conducted for two consecutive seasons to study the effect of *Bradyrhizobium* inoculation, farmyard manure and urea on growth and yield of guar cultivar HFG53 under irrigation. The design selected was the randomized complete block design with sixteen treatments and four replications for each. The treatments used in both seasons are showing in the Table 3. All treatments received a basal dose of 43 kg $P_2O_5$ $ha^{-1}$ as triple superphosphate (TSP), added before sowing. Each of the *Bradyrhizobium* inoculated treatments (B.1.1, B.1.2, B.1.3 and B.1.4) received only 43 kg N $ha^{-1}$ as urea, as a starter dose to initiate the growth of *Bradyrhizobium* bacteria. The farmyard manures were applied at two rates, 5 and 10 tones $ha^{-1}$, which corresponding to 118 and 236 Kg N $ha^{-1}$ in the first season and 125 and 250 Kg N $ha^{-1}$ in the second season, respectively. All plots irrigated before sowing to avoid the effect of fermentation heat on seed germination.

## 2.5. Planting and Harvesting

Seeds of guar (Cyamopsis tetragonoloba L. taubert) were coated with *Bradyrhizobium* inoculum, and then five seeds were sown per hole at 60 cm inter and 30 cm intra-row spacing. Irrigation water was applied immediately after sowing, and thereafter the crop was watered every 14 days. After the third irrigation, plants were thinned to two plants per hole. Three hand weeding were carried out in each season. Urea was applied at the rate equivalent to 86 kg N ha$^{-1}$, a week after sowing. Plant height (cm) was measured 4, 6 and 8 weeks after sowing (WAS) and then at maturity (14 WAS). Shoot dry weight (g) determined 4, 6 and 8 WAS. Pod dry weight (g) were collected 6 and 8 WAS and at maturity and then dried at 70ºC for 48 hours and weight was determined. The crop was harvested manually, when the pods were brown and dry (120 day from sowing). The pods were cut, and then stocked to dry and threshed by hand. Then seed yield was determined on an area from the inner two ridges (5x1.5 m) of each plot, from which seed yield per hectare estimated. Samples of 100 seeds were randomly taken from seed yield of each plot and their weights (g) were determined. Total nitrogen in the seeds was determined using Kjeldahl method described by Bradstreet [19]. Phosphorus percentage was determined according to Jackson [22].

**Table 3. Treatments used in the experiment in both seasons**

| No. | Abbreviation | Treatments |
|---|---|---|
| 1 | Control | No fertilizer or inoculation was applied |
| 2 | 2N | Urea applied at a rate equivalent to 86 kg N ha$^{-1}$ |
| 3 | FYM1 | Only 5 tons of chicken manure ha$^{-1}$ was applied |
| 4 | FYM2 | Only 10 tons of chicken manure ha$^{-1}$ was applied |
| 5 | B.1.1 | Only *Bradyrhizobium* inoculation by strain USDA 3089 |
| 6 | B.1.2 | Only *Bradyrhizobium* inoculation by strain USDA 3385 |
| 7 | B.1.3 | Only *Bradyrhizobium* inoculation by strain USDA 3386 |
| 8 | B.1.4 | Only *Bradyrhizobium* inoculation by isolate ENRRI 16A |
| 9 | B.1.1 + FYM1 | 5 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3089 |
| 10 | B.1.1+ FYM2 | 10 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3089 |
| 11 | B.1.2 + FYM1 | 5 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3385 |
| 12 | B.1.2+ FYM2 | 10 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3385 |
| 13 | B.1.3 + FYM1 | 5 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3386 |
| 14 | B.1.3+ FYM2 | 10 tons of chicken manure ha$^{-1}$ plus inoculation by strain USDA 3386 |
| 15 | B.1.4 + FYM1 | 5 tons of chicken manure ha$^{-1}$ plus inoculation by strain ENRR 16A |
| 16 | B.1.4+ FYM2 | 10 tons of chicken manure ha$^{-1}$ plus inoculation by strain ENRR 16A |

## 2.6. Statistical Analyses

The results were analyzed using the SAS procedure analysis of variance (ANOVA) and mean separation according to Duncan's Multiple Range Test to compare results from treatments regarding plant height, shoot dry weight, pod dry weight, yield, N and P percentages. Differences between treatments were deemed statistically significant at p<0.05 unless otherwise not stated.

# 3. Results

## 3.1. Plant Height

Plants height increased significantly (P≤0.05) in all treatments in comparison with the control at week 4, 6, 8 and 14 in both seasons (Figure 1. A, B). With the exception of treatments B.1.1 + FYM1 and B.1.3 + FYM1 at 4 and 14 WAS and B.1.2 + FYM1 at 8 WAS, all other treatments combining FYM and *Bradyrhizobium* strains significantly increased plants height in the first and second season compare to *Bradyrhizobium* strains inoculation and both levels of FYM treatments (Figure 1. A, B). Application of 10 tons ha$^{-1}$ FYM to inoculated guar plant, resulted in significantly (P≤0.05) increase plants height compare to the control, urea, *Bradyrhizobium* strains and 5 tons ha$^{-1}$ FYM at all sampling dates in first season (Figure 1. A). But in the second season, urea treatment (2N) significantly increase plants height compare to the other treatments (Figure 1. B). No significances different were observed between *Bradyrhizobium* strains and FYM1 application in most treatments in both seasons, whereas FYM2 treatment significantly (P≤ 0.05) increased plant height in most treatments at both seasons compare with *Bradyrhizobium* strains. Urea application significantly (P≤ 0.05) increased plant height over most of the treatments (FYM, *Bradyrhizobium* strains and FYM + inoculation) in both seasons, excluding B.1.4+FYM2 where plants height was taller at most measuring times.

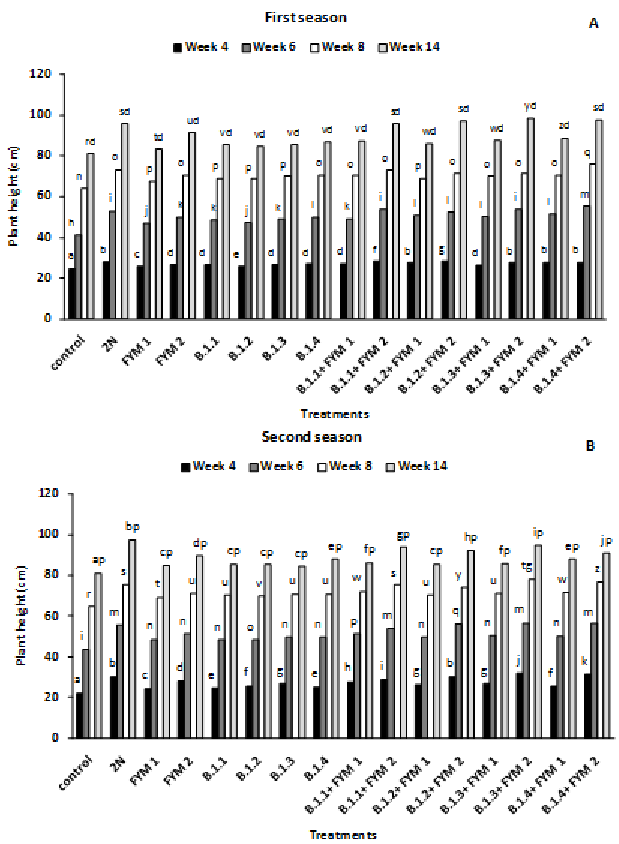


**Figure 1.** Effect of *Bradyrhizobium* inoculation, farmyard manure and nitrogen on plant height in first (A) and second (B) season. Means followed by the same letters in bars are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (n = 4)

## 3.2. Shoot Dry Weight

Effects of *Bradyrhizobium* inoculation, farmyard manure and urea application on shoot dry weight (SDW) of guar crop are showing in Figure 2. A and B. Adding FYM1 and FYM2 to inoculated guar significantly (P≤ 0.05) increased SDW over the control at 6 and 8 WAS in the first season (Figure 2. A), and at 4, 6 and 8 WAS in the second season (Figure 2. B). *Bradyrhizobium* inoculation, however, significantly increased SDW over the control at 6 and 8 WAS in the first season. In the second season with the exception of B.1.2 at 4 WAS, all other *Bradyrhizobium* strains significantly increased SDW over the control at all sampling dates. There was no significant difference observed among most *Bradyrhizobium* strains at most of measuring times especially in the second season. FYM1 significantly increased SDW over the control at 6 WAS in the both season, FYM2 treatment except at 4 WAS in the first season, significantly increased SDW over the control at all sampling dates. Application of urea significantly increased SDW over the control and *Bradyrhizobium* strains and *Bradyrhizobium* + FYM at all measuring dates in the both seasons, with the exception of B.1.4 + FYM2 especially at 8 WAS.

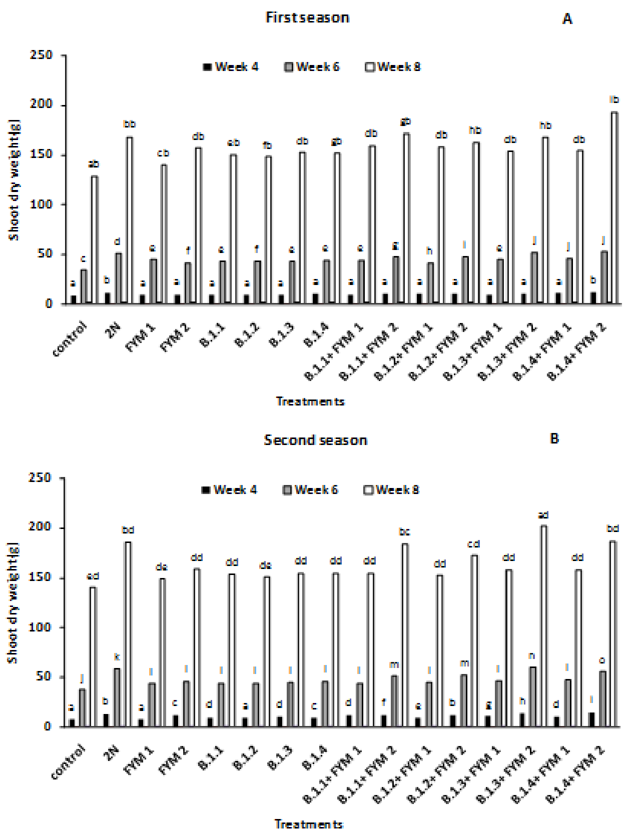


**Figure 2.** Effect of *Bradyrhizobium* inoculation, farmyard manure and nitrogen on shoot dry weight (g) of guar in first (A) and second (B) season. Means followed by the same letters in bars are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (n = 4)

## 3.3. Pod Dry Weight

Effects of *Bradyrhizobium* inoculation, farmyard manure and urea on pod dry weight (PDW) are showing in Figure 3. A and B. In the first season, the treatments containing *Bradyrhizobium* strains plus both FYM levels, with the exception of B.1.3+FYM1 treatment significantly (P≤0.05) increased PDW at 6 WAS, whereas at 8 WAS only B.1.2 + FYM1, B.1.2 + FYM2 and B.1.4 + FYM2 treatments significantly increased PDW. In the second season, all treatments significantly increased PDW over the control at 6 and 8 WAS. Furthermore, the treatments containing *Bradyrhizobium* strains and FYM2 significantly increased PDW over FYM1 and FYM2 as well as over the control and *Bradyrhizobium* strains at all sampling dates in both seasons, but not compare with 2N treatment. The *Bradyrhizobium* strains significantly increased PDW over the control in both season. Moreover, application of FYM1 and FYM2 significantly increased PDW over the control at both sampling dates in the first and second season. Application of urea resulted significantly increased PDW over control and FYM and *Bradyrhizobium* strains at all sampling dates in both seasons especially at week 8 (Figure 3. A and B).

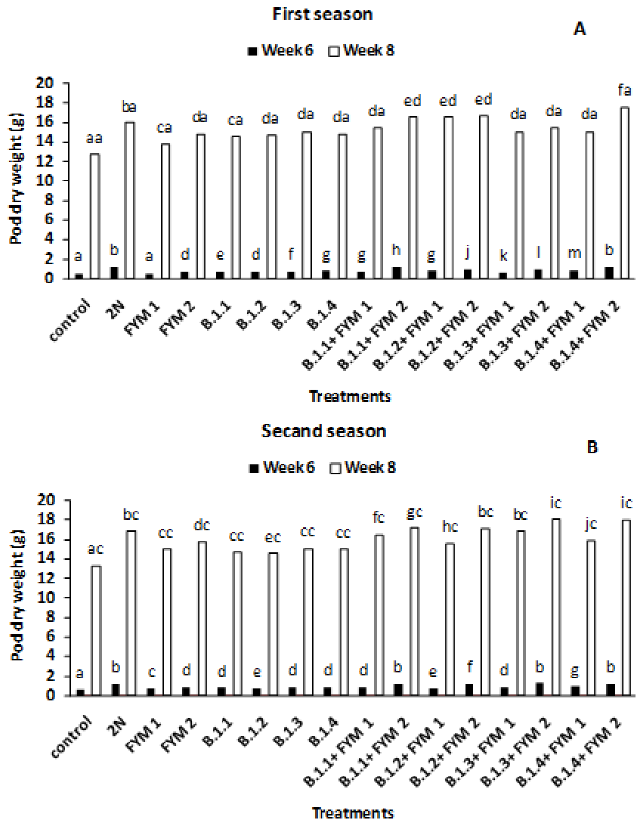


**Figure 3.** Effect of *Bradyrhizobium* inoculation, farmyard manure and N on pod dry weight (g) of guar in first (A) and second (B) season. Means followed by the same letters in bars are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (n = 4)

## 3.4. Seed Yield and Seed Weight

Application of FYM1 and FYM2 to inoculated guar plant significantly (p≤0.05) increased seed yield over the control, but there were no significant differences among them, except that in the second season *Bradyrhizobium* strains + FMY2 increased the yield significantly compared with *Bradyrhizobium* strains + FMY1. On the other hand, with the exception of *Bradyrhizobium* strain B.1.3 and B.1.4 in the first season, inoculation had no significant improve on yield in both season .The addition of FYM1 enhanced yield in both season but not significantly, whereas FYM2 and urea significantly increased yield over the control in both season (Table 4). Regarding 100 seed weight there were no significant differences among treatments in both seasons (Table 4).

**Table 4. Effect of *Bradyrhizobium* inoculation, farmyard manure and nitrogen on 100-seed weight (g) and seed yield (t ha$^{-1}$). Means followed by the same letter in a column are not significantly at 5% level of probability according to Duncan's Multiple Range Test (n = 4). SE± represent standard error from ANOVA**

| Treatment | 100 seed weight (g) | | | | Seed yield (t ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | Second season | | First season | | Second season | |
| Control | 3.3 | a | 3.2 | a | 1.8 | b | 1.8 | c |
| 2N | 3.5 | a | 3.4 | a | 2.5 | a | 2.5 | a |
| FYM1 | 3.3 | a | 3.3 | a | 2.1 | ab | 2.2 | abc |
| FYM2 | 3.4 | a | 3.4 | a | 2.3 | a | 2.4 | ab |
| B.1.1 | 3.3 | a | 3.3 | a | 2.2 | ab | 2.1 | abc |
| B.1.2 | 3.3 | a | 3.3 | a | 2.2 | ab | 2.0 | bc |
| B.1.3 | 3.3 | a | 3.3 | a | 2.3 | a | 2.1 | abc |
| B.1.4 | 3.3 | a | 3.3 | a | 2.3 | a | 2.2 | abc |
| B.1.1+FYM1 | 3.4 | a | 3.3 | a | 2.4 | a | 2.4 | ab |
| B.1.1+FYM2 | 3.4 | a | 3.5 | a | 2.6 | a | 2.5 | a |
| B.1.2+FYM1 | 3.4 | a | 3.4 | a | 2.4 | a | 2.4 | ab |
| B.1.2+FYM2 | 3.4 | a | 3.4 | a | 2.5 | a | 2.5 | a |
| B.1.3+FYM1 | 3.4 | a | 3.4 | a | 2.4 | a | 2.3 | ab |
| B.1.3+FYM2 | 3.4 | a | 3.4 | a | 2.5 | a | 2.5 | a |
| B.1.4+FYM1 | 3.4 | a | 3.4 | a | 2.4 | a | 2.5 | a |
| B.1.4+FYM2 | 3.4 | a | 3.5 | a | 2.5 | a | 2.6 | a |
| SE± | 0.11 | | 0.13 | | 0.25 | | 0.20 | |

## 3.5. Content of N and P in the Seed

As far as the seed nitrogen percent is concerned there were no significant differences among all treatments in both seasons (Table 5). Regarding P, the treatments combining FYM and *Bradyrhizobium* strains significantly increased seed P percent over the control in both seasons. On the other hand, *Bradyrhizobium* strains, FYM1 and urea had no significant effect on P percent, whereas FYM2 significantly increased P percent over the control in both seasons (Table 5).

**Table 5. Effect of *Bradyrhizobium* inoculation, farmyard manure and nitrogen on N and P present of seeds. Means followed by the same letter in a column are not significantly at 5% level of probability according to Duncan's Multiple Range Test (n = 4). SE± represent standard error from ANOVA**

| Treatments | N (%) | | | | P (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | Second season | | First season | | Second season | |
| Control | 3.1 | a | 3.2 | a | 0.21 | c | 0.25 | f |
| 2N | 3.5 | a | 3.7 | a | 0.26 | bc | 0.29 | ef |
| FYM1 | 3.2 | a | 3.2 | a | 0.29 | abc | 0.36 | abc |
| FYM2 | 3.4 | a | 3.3 | a | 0.36 | ab | 0.36 | abc |
| B.1.1 | 3.3 | a | 3.3 | a | 0.27 | bc | 0.30 | cdef |
| B.1.2 | 3.3 | a | 3.3 | a | 0.26 | bc | 0.29 | ef |
| B.1.3 | 3.3 | a | 3.4 | a | 0.27 | bc | 0.28 | ef |
| B.1.4 | 3.3 | a | 3.4 | a | 0.30 | abc | 0.29 | ef |
| B.1.1+FYM1 | 3.2 | a | 3.6 | a | 0.32 | ab | 0.36 | abc |
| B.1.1+FYM2 | 3.5 | a | 3.7 | a | 0.37 | a | 0.37 | a |
| B.1.2+FYM1 | 3.4 | a | 3.4 | a | 0.31 | ab | 0.35 | abcd |
| B.1.2+FYM2 | 3.6 | a | 3.4 | a | 0.35 | ab | 0.36 | ab |
| B.1.3+FYM1 | 3.5 | a | 3.4 | a | 0.33 | ab | 0.35 | abcd |
| B.1.3+FYM2 | 3.6 | a | 3.6 | a | 0.37 | a | 0.37 | a |
| B.1.4+FYM1 | 3.4 | a | 3.6 | a | 0.34 | ab | 0.36 | abc |
| B.1.4+FYM2 | 3.6 | a | 3.7 | a | 0.37 | a | 0.39 | a |
| SE± | 0.27 | | 036 | | 0.04 | | 0.03 | |

# 4. Discussion

## 4.1. Plant Height

Addition of FYM to inoculated guar resulted in significantly increase plant height. This was also seen by Gomaa and Mohamed [28] who found that application of farmyard manure to inoculated guar increase its height. This probably occurred due to the high N available in the soil after treating inculcated guar with FYM.

## 4.2. Shoot Dry Weight

Farmyard manure at both levels significantly increased shoot dry weight of both inoculated and uninoculated guar plants. Ghosh et al. [33] reported that application of farmyard manure significantly increased dry matter of soybean. This could be attributed to the supply of major and minor plant nutrients [34]. Since *Bradyrhizobium* inoculation resulted in significant increase in shoot dry weight, it can be concluded that *Bradyrhizobium* inoculation had increased nitrogen fixation capacity since in the vegetative stage, foliage dry matter production is the most reliable index of total nitrogen uptake [35]. The positive effect of *Bradyrhizobium* inoculation has been reported in several studies to increase the shoot dry weight of guar plants [11,30]. Nitrogen application increased shoot dry weight significantly. Shu et al. [36] reported that nitrogenous compounds play a major role in protein and chlorophyll synthesis and thus increase the photosynthetic ability and consequently dry matter production. Forawi and Elsheikh [37] reported that, application of 86 Kg N $ha^{-1}$ significantly increased shoot dry weight of fenugreek.

### 4.3. Pod Dry Weight

Application of FYM to inoculated and uninoculated guar plant increased pod dry weight. But the addition of high rate of FYM (10 tons $ha^{-1}$) to both inoculated and uninoculated guar plant gave better results than 5 tons $ha^{-1}$. This was probably due to FYM supplies major and minor plant nutrients that essential for plant growth [38]. Furthermore, pods dry weight was improved with *Bradyrhizobium* inoculation, which in agreement with that of Ibrahim et al. [30] and Elsheikh and Ibrahim [11] who reported that inoculation significantly increased pods dry weight of guar. The results in present study showed that nitrogen application gave the highest pod dry weight, which indicates that neither native nor important rhizobia can produce full N requirement of guar. Wedderburn [39] stated that small doses of nitrogen applied at earlier stage of growth help the plant to establish well and encourage better nodulation and hence nitrogen fixation.

### 4.4. Seed Yield and Seed Weight

Dose of 5 tons $ha^{-1}$ of farmyard manure improved seed yield significantly with inoculated plants and insignificantly with uninoculated plants, whereas application of 10 tons $ha^{-1}$ significantly increased seed yield over the control with both inoculated and uninoculated guar plant.

This also has been reported in several studies, Ayoola and Makinde [40] reported that cow manure give comparable seed yields of maize. Nira and Hamaguchi [41] stated that cattle manure significantly increased yield of soybeans over control.

Inoculation with each of the four *Bradyrhizobium* strains did not significantly affect seed yield. However, seed yield of guar was significantly increased by nitrogen application. Recommendation on the application levels of nitrogen fertilizer for the establishment of legumes nodules varies widely [42]. For example application of nitrogen at a rate of 25 Kg $ha^{-1}$ appeared to improve nodulation but higher rates reduced it. Nitrogen applied at a rate of 79 Kg N $ha^{-1}$ to non-inoculated fenugreek plants at flowering increased yield significantly [37].

Application of FYM to both inoculated and uninoculated guar plants increased the 100 seed weight but the differences in 100 seed weight between inoculated and uninoculated plants were not significant. Similar results on fenugreek were obtained by Abdelgani et al. [43]. Inoculated or fertilized guar accumulates more shoot dry matter than the control. Shibles et al. [44] confirmed that carbohydrates accumulating in soybean leaves prior to seed development are later utilized in seed growth. The slight increments in the 100 seed weight of fertilized and inoculated guar plants over those of the control might be due to comparatively higher amounts of stored carbohydrates which were then utilized in seed growth. Similar result were observed by Ibrahim et al. [30] and Abdelgani et al. [43] in fenugreek, who reported that inoculation and nitrogen application had no significant effect on 100 seed weight.

### 4.5. Content of N and P in the Seed

All treatments enhanced N content but not significantly. Urea and *Bradyrhizobium* treatments yielded seeds with higher N content compare to FYM.

This is probably due to that almost all the nitrogen in FYM is combined with organic substances and released only after decomposition. In practice about a third of the nitrogen is released quite quickly, but the rest is very resistant and persists for a long time in the soil [45]. Singh and Singh [46] reported that inoculation with *Bradyrhizobium* strains increased N content in guar seeds over uninoculated control by 28%. This could probably be due to the increase in N fixing efficiency of inoculated plants. This inoculation should have enhanced the symbiotic properties of guar plants leading to better growth and production.

Application of FYM to both inoculated and uninoculated guar significantly increased P concentration. Much of P is combined with organic matter and little is known of its values but roughly half of the total P content is readily available to crops [47]. Application of FYM will supply the soil with P which enhances germination of nodules and N fixation as reported by Kouas et al. [48].

*Bradyrhizobium* inoculation and nitrogen fertilizer had no significant effect on P concentration, which in agreement with Gomaa and Mohamed [28] foundation, who reported that seed P content, was not significantly affected by *Bradyrhizobium* strains and nitrogen application.

## 5. Conclusions

The result obtained in this study clearly indicated *Bradyrhizobium* inoculation substantially enhanced growth, yield components, seed yield and seed quality of guar. Whereas farmyard manure in combination with *Bradyrhizobium* inoculation were to be better than the farmyard manure used alone. Also fertilization of inoculated or uninoculated guar with farmyard manure and urea not only increased plant growth and yield, but also improved seed N and P.

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