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Evaluation of elites isolates of Bradyrhizobia nodulating groundnut (*A. hyogaea* L.) on major growing parts in Metekel Zone, northern western Ethiopia

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Abstract

The formation of effective (functional) nodules in groundnut when inoculated with compatible rhizobia leads to fixation of atmospheric nitrogen (N2) making nitrogenous fertilization of the groundnut unnecessary. This study was conducted during 2018 cropping season at Pawe, Dibate and Manbuk district in Metekel Zone of Benishangul Gumuz National Regional State. The aim of this research was to screen and evaluate of efficient isolates of Brady rhizobia nodulating groundnut (Arachishyogaea L.) at major growing areas of Metekel zone. The experiment was laid out in randomized complete block design with three replications. Four pre-selected isolates (based on the greenhouse experiment) of rhizobia nodulating groundnut including TSP 100 kg/ha, positive and negative control was the treatments of the field experiment. Groundnut grain yield, biomass yield, number of peg per plant, pod per plant, seeds per plant and stand count were collected at recommended time. Grain yield was estimated by adjusting moisture content to 12.5%. Then these data were managed properly using the Excel computer software and subjected to the analysis of variance using the SAS software. The Analysis of Variance combined overall locations showed that the main effects of strains had significant ($P < 0.01$) effects on pod per plant, seeds per plant, biomass and grain yields. The highest biomass yield and grain yield of combined overall locations were recorded from inoculated the Dibate-Modermo strain whereas the lowest grain yields were recorded under-v control (no input), GN-A7 strain, TSP 100 kg ha^{-1}, GN-A10 and GN-Dibate 2 strains. Inoculated of Dibate-Modermo strain had increased grain yield by about 58, 32.8, and 30 % as compared to the -v control (no input), GN-A7 strain and TSP 100 kg ha^{-1}, respectively. The utilization of groundnut strain plays significant role in improving its productivity. Hence, the native strain Dibate-Modermo improves grain yield of groundnut with over all location and it's the best candidate strain the study area similar areas.

Keywords: strain, groundnut, yield

1. Introduction

Groundnut (*Arachis hyogaea* L.) was originated in South America. It was introduced to Africa, North America, Asia and Europe between the 16th and 17th centuries (Weiss, 1983). It is grown in tropical and subtropical countries and in the continental parts of temperate countries for its seeds, which contain up to 50% of nondrying oil and about 35% protein and are used in the oil and feed industries. It is the major oil crop grown in Ethiopia mainly cultivated in eastern, southern, western and northwestern part of the country and occupies about 41 thousand hectares of land with a corresponding gross annual production of about 468,872 quintals per year (CSA, 2009).

The yield of pulses in Ethiopia is extremely low mainly due to low soil fertility, smallholder farming and limited access to external inputs (Amare, 1987; EARO, 2000). One of the most important factors of soil fertility is nitrogen (N) deficiency of most Ethiopian soils (Desta and Angaw, 1986). Studies carried out by the National Soil Survey Project (NSSP 1990); by the Alemaya University of Agriculture (Mitiku, 1990) and Asfaw and Angaw (2006) clearly revealed inoculation with rhizobia has improved the yield of legume pulses in Ethiopia. Therefore, biological nitrogen fixation should be more exploited to increase nitrogen for pulses cultivation in Ethiopia.

In Ethiopian soils, numbers of resident rhizobia nodulating pulses and bean can vary considerably in size, ranging from, 10^3 to.10^8 rhizobia /g of soil (Anteneh, 2007). The size of the soil rhizobial community is dependent on many factors including field history, soil and environmental characteristics and the presence of host plants. Successful establishment of inoculant strains into the soil is also dependent on the numbers of resident populations, host plant activity, as well as other soil characteristics (Brockwell *et al.,* 1995). Where the resident populations of rhizobia are small (50 *Rhizobium*/ g of soil) and specific to a target legume, the introduction of new strains by seed inoculation is usually successful. On the other hand, many authors have reported low recovery of the inoculant strain where resident rhizobial populations are large (10^3 rhizobia /g of soil) (Anteneh, 2007 and Brockwell *et al.,* 1995). Hence, we have to enumerate of rhizobia nodulating ground nut found in indigenous soil and again have to test soil chemical and physical properties that affected mainly survival of rhizobia, nodulation process and nitrogen fixation of endosymbionts. And this study will be initiated with the aim to isolate rhizobia nodulating ground nut and characterize its symbiotic effectiveness under control and field condition, and finally deliver efficient *Rhizobium* isolate nodulating ground nut for national biofertilizer production. With this, the objective has stated as to screen and evaluate of efficient isolates of bradyrhizobianodulating groundnut (*Arachis hyogaea* L.) at major growing areas of Metekel zone.

2. Materials and Methods

2.1 Description of Study Area

The study was conducted in Metekel zone, North-West of Ethiopia. It is the largest zone of the region covering an area of 3,387,817 hectares. The topography of the zone presents undulating hills slightly sloping down to low land Plateaus having varying altitudes from 600- 2800 m.a.s.l. and the annual rainfall of the area is 900-1580mm. About 80% of the area is characterized by sub-humid and humid tropical climate with annual minimum and maximum temperature of 20^oC and 35^oC respectively (Metekel Zone, Department of Agriculture).

2.2 Description of the Experimental Materials

Improved groundnut (A. *hyogaea* L.) variety named Maniputer was used a test crop with the seed rate of 70 kg ha^{-1}. Urea and triple super phosphate (TSP) fertilizers were used as the source of N and P, respectively. Four pre-selected isolates (based on the greenhouse experiment) of rhizobia nodulating groundnut produced at Haramaya university, bio fertilizer production and research laboratory.

2.3 Experimental Design and Treatments

Four pre-selected isolates (based on the greenhouse experiment) of rhizobia nodulating groundnut named GN-A7, GN-A10, GN-Dibate-2 and Dibate Modermo strains including TSP 100 kg/ha, positive and negative control total seven treatments were the treatments of the field experiment. The design was complete randomized block design where each treatment was replicated three times.

2.4 Experimental Procedure

The experimental field was plowed three times exclusively using tractor mounted moldboard plough to 30 cm soil depth. Subsequent tilling operations were done by harrowing to about 10 cm depth tillage. During field layout preparation, space between plots and blocks were separated by path of 1m and 2m, respectively. Groundnut was sown at 10cm between plant and 60 cm inter-row spacing. Groundnut was planted on plot area of 4.2 m x 3m (12.6 m^2). All recommended cultural practices of groundnut production were adopted for the management of the experiment. Blanket application of phosphorus (46 Kg P_2O_5 ha^{-1}) was applied at planting the crop.

2.5 Agronomic Data Collection

Important plant data were collected from crop emergence to harvest was treated as growth parameters. Groundnut grain yield, biomass yield, number of peg per plant, pod per plant, and seed per plant were collected at recommended time. Number of peg per plant, pod per plant, and seed per plant were measured from ten randomly sampled plants at physiological maturity. Grain yield was estimated by adjusting moisture content to 12.5%.

2.6 Statistical Analysis

Analysis of variance (ANOVA) was performed using SAS statistical software 9.3 version (SAS, 2014). Whenever the ANOVA detected significant differences between treatments, mean separation was conducted using least significant difference (LSD)

3. Results and Discussion

3.1 Effects of elite isolates of Brady rhizobia nodulating groundnut on grain yield and yield components

The results analysis of all locations of the study showed that the seed inoculation caused an increase in the number of root nodules in inoculated plants might have increased the pod per plant (PPP), seed per plant (SPP), biomass yield and grain yield productivity over controls as its evident from Tables 1, 2, 3 and 4.

3.1.1 Number of pegs per plant (NPPP)

The Analysis of Variance was showed that the main effects of strains had highly significant ($P < 0.01$) effect on pegs per plant at only Dibate district (Table 1). The highest pegs per plant(42.13, 41.47 and 40.53) were recorded fromGN-A10 strain, DAP 100 kg ha^{-1} (+v control) and Dibate-Modermo strain whereas the lowest pegs per plants 30.47 and 32.07 were recorded at the control (no input)and GN-A7 strain, respectively. However, the mean of number of pegs per plant recorded from plot received GN-A10 strain, DAP 100 kg ha^{-1} (+v control) and Dibate-Modermo strain were not statistically different with TSP100kg/ha and GN-Dibate 2 strain. Number of pegs per plant recorded from the applications of GN-A10 strain, DAP 100 kg ha^{-1} (+v control) and Dibate-Modermo strain resulted in 38, 36 and 33% increments to the control (no input) andin 31, 29 and 26% increments to theGN-A7 strain, respectively. In line with this finding Tamiru *et al.* (2012) and Slattery *et al*. (2004)

3.1.2 Pod per plant (PPP)

The analysis of variance showed that significantly ($P< 0.05$) effects on numbers of pod per plant at all locations and over location combined except Pawe district (Tables 1, 2, 3 and 4). Result of over location combined analysis showed that, numbers of pod per plant of the groundnut was higher under strains than uninoculated treatment. Hence, the highest numbers of pod per plant 27.62 and 25.82were recorded from GN-A10 and Dibate-Modermo strains whereas the lowest number of pod per plants 21.27 was recorded at the control (no input) (Table 4), respectively. Previous research findings also indicate that, the highest number of pods per plant (39.40) was produced when the crop was grown in both limed soil and bradyrhizobia inoculation (Workneh, 2013).Also, number of pods per plant was recorded from the treatments inoculated GN-A10 and Dibate-Modermo strains resulted in 30 and 21.4% increments to the control (no input), respectively. Likewise, Antenah (2014) said that, the average number of pods per plant produced by the inoculated soybean plants was 30% higher than number of pods per plant produced by soybean plants in the control treatment. This finding is also in line with reports of Malik *et al.* (2006) and Bhuiyan *et al.* (2008) who indicated more pod number per plant of soybean and mung bean with rhizobia inoculation than uninoculated treatment. The maximum number of pod and seeds per plant was 43.58 and 75.66 obtained from the plant inoculated with strain-J43 (Sultana, 2014).

3.1.3 Seeds per plant (SPP)

The main effect of strains was significantly affected on number of seeds per plant at all locations and over location combined except Pawe district (Tables 1, 2, 3 and 4). Result of over location combined analysis showed that, the highest number of seeds per plant 39.58 and 36.89 was recorded from the plots inoculated with GN-A10 and Dibate-Modermostrains whereas the lowest number of seeds per plant 30.11 was recorded from GN-Dibate 2 strain inoculation plot, respectively **(**Table 4). Similar results also obtained by Solaiman (1999) in chickpea, Feng *et al.* (1997) in pea, Hoque and Haq (1994) in lentil. Podder *et al.* (1999) carried out a field experiment with soybean and found that *Bradyrhizobium* inoculation had favorable effect on seed number per plant and yield.

3.1.4 Biomass yield

The Analysis of Variance showed that the main effects of strains had highly significant (P< 0.01) effect on Biomass yield at both locations and combined of overall locations (Tables 1, 2, 3 and 4). Hence, results of combined overall locations analysis showed that, the highest biomass yield was recorded from inoculated of Dibate-Modermo strain whereas statistically similarly with DAP 100 kg ha^{-1} (+v control) and GN-Dibate 2 strain, and significantly superior to -v control plot (No input), TSP 100 kg ha^{-1}, GN-A7 and GN-A10 strains (Table 4). Accordingly, the highest biomass yield5925.9 kg ha^{-1} was recorded under inoculated of Dibate-Modermo strain whereas the lowest biomass yields 3919.8, 4351.8, 4660.5 and 4722.2 kg ha^{-1} were recorded under-v control plot (No input), TSP 100 kg ha^{-1}, GN-A7 and GN-A10 strains, respectively. Moreover, inoculated of Dibate-Modermo strain had increased biomass yield by about 51, 36, 27 and 25% as compared to the -v control (no input), 17 and 11.6% as compared to the 100 kg TSP ha^{-1} and, 15 and 9.5% as compared to the -v control plot (No input), TSP 100 kg ha^{-1}, GN-A7 and GN-A10 strains, respectively. Other studies have similarly found variations in plant growth, nodulation and N_2 fixation of soybean genotypes due to differences in N_2-fixing efficiency of the microsymbiont (Pule-Meulenberg *et al*. 2011; Salvucci *et al*., 2012).

3.1.5 Grain yield

The Analysis of Variance showed that the main effects of strains had highly significant (P < 0.01) effect on grain yield at both location and combined overall locations(Tables 1, 2, 3 and 4). Hence, the results of combined overall locations analysis showed that the highest significant grain yield was obtained on plots that inoculated the Dibate-Modermo strain whereas statistically, comparable with these treatment DAP 100 kg ha^{-1} (+v control) but it is superior to -v control (no input), GN-A7 strain, TSP 100 kg ha^{-1},GN-A10 and GN-Dibate 2 strains. Accordingly, the highest grain yield (1175.4 kg ha^{-1}) was recorded at the Dibate-Modermo strain whereas the lowest grain yields (743.6,884.8 and904.3 kg ha^{-1}) were recorded at the -v control (no input),GN-A7 strain and TSP 100 kg ha^{-1}, respectively. Similarly, inoculated of Dibate-Modermo strain had increased grain yield by about 58, 32.8, and 30 % as compared to the -v control (no input), GN-A7 strain and TSP 100 kg ha^{-1}, respectively. Similar result was obtained by another researcher Asei Rechiatu *et al.* (2015) and Fistum *et al.* (2016).

Table 1.Effects of elites isolates of Bradyrhizobia nodulating groundnut on yield and yield components in Dibate district

S. N.	Treatment	NPPP	PPP	SPP	SC	BMY (kg ha^{-1})	GY (kg ha^{-1})
1	GN-A7 Strain	32.07b	23.73dc	38.47c	48.00	3333.3b	816.5c
2	GN-A10 Strain	42.13a	32.60ba	52.80a	49.67	3287.1b	800.0c
3	GN-Dibate 2 Strain	36.60ba	25.87bdc	38.47c	63.00	3888.9b	1065.3b
4	Dibate Modermo Strain	40.53a	30.33bac	47.00bac	71.00	5370.3a	1302.4a
5	DAP 100 kg ha^{-1} (+v control)	41.47a	33.13a	49.20ba	64.00	5463.0a	1307.1a
6	TSP 100 kg ha^{-1}	37.53ba	27.87bdac	43.20bc	68.00	4213.0ba	991.3cb
7	No input (-ve control)	30.47b	22.87d	38.07c	65.67	3055.6b	781.2c
	CV (%)	12.2	14.3	12.1	17.4	18.9	12.8
	LSD (0.05)	8.0742	7.1371	9.425	ns	1378	230.03
	Significance levels	*	*	*	ns	**	***

*** Significant at *P* < 0.001, ** significant at *P* < 0.01, * significant at *P* < 0.05, ns – no significant difference. Means along the column with the same letter are not significantly different. NPPP= number peg per plant, PPP= total pod per plant, SPP= seed per plant, SC= stand count, BMY= biomass yield, GY= grain yield

Table 2. Effects of elites isolates of Bradyrhizobia nodulating groundnut on yield and yield components in Pawe district

S. N.	Treatment	NPPP	PPP	SPP	SC	BMY (kg ha^{-1})	GY (kg ha^{-1})
1	GN-A7 Strain	39.13	25.47	42.80	89.67	6944.4a	1409.5ba
2	GN-A10 Strain	41.67	27.87	45.07	91.67	6713.0ba	1423.9ba
3	GN-Dibate 2 Strain	40.80	24.93	35.80	91.33	5833.3ba	1352.3ba
4	Dibate Modermo Strain	39.47	28.40	46.47	93.33	7314.8a	1640.9a
5	DAP 100 kg ha^{-1} (+v control)	35.87	23.73	37.40	89.67	5555.6ba	1331.8ba
6	TSP 100 kg ha^{-1}	43.27	30.13	49.07	95.67	5231.5ba	1303.4ba
7	No input (-ve control)	39.13	28.93	49.27	85.33	4629.6b	1138.2b
	CV (%)	12.7	30.9	18.8	4.2	20.9	18.4
	LSD (0.05)	ns	ns	ns	ns	2246	449.66
	Significance levels	ns	ns	ns	ns	*	*

* Significant at $P < 0.05$, ns – no significant difference. Means along the column with the same letter are not significantly different. NPPP= number peg per plant, PPP= total pod per plant, SPP= seed per plant, SC= stand count, BMY= biomass yield, GY= grain yield

Table 3. Effects of elites isolates of Bradyrhizobia nodulating groundnut on yield and yield components in Dangur district

S. N,	Treatments	NPPP	PPP	SPP	SC	BMY (kg ha^{-1})	GY (kg ha^{-1})
1	GN-A7 Strain	30.67	21.53ba	18.33ba	67.00	3703.7b	428.5ba
2	GN-A10 Strain	37.60	22.40a	20.87a	71.33	4166.7b	531.0ba
3	GN-Dibate 2 Strain	30.07	15.80ba	16.07ba	65.00	5185.2a	399.9ba
4	Dibate Modermo Strain	28.53	18.73ba	17.20ba	73.00	5092.6a	582.9a
5	DAP 100 kg ha^{-1} (+v control)	31.20	17.93ba	17.80ba	49.33	3750.0b	524.7ba
6	TSP 100 kg ha^{-1}	29.33	16.67ba	13.33ba	65.00	3611.1b	418.2ba
7	No input (-ve control)	28.80	12.00b	9.20b	63.33	4074.1b	311.4b
	CV (%)	26.2	30.7	35.3	27.5	22.1	29.5
	LSD (0.05)	ns	9.7497	10.134	ns	1201.52	334.41
	Significance levels	ns	*	*	ns	*	*

* Significant at $P < 0.05$, ns – no significant difference. Means along the column with the same letter are not significantly different. NPPP= number peg per plant, PPP= total pod per plant, SPP= seed per plant, SC= stand count, BMY= biomass yield, GY= grain yield

Table 4. Effects of elites isolates of Bradyrhizobia nodulating groundnut on yield and yield components on overall locations combined analysis

S. N.	Treatments	NPPP	PPP	SPP	SC	BMY (kg ha-1)	GY (kg ha-1)
1	GN-A7 Strain	33.96	23.58ba	33.20ba	68.22	4660.5b	884.8bc
2	GN-A10 Strain	40.47	27.62a	39.58a	70.89	4722.2b	918.3b
3	GN-Dibate 2 Strain	35.82	22.20b	30.11b	73.11	4969.1ba	939.2b
4	Dibate Modermo Strain	36.18	25.82ba	36.89ba	79.11	5925.9a	1175.4a
5	DAP 100 kg ha-1 (+v control)	36.18	24.93ba	34.80ba	67.67	4922.8ba	1054.5ba
6	TSP 100 kg ha-1	36.71	24.89ba	35.20ba	76.22	4351.8b	904.3b
7	No input (-ve control)	32.80	21.27b	32.18ba	71.44	3919.8b	743.6c
	CV (%)	17.9	22.3	23.5	16.5	24	21.6
	LSD (0.05)	ns	5.125	7.683	ns	1097.1	90.9
	Significance levels	ns	*	*	ns	*	***

*** Significant at P < 0.001, * significant at P < 0.05, ns – no significant difference. Means along the column with the same letter are not significantly different. NPPP= number peg per plant, PPP= pod per plant, SPP= seed per plant, SC= stand count, BMY= biomass yield, GY= grain yield

4. Conclusion

The utilization of groundnut strain plays significant role in improving of productivity. From the cumulative result obtained from the yield evaluation showed that the native strain Dibate-Modermo had significantly improved groundnut yield than the other treatments except DAP 100 kg ha^{-1} (+v control). Similarly, the highest grain yield was obtained on plots that inoculated the Dibate-Modermo strain than the -v control (no input) and GN-A7 strain, TSP 100 kg ha^{-1}, GN-A10 and GN-Dibate 2 strains. Moreover, inoculated of Dibate-Modermo strain had increased grain yield by about 58, 32.8, and 30% as compared to the -v control (no input), GN-A7 strainand TSP 100 kg ha^{-1}, respectively. Hence it is concluded that the native strain Dibate-Modermo used by as in seed inoculation of the improved groundnut variety named Maniputer has resulted in significant increases in grain and biomass yields potential over the respective strains and +v and -v control of treatments.

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