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Influence of NPK, N Fixing Bacteria and Antioxidants on Growth, Seed and Guaran Yield and Chemical Composition of Guar Plants

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Abstract: This trial was carried out during the two successive seasons 2010 and 2011 at the experimental farm, Faculty of Agriculture, Minia University to explore the response of guar (*Cyamopsis tetragonoloba*) plants to mineral NPK, N fixing bacteria and antioxidant treatments. The partial replacement of mineral NPK, at different degrees, by N fixing bacteria, gave reasonable vegetative growth traits (plant height, branch number and herb dry weight), number of pods/ plant and seed yield per plant and fed, guaran yield per plant and fed, photosynthetic pigments and N, P and K % in the herb, especially the treatment of 75% NPK+ N-fixing bacteria. Concerning antioxidants, salicylic acid followed by ascorbic acid each at 200 ppm caused remarkable enhancement in all of the previous studied characters. However, the use of 25% NPK+ N fixing bacteria in combination with ascorbic acid at 200 ppm or salicylic acid at 200 ppm gave equal or better growth and yield of seeds and guaran values than those given by the recommended mineral NPK fertilization.

Key words: *Cyamopsis tetragonoloba* · Guar · NPK · *Bradyrhizobium japonicum* · Antioxidant

INTRODUCTION

Guar (*Cyamopsis tetragonoloba*, L. Taub.) is a drought resistant annual herb. It is considered as an agricultural crop in India and Pakistan, where it has been used for food and animal fodder. It is adapted well to arid and semi- arid climates and considered as one of the most important sources of mucilage, which makes special type of gum, used in industry and pharmaceutical preparations. Guar seeds contain about 34% protein, 23 % gum and 40 % fixed oil.

In Egypt, chemical fertilizers are heavily used to maintain soil fertility and ensure high crop productivity; however, recent documentation of adverse effects of chemical fertilizers emphasizes the importance of developing new production methods that are sustainable agriculturally, economically and environmentally.

So, the present study was planned to substitute some amounts of NPK chemical fertilizers by N- fixing bacteria and some antioxidant treatments in producing safer and less expensive vegetative growth and seed and guaran yield of guar plants under the environmental conditions of Minia Governorate.

Many authors observed that growth, seed yield, guaran production and/ or chemical composition of guar plants were enhanced due to NPK fertilization [1-8]. Meanwhile, the effectiveness of N- fixing bacteria products was revealed on guar [2, 3, 7, 9]; fennel [10, 11]; caraway [12] and *Nigella sativa* [13]. In addition, the efficiency of antioxidants was found by Deore and Bharud [14] and Mohamed and Naguib [15] on fenugreek, Tanious [16] on fennel, Helmy [17] on *Nigella sativa* and Badran *et al.* [17, 18] on coriander.

MATERIALS AND METHODS

The present study was carried out during two successive seasons 2010 and 2011 at the experimental farm and the laboratory of Faculty of Agriculture, Minia University to explore the influence of chemical and bio-fertilizers, as well as, antioxidant treatments on growth, yield, guaran and chemical composition of guar (*Cyamopsis tetragonoloba*, L. Taub.) plants.

The seeds were sown on April 12th and April 15th for the two successive seasons in 3x2 m plots. Each plot contained 3 rows, 60 cm apart, with 6 hills (50 cm apart)

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Table 1: Physical and chemical analysis of the soil

Sand (%)	Silt (%)	Clay (%)	Soil type	Org. atter (%)	$CaCO_3$ (%)	pH (1: 2.5)	E.C. (mmhos/cm)
28.20	30.70	41.10	Clay loam	1.62	2.09	7.82	1.04

Total N (%)	Available P (%)	Exch. K (mg/100 g)	Exch. Ca^{++} (mg/ 100 g)	Exch. Na^{+} (mg / 100 g)	DTPA Ext. (ppm) Fe	Cu	Zn	Mn
0.08	15.12	2.11	31.74	2.40	8.54	2.06	2.75	8.26

per row. Planting was done on one side of the row. Thinning was executed twice after 6 and 8 weeks from sowing date by leaving one plant/ hill. Physical an chemical analysis of the soil are shown in Table 1.

The layout of the experiment was randomized complete blocks in split – plot design with three replications. The main plots presented 6 mineral / N- fixing bacterial treatments as follows:

- Control (without any fertilizers).
- 100% mineral NPK (recommended dose).
- 75 % mineral NPK + *Bradyrhizobium japonicum*.
- 50% mineral NPK + *Bradyrhizobium japonicum*.
- 25% mineral NPK + *Bradyrhizobium japonicum*.
- 0 % mineral NPK + *Bradyrhizobium japonicum*.

The sub-plots devoted to the following five antioxidant treatments, control, 100 and 200 ppm ascorbic acid and 100 and 200 ppm salicylic acid. The recommended NPK mineral fertilizers (100%) were 100 kg/ fed urea (46 %N), 100 kg/ fed calcium superphosphate (15.5 % P_2O_5) and 50 kg/ fed potassium sulphate (48.5 % K_2O). The amounts of N and K fertilizers were divided to 3 equal batches added after final thinning and every 2 weeks thereafter. The amounts of P fertilizer were applied during soil preparation. Guar seeds were inoculated, shortly before planting, with effective strain of *Bradyrhizobiom japonicum* using Arabic gum as sticker. Meanwhile, antioxidant treatments were applied as foliar spray, till run off, 3 times with three week intervals starting 3 days after final thinning. Farmyard manure was added to the experimental area at the rate f 10 m^3/ fed during soil preparation. Other agricultural practices were performed as usual.

At harvesting time, on the third week of September for both seasons, data were recorded for plant height (cm), number of branches / plant, herb dry weight / plant (g), number of pods/ plant, weight of seeds / plant(g) and seed yield/ fed (kg.), in addition to guaran % and guaran yield (g/ plant and kg/ fed) as described by Anderson [20]. Also, chlorophyll a and b and carotenoids contents (mg/g F.W.) according to Fadl and Seri- Eldeen [21] and leaves N, P and K % [22] were determined. Obtained data were statistically analyzed using MSTAT-C [23].

RESULTS AND DISCUSSION

Vegetative Growth: Table 2 showed that the three studied vegetative growth traits, plant height, branch number/ plant and herb dry weight / plant, were significantly augmented, in both seasons due to all five NPK and/ or N-fixing bacteria treatments in comparison with control treatment. Gradual reduction in the values of these traits was obtained due to the gradual decrease in the NPK amount from 100% to zero %. However, no significant differences were existed between 100 % NPK and 75% NPK + N- fixing bacteria. The role of NPK in promoting vegetative growth of guar plants was revealed by previous studies [3, 6 -8]. While the role of N- fixing bacteria in enhancing the vegetative growth was emphasized by previous studies on guar [3, 7] and on *Nigella sativa* [13].

The use of the two antioxidants, ascorbic acid and salicylic acid at both 100 and 200 ppm, caused significant increase in plant height and branch number and herb dry weight/ plant, in the two seasons over those of control treatment (Table2). The best results were obtained from 200 ppm salicylic or ascorbic acids. These results were in agreement with those reported by other studies on fenugreek [14, 15]; fennel [16] and on coriander [18].

The interaction between NPK, N fixing bacteria and antioxidant treatments was significant for plant height and herb dry weight/ plant with the best results being given by 100% NPK or 75% NPK + N fixing bacteria in combination with salicylic acid or ascorbic acid at 200 ppm as shown in Table 2.

Yield and Yield Components: All NPK and/ or biofertilization treatments caused significant increase in pod number and seed weight / plant and seed yield/ fed, in the two seasons, compared to unfertilized plants (Table 3). The highest values, for the three yield aspects, were given by 100% NPK, followed by 75% NPK + N fixing bacteria treatment, while the lowest values were those of N fixing bacteria only. Other researches on guar were In accordance with these results concerning NPK [3, 4, 6, 7] and regarding N biofertilization those of Hussein [3] on guar, Badran and Safwat [11] on fennel and Ahmed [13] on *Nigella sativa*.

Table 2: Effect of mineral NPK, N fixing bacteria and antioxidant treatments on vegetative growth of guar plants during 2010 and 2011 seasons

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc.200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Plant height (cm)											
Control	81	86	94	89	98	90	83	88	95	91	100	91
100 NPK	102	112	129	118	134	119	104	117	131	124	136	122
75 NPK + N Fix.	96	112	130	117	132	118	98	115	127	119	128	117
50 NPK + N Fix.	98	103	119	108	125	111	97	105	121	110	126	112
25 NPK + N Fix.	90	99	111	103	121	105	92	101	113	105	123	107
0 NPK + N Fix.	87	96	102	95	104	97	91	98	104	98	105	99
Mean B	92	101	114	105	119		94	104	115	108	120	
LSD 5 %	A:	5	B:	2	A×B:	5	A:	5	B:	3	A×B:	7
	Number of branches / plant											
Control	7.8	9.0	9.6	9.4	10.3	9.2	7.3	8.1	9.0	8.4	9.3	8.4
100 NPK	12.0	12.8	14.3	13.2	15.2	13.5	11.0	12.0	13.5	12.2	14.2	12.6
75 NPK + N Fix.	11.5	12.5	13.8	12.9	14.4	13.0	10.9	11.5	12.8	11.9	13.9	12.2
50 NPK + N Fix.	11.0	12.2	13.6	12.7	14.3	12.8	10.4	11.3	12.6	11.5	13.3	11.8
25 NPK + N Fix.	9.4	10.6	12.5	11.3	13.5	11.5	8.7	10.6	11.5	11.3	12.4	10.9
0 NPK + N Fix.	8.5	9.9	11.1	10.6	12.1	10.4	8.4	9.0	10.1	9.6	11.3	9.7
Mean	10.0	11.2	12.5	11.7	13.3		9.5	10.4	11.6	10.8	12.4	
LSD 5 %	A:	0.6	B:	0.4	A×B:	N.S.	A:	0.6	B:	0.4	A×B:	N.S.
	Herb dry weight / plant (g)											
Control	82	98	125	103	127	107	86	110	140	117	140	119
100 NPK	178	210	213	212	219	206	197	233	326	235	238	228
75 NPK + N Fix.	173	210	212	211	213	204	191	227	229	232	233	222
50 NPK + N Fix.	170	201	205	203	209	198	178	220	222	226	228	215
25 NPK + N Fix.	164	189	195	190	200	188	171	206	211	208	219	203
0 NPK + N Fix.	152	172	184	173	186	173	156	189	198	186	201	186
Mean	154	180	189	182	193		163	198	206	201	210	
LSD 5 %	A:	6	B:	6	A×B:	14	A:	10	B:	5	A×B:	13

Concerning antioxidant treatments, both ascorbic acid and salicylic acid at 100 and 200 ppm resulted, significantly in both seasons, in better results than control treatment. However, the high concentration of ascorbic or salicylic acid gave as much as double seed yield per plant and per feddan as that of control treatment as illustrated in Table 3. These results were insured by other researches [12, 15, 16, 19].

The interaction between fertilization and antioxidant treatments was significant, in both seasons, for seed yield per plant and feddan, with the heaviest yield being given due to the combined treatments 100% NPK or 75% NPK plus N fixing bacteria with salicylic acid at 200 ppm as indicated in Table 3.

Guaran percentage and Yield: Table 4 showed clearly that guaran % and yield were greatly and significantly augmented, in both seasons, due to the use of any NPK and/ or N- biofertilizer treatment. However, the 100% NPK followed by 75% NPK plus *Bradyhizobium japoniocum* treatment overcome all other treatments. The obtained results are on the line with prior studies [1, 2, 4, 9].

Guaran percentage and yield per plant and per feddan were considerably and significantly increased due to the application of either antioxidant at 100 and 200 ppm in comparison with untreated control plants. However, salicylic acid at 200 ppm followed by ascorbic acid at 200 ppm gave the highest overall values as shown in Table 4.

The interaction between fertilization and antioxidant treatments was significant in the two seasons for guaran yield per plant and feddan with the best results being given due to supplying guar plants with 100% NPK with the supplement of salicylic acid at 200 ppm (Table 4).

Chemical Composition: Tables 5 and 6 declared that the three photosynthetic pigments, chlorophyll a and b and carotenoids contents, as well as, nitrogen, phosphorus and potassium percentage were greatly augmented due to the use of all tested NPK and/ or N- fixing bacteria in both seasons. However, the 100 % NPK and 75% NPK plus *Bradyrhizobium japonicum* gave significantly the highest values over all other treatments including control for the

Table 3: Effect of mineral NPK,N fixing bacteria and antioxidant treatments on the yield of guar plants during 2010 and 2011 seasons

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc.200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Number of pods/ plant											
Control	59	82	101	98	109	90	63	86	106	101	110	93
100 NPK	188	207	216	211	218	208	187	211	220	214	222	211
75 NPK + N Fix.	180	204	214	207	216	204	175	204	211	210	221	204
50 NPK + N Fix.	173	191	197	192	197	190	161	194	200	200	203	192
25 NPK + N Fix.	164	172	185	177	187	177	142	176	185	179	191	175
0 NPK + N Fix.	114	123	138	132	146	131	111	126	143	135	149	133
Mean	146	163	175	170	179		140	166	178	173	183	
LSD 5 %	A:	7	B:	5	A×B:	N.S.	A:	5	B:	7	A×B:	N.S
	Seed weight / plant(g)											
Control	3.5	6.1	9.9	8.5	11.5	7.9	4.5	7.0	11.5	7.8	11.8	8.5
100 NPK	36.1	48.6	73.9	57.4	93.2	61.8	40.0	62.5	92.5	68.3	103.4	73.3
75 NPK + N Fix.	31.0	41.5	67.4	50.0	88.1	55.6	33.8	55.5	75.2	61.8	97.4	64.7
50 NPK + N Fix.	26.3	36.1	55.2	41.3	59.6	43.7	27.0	46.7	65.3	53.4	77.5	54.0
25 NPK + N Fix.	15.9	22.7	40.0	26.3	45.8	30.1	14.1	22.3	38.3	24.8	43.1	28.5
0 NPK + N Fix.	7.9	10.0	17.0	12.4	18.9	13.2	9.5	12.4	19.4	14.3	23.7	15.8
Mean	20.1	27.5	43.9	32.6	52.8		21.5	34.4	50.3	38.4	59.5	
LSD 5 %	A:	3.3	B:	2.1	A×B:	5.1	A:	5.2	B:	3.5	A×B:	8.6
	Seed yield / fed(kg)											
Control	42	73	122	102	138	95	52	84	138	108	155	107
100 NPK	433	583	887	689	1118	743	480	750	902	852	1276	852
75 NPK + N Fix.	372	498	718	600	1053	648	406	666	866	742	1168	770
50 NPK + N Fix.	316	434	662	514	863	558	340	561	784	640	969	659
25 NPK + N Fix.	190	272	480	316	573	366	169	267	460	294	517	341
0 NPK + N Fix.	95	120	199	148	235	159	111	150	241	172	281	191
Mean	241	330	511	395	663		260	413	565	468	728	
LSD 5 %	A:	38	B:	32	A×B:	79	A:	39	B:	61	A×B:	149

Table 4: Effect of mineral NPK, N- fixing bacteria and antioxidant treatments on guaran determinations of guar plants during 2010 and 2011 seasons

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Guaran (%)											
Control	20.3	24.3	26.7	26.0	28.7	25.7	22.3	26.6	28.6	28.0	31.0	27.3
100 NPK	34.0	39.3	42.0	41.0	45.0	40.3	36.0	41.3	44.0	43.0	46.6	42.2
75 NPK + N Fix.	32.7	38.3	41.1	40.0	43.0	39.0	34.6	40.3	43.0	42.0	45.0	41.0
50 NPK + N Fix.	30.0	35.7	39.0	37.3	40.7	36.5	32.0	37.6	41.0	39.3	42.6	38.5
25 NPK + N Fix.	26.0	32.3	35.3	33.7	36.3	32.7	31.3	34.3	37.3	35.3	38.3	35.3
0 NPK + N Fix.	22.3	28.3	31.3	29.7	32.3	28.2	24.3	30.3	33.3	31.6	33.6	30.6
Mean	27.6	33.1	35.9	34.6	37.7		30.1	35.1	37.8	36.5	39.5	
LSD 5 %	A:	2.2	B:	2.6	A×B:	N.S	A:	2.8	B:	2.5	A×B:	N.S.
	Guaran yield / plant (g)											
Control	.7	1.5	2.7	2.2	3.3	2.1	.6	1.9	3.9	2.7	4.1	2.6
100 NPK	12.3	19.0	31.2	23.6	41.8	25.6	14.4	29.2	44.5	30.6	49.3	33.6
75 NPK + N Fix.	10.0	15.9	24.5	19.9	37.8	21.6	14.2	22.2	39.1	25.8	43.8	29.0
50 NPK + N Fix.	8.0	13.0	21.5	16.0	29.0	17.5	7.6	17.5	30.1	20.9	34.4	22.1
25 NPK + N Fix.	4.1	7.3	14.1	9.2	17.3	10.4	4.0	7.7	14.2	11.7	16.4	10.8
0 NPK + N Fix.	1.8	2.8	5.2	3.7	6.4	4.0	3.3	4.5	7.2	6.7	8.6	6.1
Mean	6.2	9.9	16.5	12.4	22.6		7.4	13.8	23.2	16.4	26.1	
LSD 5 %	A:	1.3	B:	1.4	A×B:	3.4	A:	2.5	B:	1.0	A×B:	2.5

Table 4: Continue

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Guaran yield/ fed (kg)											
Control	8	18	32	26	40	25	7	23	47	32	49	32
100 NPK	148	228	374	283	502	307	173	350	534	367	592	403
75 NPK + N Fix.	120	191	294	239	454	258	170	266	469	310	526	348
50 NPK + N Fix.	96	156	258	192	348	210	91	210	361	251	413	265
25 NPK + N Fix.	49	88	169	110	208	125	48	92	170	140	197	129
0 NPK + N Fix.	22	34	62	44	77	48	40	54	86	80	103	73
Mean	74	119	198	149	272		88	166	248	197	313	
LSD 5 %	A:	18	B:	18	A×B:	43	A:	15	B:	18	A×B:	43

Table 5: Effect of mineral NPK,N fixing bacteria and antioxidant treatments on photosynthetic pigments of guar plants during 2010 and 2011 seasons

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Chlorophyll a content (mg/ g F.W.)											
Control	1.50	1.53	1.59	1.55	1.61	1.56	1.50	1.54	1.59	1.56	1.62	1.56
100 NPK	1.76	1.87	1.94	1.89	1.96	1.88	1.77	1.87	1.95	1.89	1.97	1.89
75 NPK + N Fix.	1.75	1.87	1.94	1.90	1.96	1.88	1.76	1.87	1.94	1.90	1.96	1.89
50 NPK + N Fix.	1.62	1.77	1.80	1.78	1.83	1.76	1.62	1.77	1.81	1.78	1.84	1.76
25 NPK + N Fix.	1.59	1.62	1.67	1.64	1.67	1.64	1.59	1.62	1.67	1.65	1.68	1.64
0 NPK + N Fix.	1.51	1.57	1.61	1.59	1.64	1.58	1.52	1.57	1.61	1.60	1.64	1.59
Mean	1.62	1.71	1.76	1.73	1.78		1.63	1.71	1.76	1.73	1.79	
LSD 5 %	A:	0.02	B:	0.01	A×B:	0.02	A:	0.02	B:	0.01	A×B:	0.03
	Chlorophyll b content (mg/ g F.W.)											
Control	.89	.94	.95	.95	.99	.95	.88	.93	.95	.94	.97	.93
100 NPK	1.08	1.18	1.25	1.24	1.27	1.20	1.08	1.18	1.25	1.24	1.26	1.20
75 NPK + N Fix.	1.07	1.17	1.24	1.22	1.26	1.19	1.07	1.17	1.23	1.21	1.25	1.19
50 NPK + N Fix.	1.04	1.14	1.16	1.16	1.21	1.14	1.04	1.13	1.19	1.15	1.20	1.14
25 NPK + N Fix.	.99	1.07	1.09	1.08	1.10	1.07	.99	1.07	1.09	1.08	1.10	1.06
0 NPK + N Fix.	.91	.99	1.03	1.01	1.04	1.00	.91	.99	1.03	1.01	1.04	.99
Mean	1.00	1.07	1.12	1.11	1.15		1.00	1.08	1.12	1.10	1.14	
LSD 5 %	A:	0.01	B:	0.01	A×B:	0.02	A:	0.01	B:	0.01	A×B:	0.03
	Carotenoids content (mg/ g F.W.)											
Control	1.20	1.23	1.29	1.25	1.31	1.26	1.20	1.24	1.29	1.26	1.32	1.26
100 NPK	1.46	1.57	1.64	1.59	1.66	1.58	1.46	1.57	1.65	1.59	1.67	1.59
75 NPK + N Fix.	1.45	1.56	1.64	1.57	1.65	1.57	1.45	1.57	1.64	1.57	1.65	1.58
50 NPK + N Fix.	1.32	1.47	1.50	1.48	1.53	1.46	1.32	1.47	1.51	1.48	1.54	1.46
25 NPK + N Fix.	1.28	1.33	1.37	1.34	1.37	1.34	1.29	1.32	1.37	1.34	1.38	1.34
0 NPK + N Fix.	1.21	1.27	1.31	1.29	1.33	1.28	1.22	1.27	1.31	1.30	1.34	1.29
Mean	1.32	1.40	1.46	1.42	1.48		1.32	1.41	1.46	1.42	1.48	
LSD 5 %	A:	0.02	B:	0.02	A×B:	0.04	A:	0.01	B:	0.02	A×B:	0.04

Table 6: Effect of mineral NPK, N fixing bacteria and antioxidant treatments on N, P and K% of guar plants during 2010 and 2011 seasons

	Antioxidant treatments (ppm) B											
Fertilization Treat. A	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Herb nitrogen (%)											
Control	1.31	1.64	1.55	1.75	1.75	1.55	1.45	1.60	1.66	1.64	1.72	1.61
100 NPK	3.14	3.84	3.65	3.82	3.82	3.62	3.19	3.68	3.80	3.73	3.92	3.66
75 NPK + N Fix.	3.02	3.67	3.48	3.76	3.76	3.48	2.97	3.52	3.62	3.72	3.81	3.53
50 NPK + N Fix.	2.82	3.30	3.44	3.34	3.54	3.29	2.86	3.23	3.42	3.39	3.66	3.31
25 NPK + N Fix.	2.22	2.54	2.83	2.61	2.89	2.62	2.45	2.77	2.93	2.81	3.11	2.81
0 NPK + N Fix.	1.83	2.05	2.24	2.15	2.36	2.13	1.97	2.32	2.41	2.55	2.65	2.38
Mean	2.39	2.74	2.95	2.80	3.02		2.48	2.85	2.97	2.73	3.14	
LSD 5 %	A:	0.07	B:	0.06	A×B:	0.14	A:	0.08	B:	0.04	A×B:	0.09

Table 6: Continue

Fertilization Treat. A	Antioxidant treatments (ppm) B											
	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean	Cont.	Asc. 100	Asc. 200	Sal. 100	Sal. 200	Mean
	Herb phosphorus (%)											
Control	0.16	0.18	0.19	.19	.22	0.19	0.14	0.16	0.17	0.16	0.19	0.16
100 NPK	0.44	0.47	0.49	.48	0.49	0.47	0.41	0.44	0.47	0.47	0.48	0.45
75 NPK + N Fix.	0.42	0.45	0.47	.45	0.47	0.45	0.39	0.42	0.45	0.45	0.47	0.44
50 NPK + N Fix.	0.37	0.41	0.42	.42	0.45	0.41	0.38	0.41	0.42	0.42	0.45	0.42
25 NPK + N Fix.	0.33	0.37	0.38	.38	0.41	0.37	0.33	0.36	0.37	0.37	0.38	0.36
0 NPK + N Fix.	0.21	0.23	0.24	.25	0.26	0.24	0.18	0.21	0.24	0.23	0..25	0.22
Mean	0.32	0.35	0.37	.36	0.38		0.31	0.33	0.35	0.35	0.37	
LSD 5 %	A:	0.01	B:	0.01	A×B:	0.03	A:	0.01	B:	0.01	A×B:	0.02
	Herb potassium (%)											
Control	1.20	1.42	1.48	1.45	1.51	1.41	1.34	1.45	1.51	1.47	1.53	1.46
100 NPK	3.08	3.54	3.65	3.58	3.69	3.51	3.08	3.59	3.66	3.61	3.70	3.53
75 NPK + N Fix.	2.91	3.35	3.49	3.41	3.57	3.35	2.79	3.31	3.42	3.41	3.53	3.29
50 NPK + N Fix.	2.73	3.20	3.25	3.23	3.35	3.16	2.69	3.16	3.22	3.18	3.31	3.11
25 NPK + N Fix.	2.11	2.45	2.46	2.54	2.71	2.49	2.09	2.42	2.59	2.52	2.75	2.47
0 NPK + N Fix.	1.69	1.91	2.01	2.03	2.11	1.95	1.66	1.85	2.03	2.00	2.13	1.94
Mean	2.29	2.65	2.75	2.71	2.83		2.28	2.63	2.74	2.70	2.83	
LSD 5 %	A:	0.08	B:	0.04	A×B:	0.10	A:	0.05	B:	0.04	A×B:	0.10

six studied chemical constituents. The role of NPK mineral fertilization in promoting such chemical constituents was revealed by other works [2, 5, 6-8, 12, 13].

Regarding antioxidant treatments, both ascorbic acid and salicylic acid at 100 and 200 ppm resulted in significant increase in the three photosynthetic pigments and N, P and K % in comparison with control treatment. However, 200 ppm salicylic acid followed by 200 ppm ascorbic acid gave the highest chemical constituent values as shown in Tables 5 and 6. In agreement with these results previous studies [12, 16 -19].

The interactions between fertilization and antioxidant treatments for chlorophyll a, chlorophyll b, carotenoids, as well as, nitrogen, phosphorus and potassium percent were significant in the two seasons as illustrated in Tables 5 and 6. The best overall results were obtained due to supplying guar plants with either 100% NPK or 75% NPK plus N fixing bacteria and spraying them with either salicylic or ascorbic acid at 200 ppm.

DISCUSSION

The effectiveness of mineral NPK and/ or N fixing bacteria (*Bradyrhizobium japonicum*) in augmenting different vegetative growth characters, seed yield, guaran aspects and chemical constituents of guar plants could be explained in the light of their vital roles in plant growth and development. The superiority of mineral N, P and K fertilizers could be attributed to their unique physiological and biological roles. In the meantime, *Bradyrhizobium japonicum* as a N fixing bacteria may affect the host plant by one or more mechanism such as nitrogen fixation, production of growth promotion substances or organic acids, enhancing nutrients uptake or protection against plant pathogens [24, 25] added that such organism produced adequate amounts of IAA and cytokinins which increased the surface area per unit of root length and were responsible for hair branching with an eventual increase in the uptake of nutrients from the soil.

Concerning antioxidants, ascorbic acid occurs in all plant tissues, usually being higher in the cloroplasts, cytosol, vocuoles, mitochondria and cell wall. It protects the plants against damage resulting from aerobic metabolism and pollutants. It stimulates cell division and has significant resistant against many plant pathogens such as nematode, fungi, bacteria and parasitic plants [26]. Meanwhile, salicylic acid has direct involvement in plant growth, thermogenesis, flower induction and uptake of ions. It affects ethylene biosynthesis, stomatal movement, reverses the effect of ABA on leaf abscission, enhances the photosynthetic rate and exhibits a rapid rate of root differentiation [27].

It is obvious from the obtained data that supplying the plants with 25% NPK plus *Bradyrhizobium japonicum* in combination with ascorbic acid or salicylic acid at 200 ppm resulted in equal or better values of seed and guaran yield in comparison with the recommended NPK treatment.

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