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Evaluation of a "Natural" Fertilizer for Vegetable Production in the Lower Rio Grande Valley of Texas

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ABSTRACT

Bradfield natural fertilizer, an organically based material containing major and minor nutrients, offers potential benefits for vegetable production in South Texas. Besides water, nitrogen is usually the main factor limiting plant growth on the fertile alluvial soils of this region. A study was conducted to evaluate this product on tomatoes and bell peppers in the Lower Rio Grande Valley of Texas. In a greenhouse test where N appeared to be the primary factor limiting crop growth, Bradfield natural fertilizer gave growth responses on both tomatoes and peppers not significantly different from growth responses obtained for urea, which was applied at much higher N rates. In a fall planted field test, Bradfield natural fertilizer produced the highest tomato yields in the first picking and in total, although not significantly different than responses for urea. Responses on peppers in the field were not significantly affected by fertilizer treatments. Response to this material was observed primarily as an increase in number of fruit rather than an increase in fruit size. Bradfield natural fertilizer was applied at substantially lower rates of N than urea, indicating either that this product more efficiently met N requirements, or that benefits may have been obtained from some other beneficial property of this product other than as an N source. The Bradfield natural fertilizer, while more expensive than soluble chemical fertilizers, may justify the costs depending on the yield levels obtained, and would add substantial value if the crop produced could be certified as organically grown.

RESUMEN

El fertilizante natural Bradfield, un producto basado en material orgánico que contiene macronutrientes y micronutrientes, ofrece beneficios potenciales para la producción de vegetales en el sur de Texas. Además de agua, el nitrógeno es usualmente el principal factor limitante para el crecimiento de las plantas en los fértiles suelos aluviales de esta región. Se condujo un estudio para la evaluación de este producto en tomates y chile pimiento dulce en el Bajo Valle del Río Bravo de Texas. En un experimento en invernadero, donde el N pareció ser el principal factor limitante para el crecimiento del cultivo, el fertilizante natural Bradfield produjo una respuesta en el crecimiento de tomate y chile que no fue significativamente diferente a la respuesta de crecimiento observada con la aplicación de urea, la cual se aplicó a dosis más altas de N. En un experimento de campo plantado en otoño, el fertilizante natural Bradfield produjo las cosechas más altas de tomate en la primera colecta de frutos y en total, aunque esta respuesta no fue significativamente diferente a la observada con la urea. Las respuestas de los chiles en el campo no fueron significativamente afectados por los tratamientos fertilizantes. La respuesta a este material se manifestó primariamente como un incremento en el número de la fruta mas que como un incremento en el tamaño de esta. El fertilizante natural Bradfield se aplicó a tasas substancialmente más bajas de N que la urea indicando o que este producto cumple más eficientemente con los requerimientos de N o que los beneficios pueden haberse obtenido de otra propiedad benéfica del producto diferente a la de ser una fuente de N. Aunque el fertilizante natural Bradfield es más caro que los fertilizantes químicos solubles, su costo puede justificarse dependiendo de los niveles de las cosechas que se obtengan y podría añadir un valor substancial al cultivo si este pudiera ser certificado como cultivado orgánicamente.

Nitrogen is the primary nutrient needed to be applied for vegetable production in the Lower Rio Grande Valley of Texas. In most field situations, a single banded application of a soluble N fertilizer has been found to adequately and economically meet crop requirements and provides for maximum yields (Texas Plant Food Institute, 1982). Uptake efficiency of nutrients from such materials, however, is quite low, usually less than 50% (Wiedenfeld, 1988). The nitrogen in soluble N fertilizers is quickly transformed to the NO_3^--N form which is vulnerable to loss. Soluble N fertilizers have a high salt index, therefore high preplant rates can not be placed too close to the germinating seed without risking injury. Post-emerge sidedress applications must be placed far enough away from the plant so that the applicator shank does not injure roots. In both cases inefficient diffusion in the water is relied on to move the fertilizer nutrient to the root where it can be utilized by the plant. The potential for contamination of groundwater is high.

Bradfield natural fertilizer (Bradfield Industries, 610A E. Battlefield, #103, Springfield, MO 65807) is an organically based material, offering the potential to improve soil physical properties, enhance nutrient availability to the crop while minimizing the risk of salt injury, and reduce the risk of nutrients leaching into ground water. This product would also meet nutrient and certification requirements for organically grown produce without using traditional chemical based fertilizers. The objective of this study was to evaluate Bradfield 3-1-5 natural fertilizer on vegetable production in subtropical South Texas.

PROCEDURES

A greenhouse test and a field test were conducted in 1997-98 at the Texas A&M Research and Extension Center at Weslaco to determine the effectiveness of Bradfield 3-1-5 natural fertilizer on tomato and pepper production in the Lower Rio Grande Valley. Bradfield fertilizer is an alfalfa based material blended with animal protein, potash, molasses, corn steep and bacteria; contains Ca, S, Mg, micronutrients B, Mn, Fe, Cu and Zn; and is 75% organic matter. Six treatments were used for both tests: application of Bradfield natural fertilizer (3-1-5) at rates of 2.4, 4.9 or 9.8 kg • 100 m^{-2}; urea (46-0-0) at rates of 1.5 or 2.9 kg • 100 m-2; and an unfertilized check. Equivalent rates in english units as well as in units of N applied are given in Table 1.

Table 1. Rate of each product applied in the treatments used in this study in terms of fertilizer and units of N, and in metric and english units

product	rate			
	fertilizer		N	
	kg • $100m^{-2}$	lbs • $1000ft^{-2}$	kg • ha^{-1}	lbs • ac^{-1}
check	0	0	0	0
Bradfield	2.4	5	7.3	6.5
3-1-5	4.9	10	14.6	13
	9.8	20	29.3	26
urea	1.5	3	67	60
46-0-0	2.9	6	134	120

The greenhouse test was conducted using field soil taken from the surface “A” horizon of a Raymondville clay loam soil (32-42% clay, 1-3% organic matter) obtained from the same location where the field test was grown. Plants were grown in “1 gallon” (3.8 l) pots and received the appropriate amount of fertilizer based on volumetric conversion from field to greenhouse rates assuming broadcast application and incorporation to a depth of 15 cm. Treatments were replicated 8 times with one pot representing a plot, and were arranged in a randomized block design for each crop. Peppers (*Capsicum annum* cv. Jupiter) and tomatoes (*Lycopersicon esculentum* cv. Floradade) were direct seeded on 24 Apr 97 by planting 3 seeds per pot, and later hand thinning to a single plant. Plants were watered automatically each day using an overhead mist sprinkler system. Pesticide applications were made for control of insect pests as needed. Measurements were taken on several dates on plant height and leaf greenness content. Greenness measurements were taken with a Minolta SPAD-502 chlorophyll meter. At the end of the greenhouse study, total leaf area was determined using a LI-COR LI-3100 area meter; and plants were separated into leaves, stems and roots; then dried and weighed.

At the site of the field test, soil samples were taken by sampling at 0-30 cm in depth at randomly selected spots throughout each block and mixing, to create 6 composite soil samples. These samples were analyzed by the Texas A&M University Extension Soil Testing Laboratory for NO_3^--N, P, K, Ca, Mg, Na, S, salinity and pH.

The field test was set up with treatments arranged in a randomized complete block design with 4 replications for each crop. The tomatoes and bell pepper plots consisted of 6 rows on 1.02 m centers by 7.6 m in length separated by 1.5 m alleys. Water was applied by subsurface drip irrigation.

Fertilizer treatments were applied on 10 Jul 97; the Bradfield 3-1-5 was banded 2.5 cm below the seed row, and

Table 2. Plant heights on several dates in the greenhouse test for tomatoes and peppers reveiving Bradfield 3-1-5 fertilizer or urea at different rates.

Crop	Product	Rate	Date			
			26 Jun	15 Jul	21 Jul	28 Jul
		kg • $100m^{-2}$	cm			
tomatoes	check	0	38.4 c[z]	58.0 b	61.3 c	70.6 c
	Bradfield	2.4	42.1 bc	62.8 b	68.3 bc	77.4 bc
	3-1-5	4.9	49.8ab	72.0a	76.1ab	81.9ab
		9.8	51.5ab	76.0a	78.6a	86.8a
	46-0-0	1.5	53.4a	74.6a	79.1a	87.0a
		2.9	48.3ab	72.1a	78.1a	88.9a
peppers	check	0	13.0ab	18.3 b	18.3 b	19.1 b
	Bradfield	2.4	11.7 b	18.0 b	17.9 b	18.4 b
	3-1-5	4.9	14.9ab	20.9ab	20.9ab	21.0ab
		9.8	15.1ab	20.8ab	21.1ab	21.6ab
	46-0-0	1.5	13.6ab	20.1ab	20.3ab	21.1ab
		2.9	16.6a	24.1a	24.0a	24.4a

[z]Means in each column for each crop followed by the same letter are not significantly different.

Table 3. Leaf greenness on several dates in the greenhouse test for tomatoes and peppers receiving Bradfield 3-1-5 fertilizer or urea at different rates.

Crop	Product	Rate	Date				
			18 Jun	26 Jun	15 Jul	21 Jul	28 Jul
		kg • 100m^{-2}	SPAD[z] units				
tomatoes	check	0	33.3 bc[y]	32.4 b	33.9	32.9 b	31.9 c
	Bradfield	2.4	37.3abc	35.0ab	38.0	37.1a	33.5ab
	3-1-5	4.9	31.9 c	37.2a	36.8	37.1a	31.9 b
		9.8	38.5ab	36.1ab	36.9	35.0ab	32.5 b
	46-0-0	1.5	39.3ab	37.0a	35.3	37.3a	33.8ab
		2.9	41.2a	38.0a	38.2	37.7a	35.8a
peppers	check	0	33.0	33.0	34.7	32.1	33.9
	Bradfield	2.4	35.9	33.0	33.7	33.5	32.5
	3-1-5	4.9	35.0	36.6	32.7	31.1	30.8
		9.8	34.7	33.9	33.0	32.9	31.8
	46-0-0	1.5	35.3	35.0	36.3	34.9	33.2
		2.9	35.1	35.4	37.2	36.5	34.3

[z]Greenness measurements were made with a Minolta SPAD-502 chlorophyll meter which gives readings in relative “SPAD” units.
[y]Means in each column for each crop followed by the same letter are not significantly different. Where no letters follow, differences were not statistically significant.

Table 4. Leaf area, leaf and stem weights and root weights in the greenhouse test for tomatoes and peppers receiving Bradfield 3-1-5 fertilizer of urea at different rates.

Crop	Product	Rate	leaf area	leaves & stems	roots
		kg • 100m^{-2}	cm^2	gms	
tomatoes	check	0	180 c[z]	1.99 c	0.41 bc
	Bradfield	2.4	189 c	1.97 c	0.30 c
	3-1-5	4.9	214 bc	2.97 b	0.63 bc
		9.8	230 bc	3.22 b	0.55 bc
	46-0-0	1.5	267 b	3.69ab	1.06a
		2.9	343a	4.50a	0.76ab
peppers	check	0	172 b	0.94 b	0.76
	Bradfield	2.4	179 b	0.87 b	0.66
	3-1-5	4.9	188 b	1.05ab	0.71
		9.8	222ab	1.28ab	0.86
	46-0-0	1.5	220ab	1.11ab	0.70
		2.9	284a	1.56a	0.86

[z]Means in each column for each crop followed by the same letter are not significantly different. Where no letters follow, differences were not statistically significant.

the urea was banded 15 cm below and to the side of the plant row. Seedlings were started in the greenhouse on 14 Aug in speedling trays; and were transplanted to the field on 18 Sep. Peppers were planted in 2 rows per bed spaced 56 cm apart and with 25 cm in-row spacing, and tomatoes were planted single row and were spaced 76 cm apart.

Yields of tomatoes and peppers were determined by picking mature fruit on several dates. Two 7.6 m rows were picked in each plot, and total fruit number and weight were determined.

All data were analyzed statistically using analysis of variance, and mean comparisons were made using Duncan’s multiple range test at a 5% significance level.

Table 5. Average of analyses of soil samples take 3 July 1997 prior to planting the field study. All measurements except pH are in parts per million (ppm).

Parameter	Level	Rating
NO_3^--N	18	very low
P	200	very high
K	510	very high
Ca	27701	very high
Mg	540	high
Na	141	low
S	276	high
salinity	373	no hazard
pH	8.0	mildly alkaline

Table 6. Tomato fruit counts, total weight, and fruit size in the field test on different picking dates, and total or average for all pickings.

Product	Rate	Date 13 Jan	26 Jan	4 Feb	10 Feb	17 Feb	23 Feb	Season Total
	kg•100m^{-2}				Fruit count (# • 100m^{-2})			
check	0	23 b[z]	31	68	170	389	418 bc	1098 b
Bradfield	2.4	55ab	39	71	220	399	304 c	1087 b
3-1-5	4.9	99a	36	103	237	421	615ab	1511ab
	9.8	71ab	36	84	189	483	691a	1553a
46-0-0	1.5	23 b	39	77	226	337	515ab	1217ab
	2.9	44ab	40	76	192	429	501abc	1282ab
					Fruit weight (Mg • ha^{-1})			
check	0	.37 b	.41	.82	2.18	5.83	4.94	14.55 bc
Bradfield	2.4	.78ab	.53	.72	2.74	5.13	3.66 d	13.55 c
3-1-5	4.9	1.73a	.48	1.41	2.83	5.96	7.43ab	19.83a
	9.8	1.23ab	.48	1.13	2.18	6.24	8.03a	19.29ab
46-0-0	1.5	.43 b	.56	.86	2.67	4.91	5.82 bc	15.23abc
	2.9	.63 b	.57	1.06	2.70	6.02	5.54 bcd	16.51abc
					Fruit size (kg)			
check	0	.129	.145	.115	.133	.152	.120	0.132
Bradfield	2.4	.143	.134	.095	.127	.131	.12	0.127
3-1-5	4.9	.170	.137	.137	.122	.147	.122	0.132
	9.8	.172	.137	.116	.117	.131	.117	0.125
46-0-0	1.5	.183	.143	.119	.116	.147	.113	0.126
	2.9	.149	.144	.142	.136	.140	.112	0.129

[z]Means in each column for each parameter followed by the same letter are not significantly different. Where no letters follow, differences were not statistically significant.

Table 7. Pepper fruit counts, total weight, and fruit size in the field test on different picking dates, and total or average for all pickings.

Product	Rate	Date 5 Jan	13 Jan	26 Jan	4 Feb	Season Total
	kg • 100m^{-2}			Fruit count (# • 100m^{-2})		
check	0	171[z]	247	216	61	696
Bradfield	2.4	275	270	229	45	819
3-1-5	4.9	308	321	252	60	941
	9.8	318	341	189	52	899
46-0-0	1.5	268	283	266	66	869
	2.9	207	268	268	48	791
				Fruit weight (Mg • ha^{-1})		
check	0	2.21	2.08	1.38	.34	6.01
Bradfield	2.4	4.03	2.62	1.54	.22	8.41
3-1-5	4.9	4.44	3.31	1.99	.37	10.11
	9.8	4.64	3.35	1.49	.29	9.78
46-0-0	1.5	3.67	3.32	2.18	.42	9.60
	2.9	3.14	2.83	2.04	.28	8.28
				Fruit size (kg)		
check	0	.120	.086	.059 b	.052	.082
Bradfield	2.4	.138	.099	.066ab	.049	.098
3-1-5	4.9	.145	.103	.081a	.057	.107
	9.8	.141	.099	.075ab	.059	.106
46-0-0	1.5	.140	.109	.081a	.063	.106
	2.9	.141	.094	.075ab	.075	.096

[z]Means in each column for each crop followed by the same letter are not significantly different. Where no letters follow, differences were not statistically significant.

Table 8. Crop yield, crop value, fertilizer cost, net return to fertilizer and per dollar of fertilizer invested for tomatoes and peppers.

		crop			net return	
Product	Rate	yield	value[z]	fertilizer cost	to fertilizer	per $ of fertilizer
	kg • 100m-[2]	Mg • ha^{-1}	$ • ha^{-1}	$ • ha^{-1}	$ • ha^{-1}	$
				tomatoes		
check	0	14.6	12,300	0		
Bradfield	240	13.6	11,460	95	–	–
3-1-5	490	19.8	16,680	194	4,380	22.58
	980	19.3	16,260	387	3,960	10.23
46-0-0	150	15.2	12,810	34	510	15.06
	290	16.5	13,900	65	1.600	24.44
				peppers		
check	0	6.0	4,240	0		
Bradfield	240	8.4	5,940	95	1,700	17.89
3-1-5	490	10.1	7,140	194	2,900	14.95
	980	9.8	6,930	387	2,690	6.95
46-0-0	150	9.6	6,790	34	2,550	75.29
	290	8.3	5,870	65	1,630	24.90

[z]Crop value was determined using 1997 average price to growers as reported by the National Agricultural Statistics Services, USDA (tomatoes - $38.25, peppers - $32.10 per cwt).

RESULTS & DISCUSSION

In the greenhouse experiment, plant heights of both crops increased with increasing rate of Bradfield 3-1-5 and urea on all measurement dates (Table 2). Height responses to urea application tended to be slightly larger than for Bradfield 3-1-5, but differences between the fertilizers were not statistically significant. Tomato leaf greenness, or SPAD units, showed similar responses, increasing with increasing rate of both fertilizers applied on most dates (Table 3). Pepper leaf greenness in the greenhouse test was not affected by fertilizer treatments. Both tomato and pepper leaf area and leaf, stem and root weights also increased with increasing rate of both fertilizer materials (Table 4).

Analysis of soil samples taken prior to fertilizer application and planting of the field test indicated that the site had very low inorganic N levels, good levels of the other plant nutrients, alkaline pH, and essentially no risk due to high salt levels (Table 5). This is typical of the condition for most soils in the Lower Rio Grande Valley of Texas.

Tomato yields showed an increase in the number of fruit and total weight of fruit with fertilizer application in the 1st picking, the last picking (the “cleanup” harvest when all remaining fruit was picked), and in the total for all harvests (Table 6). Highest fruit count and total weight in the 1st picking was for the Bradfield 3-1-5 at the 4.9 kg • 100 m^{-2} rate, although values for this treatment were not significantly different from several other treatments. Highest numeric total fruit counts and total weights were associated with the Bradfield 3-1-5 at the 4.9 and 9.6 kg • 100 m^{-2} rates, although again these were not significantly different from other treatments. Tomato fruit size showed no statistically significant differences due to fertilizer treatments on any harvest date, or when averaged over all harvest dates.

Pepper yields seemed to show similar trends in responses to N fertilizer application, but differences in fruit count or fruit weight due to fertilizer treatment were not statistically significant (Table 7). On one harvest date, 26 Jan, larger peppers were produced by the Bradfield 3-1-5 at the 4.9 kg • 100 m^{-2} rates and by urea at the 1.5 kg • 100 m^{-2} rates than for the unfertilized check. No other significant effects of fertilizer treatments on pepper size were found on any date, or averaged across dates.

CONCLUSIONS

In the greenhouse test, the various growth responses to the fertilizer treatments were greatest for urea, an N source only, indicating that a primary deficiency being met was for N. A similar conclusion has been suggested by most previous fertilizer studies conducted in this region (Texas Plant Food Institute, 1982). Growth responses in the greenhouse to Bradfield 3-1-5 were almost as great, and in most cases not significantly different from responses to urea, even though highest Bradfield 3-1-5 rates contained only 22% of the total amount of N as the highest urea rate.

In the field test the Bradfield 3-1-5 produced the highest tomato yield responses primarily by producing a greater number of fruit rather than larger size fruit. Yield increases due to the Bradfield 3-1-5, though larger, were not significantly different from yield increases due to urea application. These high yield responses, however, were again being produced at a much lower rate of N application, indicating that yield responses were being obtained from some other beneficial aspect of the Bradfield 3-1-5, or that the Bradfield natural fertilizer was more effectively meeting the N needs of the crop. Bell peppers yield responses to the fertilizer treatments showed a similar trend, but differences were not statistically significant.

Considerable skepticism usually meets new products intended to improve plant nutrition until benefits can be objectively demonstrated (McFarland et al. 1998). In this case, comparable yields at substantially lower application rates should result in several significant benefits. Similar growth and yield responses at lower N application rates results in substantially increased uptake efficiency of the applied N. This increased uptake of applied nutrients would in turn lead to reduced risk of contamination of ground and drainage waters by residual fertilizer nutrients.

The Bradfield fertilizer is considerably more expensive to apply than urea (Table 8), but the benefits may or may not justify the cost. Using the yield data obtained in this study, the following economic analysis was conducted. Yields and returns will vary considerably depending on growing and market conditions. The high rate of urea used in this study, which is the recommended level based on past fertilization studies in this region, on a hectare basis costs about $65 and increased returns on average about $1600 for both crops. Based on the results of this study, the recommended rate of Bradfield 3-1-5 would be 4.9 kg • 100 m^{-2} (10 lbs • 1000 ft^{-2}), which per hectare costs $194 while increasing returns around $3600, assuming the same commercial markets. Variability in the yield data mean that the increased returns associated with the Bradfield 3-1-5 were only achieved in this particular study and may not be consistently obtained in other situations, since yield differences between urea and Bradfield 3-1-5 were not statistically significant. This economic analysis therefore illustrates only the possible benefit that could potentially be obtained, not what is to be expected. If the produce grown using the Bradfield 3-1-5 were certified as organically grown, then it could be sold for a considerably higher price and would substantially increase returns regardless of the yield levels obtained.

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