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Contents

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Soybean Inoculation In Louisiana

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The question of whether or not to inoculate soybean seeds prior to planting has plagued both growers and researchers in recent years. Several reports in the scientific literature (Johnson et al., 1965; Caldwell and Vest, 1970; Ham et al., 1971; Boonkerd et al., 1978) have indicated very low recovery of the inoculant-bacteria from soybean nodules. Weaver and Fredericks (1974a) found that when soybeans were grown in Iowa soils containing 1,000 or more *Rhizobium japonicum* per gram, the roots were not likely to be extensively nodulated by the inoculant rhizobia when it was applied at normal rates of less than 10,000 rhizobia per seed. In a companion study (1974b), they predicted that if the inoculant-rhizobia were to form 50 percent of the nodules, an inoculation rate of at least 1,000 times the soil population per gram would have to be used. At the same time, Kvien et al. (1978) noted in greenhouse and field experiments that both nitrogen fixation and seed yield could be increased through proper *Rhizobium* strain selection. Researchers in Arkansas (Wolf and Nester, 1980) have reaffirmed that use of a good inoculant may be necessary when soybeans are grown in fields where the nodulating rhizobia are not present. However, most researchers in the South are of the opinion that if soybeans were well nodulated in one growing season, they will be nodulated in that same field in subsequent years. Some recommend inoculation every 4 to 5 years.

When one sifts through the conflicting reports, it is apparent that this lack of general agreement would not lend itself well to making an inoculation recommendation to Louisiana soybean growers. Inoculation problems in Louisiana are unique to the state and cannot be solved by research reports from states in the Midwest or even other southern states. For this reason a study was initiated in the Department of Agronomy of the Louisiana Agricultural Experiment Station in 1979 to investigate the effects of inoculation of seed on nitrogen fixation and seed yield of

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soybeans. Four year's outfield data were gathered from cooperating Louisiana farmers located throughout the state. Tests were conducted on both first-year soybean land and in fields previously cropped to soybeans.

Test Procedures

In 1979, a letter was sent to most Louisiana Cooperative Extension Service parish agents located in the soybean growing areas of Louisiana asking them to aid in locating farmers who would cooperate in a soybean inoculation test. Eighteen growers in 15 parishes agreed to cooperate. In 1980, 10 outfield tests were planned but only four were successfully carried to completion. In 1981, 13 tests were conducted at nine outfield locations. In 1982, three test sites were used. These test areas are shown in Figure 1.

All participating growers agreed to plant both inoculated and uninoculated soybean seed within one field. Almost all of the participants already used an inoculation program so the usual procedure was to plant several planter box widths of uninoculated seed when first beginning to plant the test field. This usually varied from 12 rows to 50 or more rows of uninoculated seed. Usually it consisted of one planter box (several bushels) of seed. These strips extended the entire distance of the field regardless of length. Once the uninoculated seed were planted, the hopper box was filled with inoculated seed of the same cultivar and planting was resumed. The dividing row was plainly marked for future reference. In one exception, one grower indicated he was not going to inoculate his seed. Inoculum was provided to him and he reversed the previous procedure, first inoculating and then continuing with uninoculated seed. No attempts were made to influence the growers with respect to brand or type of inoculant used. All inoculants were applied by the farmer and all subsequent management practices were carried out by him according to his own plans.

In 1979, nodulation and nitrogen fixation were checked once at all locations. This was done as close to flowering as possible. In 1980, 1981, and 1982, these tests were conducted twice at each location, once at flowering and again at early pod fill. Ten plant samples were carefully excavated within a large area of both inoculated and uninoculated areas. Large distances were maintained between the two sampling areas. Sampling was never conducted on the several outside rows so as not to encounter border effects. Nitrogen fixation rates were determined by the Acetylene Reduction technique right in the field (Hardy et al., 1968). This is a test in which acetylene (C_2H_2) is preferentially fixed to ethylene (C_2H_4) by the nitrogen-fixing system of the plant. Although it is not possible to express these values as nitrogen fixed without the use of a second test ($^{15}N_2$ reduction), it is a valuable tool to compare rates of

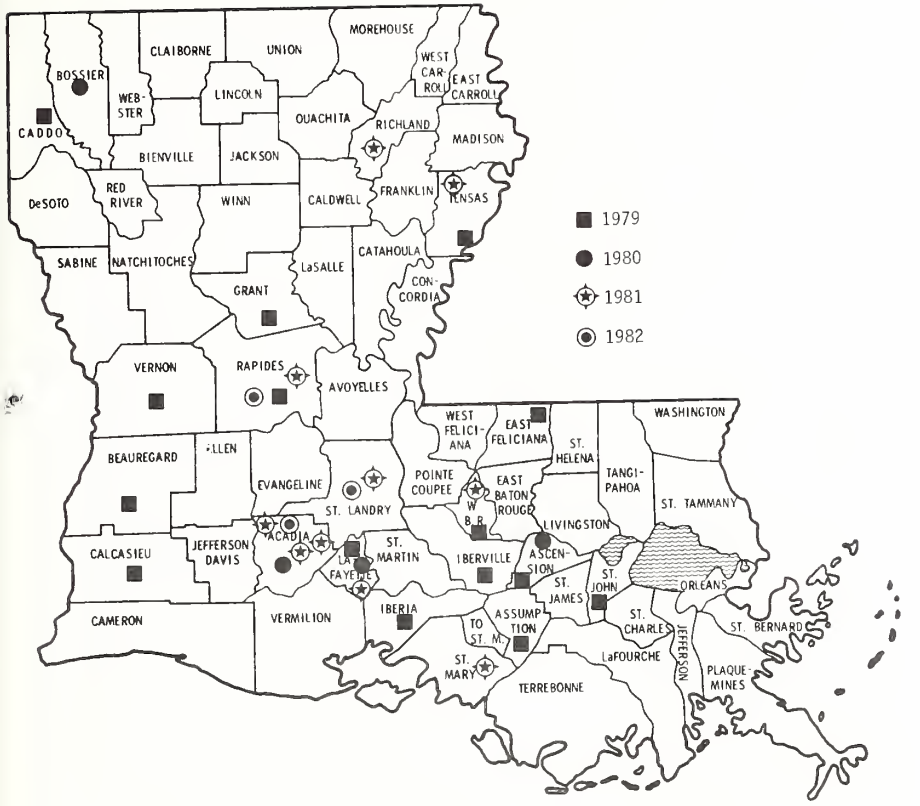

Fig. 1.—Location of soybean inoculation trials, 1979-82.

fixation between treatments. The roots were removed to the laboratory and nodule numbers and nodule dry weight were determined. Ethylene was determined with a Perkin-Elmer gas chromatograph. Rates of reduction were then calculated from these data.

Seed yields were obtained when the farmer was ready to harvest the test field. Just prior to harvesting, 10 yield strips were measured out within the center of each test area and marked with brightly colored flags. In most instances, each yield strip was 25 feet in length. In a few tests, 50-foot harvest strips were used. These lengths were dictated by the number of rows that the farmer's combine would accommodate. When more than four rows were harvested, it was difficult to hold the test sack in place for more than 25 feet. The actual harvesting was performed by two people located inside the combine box. The combine was run through 50 to 100 yards of row to allow a full flow of seed into the catch box. One person then indicated the start and finish of each test strip while the other held a large sack under the delivery tube of the

combine. Strips were left between each yield strip to allow for switching to the next sack. Seeds continued to enter the box during this time as harvesting was still continuing on the test rows.

Seed weights were taken immediately in the field. All seeds, with the exception of a small moisture sample, were then left in the combine. Yields were determined at 13 percent moisture content. All data pertaining to nodulation and nitrogen fixation were analyzed by a completely randomized design for each farmer's field. For data analysis, the SAS analysis of variance program was used and computations were done through the Systems Network Computer Center at LSU. Yield data were handled by a more restrictive test. Yield values for new and previously cropped soybean land were compared using an analysis of variance for a randomized block design with fields as blocks. An estimate of error variance was calculated. Using this value, yield differences from individual fields were tested for significance and confidence intervals for mean yield differences were obtained.

All soil properties were determined by the LSU Soil Testing Laboratory.

Results

Test sites for the 3-year soybean inoculation study are shown in Figure 1. Although some growers cooperated in more than 1 year, no two tests were ever conducted on the same field. The locations indicate that, during the 3-year period, tests were conducted in most of the soybean growing areas of the state.

A complete list of all of the cooperators, arranged alphabetically by parish, is shown in Table 1. Data on the brand of inoculant, soybean seed variety, and row spacings employed in the tests, plus some soil chemical and physical properties, are also listed. Each location is also classified by whether or not it had a previous history of soybean growth. These data indicate that the tests encompassed diverse choices within each column of the table. Two different types of seed inoculant were employed. One was a peat-base inoculant, i.e. Nitragin or Rudy Patrick, while the second type was an oily liquid, Setre or Kalo's Triple Noctin. Forrest was the most popular choice of seed varieties and it was used at 13 of the locations during the 3-year period. Davis was used as the test variety at five locations, while Bragg, Ransom, and the Terra Vigs were each used at four different sites. Centennial and Tracy were the choices at three locations, and Bossier, DPL 345 and 506, Hood, Lee, and SRF 450 were each used at one location.

Row spacings varied from broadcast and closely drilled rows to the more standard 30- to 40-inch row spacings.

One objective of the study was to determine the response of seed inoculation on land that had no previous history of soybean growth (new

soybean land). This would be the land that would be most likely to have no indigenous populations of *Rhizobium japonicum* and therefore would be most apt to respond to seed inoculation with the nodulating bacteria. Seventeen of the tests were put on land planted to soybeans for the first time, while 26 of the sites had a previous history of soybean growth.

Soil texture varied from light-textured soil, very fine sandy loam (vfsl), to heavy clay (c) soils. Most of the tests were on medium-textured, silt loam (sil) soils to heavy textured, silty clay loam (sicl) or clay (c) soils.

The pH values encountered ranged from 5.0 to 7.6. Most soil pH values were in the pH 6 to 7 range. This is a desirable pH range with respect to nodulation and growth of soybeans. Alexander (1977) indicated that rhizobial infection of leguminous root systems is adversely affected by pH values below 5.0. None of the pH values for the test soils fell below this value, although two locations did have pH values of 5.0.

Organic matter percent varied from 0.39 percent to 4.14 percent. The maximum value was considered unusually high for Louisiana soils and most of the locations had organic matter contents in the range of 1 percent to 2 percent.

Phosphorus values varied from 10 to 277 parts per million (ppm), potassium ranged from 30 to 473 ppm, and calcium and magnesium values ranged from low values of 261 and 32 ppm, respectively, to in excess of the test limits, 4,000 and 1,000 ppm, respectively.

Nodulation and N_2 fixation values, measured in terms of reduced acetylene, are summarized in Table 2. The acetylene reduction technique is an accepted standard method used to measure rates of N_2 fixation. When nitrogen is fixed by a soybean plant, N_2 reacts with H_2 within the nodule and NH_3 and then amino acids are quickly formed:

$$N_2 + 3H_2 \xrightarrow[\text{soybean roots}]{\text{nodulated}} NH_3 \longrightarrow \text{amino acids.}$$

It is very difficult to test this rate of fixation in the field. However, it is quite easy to shut this system off with acetylene. The plant can then reduce this acetylene to ethylene, which can be measured easily in the field.

$$HC{\equiv}CH + H_2 \xrightarrow[\text{soybean roots}]{\text{nodulated}} H_2C{=}CH_2$$

Although the rates of ethylene to reduced nitrogen usually are not found to be in a 3:1 ratio as it would appear from the equations, the test still allows quantitative comparisons to be made between different treatments.

Table 1. — Summary of locations, growers, and physical and chemical properties of soils used in soybean inoculation tests, 1979-82

Parish	Nearest town	Caaperating grawer	Inaculent brand	Seed variety	Raw spacing (inches)	New saybean land	Soil texture	pH	Organic matter (%)	Sail chemical analysis P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
				1979									
Ascensian	Burnside	J. & R. Rabert	Setre	Bragg	36	Yes	vfsl	5.6	1.54	236	164	3227	682
Assumptian	Napaleanville	R. Landry	Setre	Lee 74	36	Yes	sicl	6.0	1.59	159	95	3131	651
Beauregard	Dry Creek	M. & D. Farmer	Rudy Patrick	Davis	30	Na	c	5.8	4.14	58	302	4000+	1000+
Beauregard	Langville	S. Jacabsan	Rudy Patrick	Ransam	32	Na	vfsl	6.0	1.88	45	68	622	129
Cadda	Shrevepart	K. Bell	Setre	Forrest	38	Yes	sicl	7.6	1.97	268	444	4000+	853
Calcasieu	Lake Charles	L. & D. Haffpauir	Rudy Patrick	Terra Vig	30	Yes	sil	5.8	2.55	37	157	813	170
E. Feliciana	Clintan	J. Freeman	Nitragin Kala	Bragg	14	Yes	sl	6.4	1.25	44	59	552	75
E. Feliciana	Clintan	L. Harvey	Triple Nactin	Farrest	32	Na	sil	5.5	1.47	59	94	456	62
E. Feliciana	Clintan	S. Guttzeit	Nitragin	Farrest	7	Yes	sil	6.9	2.64	10	123	1183	322
Grant	Calfax	G. Randalph	Nitragin Kala	Ransam	36	Na	sil	6.5	0.39	160	86	682	186
Iberia	New Iberia	A. Guillatte	Triple Nactin	Farrest	36	Na	sil	5.0	2.12	16	125	703	221
Iberville	Plaquemine	D. Purpera	Nitragin	Farrest	38	Yes	sil	6.9	2.84	277	140	2667	598
Lafayette	Yaungsville	D. Viatar	Nitragin	Farrest	35	Yes	sil	6.2	1.20	25	47	1152	146
Rapides 1	Cheneyville	W. Ballich	Rudy Patrick	Davis	40	Na	c	6.0	2.31	110	257	3331	950
Rapides 2	Cheneyville	W. Bollich	Rudy Patrick	Terra Vig	40	Na	c	6.4	2.40	116	387	4000+	1000+
Rapides 3	Cheneyville	W. Ballich	Rudy Patrick	Tracy	40	No	c	7.0	2.31	123	345	4000+	1000+
Rapides 5[1]	Cheneyville	W. Ballich	Rudy Patrick	Centennial	40	Na	c	7.6	1.40	146	299	4000+	871
St. Jahn Baptist	Edgard	S. Radrique	Nitragin	Farrest	30	Yes	sicl	7.5	1.15	217	111	3791	671
St. Jahn Boptist	Edgard	S. Radrique	Nitragin	Farrest	30	Yes	sicl	7.6	1.30	204	53	1943	432
Tensas	St. Jaseph	W. Butler	Setre	Davis	10	Yes	c	5.0	1.68	15	49	261	54
Vernan	Leesville	C. Baley	Rudy Patrick	Farrest	10	Yes	sl	6.7	0.58	29	30	350	32
W. Batan Rauge	Part Allen	C. & N. Arnald	Setre	SRF 450[2]	36	Yes	sil	6.5	0.96	172	83	2386	527
				1980									
Acadia	Rayne	G. Zaunbrecher	Rudy Patrick Kala	Ransam	32	Na	sil	6.1	0.63	35	75	874	849
Ascensian	Danaldsanville	J. & R. Rabert	Triple Nactin	Bragg	36	Na	c	6.4	2.02	23	54	1339	524
Bossier	Bassier City	J. Rabinsan	Rudy Patrick	Bassier	30	Na	sil	6.1	0.63	257	467	4000+	1000+
Lafayette	Yaungsville	D. Viatar	Nitragin	Haad 75	35	Na	sil	6.4	0.96	17	75	1012	59

(Continued)

Table 1. — (Continued)

Parish	Nearest tawn	Caaperating grawer	Inaculent brand	Seed variety	Raw spacing (inches)	New saybean land	Sail texture	pH	Organic matter (%)	Sail chemical analysis P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
				1981									
Acadia	Dusan	G. Zaunbrecher (1)	Rudy Patrick	Ransam	32	Na	sicl	5.8	0.78	98	107	1587	440
Acadia	lata	W. Garber (1)	Nitragin	Davis	30	Na	sil	6.3	1.15	120	46	999	144
Acadia	lata	W. Garber (2)	Nitragin	Davis	30	Na	sil	6.4	1.15	199	248	821	88
Acadia	Rayne	G. Zaunbrecher (2)	Rudy Patrick	Centennial	32	Yes	c	6.1	1.28	29	92	1621	570
Lafayette	Yaungsville	D. Viatar	Nitragin	Farrest	35	Na	sil	5.2	1.28	241	397	4000+	818
Rapides	Cheneyville	W. Ballich	Nitragin	Tracy	30	Na	c	7.0	1.04	47	86	717	76
Rapides	Cheneyville	W. Ballich	Nitragin	Terra Vig 606	30	Na	c	6.7	0.96	141	473	4000+	1000+
Rapides	Cheneyville	W. Ballich	Nitragin	Terra Vig 708	30	Na	c	7.2	1.28	141	401	3997	1000+
Richland	New Light	T. Herringtan	Nitragin	DPL 506	38	Na	c	7.1	1.41	208	405	4000+	1000+
St. Landry	Melville	J. Artall	Rudy Patrick	Farrest	36	Yes	c	7.4	1.41	253	237	3792	763
St. Landry	Palmetta	G. Hubbard	Nitragin	Centennial	B.C.[3]	Na	c	6.8	1.91	151	408	4000+	790
St. Mary	Franklin	B. Allain	Nitragin	Bragg	34	Yes	c	6.6	1.91	69	169	3735	759
W. Batan Rauge	Part Allen	C. Wilkinson	Nitragin	Farrest	36	Na	c	6.3	0.78	256	281	2979	611
				1982									
Acadia	Rayne	G.& F. Zaunbrecher	Rudy Patrick	DPL 345	32	Na	sicl	5.8	2.40	38	128	2242	653
Rapides	Cheneyville	W. Ballich	Nitragin	Tracy	30	Na	c	—[4]	—	—	—	—	—
St. Landry	Melville	J. Artall	Nitragin	Farrest	36	Yes	sicl	7.3	1.74	181	232	3992	672

[1]Field number 4 was nat sample; hawever, yield data was gathered. It was nat new saybean land.

[2]SRF 450 is a Graup IV maturity graup variety and was used in attempt ta daublecrap saybeans and sugarcane.

[3]B.C. — Broadcast.

[4]Na sail sample taken in 1982.

Data in Table 2 summarize nodulation, i.e. nodule number and dry weight, and nitrogen (C_2H_2) fixing abilities of the plants, plus seed yield for the entire period. The first row (YES) of values for each location gives the average values found on the plants grown from inoculated seed, while the second row (NO) values are the data from plants grown from uninoculated seed. These data summarize the results gathered from 43 separate tests. In a few instances, one grower provided two or more different fields in a single year and several growers cooperated for 2 or more years, but no two tests were ever planted on the same field during the 4 years of the experiment. Occasionally something interfered with gathering either nodulation and nitrogen-fixing data, or yield data, but never were both parameters lost from any of the test locations.

No statistically significant differences in any of the six parameters were noted at 22 of the 43 fields during the 4 years of the test. These fields comprised 51 percent of the total population. Statistical differences, both increases and decreases, were therefore detected in at least one parameter during the growing season at 49 percent of the locations.

Summarizing the statistical data for nodulation (nodule number and nodule dry weight) indicated five statistical decreases in nodule number with no increases in 1979. One location had a significant increase in nodule weight, while two had significant decreases. In 1980, two significant increases occurred in nodule weight with one decrease in nodule number. Three statistically significant increases occurred in nodule number and in dry weight in 1981 while one significant decrease in each parameter also occurred. In 1982, there was one significant decrease in nodule number.

Nitrogen (C_2H_2) fixation parameters in 1979 indicated significantly higher values for C_2H_4 produced per nodule at two locations with one corresponding decrease. Five C_2H_4 values per plant and three per gram of nodule were lowered significantly by the inoculation treatments. In 1980, one value was significantly lower than the inoculated value. This was the value of C_2H_4 produced per nodule at the Acadia location. In 1981, results were split almost evenly with two significant increases and two decreases in C_2H_4 produced per plant and per gram of nodule, and two increases versus three decreases with respect to C_2H_4 produced per nodule. Significant decreases were noted at one location (St. Landry) for all three values in 1982.

Seed yields were analyzed to test for differences of inoculated versus uninoculated soybeans and to estimate the magnitude of seed yield differences. Separate analyses were also conducted on previously cropped soybean land and on new, first-year bean land. Results of these analyses indicated that inoculated test areas yielded significantly higher ($P < .05$) than uninoculated areas. The average yield difference was 1.9 bushels per acre. Confidence limits (95 percent) for the average yield increases were 0.3 to 3.4 bushels per acre.

Table 2. — Nodulation and nitrogen fixation parameters and seed yield of soybeans grown with and without seed inoculation, 1979-82

Porish/grower	Sampling date	Inoculotion	Nadules		μMC_2H_4 Produced per hour per:			Seed yield (bu/o)
			No.	Dry wt. (mg)	Plont	Nadule	g nadule	
				1979				
Ascension	8/5	Yes	27	225	2.22	0.0871	9.58	35.4
J. & R. Robert		No	43	211	2.14	0.5979	10.98	36.2
Assumption	7/31	Yes	169	638	1.86	0.0127	2.65	24.9
R. Londry		Na	160	516	2.24	0.0104	4.08	22.9
Beouregard	8/21	Yes	27	190	0.13	0.0047*	2.19	34.9
M. & D. Farmer		No	26	167	0.06	0.0018	2.58	42.1*
Beouregard	8/21	Yes	32	124	1.19	0.0383	0.10	—
S. Jacobsan		No	48*	185*	1.97	0.0444	0.11	—
Codda	8/29	Yes	26	96	4.49	0.2451	62.29	—
K. Bell		Na	21	61	22.03	2.0874	56.51	—
Calcasieu[1]	8/21	Yes	—	—	—	—	—	32.2
L. & D. Hoffpauir		No	—	—	—	—	—	34.9
E. Feliciana	9/6	Yes	38	336	0.36	0.0061	3.76	—
J. Freemon		No	96*	242	1.60*	0.0167*	23.05	—
E. Feliciona	9/6	Yes	44	105	0.34	0.0429	6.76	42.9
L. Harvey		Na	63	114	0.22	0.124	6.52	39.4
E. Feliciana	9/6	Yes	22	502*	0.83	0.0542	2.20	39.7
S. Guttzeit		No	27	251	2.50*	0.1002	16.28*	34.3
Grant	8/7	Yes	151	481	2.08	0.0143	4.60	44.7
G. Randolph		No	196	641	3.06	0.0165	4.89	43.1
Iberia	7/30	Yes	39	81	1.90	0.0539	24.15	32.2*
A. Guillote		Na	32	58	1.19	0.0336	18.44	25.6
Iberville	8/6	Yes	33	153	7.79	0.2457	47.36	43.1*
D. Purpera		No	27	89	5.33	0.2754	60.74	32.8

(Continued)

Table 2. — (Continued)

Parish/grower	Sampling date	Inoculation	Nadules		μMC_2H_4 Produced per hour per:			Seed yield (bu/a)
			Na.	Dry wt. (mg)	Plant	Nodule	g nodule	
Lafoyette	8/27	Yes	74	475	8.28	0.1064*	16.70	—
D. Viator		No	115*	547	6.36	0.0567	11.21	—
Rapides 1	7/31	Yes	38	225	4.38	0.1176	17.68	46.2
W. Bollich		No	72	373*	8.65*	0.1372	24.32*	49.0
Rapides 2	7/31	Yes	30	158	6.76	0.2359	42.17	51.4
W. Bollich		Na	47*	220	11.95*	0.2589	55.81	50.4
Rapides 3	7/31	Yes	48	233	6.90	0.1545	31.79	—
W. Ballich		No	42	247	7.57	0.1836	30.55	—
Rapides 4[1]	—	Yes	—	—	—	—	—	37.1
W. Ballich		Na	—	—	—	—	—	37.7
Rapides 5[1]	—	Yes	—	—	—	—	—	48.9
W. Bollich		Na	—	—	—	—	—	47.6
St. Jahn Baptist	7/28	Yes	50	234	0.67	0.0148	2.85	—
S. Radrique		Na	89	179	1.74*	0.0235	9.56*	—
St. John Boptist	7/28	Yes	2	38	0.25	0.1008	3.37	—
S. Rodrique		No	2	49	0.36	0.2200	4.54	—
Tensos	8/23	Yes	34	105	1.12	0.0331	9.13	18.6
W. Butler		No	51	223	1.79	0.0298	6.23	16.2
Vernon[1]	—	Yes	—	—	—	—	—	23.8
C. Bailey		No	—	—	—	—	—	24.5
W. Batan Rouge	7/30	Yes	76	551	2.82	0.0263	3.76	26.7
C. & N. Arnold		Na	119	590	3.85	0.0429	5.41	29.8
1980								
Acadia	7/21	Yes	47	135	8.83	0.1635	49.35	—
G. Zaunbrecher		Na	52	124	11.20	0.1775	49.71	—
	8/5	Yes	39	192	11.41	0.0784	29.99	45.0
		No	40	184	9.10	0.1324*	28.19	44.8

(Continued)

Table 2. — (Continued)

Parish/grower	Sompling date	Inoculotion	Nodules No.	Nodules Dry wt. (mg)	μMC_2H_4 Produced per hour per: Plant	Nodule	g nodule	Seed yield (bu/a)
Ascension	8/25	Yes	54	188	5.33	0.1123	40.11	—
J. & R. Robert		No	61	241	5.92	0.1103	46.60	—
Bassier	9/10	Yes	131	429	1.74	0.0099	2.93	42.3*
J. Rabinson		Na	105	394	2.04	0.0152	4.40	28.8
Lafoyette	7/21	Yes	15	45	0.88	0.0584	19.25	—
D. Viatar		Na	25	130*	0.27	0.0108	2.07	—
				1981				
Acodia	7/22	Yes	40**	164*	2.70	0.0631	15.33	—
G. Zounbrecher (1)		No	21	88	1.22	0.0605	13.17	—
	8/11	Yes	49	225	6.28	0.1297	27.92	31.6
		No	32	135	3.98	0.1417	30.18	27.5
Acadio	7/15	Yes	60	313	2.92	0.0746	15.52	—
W. Gorber (1)		Na	76	419	2.51	0.0360	6.38	—
	8/5	Yes	40	259	2.34	0.0501	7.42	38.7
		No	58	355	3.47	0.0593	9.32	35.4
Acodia	7/15	Yes	60	313	2.21	0.0370	6.98	—
W. Garber (2)		No	76	419	3.32	0.0455	7.51	—
	8/5	Yes	77	440	6.43	0.0728	11.51	42.4
		No	57	422	10.77	0.1734	22.81	41.8
Acodia	7/15	Yes	31	179	4.76	0.1593	27.15	—
G. Zounbrecher (2)		No	43	160	4.85	0.1132	30.91	—
	8/5	Yes	48	304	4.09	0.0856	14.12	39.5
		Na	54	264	5.09	0.0972	20.37	39.1
Lofayette	7/9	Yes	24	125	3.94	0.1685	33.23	—
D. Viatar		No	26	149	4.08	0.1793	29.02	—
	7/30	Yes	44	366	14.22	0.3483	39.46*	37.6
		No	63	376	11.35	0.2358	29.79	35.5

(Cantinued)

Table 2. — (Continued)

Parish/grower	Sampling date	Inoculation	Nodules		μMC_2H_4 Praduced per hour per:			Seed yield (bu/a)
			No.	Dry wt. (mg)	Plont	Nodule	g nodule	
Rapides	7/23	Yes	27	200	1.97	0.0897	12.90	—
W. Bollich (1)		No	24	195	1.80	0.0837	12.43	—
	8/17	Yes	29	218	1.00	0.0385	4.53	44.2
		No	38	278	1.31	0.3770	4.91	42.2
Rapides	7/23	Yes	23	150	0.54	0.0232	4.40	—
W. Bollich (2)		Na	23	137	1.18	0.1050	17.01	—
	8/17	Yes	17	120	0.12	0.0077	1.12	36.3
		No	16	121	0.49**	0.0276**	4.55	33.3
Rapides	8/17	Yes	20	106	1.97	0.0763	15.40	—
W. Ballich (3)		Na	24	91	1.86	0.0694	16.49	—
	8/29	Yes	28	90	0.90	0.0346	11.41	31.7
		Na	78**	198**	7.67**	0.1051**	38.41**	32.1
Richland	7/13	Yes	69	275	6.25	0.0964	23.62	—
T. Herrington		No	82	291	6.06	0.0738	21.70	—
	8/3	Yes	92	367	1.99	0.0231*	7.22	25.1
		Na	81	246	0.88	0.0100	3.35	25.8
St. Landry	7/10	Yes	24	181	11.49*	0.6566	69.13	—
J. Artall		No	17	104	5.35	0.3014	44.95	—
	7/31	Yes	69	232	3.64	0.0883	19.33	50.1*
		Na	69	212	3.88	0.1396	24.48	41.4
St. Landry	7/31	Yes	6	25	0.56	0.0621	12.73	—
G. Hubbard		Na	4	17	0.20	0.0192	3.52	—
	8/17	Yes	4	28	0.42	0.1310	10.20	—
		Na	2	20	0.56	0.1884	15.68	—
St. Mary	7/13	Yes	39	364	12.44**	0.3184**	33.27**	—
B. Alloin		No	35	222	2.56	0.0903	12.37	—
	8/3	Yes	56**	455**	8.97	0.1684	20.03	58.8*
		No	31	298	6.24	0.1955	22.64	52.8

(Continued)

Table 2. — (Continued)

Porish/grower	Sampling dote	Inoculotion	Nodules		μMC_2H_4 Produced per hour per:			Seed yield (bu/o)
			No.	Dry wt. (mg)	Plont	Nodule	g nodule	
W. Boton Rouge	7/8	Yes	46	146	6.10	0.1242	41.47	—
C. Wilkerson		No	34	114	4.16	0.1233	35.02	—
				1982				
Acodio	7/21	Yes	102	292	2.16	0.0240	7.74	—
G. & F. Zounbrecher		No	80	316	2.38	0.0297	8.06	—
	8/10	Yes	87	259	5.28	0.0604	20.03	45.9
		No	87	294	6.55	0.0787	22.66	47.8
Ropides	9/5	Yes	34	194	2.35	0.0687	12.32	—
W. Bollich		No	40	228	3.38	0.0871	14.71	—
St. Londry	7/21	Yes	60	321	1.63	0.0261	5.33	—
J. Artoll		No	66	329	4.44	0.0725*	12.91**	—
	8/11	Yes	72	300	1.56	0.0270	6.58	52.8
		No	124**	361	2.16	0.0194	5.98	51.6

[1]It was not possible to acquire this data at this location.
*Significantly higher at .05 level of probability.
**Significantly higher at .01 level of probability.

The average seed yield increase from the use of inoculum on new soybean land was 2.4 bushels per acre with 95 percent confidence limits of −0.1 to 4.9 bushels per acre. The average seed yield increase on land previously cropped to soybeans was 1.5 bushels per acre with 95 percent confidence limits of −0.4 to 3.5 bushels per acre. Neither of the latter two were significant because of the lower number of observations per mean when the entire test (inoculum versus no inoculum) was split into inoculum versus no inoculum for the 12 new land sites or the 19 old bean field sites.

Discussion

Nodulation and nitrogen (C_2H_2) fixation parameters did not support the need for soybean seed inoculation at planting. Values in 1979, 1980, and 1982 were predominantly against the practice of inoculation while 1981 values were slightly in favor of seed inoculation. Nodulation and nitrogen fixation values are evaluated during a 1-hour period chosen arbitrarily at flowering and pod-fill and may not totally represent what happens during an entire growing season.

Seed yield values presented a different picture with respect to the need for seed inoculation. No reason can be given for the significant decrease in yield at the Beauregard location in 1979. Occasionally a strain of *Rhizobium japonicum* can cause temporary adverse effects in soybean plants but these influences are usually overcome within a period of several days and are never reflected at harvest time. The statistically significant increases in seed yield over all locations does, however, present a good argument to advocate preplant inoculation of soybean seed on both "old" and "new" soybean land.

The seed yield increase at the Iberia locations in 1979 could possibly have been a molybdenum and/or fungicide response. The inoculant used at that site contained both molybdenum and fungicide mixed with the nodulating bacteria. Since the soil had a very acid pH value of 5.0, a molybdenum response may have been measured. There was no apparent fungal damage in the uninoculated plots, which would rule out any fungicide effect. The pH values were considered quite acidic for soybean growth and the plants could have been in need of additional molybdenum for maximum plant growth and yield.

The remaining three seed yield increases all occurred on new, first-year bean land. Although statistical analyses did not demonstrate significance with respect to yield increases from inoculation on new land in general, this data would present a strong argument for the use of inoculum when one is growing beans on land with no previous history of soybean growth.

Conclusions

Nodulation and nitrogen (C_2H_2) fixation test parameters did not present much evidence to support the need for soybean seed inoculation at planting. However, seed yield values did indicate some statistically significant responses. Of the 43 test areas, yield data were gathered at 31. Five statistically significant increases in seed yield were found. This comprised 16 percent of the test locations. One significant decrease (3 percent) in seed yield also occurred. Of the five significant increases in seed yield, one could possibly have been a molybdenum response by the plants that were grown in a soil that was considered quite acidic for soybean growth. Although it is certainly a desirable management practice to provide small amounts of molybdenum to the plants under these acidic conditions, molybdenum in direct combination with live rhizobia in an inoculum is not a good way to provide it. There is good evidence (Burton and Curley, 1966; Hiltbold et al., 1980; Skipper et al., 1980) that inoculants which contain molybdenum and/or fungicide (such as Triple Noctin did in 1979) probably did not contain many live rhizobia due to the lethal effects of the molybdenum and fungicide. These combination products are now usually sold in separate containers to be mixed just prior to inoculating and sowing the seed. Each grower should determine his own economics if he is faced with a need for rhizobial seed inoculant and molybdenum and/or fungicide. There are ways to accomplish this that are compatible with the rhizobia.

The other four significant yield increases in these tests were attributed to inoculation of seed with the inoculant-rhizobia. That was still a 13 percent overall response to inoculation. In all instances, the inexpensive peat-base inoculants were used.

These results indicated that a soybean grower could easily decide not to inoculate his seed and stand a good chance of suffering no ill effects with respect to final seed yield. In no instance did any grower ever suffer a crop failure due to lack of inoculation. However, the cost of seed inoculation with the inexpensive but adequate peat-base materials is very low. Although peat-base products vary in cost from location to location, it is still possible to inoculate at a cost of less than $1.00 per acre. The cost in time is only a few minutes at planting. Planter box inoculation, although not the best way to inoculate, requires no additional equipment with the exception of a stick to stir the seed and inoculum together. No additional field transportation or planting costs are involved. The cost of the inoculum, compared with the cost of soybean seed, fertilizer, herbicides, fungicides, nematocides, adjuvants, fuel, etc., is negligible. Statistical analyses of data from all locations did indicate that a soybean grower could expect a significant increase of about 1.9 bushels per acre from inoculation. This would more than pay for the peat-base inoculum.

In fact, even after subtracting 0.2 bushels per acre as the cost for inoculum, we can say with 95 percent confidence that the expected yield profit from inoculation in Louisiana would be about 0.1 to 3.2 bushels per acre.

Soybean seed inoculation with a reputable inoculant seems like an inexpensive form of insurance for the Louisiana soybean grower regardless of whether he is planting on land that will be put into soybeans for the first time or on "old" soybean land.

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