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RESPONSE OF SOYBEANS TO PLOW-DOWN AND SIDE-DRESS APPLICATIONS OF NITROGEN ON IRRIGATED AND NON-IRRIGATED SOILS

H. J. MEDERSKI, J. H. WILSON and G. W. VOLK

Data collected from a number of field and greenhouse experiments at the Ohio Agricultural Experiment Station indicate that soybeans may not obtain enough nitrogen from symbiotic association with nodule bacteria to produce maximum yields. That soybeans do not produce maximum dry weight yields when relying predominantly on symbiotic nitrogen was also demonstrated by Norman and Krampitz (6) and Thornton (7). Norman (5) demonstrated that non-nodulated soybeans supplied with adequate fertilizer nitrogen produced yields as large as those produced by nodulated but non fertilized beans. This work indicates that either fertilizer nitrogen or nitrogen fixed by the symbiotic bacteria were equally effective and that yield depended on the quantity of nitrogen fixed by the plant plus the quantity of nitrogen the plant was able to obtain from the soil. In the event that environmental conditions limit symbiotic nitrogen fixation, the yield may depend upon the quantity of "supplemental" nitrogen available in the soil.

The purpose of the work reported in this paper was to study the effect of various rates and methods of applying nitrogen on soybean yields and to investigate the effect of irrigation on the response to the applied nitrogen.

MATERIAL AND METHODS

Experiments at Wooster, Ohio

The Lincoln variety of soybeans was grown for four successive years; each year the soybeans were inoculated and planted on different but adjacent areas of Wooster silt loam. The basic treatment applied each year consisted of liming to neutrality and plowing down 300 pounds per acre of 0-12-12.

The nitrogen used for treatment was applied in the form of ammonium sulfate. The plow-down nitrogen was broadcast before plowing; the side dress nitrogen was applied at the initiation of flowering in a narrow single band at a depth of two inches and at a distance of three inches to the side of the row.

In 1947, nitrogen at the rate of 40, 80, and 120 pounds per acre was side dressed and plowed down. During 1948, 1949, and 1950 three rates of nitrogen, 50, 100, and 200 pounds per acre were side-dressed and a 100 pound application was plowed down; each treatment appeared on irrigated and non irrigated plots.

In 1948, split plots were arranged in a randomized block with four replications; one-half of each plot was irrigated. In 1947, 1949, and 1950 the design was a simple randomized block layout with four replications. Individual plots contained five rows spaced 28 inches apart with a common border row between plots. Plot area was 0.016 acre.

Irrigation was accomplished with an over-head sprinkler system in 1948 and with canvas ooze hoses during 1949 and 1950. One inch of water was applied whenever soil moisture tensiometers indicated a tension of approximately 0.75 atmospheres.

Northwest Farm Experiments

From 1954 through 1956 two soybean experiments were carried out each year on a Hoytville clay loam at the Northwest Substation, Hoytville, Ohio. In one experiment two rates of ammonium nitrate nitrogen, 0 pounds per acre and 100 pounds per acre were applied to continuous soybeans. In the second experiment these same rates of nitrogen were applied to both corn and soybeans in a corn-soybean cropping sequence. The purpose of these experiments was to provide additional data on the frequency and magnitude of response of soybeans to applied fertilizer nitrogen.

The Monroe variety of soybeans was grown in rows 100 feet long with three rows per plot spaced 35 inches apart. Five hundred pounds of 0-20-20 was broadcast and plowed down in 1954. An additional 100 pounds per acre of 5-20-20 was applied near the seed each year the beans were planted.

RESULTS

The data obtained from the field experiment conducted in 1947 (Table 1) show that the side-dress application of nitrogen resulted in yields which are significantly larger than those produced by equal rates of plow-down nitrogen. Maximum yield increases were produced by the side-dress application of 120 pounds of nitrogen. The efficiency of the respective side-dress applications measured in terms of bushels increase per acre per pound of nitrogen applied is approximately the same for all rates of nitrogen.

TABLE 1.—Effect of plow-down and side-dress applications of nitrogen on soybean yields

1947 Yields

Pounds of nitrogen per acre	Bushels per Acre	
	P.D.*	S.D.†
0	30.3	----
40	30.4	32.5
80	30 6	33.8
120	31.9	35.8
	LSD 05—1.5 bu.	

*Nitrogen plowed down before planting.
†Nitrogen side dressed at flowering.

The data for the field experiments conducted during 1948, 1949, and 1950 appear in Table 2. Only one rate of nitrogen was plowed down during these three years because the results secured in 1947 and in previous years indicated that the plow-down application is less effective than side-dressing.

The data for 1948 show that all rates of nitrogen including the 100 pounds plowed down produced yields which were significantly larger than the check plot yields. At each rate of side-dress nitrogen, the increase in bushels per acre over the check plots was greater when the soil was irrigated. This interaction between irrigation and nitrogen application was found to be statistically significant. The data also show that when soil moisture is not limiting, more efficient utilization of nitrogen may be realized when it is applied as a side-dressing. This can be readily seen by comparing the 100 pounds side-dress with the 100 pounds plow-down application on both the irrigated and non-irrigated soils.

In 1949 the yield increases, produced by the respective rates and placements of nitrogen, were not statistically significant. The large yields produced by the check plots are indicative of a high level of fertility and good growth conditions, and under these conditions a marked response to nitrogen fertilization would not be expected.

TABLE 2.—Yield of soybeans as affected by plow-down and side dress nitrogen application on irrigated and non-irrigated soils. (Wooster, Ohio)

	Pounds of Nitrogen per Acre					Irrigation means
	0	50SD	100SD	200SD	100PD	
	1948 yield. Bushels per acre					
Non-irrigated	23.0	26.9	30.0	29.7	31.7	
Irrigated	29.7	36.8	39.9	43.3	35.5	

Nitrogen × irrigation significant at 1% level.
L.S.D. (.01) between two irrigation means at one level of nitrogen —3.5 bu.
L.S.D. (.01) between two nitrogen means at one level of irrigation—6.0 bu.

	1949 yield. Bushels per acre					
Non-irrigated	45.1	47.8	48.8	49.3	45.4	47.2
Irrigated	**51.4**	**52.6**	**51.6**	**52.7**	**49.0**	51.4
Nitrogen means	48.3	50.2	50.2	51.0	47.2	

Nitrogen × irrigation non significant at 5% level.
Nitrogen means non significant at 5% level.
F values for irrigation means significant at 1% level.

	1950 yield. Bushels per acre					
Non-irrigated	31.7	33.3	37.5	36.7	32.6	34.3
Irrigated	**31.4**	**35.5**	**36.4**	**36.3**	**35.3**	34.9
Nitrogen means	31.3	34.4	36.9	36.5	34.0	

Nitrogen × irrigation non significant at 5% level.
F value for irrigation means non significant at 5% level.
L.S.D. (.05) between nitrogen means—2.1 bu.

The data for 1950 are similar to those for 1948 except that soil moisture was adequate throughout the growing season and no yield increase was realized from irrigation. The 50 and 100 pound side-dress applications again produced yield increases which were statistically significant. The yield increase produced by the 200-pound side-dress application was no greater than that produced by 100 pounds of nitrogen applied in the same manner.

The results of applying nitrogen to continuous soybeans and to soybeans in a corn-soybean sequence at the Northwest Substation are shown in Table 3. With the exception of continuous soybean experiment in 1954 and the corn-soybean experiment in 1955, the application of 100pounds of nitrogen increased soybean yields each year in both rotations. However, the acreage yield increases for the three years were not large enough to justify the cost of the nitrogen.

TABLE 3.—Yield of soybeans per acre as affected by the application of nitrogen to continuous soybeans and to soybeans in a corn-soybean cropping sequence

Nitrogen per acre*	1954	1955	1956	Average
	bu.	bu.	bu.	bu.
	Continuous Soybeans			
None	35.2	25.6	15.7	25.5
100 pounds	34.6	30.5	19.6	28.3
	Corn-soybean Sequence			
None	31.6	32.2	17.7	27.2
100 pounds	35.3	31.5	19.9	28.9

*Plowed down prior to planting.

The results of these field experiments conducted for four years at Wooster and for three years at the Northwest Substation indicate that the yields produced by inoculated soybeans were significantly increased by the application of nitrogenous fertilizers. Under the conditions of these experiments, the side-dress method of application was superior to the plow-down placement when equal rates of nitrogen were applied.

DISCUSSION

While the application of nitrogen to legumes increases dry matter production, it also decreases the amount of nitrogen fixed by the plant (2, 6). Thus, the application of nitrogen tends to depreciate the benefit derived by the plant by virtue of its symbiotic association. The data in Tables 1, 2 and 3 indicate that, on the average, the increases in soybean yield from nitrogen applied to non-irrigated soils are not sufficient to compensate for the cost of the applied nitrogen. This conclusion is supported by other data (3, 4) accumulated at the Ohio Agricultural Experiment Station.

The use of a legume green manure crop preceding soybeans might be considered as a less costly alternative to applying combined nitrogen. However, experiments conducted at the Ohio Agricultural Experiment Station (3) indicate that soybeans yield as well after corn as after sweetclover.

The variable response of soybeans to applications of supplemental nitrogen emphasizes the need for defining those soil and plant characteristics which are responsible for the variability.

SUMMARY

In these experiments the yield of soybeans was increased by the application of fertilizer nitrogen in three out of four years at Wooster, Ohio and in two out of three years at Hoytville, Ohio. In six of the seven experiments the application of nitrogen to soybeans did not produce yield increases which were profitable at current price levels.

The increase in soybean yield was related to the level of soil moisture, the quantity of nitrogen that was applied and the method of applying the nitrogen.

Side dressing the soybeans with nitrogen when the beans began to flower produced larger yields than when the nitrogen was plowed down prior to planting; the yield differences, however, were small.

Soybean yields increased progressively with increasing rates of nitrogen from 0 to 100 pounds per acre. Application of nitrogen in excess of 100 pounds per acre did not produce an additional yield increase.

The effect of irrigation varied with season and rate of applied nitrogen. In 1948 the single effect of irrigation or the highest rate of nitrogen increased yield approximately 7 bushels per acre while the combined effect of these treatments increased yield 20 bushels per acre. Irrigation increased the 1949 yield approximately 4 bushels per acre at all levels of nitrogen, but did not affect yield in 1950.