No-tillage Yield of Double-cropped Rye and Soybean in Relation to Nitrogen and Potassium Fertilization

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Abstract

Fertility requirements for no-tillage (NT) double-cropping (DC) systems need to he studied. The purpose of this research was to determine the Nand K feriilizer requirements in a 11-yr-old NT rye (Secale cereale L.) -soybean *(Glycine* max L.) DC system. 'Wrens Abruzzi' rye was seeded in November 1985 and 1986 followed each year by 'Centennial' soyhean planted in mid-June in 10 in-wide rows using a NT 'Tye" drill. A randomized complete block design with four replications was used. Main plots consisted of five N rates in a randomized complete block with four replications. Each main plots had five sub plots of K. Fertilizer had a positive effect on rye whole plant and grain yield, other rye variables and soybean seen yield. Soybean seed yield responded positively to residual K which had been applied to the rye crop.

Introduction

Small grain followed by soybean *(Glycine* ***max*** L.) is the agronomic double-cropping (DC) system most widely grown in the United States and probably in the world. Tillage and related management practices for this DC system have been evaluated by numerous researchers (Gallaher, 1977a; Gallaher, 1977b; Gallaher and Weaver. 1982; Hargrove et al., 1982; Sanford, 1982;). A larger variety of small grain-soybean DC systems (Soybean followed by rye *(Secale cerealw* L.) grain (Westberry and Gallaher. 1979), wheat (Triticum *aestivum* L.) after soybean or dormant summer perennial grasses (Wright, 1984), soybean or grain sorghum *(Sorghum bicolor* L.) followed by oat *(Avena sativa* L.) (Ortiz and Gallaher, 1984), and others suggested by Gallaher et ai. (1980)) can be practiced in the prevailing warm climate of Florida. Hargrove et al. (1983) indicated that wheat growth, N status, and grain yield are influenced by the previous crop and are important to the management of DC systems. Gallaher (1977a) mentioned that "In general that DC systems were fertilized with leas N and about equal or slightly more P and K than the sum of what would be recommended for the winter and summer crops if. grown separately as monocrops." Post (1983) indicated that soybean appeared to leave sufficient N to meet the needs of rye in a no-tillage (NT) rye-soybean DC system. However, insufficient soil K may be a problem when such DC is practiced. This study was

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conducted to evaluate the yield response of a 11-yr-old NT rye-soybean DC system to N and K fertilizer.

Materials and Methods

"Wrens Abruzzi" rye was seeded at the rate of 90lb. A^{-1}on 20 November 1985, and 1986. Following the rye crop, "Centennial" soybean was planted in mid-June 1986 and 1987 in 10 in-wide rows using a NT "Tye" drill. Soybean was seeded at the rate of 9 seed ft^{-1} of row. Standard cultural and pest management practices were carried out as required for each crop (Table I).

Double-cropping of rye and soybean during November 1985 to October 1986 constituted the first cropping cycle (CC) (85-86) and from November 1986 to October 1987 constituted the second CC (86-87). Plots used during the 86-87 CC were adjacent to plots used during the 85-86 CC. Identical data were collected for both the 85-86 and 86-87 CC.

A randomized complete **block** design with four replications nested within CC in a modified 5 x 5 factorial with N assigned at random and K assigned at random within each N treatment was used. Main plots consisted of five N rates (0, 35, 70, 105, and 140 lb a^{-1}) each containing five sub-sub-plots of K (0,40,80, 120, and 160lb A^{-1}). Sub-sub-plots were 10 by 16 ft in size.

Ammonium nitrate and muriate of potash were used as sources of N and K, respectively. All K applications were made at rye planting time while N was applied l/3rd at planting and 2/3rd at the beginning of February. Fertilizer was applied only to the rye crop in a cycle.

A 20 in. by 10ft (17 ft^2) quadrant from the center of each plot was used to collect samples for evaluating rye whole plant dry matter (WPDM), rye grain yield (GYL), percent ground cover of rye (GC), and yield of soybean grain (SY). A 3.3ft. by 10 in (2.75 ft^2) quadrant was also used to evaluate grain yield (GY2), head weight (HW), percent grain $head^{-1}$ (PGH), and head area index (HAI) of the rye. Testing of differences among treatments was made by the Fisher Protected Least Significant Difference Test (FPLSD) (Steel and Torrie, 1980; Chew, 1976).

Results and Discussion

No interactions occurred in this experiment. Highest yields of rye WPDM were obtained when 105 lb NA^{-1} were applied (Table 1) during the 85-86, 86-87, and CC avg. Response to N increased linearly up to the 105 lb A fertilizer rate and then decreased at the highest N rate (I40 lb A^{-1}). Similar results were observed for rye GYI, even though no differences were found for the 86-87 CC year according to the F-test (P is less than 0.05). When compared to the 0 lb K A^{-1} rate, rye WPDM responded to k application at all rates during the 85-86. 86-87, and CC avg (Table I). There was a slight trend toward higher yields of rye WPDM when higher K rates were applied. An analogous trend was observed for the response of rye GYI to K application. In this case statistical differences were found only to the highest rate of K applied (160 lb A^{-1} for the 85-86. 86-87, and the CC avg, respectively (Table 1).

Soybean seed yield did not respond to residual N. However, a trend of greater SY was observed from increasing N rates applied to the rye crop. Soybean seed yield showed a response to the residual K at the 40 lb K A^{-1}rate for the 85-86 and the CC avg, and to the 160lb K A^{-1}rate for the 86-87 CC (table 1). This indicated that the K applied to the rye crop was cycled through the rye residue and returned to the soil to be used by the succeeding soybean crop. These results reinforce Post's (1983) conclusions that "In general, DC of rye followed by soybean efficiently recycles nutrients from crop to soil" (p.viii).

Rye PGC responded significantly to the application of 35 lb N $A^{-1}$for the 85-86 CC and 140 lb N A^{-1} for the CC avg (Table I). Rye PGC responded to the application of 120 lb K A^{-1} during the 85-86 CC. A response to the application of 40 lb K $A^{-1}$was observed for this variable for both the 86-87 and the CC avg. A linear increase in rye PGC in response to both N and K applications was observed for the 86-87 CC and the avg CC. Greater PGC could be important to protect the soil against water and wind erosion. This could be an important factor when the rye crop is grown for the dual purpose of either dry matter (pasture grazing and/or silage) or grain production and as a winter cover crop for erosion control.

Rye HA1 responded to the application of 105lb N A^{-1}in all years and showed a linear increase in response to N for the 85-86 and avg CC (Table I). Rye HA1 increased linearly up to the rate of 105 lb N $A^{-1}$and decreased at the highest N rate of 140 lb N A^{-1} during the 86-87 CC. A similar response was observed for rye HW. Rye HA1 responded to the application of 80 lb K A^{-1} during the 85-86 CC and 40lb K A^{-1} during the 86-87 and the CC avg, respectively (Table I). Rye HW responded to the application of 80 lb K A^{-1} during the 85-86 and to 80 lb K A^{-1} for the CC avg (Table I).

Rye GY2 showed a response to the application of 105 lb N A^{-1} during both the 85-86 and the CC avg. Rye GY2 increased linearly up to the rate of 105lb N $A^{-1'}$ and decreased at the highest N rate of 140 lb N A^{-1}(FPLSD) 0.05) (Table I). A similar trend was observed during the 86-87 CC. A response of rye GY2 to the application of 80 lb K$A^{-1}$was observed for the 85-86 and the CC avg (FPLSD 0.05) (Table 1)A trend of an analogous behaviour was observed during the 86-87 CC. Variability increased when the smaller area was used (2.75 ft^2) as compared with the larger 17 ft^2 sampling area.

Rye PGH responded to the application of 105 lb N A and 80 lb K A^{-1} during the 85-86 CC (FPLSD 0.05) (Table 1). The total grand mean for the rye PGH was 37% for the CC avg. This could be used to indicate how rye heads reached only about a third of their total potential grain filling capacity. This could be explained by the early increase in temperatures and the later freezes that occurred during the spring that is usual under Florida subtropical climate. Thus, even though the rye heads were fully developed, the rye grain filling process was disrupted by the late low temperatures.

Table 1. Rye and soybean yield variables as affected by N and K fertilization.

Yield variable	N rate	Cropping cycle 85-86	86-87	Avg	K rate	Cropping cycle 85-86	86-87	Avg
	lbA^{-1}		Ton A^{-1}		lbA^{-1}		Ton A^{-1}	
Rye WPDM"	0	0.80	0.93	0.87	0	1.51	1.42	1.47
	35	1.38	1.29	1.34	40	1.74	1.60	1.67
	70	1.91	2.00	1.96	80	1.74	1.87	1.81
	105	2.31	2.27	2.29	120	1.87	1.87	1.87
	140	2.27	2.09	2.18	160	1.83	1.87	1.85
FPLSD[b]		0.33	*0.51*	0.27		0.18	0.22	1.13
	lbA^{-1}		Bu A^{-1}		lbA^{-1}		Bu A^{-1}	
Rye grain (GY1)	0	60.4	3.2	4.8	0	11.1	4.8	8.0
	35	7.8	4.8	6.3	40	10.5	4.5	7.5
	70	12.2	5.9	9.1	80	11.8	6.0	8.9
	105	16.1	7.2	11.7	120	11.8	5.2	8.5
	140	14.8	5.6	10.2	160	12.1	6.5	9.3
FPLSD		3.5	NS	2.5		1.8	1.6	1.1
	lbA^{-1}		Bu A^{-1}		lbA^{-1}		Bu A^{-1}	
Soybean seed yield	0	32.6	20.8	26.7	0	26.7	20.8	23.8
	35	32.6	22.3	27.5	40	34.1	23.7	28.9
	70	31.2	22.3	26.8	80	32.6	25.2	28.9
	105	35.6	28.2	31.9	120	34.1	26.7	30.4
	140	32.6	31.2	31.9	160	34.1	28.2	31.2
FPLSD		NS	NS	NS		5.9	4.5	3.7
	lbA^{-1}		%		lbA^{-1}		%	
Rye ground cover	0	47	43	45	0	45	50	58
	35	67	48	58	40	70	55	63
	70	75	53	64	80	71	56	64
	105	83	61	72	120	74	56	65
	140	82	68	75	160	72	57	65
FPLSD		17	11	9		6	5	4
	lbA^{-1}		$in^2\ ft^{-2}$		lbA^{-1}		$in^2\ ft^{-2}$	
Rye head area index	0	2.0	2.0	2.0	0	2.9	3.0	3.0
	35	2.7	3.2	2.9	40	3.5	4.0	3.8
	70	3.8	4.5	4.1	80	3.9	4.2	4.0
	105	3.8	5.2	4.5	120	3.8	4.0	3.9
	140	4.6	4.5	4.5	160	3.9	4.2	4.0
FPLSD		1.2	1.2	0.7		0.9	0.6	0.4
				lbA^{-1}				
Rye head weight'	0	530	280	410	0	690	290	490
	35	600	370	490	40	710	370	540
	70	750	440	600	80	800	430	620
	105	1000	490	750	120	780	390	590
	140	870	410	640	160	800	390	600
FPLSD		190	170	120		120	NS	75

	lbA^{-1}		Bu A^{-1}		lbA^{-1}		Bu A^{-1}	
Rye grain (GY2)^{c}	0	6.4	3.3	4.9	0	8.4	5.1	6.8
	35	7.8	6.5	7.2	40	9.1	6.5	7.8
	70	10.0	7.5	8.8	80	11.9	7.5	9.7
	105	16.1	8.3	12.2	120	10.3	6.4	8.4
	140	12.4	7.2	9.8	160	11.8	6.8	9.3
FPLSD		4.8	NS	3.2		2.7	NS	1.9
	lbA^{-1}		%		lbA^{-1}		%	
Percent grain head^{-1}	0	30	42	36	0	35	43	39
	39	29	44	37	45	29	39	34
	78	32	40	36	90	35	41	38
	117	39	39	39	135	34	38	36
	156	38	27	38	180	34	40	37
FPLSD		8	NS	NS		6	NS	NS

"Whole plant dry matter, [b]Fisher Protected Least Significant Difference Test ($P < 0.05$, NS = not significant ($P = 0.05$), 'Rye head area index, rye head weight, rye grain yield (GY2), and percent grain head^{-1} were obtained from a harvested area of 2.75 ft^{2,} 17 ft^{2} harvested area was used for all other variables.

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