Does nitrogen fertilizer application rate to corn affect yield of subsequent soybean?

Maria da Conceição Santana Carvalho[1], Nelson Horowitz[2], Adriano Stephan Nascente[1], Paulo César Teixeira[3]

[1]Embrapa Arroz e Feijão, Rodovia GO-462, Km 12, Caixa Postal 179 CEP: 75375-000 - Santo Antônio de Goiás, BRAZIL (maria.carvalho@embrapa.br; adriano.nascente@embrapa.br).
[2]Yara Brasil Fertilizantes SA, Av. Carlos Gomes 1672, Porto Alegre, RS, BRAZIL, CEP: 90480-002 (nelson.horowitz@yara.com).
[3]Embrapa Solos, Rua Jardim Botânico, nº 1024, Bairro Jardim Botânico, CEP: 22460-000, RJ, BRAZIL (paulo.c.teixeira@embrapa.br).

INTRODUCTION

Soybean (*Glycine max* [L.] Merr) and corn (*Zea mays* L.) succession is the main cropping system used in Brazil. Soybean is the main crop with production in 2015/16 growing season of 95.4 million tons from a harvested area of 33.2 million hectares (CONAB, 2017). Brazil´s soybean average yield ranged from 2,629 to 3,115 kg ha^{-1} in the last ten growing seasons, although some farmers reached about 4,200 kg ha^{-1}. Soybean yield potential has been estimated to be in the range of 4,200-5,600 kg ha^{-1}, depending on the region (Sentelhas et. al., 2015). Corn is also a major crop in Brazil with production in 2015/16 growing season estimated of 81.5 million tons from a harvested area of 15.9 million hectares (CONAB, 2017). Soybean has high nitrogen (N) requirement of about 80 kg of N to produce 1,000 kg of grains. Biological N_2 fixation (BNF) by means of inoculation with *Bradyrhizobium* spp. inoculant is the recommended source for meeting the N requirement of soybean in Brazil. Recently consultants and farmers have controversial opinions on whether BNF could provide full N requirement of soybean to achieve yields levels above 3,600 kg ha^{-1}. Results from field trials performed in three ecoregions of Brazil demonstrated that basal and topdressing N (separately or combined) had strong negative effects on nodulation and may have negative impact on crop yields (Kaschuk et al., 2016). However, there is lack of information regarding the effect of increasing N fertilizer rates in this cropping system, instead of N application directly to soybean.

This study aimed to evaluate whether soybean benefits from N fertilizer rates applied to previous corn in a corn-soybean succession in Brazil´s Midwest region.

METHODS

A field trial was performed at Embrapa´s Experimental Station located in the city of Santo Antônio de Goiás, Goiás, Brazil. We used a randomized complete blocks design arranged in a 3x2+1 factorial scheme with five replications. N fertilizer was applied only to corn, at three N rates (75, 150 and 225 kg ha^{-1}) combined with two N sources (urea and calcium ammonium nitrate - CAN), and a control (without N application). The plots in the corn-soybean succession consisted of 8 ten-meter-long rows of corn spaced 0.90 m apart in 2013/14 growing season and 16 ten-meter-long rows of soybean spaced 0.45 m apart in 2014/15 growing season. We evaluated in both crops: grain yield, N leaf content, and N uptake in above ground biomass.

The analysis of variance (F test) was performed for all variables by using SAS statistical software (SAS Institute 1999).

RESULTS AND DISCUSSION

Considering that the experimental area was in fallow and covered with *Brachiaria ruziziensis* during the last three years before starting the experiment, the soil disturbance caused by the

incorporation of limestone, associated with high level of soil organic matter (3.4 g kg^{-1}) and good weather conditions during the corn cycle, enabled to reach high corn yield, even without the application of nitrogen fertilizer (Table 1). The N rates had no effect on corn grain yield, but increased N content in leaves and N accumulation in straw and grains, regardless of the N source.

About 1.0 kg of N per each 60-kg bag of corn grains were exported with the harvest. Thus, considering that the average grain yield ranged from 189 to 205 bags per hectare, the application of N rates lower than these values resulted in negative nitrogen balance (Table 1).

In short-term, soybean did not benefit from the application of higher rates of nitrogen to corn in the previous growing season, considering that both soybean yield and N uptake in aboveground biomass were not positively affected by the N fertilization of corn (Table 1). Note that soybean yield in the treatment without N fertilization tended to be higher than that ones with N fertilization (Pr=0.10).

Table 1. Corn and soybean grain yield, nitrogen content in leaves and nitrogen accumulation in aboveground biomass in response to the application of nitrogen rates and sources to corn in the corn-soybean rotation. Santo Antonio de Goiás, GO, Brazil.

N source	2013/2014 growing season - Corn						2014/2015 - Soybean		
	N rate	Grain yield	N leaf content	N remained in the straw	N accumulated in grains	N balance[/1]	Grain yield	N leaf content	N uptake in aboveground
	------- kg ha^{-1} -------		g kg^{-1}	---------- kg ha^{-1} ----------			kg ha^{-1}	g kg^{-1}	kg ha^{-1}
CAN[/2]	75	11629	35.8	230	186	-111	4389	45.8	309
CAN	150	12307	36.1	234	205	-55	4169	45.6	292
CAN	225	11987	38.1	275	203	22	4506	43.9	292
Urea	75	11782	36.2	236	189	-114	4293	43.3	302
Urea	150	12070	36.3	232	200	-50	4046	43.0	278
Urea	225	11471	40.0	256	194	31	4328	44.5	299
Control	0	11344	32.9	173	175	-175	4639	44.2	294
Average		11798	36.5	234	193	-65	4339	44.3	295
C. V. (%)		6.3	7.3	17.7	5.6	-	9.6	4.8	13.2
	DF	ANOVA - Probability of F test (Pr>F)							
N sources (S)	1	0.47	0.39	0.85	0.44	-	0.39	0.06	0.75
N rates (R)	2	0.28	<0.01	<0.01	<0.01	-	0.25	0.92	0.49
S x R	2	0.61	0.74	0.89	0.53	-	0.97	0.18	0.81
(S x R) x Control	1	0.16	<0.01	<0.01	<0.01	-	0.10	0.88	0.93

[/1] N balance = Input as fertilizer - exported in grains; DF = degree of freedom. C.V. = coeficient of variation

[/2] CAN = calcium ammonium nitrate

CONCLUSION

In short-term, both soybean yield and N uptake by soybean plants were not positively affected by the application of higher N rates to previous corn in the corn-soybean crop sequence.

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