SOURCES AND MANAGEMENT OF NITROGEN BEFORE OR AFTER IRRIGATION ON THE WINTER WHEAT AND BEAN PRODUCTION

FONTES DE NITROGÊNIO E MANEJO ANTES OU APÓS A IRRIGAÇÃO NAS CULTURAS DO TRIGO E FEIJOEIRO "DE INVERNO"

Flávio Hiroshi KANEKO[1]; Michelle Traete SABUNDJIAN[2]; João Paulo FERREIRA[3]; Douglas de Castilho GITTI[4]; Vagner do NASCIMENTO[5]; Andreza Lopes do CARMO[6]; Eric Haydt Castello Branco VAN CLEEF[7]; Salatiér BUZETTI[8]; Orivaldo ARF[9]

1. Universidade Federal do Triangulo Mineiro – UFTM, Iturama, MG, Brasil. flavio.kaneko@uftm.edu.br; 2. FAIT, Itapeva, SP, Brasil; 3 Centro Universitário Padre Albino, Catanduva, SP, Brasil; 4. Fundação MS, Departamento de Fertilidade do solo, Maracaju, MS, Brasil; 5. Universidade Estadual Paulista - UNESP, Dracena, Departamento de agronomia, SP, Brasil; 6. UFTM, Iturama, MG, Brasil; 7. UFTM, Iturama, MG, Brasil; 8. UNESP, Departamento de fitossanidade, engenharia rural e solos, Ilha Solteira, SP; 9. UNESP, Departamento de fitotecnia e sócio economia, UNESP, Ilha Solteira, SP, Brasil.

ABSTRACT: Studies that demonstrate the effects of sources of nitrogen (N) applied before or after irrigation on the yield of winter crops are limited in literature. In this sense, the objective of this study was to compare the effect of sources of N applied immediately before or after 13 mm irrigation of wheat and bean winter crops. It was used a randomized complete block design, with 4 replicates, in a 5 × 2 + 1 factorial scheme, and 11 treatments consisted of five N sources: urea, polymer-coated urea, urea + ammonium sulfate, ammonium sulfate, and ammonium nitrate and a control treatment (without N fertilization). For wheat, although ammonium nitrate provided great N content in the leaves, the grain yield was lower due to the lodging of the plants; since the application of N either before or after irrigation did not influence the grain yield. Regarding the bean, N fertilization increased productivity, but there were no differences among N sources and, despite the greater N content in the leaves observed with the N supply before irrigation the greatest grain yield was observed when N was applied after the irrigation.

KEYWORDS: Fertilizer incorporation**.** Topdressing fertilization. *Triticum aestivum* L. *Phaseolus vulgaris* L. Polymer.

INTRODUCTION

In recent years, winter cultivation of wheat and bean have been attracted great attention to irrigated production systems in the Brazilian Cerrado (PEREIRA et al., 2012; GALINDO et al., 2017), characterized by the intensification of the use of fertilizers. This is due to the major concern of more sustainable crop production over the next few decades (ADEWOPO et al., 2014), regarding groundwater contamination, as well as the greenhouse gases emission (KE et al., 2017; SUN et […]

fertilizers, such as ammonium nitrate, ammonium sulfate, and specially urea (CHIEN; PROCHNOW; CANTARELLA, 2009; KANEKO et al., 2016; PAN et al., 2016). However, in acidic tropical soils, the use of urea is the only source that can lead to significant N losses due to ammonia volatilization (THEAGO et al., 2014). Thus, one of the strategies to minimize these losses is the incorporation of urea into the soil through irrigation or rain, which, in practice, raises doubts regarding the best time for N application: before or after irrigation or rainfall.

Another strategy used to minimize N losses is the mixture of urea with other sources of N, such as ammonium sulfate. In this context, in addition to ammonium sulphate provide part of the N with low risk of volatilization, it would also minimize urea-N losses due to the greater acidification around the granules, minimizing ammonia production (LARA CABEZAS et al., 2008). In addition, the urea coating with polymers is a currently widely discussed alternative by researchers, which can release the N more slowly, decelerating the raising […]ule. Consequently, it […]ditions of deeper soil and higher temperatures (MARTINS; CAZETTA; FUKUDA, 2014), which differs from the winter cultivation conditions of irrigated wheat and bean.

Based on the hypothesis that winter wheat and bean yields are dependent on the sources of N, and on its fertilization management regarding irrigation, this study was conducted to verify the effects of topdressing N sources applied before or after irrigation in winter cultures of wheat and bean.

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MATERIAL AND METHODS

Two experiments were conducted during crop year of 2012, in an experimental area from School of Engineer of São Paulo State University, Ilha Solteira Campus, located approximately 51° 22' West Longitude and 20° 22' South Latitude, at 335 m of altitude. The average annual rainfall and temperature are 1370 mm and 23.5°C, respectively, and the relative humidity is between 70 and 80% (annual average). Values per ten-fold of rainfall, maximum and minimum air temperature recorded during the period (May 01 to August 23, 2012) are shown in Figure 1.

The local soil is classified as Dystrophic Red Latosol (Oxisol), clay texture (SANTOS et al., 2013), with the following characteristics in the layer of 0.0 to 0.20 m of depth: P (resin) - 12 mg dm^{-3}; Organic matter - 15 g dm^{-3} pH - ($CaCl_2$): 5.1; K – 2.6 mmol$_c$ dm^{-3}Ca - 26 mmol$_c$ dm^{-3}; Mg - 13 mmol$_c$ dm^{-3}; H+Al - 16 mmol$_c$ dm^{-3}; S - 11 mg dm^{-3}.

The area where the experiments were installed is managed under no-till system since 1997, with a predominance of corn or soybean crops during spring/summer, and the corn crop during autumn/winter. In crop year 2010/2011, the soybean was cultivated with fallow period in the winter and, in the crop year 2011/12, the corn was cultivated.

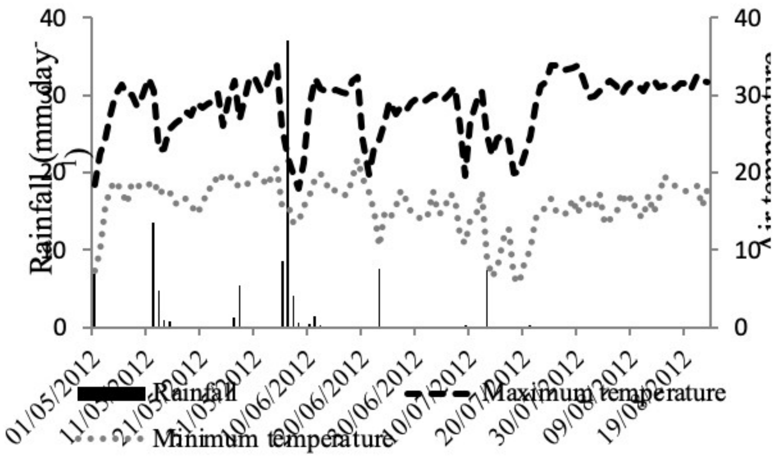

Figure 1. Rainfall (mm day^{-1}), maximum and minimum air temperature (ºC), measured in experimental area during the wheat cultivation season in Selvíria, MS, Brazil, crop year 2012.

Both experiments were allocated in a randomized block design with 4 replicates, in a 5 × 2 + 1 factorial scheme, with 11 treatments composed of nitrogen sources (1. urea, 2. polymer-coated urea [Policote®], 3. urea + ammonium sulfate [50:50], 4. ammonium sulfate, 5. ammonium nitrate) and 13 mm irrigation (before or after the topdressing fertilization), and a control treatment (without N).

The experimental plots consisted of 13 lines of 0.17m for the wheat, and 7 lines of 0,45 m for the bean, both with 5 m of length. The samples were collected from the four central lines of each plot with 4m.

Both wheat and bean were mechanically sown on May 8 and May 17, 2012, respectively, under irrigation via central pivot, with irrigation shifts ranging from 3 to 5 d with 13 mm. The desiccation of the area was performed using glyphosate (1920 g ha^{-1} of a.i.). The wheat cultivar used was the IAC 373 - Guaicuru and the bean was the IAC Pérola, with a density of 400 viable seeds m^{-2} for the wheat and 200,000 plants ha^{-1} for the bean.

In the sowing of both cultures, 250 kg ha^{-1} of the fertilizer (formula 04-30-10) were used (RAIJ et al., 1997). Seedling emergence occurred uniformly for all treatments 5 d after sowing. For the treatment of seeds, carbendazim + thiran (45 + 105 g a.i. 100 kg^{-1} of seeds) was used to control pathogens; imidacloprid + thiodicarb (45 + 135 g a.i. 100 kg^{-1} of seeds) was used to control termites and caterpillars in the early development stages. Post-emergence broad-leaf weed control was performed in the wheat with the herbicide metsulfurommethyl (3 g ha^{-1} of a.i.) 9 d after the emergence. For the bean, 250 g a.i. ha^{-1} of fluazifop-P-butyl + 175 g a.i. ha^{-1} of fomesafen were used 20 d after the emergence.

Topdressing nitrogen fertilization was performed on 06/13/2012 for the wheat (beginning of tillering), and on 06/15/2012 for the bean (V_4 stage), using 90 kg ha^{-1} of N, manually distributed superficially along the line of both crops, according to the description of the treatments, with fertilization performed at 10:00 h for the treatments with supply of N before irrigation (11:00 h), and after irrigation

(14:00 h), for those with the use of 13 mm irrigation. It is important to report that after 13 mm irrigation, there was only precipitation (irrigation) on 06/18/2018 in both areas.

Manual harvest was done on 22 and 23/08/2012 for the bean and wheat, respectively, in 3 central lines of 5 m in length for the wheat, and 2 central lines of 5 m for the bean.

The characteristics evaluated in the experiments were:

Wheat

The N and S content in the leaves: At the beginning of flowering, leaf blades of 50 leaves were collected per plot. After drying in a forced-air oven (60 to 70ºC, for 72 h), the leaves were ground in a Wiley-type mill, and then the N and S contents were determined according to Malavolta, Vitti and Oliveira (1997).

Height of the plant: determined in 5 plants per plot in the maturation, measured from the soil level to the apex of the spike, excluding the edges and considering the average of different points in each plot.

Number of spikes: determined by counting the number of spikes at a point of 1 m of row in the useful area of each plot at the time of harvest, and results expressed in square meter.

Number of grains per spike: before harvesting, 20 spikes were collected from the useful area of each plot, packed in properly identified paper bags and taken to the laboratory for the evaluation. The spikes were threshed, and the count was perform using an electronic grain counter, obtaining the total number of grains per spike.

Mass of 1000 grains: determined by random collection and weighing two samples of 1000 grains in each plot (13% wet basis).

Hectoliter mass: the sample was weighed at 0.25-L container, and then the mass was corrected to 13% moisture and the values converted to kg 100 L^{-1}.

Grain productivity: the plants of the useful area of each plot were manually harvested and mechanically threshed. The mass of the grains was determined and expressed as kg ha^{-1} (13% wet basis).

Bean

N and S content in the leaves: the leaves from the third node of 20 plants were used during the full flowering period, according to Malavolta, Vitti and Oliveira (1997).

Population of plants: at harvesting, the number of plants was recorded from two 4-m centerlines, and then the number of plants per ha was calculated.

Number of pods per plant: at harvesting, five plants per experimental unit were used to count the pods, and the arithmetic mean was calculated, obtaining the number of pods per plant.

Number of grains per pod: after determining the number of pods per plant, the pods were threshed, and the total number of grains was obtained electronically and, after the arithmetic mean, the number of grains per pod was calculated.

Mass of one hundred grains: obtained by random collection and weighing two samples of 100 grains per plot.

Grain productivity: the plants of the useful area of each plot were harvested and dried under full sun. After drying, the plants were mechanically threshed, and the data transformed in kg ha^{-1} (13% wet basis).

To verify the effect of nitrogen fertilization, the data were subjected to analysis of orthogonal contrast between the control treatment and the 5 × 2 factorial mean. The analysis of variance was performed, and the means were compared by the Tukey test ($p<0.05$) using the software SISVAR (FERREIRA, 2014).

RESULTS AND DISCUSSION

Wheat

The N sources topdressed before and after irrigation altered the S and N content in leaves, and grain yield (Table 1).

Table 1. F values of the effect of N sources supplied before and after irrigation, for S and N content in leaves, plant height, number of spikes per quadratic meter, number of grains per spike, mass of 1000 grains, hectoliter mass, plant population, number of pods per plant, number of grains per pod, mass of 100 grains, and grain yield for wheat and bean grown.

	F Contrast[1]	
Item	Wheat	Bean
S content in leaves (g kg^{-1})	10.88 $(p<0.01)$	3.67 $(p<0.05)$
N content in leaves (g kg^{-1})	15.75 $(p<0.01)$	3.61 $(p<0.05)$
Plant height (m)	0.12	-
Number of spikes m^{-2} (spikes m^{-2})	1.58	-
Number of grains $spike^{-1}$ (grains $spike^{-1}$)	0.73	-
Mass of 1000 grains (g)	1.17	-
Hectoliter mass (kg 100 L^{-1})	0.65	-
Plant population (plants ha^{-1})	-	1.21
Number of pods $plant^{-1}$ (pods $plant^{-1}$)	-	0.56
Number of grains pod^{-1} (grains pod^{-1})	-	3.79 $(p<0.05)$
Mass of 100 grains (g)	-	4.17 $(p<0.05)$
Grain yield (kg ha^{-1})	3.39 $(p<0.05)$	5.44 $(p<0.05)$

Selvíria, MS, Brazil; [1] Contrast: control treatment (without N) × factorial 5 × 2 mean.

The use of ammonium sulfate and urea + ammonium sulphate resulted in greater S content in wheat leaves, when compared to N supply via coated urea and urea with ammonium nitrate (Table 2), and no effect of topdress fertilization before or after irrigation was observed. Malavolta (2006) recommended foliar S concentration of 4 g kg^{-1} and, therefore, only the treatments that received S reached the adequate levels.

Table 2. S and N content in leaves, plant height and spike number per quadratic meter of wheat, according to the sources and N management under no-till system.

Treatments	S content in leaves (g kg^{-1})	N content in leaves (g kg^{-1})	Plant height (m)	Number of spikes (spikes m^{-2})
N sources				
Ammonium sulfate	4.25 a	45.18 b	0.76	467
Urea + Ammonium sulfate	4.10 a	45.68 a b	0.76	449
Urea	3.20 b c	44.58 a b	0.76	446
Coated urea	3.48 b	46.68 a	0.77	478
Ammonium nitrate	2.82 c	46.93 a	0.77	479
N management				
Before irrigation	3.67	45.30 b	0.76	470
After irrigation	3.47	46.26 a	0.77	446
Control	2.90	37.20	0.72	439
F test				
Sources of N (S)	15.75 $(p<0.01)$	15.03 $(p<0.01)$	1.43	0.56
N management (M)	1.80	3.55 $(p<0.05)$	0.11	2.08
S × M	2.36	0.45	0.18	0.60
DMS (S)	0.58	1.93	5.85	78.53
DMS (M)	0.26	0.66	2.10	30.06
CV (%)	12.43	3.21	5.72	12.66

Selvíria, MS, Brazil; Means followed by different letter, differ from each other at 5% probability by Tukey test.

The N content in the leaves were significantly increased when the ammonium nitrate and polymer-coated urea were used, compared to ammonium sulfate. When N fertilization was performed after the application of 13 mm irrigation, the N content in the leaves was greater ($p<0.05$) than when the supply of N was performed before irrigation (Table 2). It is important to note that the N content in the leaves of all the treatments (even the control without N supply) are above the range recommended by Malavolta (2006), which is from 30 to 33 g kg^{-1}, indicating that the soil was able to adequately supply the N demanded by the plants. This fact was also verified by Teixeira Filho et al. (2010), under similar cultivation conditions.

The wheat height ranged from 0.72 to 0.77 m, and the number of spikes m^{-2}, from 438.8 to 477.9, but there were no significant differences neither among the sources of N, nor between the N supply strategies (Table 2). There was also no significant effect of the treatments ($p>0.05$) on the number of grains per spike, or on the mass of a thousand grains (Table 3), indicating the good soil capacity to meet N requirements by the wheat. The hectoliter mass was also not influenced ($p>0.05$) by the different sources and N management (before or after irrigation). This variable is usually used for the classification and marketing of the wheat, which is related to the uniformity, shape, density and size of the grain, the content of impurities and the broken grains in the sample, thus indicating that any of the treatments tested herein could be used without depreciating the product market value.

Table 3. Number of grains per spike, mass of 1000 grains, hectoliter mass and wheat grain yield, according to the sources and N management under no-till system.

Treatments	Number of Grains $spike^{-1}$	Mass of 1000 grains (g)	Hectoliter mass (kg 100 L^{-1})	Grain yield (kg ha^{-1})
N sources				
Ammonium sulfate	37.41	39.99	85.58	3,177 a
Urea + Ammonium sulfate	35.36	39.06	83.20	3,030 a
Urea	33.98	41.59	86.12	3,195 a
Coated urea	36.28	43.28	85.08	3,361 a
Ammonium nitrate	32.80	38.85	84.71	2,531 b
N management				
Before irrigation	34.93	41.28	85.36	3,074
After irrigation	35.40	39.83	84.87	3,044
Control	36.50	40.07	86.01	2,590
F test				
Sources of N (S)	1.16	1.25	0.71	1.84
N management (M)	0.09	0.97	0.22	0.02
S × M	1.56	1.44	0.21	0.25
DMS (S)	6.11	5.77	492	449.67
DMS (M)	2.20	2.46	1.77	356.85
CV (%)	12.74	10.52	4.27	21.03

Selvíria, MS, Brazil; Means followed by different letter, differ from each other at 5% probability by Tukey test.

The lack of effect of N fertilization on the plant height, total number of spikes and hectoliter mass was also reported by other researchers, whose studies were conducted under similar cultivation conditions (GALINDO et al., 2017; TEIXEIRA FILHO et al., 2010;). Those authors also justified the results by the N supplied by the soil and by the decomposition of the organic matter present in the area due to the long period under no-till system.

Although the soil was able to provide enough N, confirmed by the leaf N content data (Table 2), there was a significant effect of N fertilization on wheat grain yield (Table 1). Comparing the N sources, there were no differences among urea, polymer-coated urea, urea +

ammonium sulfate, and ammonium sulfate; however, all these sources were significantly ($p<0.05$) greater than the ammonium nitrate (Table 3). The low grain yield verified when using ammonium nitrate can be explained by the lowest levels of S found in wheat leaves when this source was used (Table 2).

Even though the transformation of NH_4^+-N from the sources and the organic matter in the soil, by the nitrification process is usually fast, at mild temperatures (condition of wheat cultivation when compared to summer crops), the speed decreased, and plants may have absorbed more NH_4^+-N when fertilized with other sources but ammonium nitrate. When fertilizing with this source, there was possibly a greater accumulation of nitrate (NO_3^-), whose carrier is symporter-type (influx into the cell along with hydrogen). However, the entry of H^+ into the cells reduces the calcium absorption (which is responsible for structuring the cell wall, reducing lodging), by using an antiporter carrier, since for calcium to enter the cell and its organelles, H^+ must exit (FERNANDES; SOUZA, 2006).

There were no significant differences of N fertilization before or after irrigation (Table 3) on wheat grain yield, but regardless the N management, N fertilization resulted in an improvement of 469 kg ha^{-1}, comparing with the control treatment. It is important to highlight that during the period after N fertilization, the minimum air temperature was close to 20ºC (Figure 1), which probably decreased the action of urease in the treatments that received urea as source of N, minimizing possible losses by NH_3 volatilization. Thus, with 13 mm irrigation provided on 06/18/2012, it was possible to incorporate all N into the soil, minimizing possible differences between fertilization before and after irrigation. Even with greater losses of N by volatilization in treatment with urea, compared with the one with urease-inhibitor-treated urea, and by the supply of N sources after 20 mm irrigation, Viero et al. (2017) did not find differences in the yield of corn (summer crop), attributing organic matter mineralization and soil N to N supply, corroborating with the data presented herein.

Bean

There were significant effects of N fertilization on leaf S content, number of grains pod^{-1}, mass of 100 grains and grain yield (Table 1), with greater N values when compared to the control treatment (without N).

There was also a N source effect on leaf S content (Table 3), with ammonium sulfate and urea + ammonium sulfate, providing greater S values, differing from ammonium nitrate and polymer-coated urea. The N management, before or after irrigation, did not affect that variable. The N sources did not alter N concentration in the bean, showing values ranging from 45.3 to 49.0 g kg^{-1}. However, the N content in the leaves was greater when N was supplied before irrigation.

It is possible that the direct incorporation of N, applied with the irrigation, has solubilized faster the N from the fertilizer, thus making N more available to the plants at the time of full bloom. Viero et al. (2017), comparing the effect of N sources applied before or shortly after irrigation, observed less N losses due to volatilization of the conventional urea when the fertilization was performed before the irrigation with 20 mm, thus demonstrating the greater N efficiency in the present study on N accumulation in leaves.

The N levels found herein are within those recommended (30 to 50 g kg^{-1}) by Oliveira et al. (2004), indicating that the soil was able to supply most of the nutritional demand of the plant for S and N, even in the control treatment.

Table 4. N e S content in leaves and bean plant population cultivated in Selvíria, MS, Brazil.

Treatments	S content in leaves (g kg^{-1})	N content in leaves (g kg^{-1})	Plant population (plants ha^{-1})
N sources			
Ammonium sulfate	2.45 a	45.32	187,962
Urea + Ammonium sulfate	2.33 a b	49.03	174,074
Urea	2.08 b c	47.35	170,370
Coated urea	1.98 c	44.65	184,722
Ammonium nitrate	2.03 c	46.98	179,074
N management			
Before irrigation	2.16	48.20 a	176,697

After irrigation	2.16	45.61 b	183,641
Control	2.10	44.33	184,722
F test			
Sources of N (S)	7.74 $(p<0.01)$	1.16	0.99
N management (M)	0.03	4.53 $(p<0.05)$	1.63
S×M	1.60	1.92	0.55
DMS (S)	0.28	6.06	26,804
DMS (M)	0.11	2.49	9,675
CV(%)	8.31	8.45	10.99

Means followed by different letter, differ from each other at 5% probability by Tukey test.

As the treatments were applied already in the vegetative phase of the crop, there was no effect of N fertilization on the plant population (Table 3), with averages between 170,370 and 187,962 plants ha^{-1}. This population is considered adequate for the cultivar used, under the proposed condition (FERREIRA et al., 2013).

There was no effect of the sources and N management on the number of pods $plant^{-1}$ (Table 5). On the other hand, ammonium sulfate, urea and coated urea provided a greater number of grains pod^{-1}, when compared with urea + ammonium sulfate (Table 5). Regarding the N management, the supply after irrigation increased grains pod^{-1} by 0.29 ($p<0.05$), when compared with the management before irrigation.

Table 5. Number of pods per plant, number of grains per pod, mass of 100 grains and grain yield of bean cultivated in Selvíria, MS, Brazil.

Treatments	Pods $plant^{-1}$	Grains pod^{-1}	100 grains (g)	Grain yield (kg ha^{-1})
N sources				
Ammonium sulfate	17.15	5.23 a	27.43	3.599
Urea + Ammonium sulfate	14.30	4.70 b	27.06	3.471
Urea	15.08	5.24 a	27.64	3.516
Coated urea	14.35	5.25 a	26.31	3.740
Ammonium nitrate	15.70	5.06 ab	27.81	3.738
N management				
Before irrigation	15.08	4.95 b	26.81	3.533 b
After irrigation	15.18	5.24 a	27.70	3.693 a
Controle	14.90	4.70	26.77	3.209 c
F test				
Sources of N (S)	0.95	3.04 $(p<0.05)$	4.04 $(p<0.05)$	2.36
N management (M)	0.01	5.93 $(p<0.05)$	8.51 $(p<0.01)$	4.91 $(p<0.05)$
S × M	0.49	1.06	3.42 $(p<0.05)$	1.90
DMS (S)	4.20	0.49	1.25	296.10
DMS (M)	1.51	0.20	0.46	122.99
CV (%)	20.50	7.38	3.54	6.32

Means followed by different letter, differ from each other at 5% probability by Tukey test.

There was significant interaction ($p<0.05$) of the sources and N management for the mass of 100 grains of bean (Table 6). When the N supply was performed before the irrigation, the ammonium nitrate provided greater grain mass, when compared with urea or polymer-coated urea. When the N fertilization was performed after irrigation, the greater grain mass was observed for the urea, differing significantly from urea + ammonium sulfate and polymer-coated urea. Additionally, when urea was supplied after irrigation, the mass of 100 grains was 11.5% greater than when done before the application of 13 mm of water.

Table 6. Significant interaction of sources and management of N fertilization on the mass of 100 grains of bean cultivated in Selvíria, MS, Brazil.

N Sources	N management	
	Before irrigarion	After irrigation
Ammonium sulfate	27.12 a b	27.74 a b
Urea + Ammonium sulfate	26.80 a b	27.32 b
Urea	26.13 b B	29.15 a A
Coated urea	25.98 b	26.65 b
Ammonium nitrate	28.00 a	27.63 a b
DMS (Management into sources)	1.13	
DMS (Sources into management)	1.76	

Means followed by different letters, upper case in the line, and lower case in the column, differ from each other at 5% probability by Tukey Test.

It was expected to obtain in this study an opposite result for the number of grains pod^{-1} and mass of 100 grains, with N fertilization provided before irrigation (sources with urea), providing greater values because of the lesser N losses due to volatilization by the direct incorporation of the fertilizer in the soil (VIERO et al., 2014). However, Liu et al. (2011) have highlighted other factors that can influence N losses due to volatilization, such as temperature. The minimum temperature verified during the field experiment was close to 15ºC (Figure 1), when the losses by volatilization were minimized (VIERO et al., 2014). In addition, for N fertilization in saturated soils (common condition after irrigation), there is a delay in the peak volatilization of ammonia when comparing with the application in dry soil (DUARTE et al., 2007). Thus, such delay associated with irrigation 3 days after N fertilization (06/18/2012), would also minimize possible losses.

Probably, in the summer crop, the results would be controversial due to the greater air temperature. In this sense, Kaneko et al. (2015) observed greater grain mass in plots where N fertilization was performed before the 10 mm irrigation, when working with summer corn.

As shown in Table 5, there was a significant effect of N fertilization compared with the treatment without N for grain yield of bean. However, although the sources of N provided averaged above 400 kg ha^{-1} more than the control treatment, there was no difference among the sources of N used.

The N supply after irrigation with a 13 mm provided greater productivity when compared with the supply of N before irrigation, following the same trend observed for the number of grains pod^{-1} (Table 5) and mass of 100 grains for the treatment with urea (Table 6). This result is inconsistent with the initial hypothesis of the present study, in which the N supply before irrigation would improve productivity of winter bean.

Although the greatest N content in the leaves was verified with N fertilization before irrigation (Table 5), it is possible that the low temperatures hindered the redistribution of N via phloem during the grain formation phase (HAO et al., 2016). Consequently, the supply of nutrients to the pods became more dependent on the soil N, which is transported via mass flow through the xylem.

CONCLUSIONS

For the culture of wheat, although ammonium nitrate provides a great N content in the leaves, the grain yield is lower when using this source, with no difference among urea, urea + ammonium sulfate and polymer-coated urea. The supply of N before or after irrigation do not influence the productivity of grains, and this could be a strategy of N supply.

Regarding the culture of bean, N fertilization increases grain yield, with N sources resulting in similar productivities. Despite the greater N content in the leaves observed with the N supply before irrigation, the greatest grain yield occurs with the N supplied after 13 mm irrigation.

RESUMO: Estudos que demonstram os efeitos de fontes de nitrogênio (N) aplicadas antes ou após a irrigação na produtividade das culturas de inverno são limitados na literatura. Neste sentido, o objetivo deste trabalho foi comparar o efeito de fontes de N aplicadas imediatamente antes ou após a irrigação de 13 mm nas culturas do trigo e feijão de inverno. Utilizou-se o delineamento de blocos casualizados, com 4 repetições, em esquema fatorial incompleto 5 × 2 + 1, sendo 11 tratamentos com cinco fontes de N: ureia, ureia revestida com polímero, ureia + sulfato de amônio, sulfato de amônio e nitrato de amônio e um tratamento controle (sem adubação nitrogenada). Para o trigo, embora o nitrato de amônio tenha proporcionado maior teor de N nas folhas, a produtividade de grãos foi menor devido ao acamamento das plantas; já a aplicação de N antes ou após a irrigação não influenciou a produtividade de grãos. Com relação ao feijão, a adubação nitrogenada aumentou a produtividade, mas não houve diferenças entre as fontes de N e, apesar do maior teor de N nas folhas observadas com o suprimento de N antes da irrigação, a maior produtividade de grãos foi observada com a adubação após a irrigação.

PALAVRAS-CHAVE: Adubação de cobertura. Incorporação de fertilizante. *Triticum aestivum* L. *Phaseolus vulgaris* L. Polímero.

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