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EFFECT OF RATE AND TIME OF CALCIUM CARBIDE APPLICATION ON NITROGEN USE EFFICIENCY OF APPLIED UREA AND GROWTH OF WHEAT

RASHID MAHMOOD, MUHAMMAD YASEEN AND MUHAMMAD ARSHAD

Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad, Pakistan.

Abstract

Different doses of Calcium carbide (CaC_2) were tested at various growth stages of wheat (*Triticum aestivum* L.) with and without nitrogen fertilizer (urea) in a pot experiment. CaC_2 was applied @ 15, 30, and 45 mg kg^{-1} soil with N fertilizer @ 60 mg kg^{-1} soil at sowing, one, two and four weeks after sowing. Number of tillers, grain yield and N uptake were significantly improved by the application of CaC_2 plus NPK compared to fertilizer alone and control. Reduction in plant height while increased tillering were observed as inhibitory and stimulatory effects of Calcium carbide. Maximum number of tillers, grain yield and N uptake were observed by the application of 30 mg CaC_2 kg^{-1} soil with N fertilizer. Results indicated that application of 30 mg kg^{-1} among doses of CaC_2 while two weeks after sowing among time of application of CaC_2 were found better than all other treatments.

Introduction

Transformation of applied nitrogen fertilizers in the soil in the form of volatilization, nitrification, denitrification and leaching results in the poor nitrogen recovery. Most common practice of nitrogen (N) application in the country is broadcast on the surface of alkaline and calcareous soils that causes volatilization loss of N. The extent of various N losses is up to 70% in alkaline and calcareous soils (Buresh *et al*., 1993; Hazarik & Sarkar, 1996). However, volatilization loss can be minimized by incorporating nitrogenous fertilizers deep into soil instead of broadcast (Keerthisinghe *et al*., 1996). Even after adopting the recommended fertilizer application practices, N recovery seldom exceeds 40% under flooded and un-flooded conditions (Sharma & Yadav, 1996).

Incorporation into the soil or their deep placement particularly of ammonical nitrogen fertilizers may convert NH_4-N into NO_3-N by nitrification process, which is liable to either leach down or denitrify into N_2O or N_2. All of these conversions reduce the time of N stay in soil and thus result in poor nitrogen recovery efficiency (Keerthisinghe *et al*., 1996; Sharma & Yadav, 1996) and loss of costly input.

Apart from economics, nitrogen loss has serious social and environmental implications. The fertilizer nitrogen which leaches down contributes to nitrate pollution of the groundwater, while the portion of fertilizer nitrogen which enters the atmosphere in gaseous forms pollutes the environment.

Since recently Calcium carbide (CaC_2) has been considered a plant growth promoting compound (Yaseen *et al*., 2005, 2006) in view of its dual action i.e. potent nitrification inhibitor (Porter, 1992) as well as plant hormone (Arshad & Frankenber, 2002). Banerjee *et al*., (1990) have already reported that CaC_2 inhibits the *Nitrosomonas* activity to prolong the stay of N in soil as NH_4^+ ion. The work of many researchers also supported the use of CaC_2 as an effective inhibitor of oxidation of NH^+_4 into NO^-_3 under both flooded and non-flooded soil conditions (Freney *et al*., 2000; Keerthisinghe *et al*., 1996; Randall *et al*., 2001; Ahmad *et al*., 2004).

In spite of all beneficial effects of CaC_2, it is not known, how much dose of CaC_2 is appropriate with nitrogen fertilizer and what is its appropriate time of application to get optimum influence on plant growth. The present experiment was carried to find out appropriate rate and time of application of CaC_2 with appropriate dose of urea fertilizer for improving growth and yield of wheat.

Materials and Methods

An experiment was conducted in pots to find out appropriate rate and time of application of Calcium carbide (CaC_2) on growth and N use efficiency by wheat. Surface layer soil was mixed thoroughly, ground, passed through 2mm sieve and filled in polythene lined earthen pots @ 12 kg per pot. The soil used was sandy clay loam in texture and possessed other physico-chemical properties as: pH 7.7; ECe 1.16dS m^{-1}; organic matter contents 0.88% and total N contents 0.05%. Recommended doses of fertilizers (60-50-30 mg kg^{-1} soil) were applied as urea, single super phosphate and sulphate of potash. Half of nitrogen, full dose of phosphorus and potassium were thoroughly mixed in the soil before filling into pots. There were three treatments of powdered CaC_2 (15, 30, and 45 mg kg^{-1} soil) and four times of its application (at sowing, 1 week after sowing, 2 weeks after sowing, and 4 weeks after sowing of seeds). Pots were arranged according to completely randomized design. Each treatment was repeated four times.

Eight seeds of wheat were sown and thinned after germination to four seedlings per pot. Uprooted seedlings were kept in the same pot. CaC_2 was placed at 6 cm depth in the centre of pot followed by irrigation with canal water. Moisture was maintained approximately at 60% water holding capacity till grain formation stage. At booting, plant height and number of tillers were recorded. At maturity crop was harvested and weights of grain and straw samples were recorded.

Grain and straw samples were dried and ground to determine total nitrogen (Hu & Barker, 1999). Nitrogen uptake was calculated by multiplying nitrogen concentration in grain or straw with grain or straw weights.

Data collected for various characteristics were analyzed statistically using analysis of variance technique (Steel & Torrie, 1980). The treatment’s means were compared by Duncan multiple range test at 5% probability level (Duncan, 1955).

Results

Data regarding growth parameters on plant height, number of tillers, straw and grain yield revealed significant influence of addition of CaC_2 in nitrogen fertilized plots. Plant height and number of tillers were measured at grain formation growth stage. The effect of rate and time of application of CaC_2 on plant height was found to be significant (Table 1). Maximum plant height (76.4 cm) was observed where fertilizer alone was applied. It was followed by the treatment where CaC_2 was applied @ 15 mg kg^{-1} with N fertilizer at sowing time. Further application of higher rates of CaC_2 reduced the plant height. Minimum plant height was observed in treatment of N-CaC_2, 60-45 mg kg^{-1} at 1 and 2 weeks after sowing as well as control. It is obvious from the data that nitrogen application increased the plant height; however addition of CaC_2 with fertilizer reduced it. Stimulatory effect of CaC_2 on tillering is obvious from the data in Table 2. Maximum number of tillers pot^{-1} was observed where CaC_2 was applied @ 30 mg kg^{-1} 2 weeks after sowing which is ~23 % more than fertilizer alone. Application of CaC_2 2 weeks after sowing gave relatively better results compared to application of CaC_2 at the other three stages of growth.

Table 1. Effect of different doses and time of application of Calcium carbide on plant height (cm).

N – CaC_2 ($mg\ kg^{-1}$ soil)	Time of application of Calcium carbide			
	AS*	1WAS	2 WAS	4WAS
0 – 0	70.1 b	70.1 b	70.1 b	70.1 b
60 – 0	76.4 a	76.4 a	76.4 a	76.4 a
60 – 15	74.7 ab	73.0 ab	72.4 b	73.7 ab
60 – 30	72.5 b	69.8 b	70.7 bc	72.4 b
60 – 45	73.3 ab	69.5 b	69.1 c	72.1 b

Values in the same column with different letter(s) differ significantly ($p<0.05$) according to DMRT.
*AS= At sowing, 1 WAS= One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Table 2. Effect of different doses and time of application of Calcium carbide on number of tillers of wheat per pot.

N – CaC_2 ($mg\ kg^{-1}$ soil)	Time of application of Calcium carbide			
	AS*	1WAS	2 WAS	4WAS
0 – 0	11.5 b	11.5 c	11.5 d	11.5 c
60 – 0	25.0 a	25.0 b	25.0 c	25.0 b
60 – 15	26.8 a	26.8 ab	26.3 c	27.0 ab
60 – 30	26.0 a	28.4 a	33.8 a	30.8 a
60 – 45	23.6 a	24.1 b	31.0 ab	28.3 ab

Values in the same column with different letter(s) differ significantly ($p<0.05$) according to DMRT
*AS= At sowing, 1 WAS= One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Table 3. Effect of different doses and time of application of Calcium carbide on wheat straw yield ($g\ pot^{-1}$).

N – CaC_2 ($mg\ kg^{-1}$ soil)	Time of application of Calcium carbide			
	AS*	1WAS	2 WAS	4WAS
0 – 0	19.0 c	19.0 c	19.0 d	19.0 c
60 – 0	34.2 b	34.2 b	34.2 c	34.2 b
60 – 15	35.3 b	34.6 b	33.6 c	34.9 a
60 – 30	34.4 b	37.8 a	41.1 a	36.7 a
60 – 45	39.6 a	38.2 a	38.9 ab	36.1 a

Values in the same column with different letter(s) differ significantly ($p< 0.05$) according to DMRT
* AS= At sowing, 1 WAS= One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Maximum straw yield was observed where CaC_2 was applied @ 45 mg kg^{-1} along with N fertilizer. However, all the CaC_2 rates and time of application of CaC_2 did not show any significant effect on straw yield (Table 3). Unlike straw response of wheat to CaC_2 application for grain production was different and positive. Although fertilizer application increased the grain yield yet its influence was further improved with addition of CaC_2 (Table 4). This increase in grain yield could be observed at all CaC_2 application rates and time of application compared to fertilizer alone. Maximum grain yield was observed where CaC_2 was applied @ 30 mg kg^{-1}. Increase in grain yield ranged from 22.9 to 34.3 g pot^{-1}due to addition of different rates of CaC_2 with nitrogen fertilizer. Results revealed that 30 mg kg^{-1} CaC_2 among CaC_2 treatments and 2 weeks after sowing among time of application treatments were the best rate and time of application.

Table 4. Effect of different doses and time of application of Calcium carbide on grain yield of wheat (g pot^{-1}).

$N – CaC_2$	Time of application of Calcium carbide			
(mg kg^{-1} soil)	AS*	1WAS	2 WAS	4WAS
0 – 0	14.7 c	14.7 e	14.7 e	14.7 c
60 – 0	21.0 b	21.0 d	21.0 d	21.0 b
60 – 15	23.4 ab	22.9 c	27.0 c	20.5 b
60 – 30	26.4 a	29.0 a	34.3 a	25.0 a
60 – 45	24.2 ab	25.9 b	30.4 b	24.6 a

Values in the same column with different letter(s) differ significantly ($p < 0.05$) according to DMRT
*AS= At sowing, 1 WAS = One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Table 5. Effect of different doses and time of application of Calcium carbide on total N uptake by wheat (mg pot^{-1}).

$N – CaC_2$	Time of application of Calcium carbide			
(mg kg^{-1} soil)	AS*	1WAS	2 WAS	4WAS
0 – 0	335.6 d	335.6 e	335.6 e	335.6 d
60 – 0	824.6 c	824.6 d	824.6 d	824.6 c
60 – 15	941.5 b	930.7 c	1002.7 c	847.8 c
60 – 30	994.2 a	1102.8 a	1202.2 a	1011.7 a
60 – 45	1020.7 a	1064.9 b	1180.3 b	993.6 b

Values in the same column with different letter(s) differ significantly ($p < 0.05$) according to DMRT
*AS = At sowing, 1 WAS= One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Table 6. Effect of different doses and time of application of Calcium carbide on N use efficiency by wheat (%) over nitrogen fertilizer applied.

$N – CaC_2$	Time of application of calcium carbide			
(mg kg^{-1} soil)	AS*	1WAS	2 WAS	4WAS
0 – 0	-	-	-	-
60 – 0	-	-	-	-
60 – 15	15.6	14.2	23.8	3.1
60 – 30	22.6	37.1	50.3	24.9
60 – 45	26.1	32.0	47.4	22.5

Values in the same column with different letter(s) differ significantly ($p < 0.05$) according to DMRT
*AS = At sowing, 1 WAS= One week after sowing, 2 WA= Two weeks after sowing, 4 WAS= Four weeks after sowing.

Maximum total N uptake by wheat (grain + straw) was observed by application of 30 and 45 mg kg^{-1} CaC_2 2 weeks after sowing (Table 5). Results also indicate that CaC_2 application 2 weeks after sowing increased the N uptake among different treatments of time of application of CaC_2. Moreover, nitrogen use efficiency is also evident of increased N uptake by the addition of CaC_2. Maximum N recovery efficiency was observed by N-CaC_2, 60-30 mg kg^{-1} soil application 2 weeks after sowing while it was minimum at 4 weeks after sowing.

Discussion

Calcium carbide influences plant growth from germination to maturity due to its dual action of nitrification inhibitor as well as plant growth hormone and thus it influences the yield and yield contributing parameters (Muromtsev *et al*., 1988; Bronson *et al*., 1992; Arshad & Frankenberger, 2002; Ahmad *et al*., 2004; Yaseen *et al*., 2005, 2006). This experiment dealt with CaC_2 to find out appropriate rate and time of its application for wheat. Reduction in plant height due to growth inhibitory effect of CaC_2 is evident from its influence on plant growth and development, which is obvious from the increase in number of tillers in this experiment. Healthy growth led to the absorption of more nutrients from the soil to enhance tillering. Many researchers reported that CaC_2 application in rihzosphere stimulates the tillering (Freney *et al*., 1990; Sharma & Yadav, 1996; Randall *et al*., 2001; Yaseen *et al*., 2006). Application of CaC_2 @ 30 mg kg^{-1} with fertilizer increased fertile tillers over fertilizer alone, pointing towards definite role of CaC_2 on tillering. Yaseen *et al*., (2005, 2006) also reported increased tillering in rice and wheat with CaC_2 application.

Calcium carbide is also known to increase the root growth. Increase in fertile tillers and enhanced uptake of nitrogen were the attributes of application of CaC_2 at 2 weeks after sowing which caused increase in grain yield. Higher N uptake may be due to increase in root primordia (stimulatory effect of CaC_2) to explore more volume of soil to acquire nutrients (Ahmad *et al*., 2004). The influence of nutrients on crop growth is well documented. Interaction between rate and time of CaC_2 applications revealed that application of CaC_2 2 weeks after sowing provided better results compared to four other times of application. These results elucidate that application of CaC_2 @ 30 mg kg^{-1} at 2 weeks after sowing could provide promising results if applied in the field conditions.

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