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BRIEF COMMUNICATION

Effect of gibberellic acid on carbonic anhydrase, photosynthesis, growth and yield of mustard

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Abstract

The plants of mustard (*Brassica juncea* L.) were treated with 0, 25 and 50 µM gibberellic acid (GA_3) at three fully developed leaf stage (30 d after sowing). Effect of GA_3 on carbonic anhydrase activity, photosynthetic rate, leaf area index and dry mass was studied at 50, 70 and 90 d after sowing. At harvest 1000 seed mass, pod number and seed yield were recorded. GA_3 treatment (50 µM) enhanced all the characteristics studied.

Additional key words : leaf area index, *Brassica juncea*, seed mass.

Carbonic anhydrase (CA; EC 4.2.1.1) catalyses the reversible interconversion of HCO_3^- and CO_2, and in the leaves of higher plants it represents 1 - 2 % of total soluble proteins (Okabe *et al.* 1984). Its distribution pattern is similar to that of Rubisco (Tsuzuki *et al.* 1985) and the co-localization of Rubisco and CA in the stroma suggests a role for it in photosynthetic CO_2 fixation (Sultemeyer *et al.* 1993). According to Graham *et al.* (1984) CA maintains a constant supply of CO_2 to Rubisco. In our earlier work (Khan 1994) we have shown a relationship between CA activity and photosynthetic rate and dry mass of mustard.

GA_3 affects many enzymes, *e.g.* α-amylase, protease, ribonuclease and β-1,3 glucanase, and many physiological processes. However, effect of GA_3 on CA activity has not been resolved. Thus study was conducted with the aim to see whether CA activity was enhanced by GA_3 application which may lead to increase in photosynthesis and dry matter production.

Seeds of mustard [*Brassica juncea* (L.) Czern & Coss.] cv. T-59 were sown in 23 cm diameter earthen pots filled with acid washed sand. The pots were kept in a net house (temperature 23 °C, natural day length). Each pot was supplied with 200 cm^3 of full Hoagland's nutrient solution every day in the morning but the

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quantity was increased to 500 cm^3 as the growth progressed. In addition to this, 250 cm^3 of de-ionised water was also added to each pot every day in the evening as the plant mature. At two leaf stage, two plants per pot were maintained. De-ionised water or GA_3 at concentration 25 and 50 µM were sprayed at fully developed three leaf stage (30 d after sowing), and each treatment was replicated eight times. Carbonic anhydrase (CA), net photosynthetic rate (P_N), leaf area index (LAI) and dry mass were recorded at 50, 70 and 90 DAS. At each sampling stage two pots of each treatment were sampled at random. CA in the leaves was estimated by Dwivedi and Randhava (1974) method (for detail see Khan 1994). Photosynthetic rate of the leaves, which were later selected for estimation of CA, was measured by *LI 6200 Portable Photosynthesis System* (*Li-COR*, Lincoln, USA). LAI was calculated using graph paper outlining with about 10 % of the total leaves. At harvest 1000 seed mass, pod number and seed yield were recorded. Data were analysed statistically using F-test (Gomez and Gomez 1984).

Table 1. Effect of GA_3 on carbonic anhydrase (CA) activity, photosynthetic rate (P_N), leaf area index (LAI), dry mass and yield of mustard (time after sowing 50, 70, 90 or 120 d).

GA3 [µM]	CA activity [mol(CO_2) kg^{-1}(f.m.) s^{-1}]			P_N [µmol(CO_2) m^{-2} s^{-1}]			LAI		
	50	70	90	50	70	90	50	70	90
0	3.3	6.8	6.2	13.13	16.04	14.62	2.86	3.67	3.44
25	7.2	10.2	9.8	17.32	18.82	15.84	3.02	3.98	3.74
50	10.9	13.2	12.6	20.56	21.56	18.22	3.88	4.02	3.86
CD at 5 %	0.7	2.2	3.1	3.60	2.66	1.68	0.42	0.21	0.26

GA3 [µM]	Dry mass [g $plant^{-1}$]			1000 seed mass [g]	Pod number	Seed yield [g $plant^{-1}$]
	50	70	90	120	120	120
0	2.42	5.62	10.80	4,56	140.56	6.86
25	2.90	8.14	14.50	4.72	160.00	7.24
50	3.10	12.36	20.64	4.88	170.86	10.32
CD at 5 %	0.32	1.62	2.02	0.08	10.23	1.12

Application of GA_3 increased CA activity, P_N, LAI and dry mass. All the parameters increased upto 70 DAS and then at 90 DAS they decreased (Table 1), except the dry mass which increased upto 90 DAS. The increase in CA activity with GA_3 was possibly through increase in transcription of the gene that code for CA. Sugiharto *et al.* (1992) have also shown that addition of cytokinin to solutions bathing the cut ends of the detached leaves of maize inhibited the decrease of CA mRNA levels. This enhanced CA due to GA_3 may help in rapid dehydration of stored HCO_3^- which is a potential CO_2 source for Rubisco resulting in increase in photosynthetic rate in GA_3 treated plants (Table 1). Relationship between CA and P_N has been established *e.g.* by Edwards and Mohamed (1973) on *Phaseolus vulgaris*, Ohki (1978) on *Glycine max* and Khan (1994) on *Brassica juncea*. Okabe *et al.* (1980) have also found that with increase in CA, the carboxylation rate was enhanced. The K_M for the carboxylation decreased from 18 $\mu M(CO_2)$ in the absence to 7 $\mu M(CO_2)$ in the presence of CA. Enhanced P_N in the present investigation has led to accumulation of more dry mass. The increase in LAI due to GA_3 treatment showed higher photosynthetic area and has also contributed in enhancing dry mass production. The correlation coefficients for LAI with dry mass were 0.963**, 0.983** and 0.911** at 50, 70 and 90 DAS, respectively, showing dependence of dry matter production on LAI.

Dry matter accumulated in GA_3 treated plants was efficiently translocated to the developing sink, evident from increased 1000 seed mass and pod number. This resulted in increase in seed yield.

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