

## Effect of Guazatine on Wheat

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**Abstract** : Solution of guazatine triacetate (1,1'-iminodi [octamethylene] diguanidium triacetate, an agricultural fungicide ; BEFRAN®) was sprayed onto wheat plants at a rate of 0.025 or 0.25% at seedling, pre- and post-anthesis stages. Guazatine promoted seedling growth without root fraction. When guazatine was sprayed at pre-anthesis, the weight of a head was elevated by 25—27% mainly by increased number of grains and when sprayed at post-anthesis, it was elevated by 20% only by increased weight of a grain. At seedling and anthesis stages, the apparent photosynthetic rate increased by 8—16% but the transpiration rate was practically unchanged. Consequently water use efficiency increased up to 15% by guazatine.

**Key words** : Fungicide, Growth, Guazatine, Photosynthesis, Transpiration, Water use efficiency, Wheat, Yield.

コムギに及ぼすグアザチンの影響：今井 勝（筑波大学農林学系）

**要 旨**：糸状菌に対して広範な抗菌スペクトルを示すグアザチンの酢酸塩（1,1'-iminodi [octamethylene] diguanidium triacetate, 商品名ベフラン®）がコムギの収量を高めるという情報を基に、人工光ファイトロン中で栽培したコムギにその水溶液を噴霧して、生育、穂重・粒重、光合成・蒸散に及ぼす影響を検討した。グアザチン 0.025 及び 0.25% 水溶液噴霧施用は幼植物の生育を促進したが、根に対する効果はなかった。穂ばらみ期の施用は 1 穂重を 25—27% 高めたが、それは主として 1 穂粒数の増加に基いていた。開花期以降の施用は 1 穂重を 20% 高めたが、それは 1 粒重の増加のみに基いていた。幼植物期及び開花期の葉の光合成速度はグアザチン施用により 8—16% 促進されたが、蒸散に対する効果はほとんどなく、結果的に水利用効率が最大 15% 改善された。

**キーワード**：グアザチン、光合成、コムギ、殺菌剤、収量、蒸散、生育、水利用効率。

Guazatine, an agricultural fungicide, is currently considered as a chemical of a new type because of its special structure and its versatile usage on food crops as well as on fruit trees (e. g. snow mould of wheat, canker disease of apples, black head of grapes, etc., Fig. 1)<sup>3,8)</sup>.

Preliminary results obtained in Arles and other places of France showed that the application of guazatine triacetate solution to wheat stands resulted in 15—30% increase in yield (Masui, M., personal communication). Therefore, it is worth while to examine whether this increase is ascribed to the direct effect of the fungicide on the photosynthetic activity in wheat leaves or to its indirect effect through the prevention of fungal activities or both because there is no published observation. In a series of experiments, the solution of this chemical was sprayed on wheat plants at the seedling, pre- and post-anthesis stages, and their photosynthesis, transpiration, growth and part of yield component were measured to clarify the possible, direct effect of guazatine.

### Materials and Methods

#### 1. Plant material and chemical used

A wheat variety (*Triticum aestivum* L. cv.

Norin 36) and guazatine triacetate (1,1'-iminodi [octamethylene] diguanidium triacetate, mw = 535.7, BEFRAN®) were used throughout the experiments.

#### 2. Experiment on seedling growth

On 14 February 1985, three seeds were sown in each plastic pot containing 1 kg of soil and 3 g of chemical fertilizer (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O = 14-14-14, %) in a glasshouse. One week after the emergence, seedlings were thinned to one per pot and transferred into an artificially illuminated growth cabinet. Plants were grown under conditions of 450  $\mu\text{mol m}^{-2}\text{s}^{-1}$  of photosynthetic photon flux densities (PPFD) which were supplied with metal halide lamps during 12h-daytime and measured with a LI-COR quantum sensor, day/night temperatures at 20/10°C and 60% RH.

On 11, 15 and 23 March, guazatine solution was sprayed onto whole plants at a rate of 0.025 or 0.25%. The concentration of 0.025% is equivalent to that of 0.1% BEFRAN 25®, the recommended value for the general application. Plants in the control plot were sprayed with distilled water. On 25 March (two weeks from the initial spraying), twelve plants from each treatment were harvested, and their

shoot length, leaf area and tiller number were measured. Thereafter, they were separated into the leaf blade, leaf sheath plus stem and root fractions, and then oven-dried at 85°C for two days and weighed.

### 3. Experiment on yield components

Under the same conditions with the experiment on seedling growth, ten plants for each treatment were grown from seedling to maturity stage (14 Nov. 1984 to 14 Feb. 1985). Because of the limited space of the growth cabinet, plants were thinned to two stems per pot at the bolting stage to avoid mutual shading, so that there remained 20 heads per treatment.

Guazatine solution (0.025 and 0.25%) or water was sprayed onto whole plants at the booting stage to just before anthesis (21, 24 and 27 Dec.). On 14 Feb., plants were harvested and air-dried to examine the weight of a head and number of grains per head.

In 1986, a similar experiment was performed to examine the effect of guazatine spraying at post-anthesis. Plants were sprayed with 0.025% solution or water on 10 (at anthesis), 15 and 20 May and harvested on 24 June.

### 4. Experiment on photosynthesis and transpiration

To clarify the effect of guazatine on gas exchange rates in wheat plants, attached leaves in subsamples from the above two experiments were examined with an open, gas exchange measurement system which was composed of an absolute-type infrared CO<sub>2</sub> analyzer (Fuji, Model ZRC), a dew point hygrometer (EG & G, Model 911) and two leaf chambers<sup>1)</sup>. Conditions of measurement were 700  $\mu\text{mol m}^{-2}\text{s}^{-1}$  PPFD, 20°C leaf-temperature, 10 mbar vapour pressure difference between leaf and air (ca 60% RH) and 350  $\mu\text{l l}^{-1}$  CO<sub>2</sub>. Measurements were repeated four times.

## Results

### 1. Effect of guazatine on growth of wheat seedlings

As shown in Table 1, guazatine promoted the number of tillers and leaf area per plant. Dry weight of plant parts was also affected by guazatine spraying. The promotive effect of guazatine on fractions in leaf weight and leaf sheath plus stem was 27–29% and 16–17%, respectively. But there was no effect on root

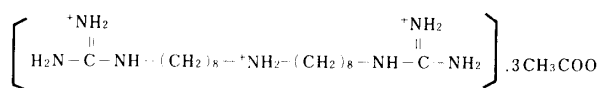


Fig. 1. Chemical structure of guazatine triacetate.

weight. Specific leaf weight, which is an index of leaf thickness, was 2.78, 3.06 and 3.31 mg leaf weight/cm<sup>2</sup> leaf area in 0, 0.025 and 0.25% guazatine plot, respectively. The total dry weight, therefore, increased by 15–16% by guazatine during the two weeks but there was no distinction in the effect between 0.025 and 0.25% solution.

### 2. Effect of guazatine on yield components of wheat

Table 2 shows the promotive effect of guazatine on the weight of a head (25–27%), number of grains per head (18–21%) and weight of a grain (4–8%) when sprayed at pre-anthesis stage. The increase of head weight was due mainly to that of the number of grains per head. Application of guazatine at post-anthesis increased the head weight (20%) of wheat by increasing only the weight of a grain.

### 3. Effect of guazatine on gas exchange of wheat leaves

Table 3 shows the effect of guazatine at the seedling stage, where apparent photosynthetic rate was increased by 14–16% by guazatine spraying but no effect was found on the transpiration rate two days after the spraying. Therefore, the water use efficiency (WUE) in leaves, which is the ratio of photosynthetic rate to transpiration rate, was increased by 14–15% by guazatine spraying. There was no distinction in the effect between 0.025 and 0.25% guazatine solutions.

Table 4 shows the effect of guazatine spraying on flag leaves at flowering time. When gas exchange rates were measured just before and one day after the spraying, photosynthetic rate was increased by 16% by 0.025% solution and 8% with 0.25% solution. On the other hand, transpiration rate was practically unchanged by the spraying. As a result, WUE increased by 7–12% by guazatine in both plots.

## Discussion

As seen in Table 1, the promotive effect of guazatine was observed on the increase in the dry weight of the whole plant. This is due

mainly to the increase in the leaf blade weight and is apparent from the change in specific leaf weight as well as leaf area per plant. Increases in the tiller number and the leaf sheath plus stem fraction partly contribute to the dry weight increment. No response of the root fraction to guazatine shows that the increased photosynthate was partitioned for the development of the aerial parts at this stage. When guazatine was sprayed at the pre-an-

thesis stage, the number and weight of the grains per head increased, but when applied at the post-anthesis stage, only the weight of a grain was increased. This suggests that guazatine simply promotes the photosynthetic activity of leaves and has no other effects seen in some hormones<sup>5,7)</sup>.

Although the duration of the effectiveness of guazatine is not determined, the promotive effect may last at least for several days in spite of the drying by 30 min after the spray. At the seedling stage, leaf photosynthesis was promoted by 14—16% but no such effect on transpiration; therefore, the water use efficiency increased up to 15% (Table 3). At the flowering stage, flag leaves responded similarly with that at the seedling stage (Table 4). Water stress occurs during the maturity period in many places<sup>2)</sup>. In such a case the improvement of water use efficiency is useful for steady production of wheat because of partial amelioration of the stress. When photosynthetic rate is elevated by cytokinins, stomatal opening or transpiration rate correlates to it<sup>5,6)</sup>. Therefore, the guazatine effect seems somewhat different with that of cytokinins, though the mechanism is unknown at present.

Table 1. Effect of guazatine spraying on the growth of wheat seedlings.

Item	Guazatine, %		
	0	0.025	0.25
Plant length, cm	32.6	33.5	32.1
No. of tillers	2.4b	2.8a	2.8a
Leaf area, cm <sup>2</sup>	66.1b	76.2a	72.0ab
Dry weight (mg) of;			
leaf blade	184b	233a	238a
leaf sheath+stem	89b	103a	104a
root	135	132	133
whole plant	408b	468ab	475a

In each row figures followed by a different letter are significantly different ( $p < 0.05$ ) by Student's t-test.

Table 2. Effect of guazatine spraying on the part of yield component of wheat.

Stage of spraying	Item	Guazatine, %		
		0	0.025	0.25
Pre-anthesis	Weight of grains per head, mg	1918b	2404a	2439a
	No. of grains per head	45.0b	54.4a	52.9a
	Weight of a grain, mg	42.6b	44.2ab	46.1a
Post-anthesis	Weight of grains per head, mg	1038b	1249a	—
	No. of grains per head	38.4	37.6	—
	Weight of a grain, mg	27.1b	33.1a	—

In each row figures followed by a different letter are significantly different ( $P < 0.05$ ) by Student's t-test.

Table 3. Effect of guazatine spraying on the gas exchange characteristics in leaves of wheat seedlings.

Item	Guazatine, %		
	0	0.025	0.25
Photosynthesis, mg CO <sub>2</sub> dm <sup>-2</sup> h <sup>-1</sup>	24.9b	28.9a	28.4a
Transpiration, g H <sub>2</sub> O dm <sup>-2</sup> h <sup>-1</sup>	1.32	1.33	1.31
Water use efficiency, mg CO <sub>2</sub> g <sup>-1</sup> H <sub>2</sub> O	19.0b	21.8a	21.7a

Data are those from two days after the guazatine spraying. In each row figures followed by a different letter are significantly different ( $P < 0.05$ ) by Student's t-test.

Table 4. Effect of guazatine spraying on the gas exchange characteristics in flag leaves of wheat plants.

Item	Before or after the spraying	Guazatine, %		
		0	0.025	0.25
Photosynthesis, $\text{mg CO}_2 \text{ dm}^{-2} \text{ h}^{-1}$	Before	30.8	30.8	30.2
	After	30.6	35.7*	32.5
Transpiration, $\text{g H}_2\text{O dm}^{-2} \text{ h}^{-1}$	Before	1.18	1.16	1.14
	After	1.19	1.21	1.16
Water use efficiency, $\text{mg CO}_2 \text{ g}^{-1} \text{ H}_2\text{O}$	Before	26.1	26.7	26.3
	After	25.8	29.8*	28.1*

“Before” or “After” indicates measurement just before the spraying or one day after the spraying guazatine solution. \*, Significantly different ( $P < 0.05$ ) from the value before the spraying.

Since urea, a nitrogen fertilizer, is known to activate plant vigour after its foliar application<sup>4)</sup>, urea solution was sprayed on the wheat plants to test any possible role of guazatine as a nitrogen source. But urea was ineffective to promote photosynthesis at the same nitrogen concentration with guazatine, which suggests that guazatine does not work as a nitrogen source.

In the other experiments, quite similar response was obtained for barley plants but little effect was obtained regarding rice and corn plants. The difference in air temperature at the time of spraying, which was 20°C for wheat and barley and 30°C for rice and corn, might have caused the specific difference. Necrotic spots appeared on rice leaves in the 0.25% guazatine plot, which was probably because of rapid drying of the chemical under high temperatures. Further tests for the applicability to other crop species in the field should be done including the examination for indirect effect through the fungal activities.

It is concluded that the application of guazatine to wheat plants promotes photosynthesis and leads to growth promotion and yield increase.

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