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## AIR POLLUTION INJURY IN RICE PLANTS UNDER KINETIN AND ASCORBIC ACID SPRAY

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*Oryza sativa* L. cv. GR 3 was grown near to a fertilizer plant which emits $SO_2$, $NH_3$, $NO_2$ and F as major air pollutants. Attempts to obviate air pollution injury by foliar application of kinetin and ascorbic acid at the age of 45-51 days has minimised the foliar injury thereby improving the photosynthetic leaf area. Accumulation of fresh and dry matter of culm was not affected by air pollution under the chemical protectants. However, plant height and panicles length were not improved. All the polluted plants produced an increased number of panicles under the kinetin and ascorbic acid spray with high total dry standing crop. Unfavourable climatic factors during the investigation acted as additional stress to Hamper the productivity.

***Key words***: Kinetin, Ascorbic Acid, Rice, Air pollution.

### Introduction

The principal atmospheric world wide pollutants are $SO_2$, $NO_2$ and $O_3$. Ammonia and flouride have also been found often in industrial atmospheres especially in the vicinity of synthetic fertilizer factories [1,2]. All are phytotoxic to varying extent. Earlier reports on rice growth [3], yield [4] showed that $SO_2$ fumigation and $SO_2 + O_3$ fumigation [5] were injurious. Three general approaches *viz.*, the use of cultural practices, chemical protectants and resistant varieties have been taken in the past to obviate or ameliorate the damage caused by air pollutants [6]. Our recent reports on rice have brought out cultivar differences in sensitivity to air pollution from a fertilizer plant [2] and deterioration of pollution resistance in rice cv. GR 3 from one generation to another with high sterility index [7]. This investigation has been carried out as an attempt to obviate air pollution injury by the foliar application of kinetin (growth regulator) and ascorbic acid (an antioxidant).

### Materials and Methods

The experiments were performed with rice plants (*Oryza sativa* L.) cv. GR 3. Three day old pregerminated seeds were sown in polythene pots containing 8 kg of garden soil. The pots were divided between two locations, a polluted site (State Fertilizer Company Ltd., near Gujarat), which emits $SO_2$, $NH_3$, $NO_2$ and F as major pollutants) and an unpoluted 'control' site, in a randomised design with 12 replicates (Table 1). The mineral composition of the soil and the standard procedure followed for the determination of concentrations of ambient air pollutants were described elsewhere [2].

It was evident from our studies that during flowering period (days between 58 and 64), the plants were severely affected by the air pollutants [7]. To cope with this condition at the pre-flowering period i.e. at the age of 45, 47, 49 and 51 days, 10 $\mu$ moles of ascorbic acid and 2 ppm of kinetin (concentrations were selected by trial experiments at seedling stage growing them at different concentrations) were sprayed at both the sites. Unsprayed control and test site plants were sprayed with distilled water.

Measurements of plant height, leaf area, dry weight of leaf and culm portions were done at the age of 70 days. Fully expanded third leaves from the top were used for the estimation of chlorophyl 'a' and chlorophyl 'b' [8]. Carotenoids content was also determined from the same extract [9], at the age of 70 days. At the same age leaf ascorbic acid content was determined [10]. From 50, 60 and 75 days old dry shoot

TABLE 1. CONCENTRATIONS OF POLLUTANTS AND METEROLOGICAL DATA MEASURED AT A CONTROL SITE AND A POLLUTED SITE DURING THE GROWTH OF AN EXPERIMENTAL CROP OF RICE.

| Parameters | Control site | Polluted site |
|---|---|---|
| Sulphation rate | $0.17 \pm 0.03$ | $1.11 \pm 0.09$ |
| mg $SO_4$/100 $cm^2/d^{-1}$ | (0.10 - 0.23) | (0.83 - 1.25) |
| $NO_2 \mu g/m^3$ | Negligible | 0.027 |
| | | (0.015 - 0.04) |
| $NH_3$ mg/$m^3$ | Negligible | 1.68 |
| | | (1.42 - 1.84) |
| F $\mu g/cm^2/month^{-1}$ | Negligible | 0.31 |
| | | (0.27 - 0.39) |
| Mean temperature | 34.7 | 35.3 |
| maximum (°C) | (29.0 - 38.0) | (29.0 - 39.5) |
| Mean temperature | 23.3 | 24.0 |
| minimum (°C) | (18.3 - 26.3) | (18.5 - 25.8) |
| Wind speed | 5.6 | 5.4 |
| ($km^{-1}/h^{-1}$) | (1.6 - 9.5) | (1.6 - 9.6) |
| Humidity (%) | 66.7 | 64.0 |
| | (13.0 - 99.0) | 16.0 - 99.0) |
| Total rainfall | 70.9 | 68.5 |
| ($mm/month^{-4}$) | | |

Values in parentheses represent minimum and maximum values.

portions the total nitrogen was estimated [11], sulphur was determined turbidimetrically, after digestion [12-13], and fluoride was determined after extraction [14-15]. Growth and yield data were analysed using analysis of variance with five replicates while standard errors were worked out for biochemical data with three replicates.

**Results and Discussion**

Air pollution inhibited the plant height even under the foliar application of kinetin and ascorbic acid (Table 2). Though the photosynthetic leaf area was reduced by 62% in kinetin sprayed polluted plants due to its vigorous growth in the sprayed control plants, there was no difference as compared to unsprayed control. The foliar injury was 12% in kinetin and 23% in ascorbic acid treated plants as against 41% in unsprayed polluted plants. The leaf dry matter showed no difference in kinetin and ascorbic acid treated plants with control plants. Interestingly, the accumulation of fresh and dry matter of culm also showed no evident deviation from the control under the spray of chemical protectants.

The length of the panicles were significantly reduced in both the set of treated polluted plants (Table 3). Paradoxically, all the polluted plants produced an increased number of panicles per plant under the kinetin and ascorbic acid sprayed plants. It was also interesting that the total dry standing crop (biological yield) was increased in the polluted environment under these chemical spray, thereby showing an improvement.

Air pollution reduced the chl 'a' content by 20% in the unsprayed polluted plants but the reduction was minimised to 7 and 6% in kinetin and ascorbic acid treated plants as compared to usprayed control (Table 4). On the other hand the chl 'b' content was reduced by 49% while it was 41 and 38%

TABLE 2. GROWTH OF RICE PLANTS TOWARDS AIR POLLUTION EXPOSURE AS MODIFIED BY FOLIAR APPLICATON OF KINETIN AND ASCORBIC ACID.

| Parameter/plant | Control unsprayed | Polluted: Unsprayed | Polluted: Kinetin sprayed | Polluted: Ascorbic acid sprayed | LSD 5% level |
|---|---|---|---|---|---|
| Plant height (cm) | 67 de | 38a | 39ab | 41ac | 8 |
| Photosynthetic leaf area (cm)$^2$ | 110bc | 65a | 100b | 90ab | 35 |
| Foliar injury (%) | – | 40.7 (8.6) | 11.9 (5.9) | 23.0 (8.5) | – – |
| Leaf fresh wt. (gm) | 0.90bc | 0.65a | 0.67ab | 0.76ac | 0.15 |
| Leaf dry wt. (gm) | 0.37cd | 0.24a | 0.31bc | 0.34bd | 0.06 |
| Fresh culm (gm) | 3.25ac | 3.05a | 3.10ab | 3.50ad | 0.50 |
| Dry culm (gm) | 0.56ac | 0.50a | 0.56ac | 0.54ab | 0.11 |

Alphabets notation represent DMRT and figures in parentheses represent SE of 5 replicates.

TABLE 3. BIOLOGICAL YIELD OF RICE PLANTS EXPOSED TO AIR POLLUTION FROM A FERTILIZER PLANT AS MODIFIED BY FOLIAR APPLICATON OF KINETIN AND ASCORBIC ACID.

| Parameter/plant | Control unsprayed | Polluted: Unsprayed | Polluted: Kinetin sprayed | Polluted: Ascorbic acid sprayed | LSD 5% level |
|---|---|---|---|---|---|
| Panicle length (cm) | 21.4b | 11.7ab | 11.5a | 11.9ab | 2.9 |
| Panicle (number) | 1.0a | 4.1c | 4.4cd | 6.6d | 1.4 |
| Grain yield (gm) | 0.40c | 0.02a | 0.02a | 0.07a | 0.14 |
| Biological yield (gm) | 1.88ac | 1.81a | 2.87ab | 3.00ad | 1.4 |
| Sterility index (%) | 45.0a | 87.0ce | 85.0cd | 84.0c | 15.7 |

Alphabets notation represent DMRT.

TABLE 4. LEAF PIGMENTS AND ASCORBIC ACID LEVELS OF RICE PLANTS TO AIR POLLUTION AS MODIFIED BY KINETIN AND ASCORBIC ACID SPRAY.

| Parameter | | Control unsprayed | Polluted: Unsprayed | Polluted: Kinetin sprayed | Polluted: Ascorbic acid sprayed |
|---|---|---|---|---|---|
| Chlorophylls (m mol/g fr. wt.) | (a) | 2.62 (0.23) | 2.10 (0.14) | 2.42 (0.11) | 2.45 (0.24) |
| | (b) | 1.95 (0.08) | 1.00 (0.07) | 1.15 (0.06) | 1.20 (0.08) |
| Total | | 4.56 (0.31) | 3.10 (0.21) | 3.57 (0.17) | 3.65 (0.32) |
| Carotenoids (mg/g fr.wt.) | | 1.45 (0.12) | 0.95 (0.09) | 1.05 (0.04) | 1.20 (0.05) |
| Ascorbic acid (mg/g fr.wt.) | | 0.62 (0.10) | 0.42 (0.09) | 0.66 (0.10) | 0.87 (0.06) |

Figures in parentheses represent SE of 3 replicates.

TABLE 5. NITROGEN, SULPHUR AND FLUORIDE CONTENTS IN THE SHOOTS OF RICE PLANTS EXPOSED TO AIR POLLUTION UNDER KINETIN AND ASCORBIC ACID SPRAY.

| Parameter | Age in days | Control unsprayed | Polluted: Unsprayed | Polluted: Kinetin sprayed | Polluted: Ascorbic acid sprayed |
|---|---|---|---|---|---|
| Nitrogen mg/g dry wt. | 50 | 23.5 (0.4) | 28.6 (0.4) | 29.4 (2.5) | 30.0 (0.4) |
| | 60 | 26.8 (0.1) | 29.4 (0.5) | 24.6 (0.8) | 26.9 (0.8) |
| | 75 | 27.2 (0.3) | 29.8 (0.7) | 24.8 (2.2) | 27.5 (1.4) |
| Sulphur mg/g dry wt. | 50 | 2.5 (0.1) | 2.8 (0.3) | 2.98 (0.23) | 2.65 (0.28) |
| | 60 | 2.6 (0.1) | 3.0 (0.1) | 2.81 (0.15) | 2.98 (0.31) |
| | 75 | 2.6 (0.1) | 3.1 (0.1) | 2.82 (0.13) | 2.92 (0.25) |
| Fouoride µg/g dry wt. | 50 | 15 (1) | 22 (2) | 20 (2) | 20 (2) |
| | 60 | 13 (1) | 19 (1) | 24 (2) | 22 (2) |
| | 75 | 14 (1) | 21 (2) | 21 (2) | 19 (1) |

Figures in parentheses represent SE of 3 replicates.

under kinetin and ascorbic acid sprayed plants and 32, 22 and 20% in their total chl content towards air pollution respectively. The reduction of carotenoids was minimised from 34 to 28 and 17% in kinetin and ascorbic acid sprayed polluted plants as compared to control. The foliar application of the chemical protectants rendered a marginal increase in the endogenous ascorbic acid levels in the polluted plants as compared to the unsprayed polluted plants.

Plants at the polluted environment accumulated higher amount of total nitrogen in their shoots under all the treatments (Table 5). However, there were reductions in total number of 60 ad 75 days old plants sprayed with kinetin. It was interesting to note that there was no significant effect on the total sulphur accumulation under air pollution exposure of the fertilizer plant. However, the shoot fluoride content was increased in the polluted environment and the percentage of increase over the control was comparatively less in ascorbic acid sprayed polluted plants than the other.

The plants grown near to the fertilizer plant experienced a sharp reduction in plant height, conforming the earlier report on rice under artificial fumigation [5]. Though the foliar application of kinetin and ascorbic acid did not increase the plant height, there was improvement of crop by decreasing foliar injury and making no difference in the production of photosynthetic leaf area due to pollution. Kats *et al.* [5] found that in rice cultivar exposed to $SO_2$ and $O_3$ fumigation, an increase in the sterility of spikelets was offset by increased number of panicles with a reduced growth and total yield. In the present study there was a considerable increase in the total yield (biological yield) in kinetin and ascorbic acid sprayed plants but with high sterility index and less filled grains. Despite of the cultivar showing higher grain filling towards these chemical protectants under controlled conditions [16] the reason for the less filled grains could be a limited diversion of photosynthates to the developing spikelets out of the leaves due to pollution [2]. A general reduction in the yield of rice regardless of site when compared to the previous year [2] might be due to the prevailed drought condition, as an additional stress to plants. Comparatively the rain fall was very meagre and the average temperature had risen to 34.7° from 32.7° of the previous year during the growth period [17]. Warm temperature during plant growth in general enhanced the sensitivity of plants to air pollutants [18]. Moreover, the temperature might also interact with $SO_2$ to modify the photosynthesis by changing the rates of detoxification or the biochemical processes themselves, as observed for irradiance [19]. Increased sensitivity of plants to $SO_2$ and HF under the influence of diurnal changes in temperature and humidity [20] also indicate the hampering of growth due to unfavourable climatic factors.

The chlorophylls contents were reduced in the polluted rice plants as have been reported under variety of stress conditions [2], but the reduction was minimised by the chemical protectants. The carotenoids seemed to be less sensitive than the chl 'b' because of higher resistance under adverse conditions [22]. Since the chlorophyll and other pigments are necessary to harnessing light energy by photosystem I and II, the effects of air pollutants would have directly impaired photosynthesis. The application of chemical protectants increased endogenous ascorbic acid levels in plants, a character of tolerance, during the growth period [23]. The increased accumulation of nitrogen content in the shoots of rice could be from the atmospheric source [24]. However, the total N content did not increase in the kinetin sprayed plants at 60 and 75 days which could be attributed to a possible dilution during anthesis followed by grain filling. There was a marginal increase in the sulphur in the polluted plants as observed in tobacco plants [25], neverthless, the magnitude of increase was less towards chemical treatments explaining the influence of chemical protectants. Higher F contents in polluted plants confirms the earlier report [26], but showed not much disparity among the treatments which might disprove the application of chemical protectants. Perhaps it requires higher frequency of chemical protectants.

It was clear that the conditions near the fertilizer plant causes a definite damage to rice plants and application of kinetin and ascorbic acid provided an improvement only in their growth. The yield of rice was hampered by the mixed polluted situation with the additional unfavourable climatic factors.

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