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Effect of air pollution on rice in north of Iran

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Abstract: Rice is produced in North of Iran ($36^0,34^{'};38^0,27^{/}$)with area 58403km^2. Testing of rice at a pollution site showed sterility index and decreased harvest index .Application of high nitrogen increased the number of tillers , panicles and biological yield against air pollution injury followed by insignificant decrease in grain yield with increased ascorbic acid and free proline contents in their leaves ; under normal N and low N the shoot length and dry matter of rice plants was increased towards NH_3 fumigation while the taxicity of NO_2 was suppressed under high N regime. The increased taxicity by NO_2 or SO_2 alone, or in combination increased the SH contents and under high N regime the chlorophyll temperature stability index was reduced, showing its ability to tolerate air pollution injury under high N, the interacting effects of soil nitrogen on the yield of rice Dam Seiah in response to air pollution of a fertilizer plant.

Keywords: Rice plant, air pollution, modifying nitrogen nutrition.

1. INTRODUCTION

Atmospheric pollution, as a consequence of urbanization and industrilization, is a principal cause of damage to plants. Environmental factors, including humidity, light intensity, day length and temperature, influence plant response to air pollutants (1), however, they are generally difficult to control in the field. On the other hand, edaphic factors such as soil moisture and nutrient availability may be readily modified. Earlier reports on rice growth (2), yield (3), and nutrient status(4) showed that sulphur dioxide(SO_2) fumigation could be injurious. It has been reported that sensitivity(injury) can be modified by nitrogen nutrition in tobacco(5,6). Since rice is the major source of calories for 90% of the Iranian population.

The present study was carried out to confirm the influence of applied nitrogen on rice Dam Seiah to ambient air pollution near the fertilizer plant for another year and to artificial fumigations.

2. EXPERIMENTAL METHODS

Three day-old pre-germinated seeds of rice cultivar Dam Seiah were sown in polythene containers at two locations, a polluted site and an unpolluted 'control' site, with five replicates. The mineral composition of test soil, crop tending, details about site, determination of air pollutants were as described elsewhere (9).Table-1 shows concentrations of pollutants measured at a control site and polluted test site during the growth of an experimental crop of rice.

Two amounts of nitrogen as urea, were tested on day-30 onwards: NN, 96mg N kg $^{-1}$ dry soil (applied in two equal amounts during growth) and HN 224mg N kg^{-1} dry soil (applied in three equal amount during growth). Growth studies were done at 75 days and at maturity all five replicate pots were destructively sampled for yield analysis (9). Fifty five-day old fresh leaf material was used for the determination of relative water content (RWC), protein (10) after extraction (11), ascorbic acid (12) and free proline (13). From 75 day old shoot dry matter total nitrogen by double iodide method after digestion (14), total sulphur (15) after digestion (16), and fluoride (17) were determined.

Plants were grown by sand culture in plastic pots with the nutrient medium suggested for rice (9).Three nitrogen levels: normal N (40ppm), low N (20ppm) and high N (80 ppm) were imposed from the day of seeding. Concentrations were doubled accordingly after day-21 onwards. 21 day old plants were fumigated with SO_2 (0.75 ppm), NH_3, (10 ppm) and NO_2 (0.3 ppm) individually and in combination with SO_2 + NH_3, SO_2 + NO_2 and SO_2+ NH_3+ NO_2, 2 hr/day for 10 days. Fumigation was accomplished by introducing generated $S0_2$, NH_3 and NO_2 in a glass chamber described elsewhere (24).

Individual and mixed fumigations were done at different times with separate controls. From the fresh leaves chlorophyll temperature, stability index, CTSI (18)on fifth day after fumigation, total water extractable SH compounds (19) on 7th day, and shoot length and dry matter on 10th day after commencement of fumigation were measured.

TABLE 1 Concentrations of pollutants.

Parameters	**Control site**	**Test site**
Sulphation rate	0.17	1.11
mg SO_4 100 cm^{-2}d^{-1}	(0.10-0.23)	(0.88-1.11)
NO_2 µg m^{-3}	Negligible	26.8
		(15-44)
		1.68
NH_3 mgm^{-3}	Negligible	(1.42-1.84)
		0.31
F µg F cm^{-2} month^{-1}	Negligible	(0.27-0.31)

3. RESULTS

Air pollution reduced the plant height of the rice cultivar about 40% at both nitrogen levels as observed in 75 day old plants Table-2 shows growth of 75 day rice plants under two N levels grown near to and distant from, a fertilizer plant.The number of tillers in the polluted plants were doubled when compared to control. Application of high nitrogen increased the number of leaves by 90% in the polluted environment as compared to normal control. Leaf area was reduced by 42% under normal nitrogen whereas it was enhanced by 29% under the application of high N. The foliar injury under high N applied plants were reduced as compared to NN polluted site plants. However, the shoot dry weight showed not much difference between the control and polluted plants. High nitrogen application minimised the reduction in the number of spikelets, grain yield and 100 grains weight as insignificant Table-3 shows yield and yield componentsof rice under two N levels grown near to and distant from, a fertilizer plant. On the other hand biological yield was increased by 100 % under the polluted environment as compared to the control. How- ever, the reduction in the panicle length and harvest index, and increased sterility index were not significantly improved. Nevertheless, the production of tillers brought about a corresponding increase in the number of panicles at the polluted environment to offset the loss in grain yield.

TABLE 2 Growth of 75 day rice plants.

Characters	Normal N		High N	
	Control	Polluted	Control	Polluted
1. Plant height (cm)	67.0	40.0**	75.0	43.0**
2. Number of tillers	1.3	3.0**	1.7	3.3 **
3. Number of leaves	5.8	8.3	8.3	11.0
4. Leaf area cm^2	106.1	61.3	109.4	141.1
5. Foliar injury (%)	-	40.7±7.8	-	31.0±6.8
6. Shoot dry weight(g)	0.89	0.85	1.05	1.11

** Significant difference over control at 1% level.

TABLE 3 Components of rice under two N levels.

components	Normal N		High N	
	Control	Polluted	Control	Polluted
1.Panicle length(cm)	20.4	11.7**	18.4	12.4**
2. Spikelets/panicle	6.2	4.0**	5.4	4.7
3.Panicles (number)	1.2	5.2**	1.0	6.8**
4.Sterility index	45.0	91.0**	42.0	87.0**
5. Grain yield (g)	0.39	0.23*	0.62	.060
6.100grains weight (g)	1.60	1.28*	1.62	1.33
7.Biological yield (g)	1.76	2.81*	2.02	4.06**
8.Harvest index	0.228*	0.088*	0.328	0.170*

Significant difference over control * at 5% ; ** at 1% level.

A marginal increase in the leaf relative water content under high N and decrease under normal N of polluted site rice plants were evident as compared to control at 55 days shows biochemical responses of rice under two N levels grown near to and distant from,a fertilizer plant, (± =SE of three replicates). Under NN the proteins: soluble, insoluble and total were decreased in the polluted environment but found no difference in high N plants. Ascorbic acid content in the leaves was decreased by 32% under NN and increased by17% under high N. Remarkably the leaf free proline content of polluted site plants was enhanced by 2 fold under high N when compared to control. At the age of 75 days the total nitrogen in the shoot system appeared to be high by 10% under NN and 29% under high N at the polluted environment. The total sulphur content also showed a marginal increase in the polluted site plants. The fluoride content in the shoot system was increased by 50% under NN and 60% under HN at the test site.

Artificial fumigation of NH_3 brought about an increase in the shoot length under low N and NN while NO_2 produced increase under high N shows effect of SO_2, NH_3 and NO_2 individually and in combination on the shoot length and dry matter of rice grown under three N levels. Nevertheless the mixture of SO_2 and NO_2 reduced the shoot length significantly under NN. The shoot dry matter was increased to NH_3 alone or with SO_2 .However, SO_2 alone had reduced the amount of dry matter at deficient N or luxury amount of N levels. Under NN the dry matter was sharply reduced to NO_2+SO_2 but was not affected under LN and HN.

The total water extractable SH scompounds was found to be less than the control when plants were fumigated either with NH_3 alone or mixture of SO_2 and NH_3, under NN and LN shows effects of SO_2, NH_3 and NO_2 individually and in combinations on the total water extractable SH compounds and chlorophyll temperature stability index (CTSI), at three N levels.(± = SE of three replicates) SO_2 and NO_2 individually and in mixture generally showed greater amount of SH compounds than the respective controls.

Mixture of all the three pollutants also increased the SH compounds in plants.

Fumigation of NO_2 alone or with S02 rendered the cultivar to be sensitive by increasing the chlorophyll temperature stability index. However, the increase was minimised under high N, to individual fumigations. NH_3 treatment reduced the stability index sharply.

4- CONCLUSIONS

It was clear from the results that air pollution is causing definite damage to rice crop as indicated by reduction in plant height, increased sterility index and decreased harvest index. Studies in the past on the effects of nutritional status on air pollution injury generally showed that the plants that were given an adequate supply of nutrients were sensitive to air pollution injury than plants with a deficient supply although there were some exceptions. Notably, working with tomato found that sensitivity to SO_2 was greatest in plants with an adequate supply of nitrogen and that it decreased in plants either with a deficient, or luxury supply of this element. In ryegrass high N application showed an indication in the severity of injury due to SO_2 fumigation. In the present study, high N application increased the number of tillers, photosynthetic leaf area, number of panicles, and biological yield and decreased the foliar injury, in response to air pollution injury. The loss in grain yield was also insignificant, suggesting the improvement of crop by nitrogen against air pollution injury. To the fumigation of 10 ppm of NH_3 a significant increase in the shoot length and increased shoot dry matter under normal N and deficient N condition, suggested a possible incorporation of treated NH_3 as a source of N Nutrient, as 30% out of 10 ppm had been reported to be absorbed by corn seedlings in studies elsewhere (20). The presence of NH_3 with SO_2 also showed more or less similar response in rice plants, as evidenced by increased shoot length, dry matter and total leaf area. The fumigation of NO_2 alone or with SO_2 produced a general decrease in the shoot length and dry matter under NN but produced no effect under dificient or high N regime. A decreased dry weight in tomato to NO_2 at 565μg/ m^3 under three rates of nitrogen(21), however, in the present study to the given concentration a general enhancement in growth under HN was evident. The latter could suggest that the N uptake from the nutrient medium could successfully ameliorate the ill-effect observed mostly under NN.

There was no difference between the control plants and polluted site plants in maintaining soluble, insoluble and total protein under high N. But under normal N the diminution in protein content indicated the effects of low level of SO_2 pollution (22). The increase in the ascorbic acid content in rice as observed (23), and free proline in rice, as per our recent report(24) could be the biochemical manifestations involved in the pollution stress tolerance. The increased amount of total N, sulphur and fluoride in the shoot could be from the atmospheric source(20, 25, 27). In the present study the increased amount of SH compounds to SO_2 to NO_2 showed the stress induced protective mechanism as its main function in cell is to protect SH groups in enzymes and structural protein against oxidation to SS (28). A general decrease in the CTSI of high N applied fumigated plants indicated the improvement of crop as observed in drought resistance of pine needles.

It can be concluded that the ill-effect of air pollution stress can be predisposed by high N application in the Dam Seiah. Further, it is clear that this cultivar is suitable to grow near the conditions of the fertilizer plant under high N.

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