Physiological Significance of Ethrel (2-Chloroethyl Phosphonic Acid) and Nitrogen in Relation to Growth and Metabolism of Mustard under Irrigated and Non-Irrigated Conditions

ABSTRACT

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Physiological Significance of Ethrel (2-Chloroethyl Phosphonic Acid) and Nitrogen in Relation to Growth and Metabolism of Mustard under Irrigated and Non-Irrigated Conditions

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Abstract of the thesis submitted to the Aligarh Muslim University, Aligarh, India for the degree of Doctor of Philosophy in Botany.

The present thesis comprises six chapters. Chapter 1 deals with the importance of the problem. Lacunae in the understanding of the problem and justifications for undertaking the present study have been put forth.

Chapter 2 is review of literature. Relevant available literature pertaining to individual as well as combined effect of plant growth regulators especially ethylene sources with nitrogen on crop growth and development has been given in this chapter.

Chapter 3 describes the details of the material used in the study and methods employed in determining observations carried out in the experiments. Relevant information on meteorological and edaphic data has been included.

In Chapter 4, the results obtained in the experiments which were found significant at P<0.05 have been recorded in detail.

In Chapter 5, significant results have been discussed in the light of earlier reported findings. Possible explanations of the data obtained have also
been given to reach a conclusion. The results of the five field experiments are summarized below.

Experiment 1 (1998-99) was conducted under irrigated conditions to study the response of two cultivars (Alankar and PBM16) of mustard (*Brassica juncea* L.) to leaf-applied ethrel at 60d after sowing (flowering stage). Alankar is a well-established cultivar and accepted by the mustard growers for a decade, whereas PBM16 is a newly released. This was a factorial experiment conducted according to randomized complete block design. The response of the cultivars to ethrel treatments was assessed by determining growth and biochemical characteristics at 80 (pod fill), 100 (pod maturity) and 120d (harvest) after sowing. Physiological characteristics were studied at 80 and 100d after sowing. Yield and quality characteristics were determined at harvest. Growth characteristics were plant height, plant leaf area, leaf area index, specific leaf area, specific leaf weight, plant dry weight and dry weights and per cent dry weight distribution in leaf, stem and pod, leaf fresh weight, leaf turgid weight and leaf relative water content. Physiological characteristics were, rate of photosynthesis, stomatal conductance, internal CO₂ concentration, transpiration rate, carboxylation efficiency, photosynthetic water use efficiency, and plant water use efficiency. Biochemical characteristics included N content and N accumulation in plant. At harvest, yield characteristics studied were, number of pods per plant, number of seeds per pod, 1000 seed weight, seed yield,
biological yield, harvest index and oil yield. The oil was assessed for acid, iodine and saponification values.

Among five concentrations of ethrel (0, 100, 200, 400 and 600µL/L) applied, 200µL/L was found superior over others in increasing the plant characteristics studied. The concentration less than 200µL/L was found less effective, whereas concentration higher than 200µL/L proved inhibitory. Spray of 200µL/L ethrel affected growth of the plants and increased total leaf area per plant. Thus, the increase in photosynthesising surface area led to increase in photosynthesis and CO₂ accumulation, which resulted in increased plant dry weight. The other effects of ethrel spray was noted in improved source-sink relationship, as seen in increase in per cent pod dry mass in ethrel-treated plants. More of the flowers developed into pods, evident from higher pod number and seed yield in ethrel-treated plants compared with water-sprayed control. The oil quality was also improved with 200µL/L ethrel spray.

Comparison of the cultivars showed that Alankar established its superiority over PBM16. Growth, physiological, biochemical, yield and quality characteristics were found superior in Alankar than in PBM16. Interaction effect between cultivar and ethrel spray was non-significant for most of the plant characteristics. This suggests that the two cultivars responded similarly to ethrel spray.

Experiment 2 (1998-99) was a factorial randomized complete block design conducted on the same lines as Experiment 1 but under non-irrigated
conditions. The scheme of the treatments, design of the experiment, ethrel spray treatments and cultivars of mustard were also similar as described for Experiment 1. The observations recorded at different sampling stages were similar to Experiment 1. In this experiment, it was noted that ethrel spray at 200μL/L concentration was more effective than any other concentrations used. The effect of the spray was manifested through changes in various characteristics as described for Experiment 1. Alankar cultivar surpassed PBM16 in performance.

Combined analysis of the two experiments showed that the factors irrigated and non-irrigated were non-significant. Ethrel spray under irrigated and non-irrigated conditions was equally effective. The two cultivars also behaved similarly in the two conditions of irrigation.

Experiment 3 (1999-2000) was a factorial randomized complete block design conducted under irrigated conditions to study the effect of leaf-applied 0, 100 and 200μL/L ethrel on the performance of Alankar cultivar of mustard (the cultivar was selected on the basis of Experiment 1) grown with soil-applied 0, 40, 60 and 80kg N/ha. Ethrel spray application was done at 60d after sowing (flowering stage) and performance of the crop was assessed by determining various plant characteristics at 80 (pod fill), 100 (pod maturity) and 120d (harvest) after sowing. Growth characteristics were those studied in Experiment 1. Among physiological characteristics, 1-aminocyclopropane-1-carboxylic acid content, ACC oxidase and ethylene evolution were also studied.
in addition to the characteristics studied in Experiment 1. Among biochemical characteristics, leaf nitrate reductase activity was also studied in addition to the determination of N content and N accumulation in plant. Among yield characteristics, seed N, nitrogen harvest index and nitrogen yield potential were also studied in addition to the yield characteristics studied in Experiment 1. Quality characteristics were similar as in Experiment 1.

Ethrel at 200μL/L concentration and nitrogen at 80kg N/ha registered significantly superior values as compared to other treatments. Ethrel (200μL/L) enhanced growth, physiological, biochemical, yield and quality characteristics. In this experiment, it was found that the effect of 200μL/L ethrel was maximal when plants received soil-applied 80kg N/ha. This combination (200μL/L ethrel and 80kg N/ha) enhanced plant leaf area, photosynthesis, CO₂ accumulation and plant dry weight. Water relations characteristics such as leaf fresh weight, leaf turgid weight and leaf relative water content were also enhanced by 200μL/L ethrel x 80kg N/ha. Pod dry weight was maximal with 200μL/L ethrel x 80kg N/ha, which showed higher translocation of dry matter towards sink (pods). Among physiological characteristics, rate of photosynthesis, internal CO₂ concentration, transpiration rate, photosynthetic water use efficiency, water use efficiency, 1-aminocyclopropane-1-carboxylic acid content and ACC oxidase were maximal in 200μL/L ethrel x 80kg N/ha. Plants grown with sufficient soil-applied N (80kg N/ha) responded to the ethrel (200μL/L). However, if soil-applied N was
less than 80kg N/ha, the effect of ethrel spray was not prominent. The increased vegetative growth due to ethrel (200µL/L) spray made the plant to extract more of the soil N and was reflected in N content and accumulation and increased growth, physiological, biochemical and yield characteristics. The calculated nitrogen uptake efficiency, nitrogen utilization efficiency and nitrogen-use efficiency showed that nitrogen use was better when plants were treated with the 200µL/L ethrel spray. Seed yield, oil yield and nitrogen yield potential were increased and were maximal with 200µL/L ethrel x 80kg N/ha.

Experiment 4 (1999-2000) was a factorial randomized complete block design conducted simultaneously with the Experiment 3 under non-irrigated conditions. The scheme of the treatments, ethrel spray concentrations and soil-applied nitrogen were same as in Experiment 3. The data on growth, physiological, biochemical, yield and quality characteristics recorded were those mentioned for Experiment 3. Individual effects of 200µL/L ethrel spray, soil-applied 80kg N/ha and their interaction proved best for most of the plant characteristics. The response of the plant to ethrel and nitrogen treatments was similar as found in Experiment 3.

Combined analysis of Experiments 3 and 4 showed that the response of the plant to ethrel spray, soil-applied nitrogen and their interaction was uniform irrespective of the irrigation conditions. The data on plant characteristics under irrigated and non-irrigated conditions were non-significant. The data suggests that 200µL/L ethrel spray on plants grown with soil-applied 80kg N/ha may be
used for improving mustard cultivation irrespective of the conditions of irrigation.

Experiment 5 (2000-2001) was a factorial conducted according to randomized complete block design. In this experiment applications of 0 and 200\,\mu L/L ethrel or 1\,mM silver thiosulphate were done as foliar spray at 60d after sowing (flowering stage) on mustard cultivar Alankar grown under irrigated and non-irrigated conditions. Plants were raised with uniform soil application of 80kg N/ha. This experiment was based on the findings of Experiments 3 and 4. The response of the plants to ethrel spray treatment was confirmed in this experiment with the use of silver thiosulphate spray treatment, as silver thiosulphate application inhibits ethylene action. The observations recorded at 80, 100 and 120d after sowing included growth (plant leaf area plant dry weight), physiological, biochemical, yield and quality characteristics were similar to Experiments 3 and 4. Maximum response was noted with 200\,\mu L/L ethrel spray treatment. However, silver thiosulphate spray inhibited the ethylene action and ethrel effect was not observed. The interaction effect of spray and irrigation was found non-significant. The results of the experiments suggest that response of the plant to ethrel treatment seen in Experiment 1–4 was manifested through the action of ethylene.
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