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REGULAR ARTICLE

EFFECT OF SILVER IONS ON ETHYLENE METABOLISM OF MUSTARD GROWN UNDER IRRIGATED AND NON- IRRIGATED CONDITIONS

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SUMMARY

A field experiment was conducted during the winter season of 2004-2005 at the Experimental farm of Aligarh Muslim University, Aligarh, India on mustard (*Brassica juncea* L. Czen and Coss, cultivar Alankar) under irrigated and non -irrigated conditions to evaluate the application of 0 and 200 µl/L ethrel (E200) or 1 mM silver thiosulphate (S) at flowering stage along with a basal uniform application of 80 kg N ha^{-1} on leaf area, plant dry mass, net photosynthetic rate and seed yield. Silver thoisulphate, which inhibits the physiological action of ethylene was used in the experiment with ethrel. Ethrel is a source of ethylene and its effects are manifested through physiological action of ethylene. Ethrel 200 µl/L (E200) treatment enhanced leaf area, net photosynthetic rate, plant dry mass and seed yield by 10.6, 9.1, 7.7 and 11.6% over S treatment. So silver thiosulphate (S) reduces the physiological action of ethrel (source of ethylene) in this study. This clearly indicates that silver ions used in this experiment in the form of silver thiosulphate inhibits the action of ethylene metabolism in mustard.

Keywords: *Brassica juncea*¸ leaf area, dry mass, net photosynthetic rate and seed yield.

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1. Introduction

Ethylene belongs to the hydrocarbon group of olefins, which exist in the gaseous state under normal physiological conditions. It effects on various physiological processes at different stages of plant growth and development has been documented (Pua and Chi, 1993; Khan *et al*., 2000). Ethylene has been shown to influence leaf expansion by suppressing cell enlargement rather than cell division (Rodriguez-pousida *et al*., 1993). Exogenous application of ethrel enhanced photosynthesis of *Brassica juncea* in irrigated conditions (Khan 1996). Increase in seed yield by the application of ethrel has been reported by Ramos *et al*. (1989); Bulman and Smith (1993) and Grewal *et al*. (1993) in several crop species.

Burg and Burg (1967) based on a correlation between the relative ethylene-like activity of a number of compounds and their known order of binding to silver ion, postulated the presence of metal in the ethylene receptor. However silver ion (Ag^+), CO_2 and Cobalt play a vital role as antagonistics of ethylene production Samimy (1978). Mhatre *et al.* (1998) reported the antagonistic properties of Ag NO_3 and $COCl_2$ on ethylene and application of these compounds reverse the effects of ethylene. Silver thiosulphate is an inhibitor of ethylene action as reported (Saniewske and Ludhika 1989) and plays antagonistic effect on ethylene (Woltering and Van Doorn, 1988). Beyer (1976 a, b) also reported that silver ion negated the effects of ethylene. The ethylene was considered to be non- competitive. Silver, applied in the form of thiosulphate, is a very effective inhibitor of ethylene responses, but it is heavy metal it cannot be used in food and feed and has been objected to by environmentalists. The inhibitory role of various compounds on the action of ethylene metabolism were studied by Sisler and Yang (1984), Veen (1986), Sisler *et al*. (1996), Sisler and Serek (1997). However the effect of silver ions on ethylene metabolism in mustard has not been reported earlier. In view of above, present investigation was aimed to study the effect of silver ions on ethylene metabolism of mustard grown under irrigated and non-irrigated conditions.

2. Materials and Mehtods

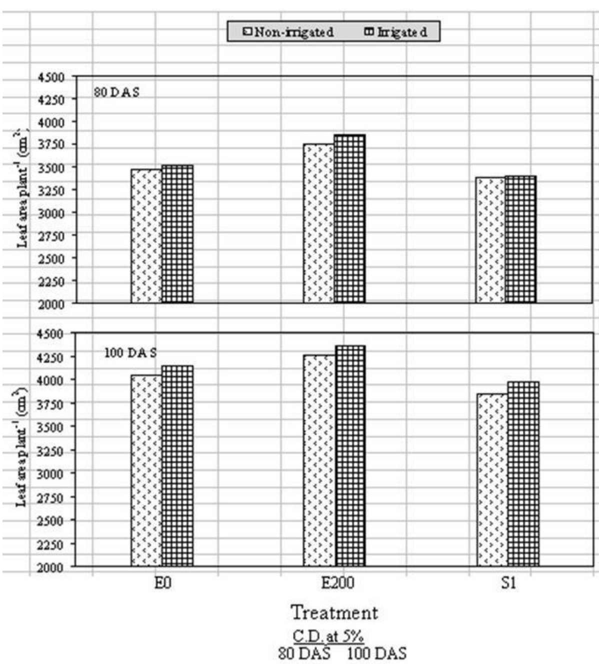
A randomized complete block designed field experiment was conducted on mustard *(Brassica juncea* L. Czern and Coss) cultivar Alankar during the winter season of 2004-2005 at the Experimental farm of Aligrah Muslim University, Aligarh, India. The experiment was carried out under irrigated as well as under non-irrigated conditions. The available soil N of the sandy loam soil in experimental field was 215 kg N ha^{-1}. Seeds of the mustard cultivar Alankar were sown $10m^2$ plot at the rate of 10 kg ha^{-1}. At seedling establishment, plant spacing of 30 x 50 cm was maintained. A uniform basal application of 80 kg N ha^{-1} in the form of urea was given. The amount of 20 l/m^2 irrigation was given only to the plots used for under irrigated conditions at 50 days after sowing. At flowering stage (60 days after sowing), ethrel (2-Chloroethyl phosphonic acid) at a concentrations of 200 µl/L (E200) or 1 mM silver thiosulphate (S) were sprayed at the rate of 600 l ha^{-1} together with 0.5% teepol (a surfactant). Control plants instead of ethrel or silver thiosulphate (S) received only an equal amount of deionized water and 0.5% teepol. Each treatment was replicated three times. At pod fill (80 DAS), pod maturity (100), five plants were removed from each plot to record leaf area and dry mass per plant. The leaf area of about 10% of the total leaves on each plant was determined by outlining the leaves on graph paper and dry weight of these leaves was recorded. The leaf area per plant was computed by using the leaf dry mass per plant mass and dry mass of those leaves for which area was estimated (Watson 1958). Total dry mass per plant was recorded by drying the plants at 80^0C for 24 h. Net photosynthetic rate (P_N) in plants were measured at all stages with Li-COR 6200 portable photosynthesis system (Nebraska, USA) as per the method described by Wells (1991). The fully expanded top leaf of each axis of five plants was selected and photosynthesis measurements were made at about 1100 µ mol m^{-2} S^{-1} photosynthetically active radiation at 1100-1200 hours (temperature 23^0C, relative humidity 72%). At harvest, seed yield from $1m^2$ of the plot was noted after threshing the pods.

3. Results and Discussion

The effect of ethrel spray proved significantly superior to the other treatments for trial studied. Fig. 1, 2 and 3 show values for leaf area, photosynthesis and plant dry mass at 80 and 100 days after sowing. Ethrel 200 µl/L (E200) increased leaf area by 4.9 and 9.6% as compared to (E0) and (S) respectively under irrigated conditions, while the exogenous application of same ethrel concentration of 200 µl/L (E200) increased leaf area by 5.2 and 10.6% as compared to (E0) and (S) respectively under non-irrigated conditions (Fig.1). The net photosynthesis rate increased significantly by

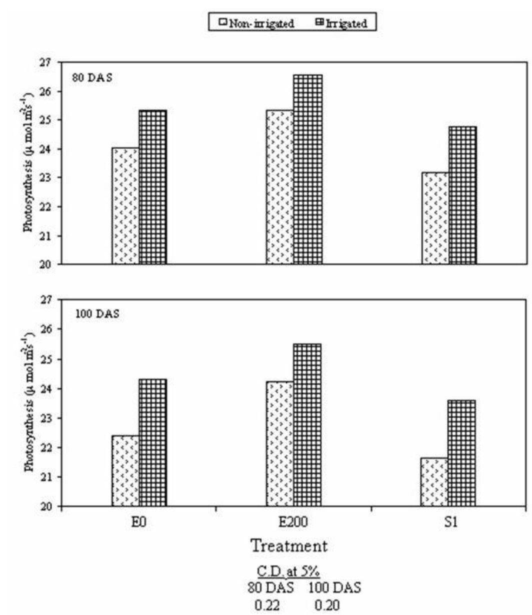
200 µl/L ethrel (E200) as compared to (E0) and (S) under irrigated as well under non-irrigated conditions respectively (Fig.2). Exogenous application of 200 µl/L ethrel (E200) increased the plant dry mass by 2.6 and 6.5% as compared to (E0) and (S) respectively under irrigated conditions. Similarly the application of ethrel 200 µl/L (E200) enhanced the plant dry mass by 2.5 and 7.7% as compared to (E0) and (S) respectively under non-irrigate conditions (Fig. 3). Ethrel 200 µl/L (E200) spray increased the seed yield by 4.4 and 11.6% as compared to (E0) and (S) respectively under irrigated conditions. Similarly the same concentration of ethrel 200 µl/L (E200) increased the seed yield by 4.4 and 7.7% as compared to (E0) and (S) respectively under non-irrigated conditions (Fig. 4).

Fig. 1. Effect of ethrel (E: 0 or 200 µl/L) or silver thiosulphate (S: 1 mM) at 60 days after sowing (DAS; flowering stage) on leaf area plant^{-1}(cm^2) of mustard (*Brassica juncea* L.) cultivar Alankar grown with basal 80 kg N ha^{-1} under irrigated and non-irrigated conditions at 80 and 100 DAS.



Ethylene has been shown to influence leaf emergence in cereal seedlings (Ievinsh and Kreicbergs, 1992) and also leaf expansion by suppressing cell enlargement rather cell division (Roderiguez-Pousida *et al* 1993). In this study, the induction of ethylene biosynthesis might be associated with the application of ethrel, which is a known source of ethylene. This effect of ethrel led to the emergence and formation of leaves with enhanced total leaf area of plant. Higher leaf area resulting in more solar radiation being retained and enhanced net photosynthetic rate (P_N) and total dry matter production. The increase in photosynthesis with ethrel has also been reported by Subrahmanyam and Rathore (1992); Pua and Chi (1993) and Khan *et al.* (2000). Exogenous application of ethrel enhanced photosynthesis of *Brassica juncea* under irrigated and non- irrigated conditions (Khan 1996; Khan 1998; Khan *et al.*, 2000; Khan 2004). The dry matter produced was efficiently translocated towards the developing pods resulting in increase in the seed yield.

Fig. 2. Effect of ethrel (E: 0 or 200 µl/L) or silver thiosulphate (S: 1 mM) at 60 days after sowing (DAS ; flowering stage) on rate of photosynthesis (µ mol m^{-2} s^{-1}) of mustard (*Brassica juncea* L.) cultivar Alankar grown with basal 80 kg N ha^{-1} under irrigated and non-irrigated conditions at 80, and 100 DAS.



It was described above that 200 µl/L ethrel (E200) increased ethylene evolution to optimum concentration causing maximum increase in growth, physiological and yield characteristics. Linking the action of ethylene with silver thiosulpahte (S) reduced the plant characteristics. Thus a reduction of growth, physiological rates, and yield characteristics was achieved by blocking the ethylene action. As silver ions have been proposed to reduce the capacity of ethylene to interact with its receptors (Beyer 1976 b). Silver thiosulpahte is readily absorbed and translocated by plants (Morgan *et al.,* 1993).

Fig. 3. Effect of ethrel (E: 0 or 200 μl/L) or silver thiosulphate (S: 1 mM) at 60 days after sowing (DAS ; flowering stage) on plant dry mass (g plant^{-1})of mustard (*Brassica juncea* L.) cultivar Alankar grown with basal 80 kg N ha^{-1} under irrigated and non-irrigated conditions at 80 and 100 DAS.

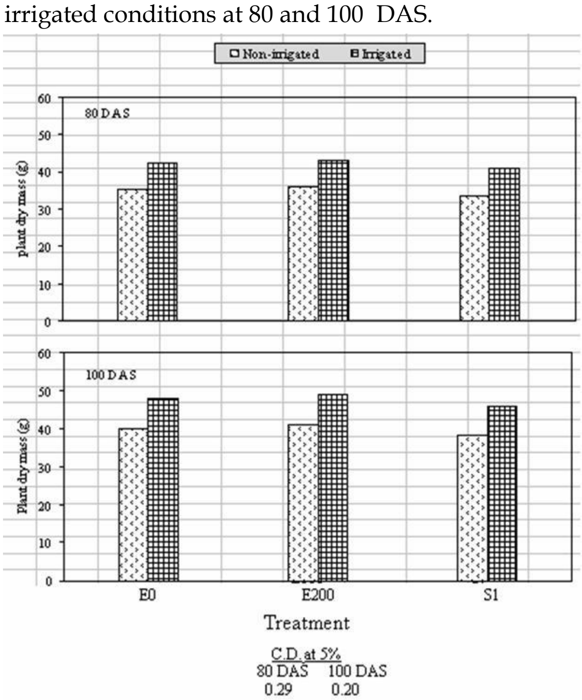
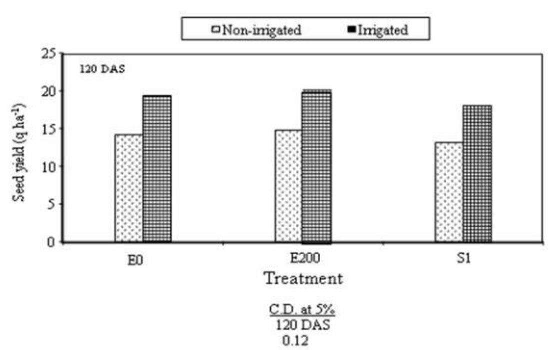


Fig. 4. Effect of ethrel (E: 0 or 200 μl/L) or silver thiosulphate (S: 1 mM) at 60 days after sowing (DAS ; flowering stage) on seed yield (q ha^{-1}) of mustard (*Brassica juncea* L.) cultivar Alankar grown with basal 80 kg N ha-1under irrigated and non-irrigated conditions at 120 DAS.



Veen (1986) also reported that silver ion inhibits the action of ethylene acting at the receptor level. Furthermore, silver applied in the form of silver thiosulphate is very effective inhibitor of ethylene response (Beyer 1976 b). Silver ion inhibits the action of ethylene metabolism were also reported by Beyer (1976 c), Beyer (1979), Aharoni *et al*. (1979), and Saniewske and Ludhika (1989), Sexton *et al*. (1995). Moreover silver thiosulpahte (S) treated plants exhibit value lower than the plants treated with water (control), the possibility that the intrinsic ethylene biosynthesis was affected may not be discounted.

It is thus concluded that silver ion inhibits the metabolism of ethylene and thereby acts as an antagonist of ethylene production.

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