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REGULAR ARTICLE

CROP RESPONSE TO INTERACTION BETWEEN ETHYLENE SOURCES AND NITROGEN WITH SPECIAL REFERENCE TO OILSEED CROPS

M. R. Mir[1*], M. Mobin[1], N.A. Khan[1], M.A. Bhat[2], N.A. Lone[1], K.A. Bhat[2], S.M. Razvi[2], S.A. Wani[3], Nowsheeba Wani[2], Sabina Akhter[2], Shazia Rashid[4], Nasir Hamid Masoodi[4], W.A. Payne[5] and A.H. Wani[1]

[1]*Department of Botany, Aligarh Muslim University, Aligarh 202002, India*
[2]*Division of Plant Breeding and Genetics, SKUAST- K, Shalimar, Srinagar*
[3]*Division of Sericulture, SKUAST- K, Shalimar, Srinagar*
[4]*Division of FMAP, SKUAST- K, Shalimar, Srinagar*
[5]*Department of Crop Physiology, Norman Borlaug Institute for International Agriculture, Teagu Building Suite 123, College Station, TX 77843-2477, U S A*

SUMMARY

Terrestrial plants assimilate approximately 1.4 gigatons of nitrogen annually and about 90 to 95% of the total in form of mineral nitrogen. Although more input of nitrogen increases growth and yield of the crops, but its excessive use causes environmental degradation phenomenon like eutrophication of the resources. Therefore, an approach is to be explored which minimizes the use of nitrogen without decreasing the growth and yield of crops. In this context, use of plant hormones may prove its potential as it has been found to enhance growth and productivity of the crop plants. It also improves the crop by manipulating source/sink relationship at pod development stage. Of several naturally occurring phytohormones, ethylene influences about all aspects of plant growth and development as well as the induction of some plant defence responses. Ethylene produced in trace amount elicits many physiological responses, acting at a concentration as low as 0.01μL/L. Ethylene releasing compounds are applied to cereal crops to prevent lodging, thereby reducing yield losses and deterioration of grain quality and to mustard for increasing yield. Ethrel is versatile ethylene releasing agent have remarkable marketed value and registered for several crops. It is involved in a diverse array of cellular, developmental and stress-released processes in plants. Ethrel reduces the problem of pod shattering by restricting the flower and pod abortions. However in this study a number of examples of has been made to cover the aspects of interactions of nitrogen and ethrel (ethylene releaser) in the growth and development of plants are described; plant height, leaf area, leaf area index, dry weight, chlorophyll, photosynthesis, photosynthetically active radiation, ethylene evolution, nitrate reductase activity, nutrient accumulation, nitrogen uptake efficiency, nitrogen use efficiency and nitrogen utilization efficiency, seed yield, biological yield, harvest index, oil yield, oil content, acid value, iodine value and saponification. So the present study indicates that the process of growth and development in addition to the yield of plants is significantly affected by the ethrel along with basal nitrogen in both irrigated and non -irrigated conditions.

Key words: *Trichoderma spp*., *Drechslera tetramera*, Biocontrol, Antagonism, *Capsicum frutescens*

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*Corresponding Author, Email: dmramzanmir3@gmail.com

1. Introduction

Indian agriculture has progressed a long way to become a significant exporter of a diversified basket of agricultural commodities. Persistent efforts have been made to harvest a larger portion of the land to agricultural purpose and for induction of new technology. In post-independent India, agriculture has been growing at a rate of about three per cent per annum, while food grains production is increasing by 1.67 per cent, which falls short of population growth of 1.80 per cent. A spectacular rise in food grains production has been observed since 1949-50. It is estimated that the production of cereal has gone to 206 million tonnes during 1999-2000. If acreage production of cereal crops is considered, rice ranks first. With an area of 44 million hectare that produces 88 million, this crop is a major contributor amongst cereal crops. Wheat and other cereal crops occupy lower position in terms of production.

The Indian oilseed scenario has also undergone a significant transformation due to contributions of oilseeds production technology, expansion in cultivated area, price support policy and institutional support. In particular, the set up of the Technology Mission on Oilseed in 1986 played a major role. The role of technology in fostering and sustaining the oilseeds production is vast. The self-sufficiency in oilseed has been possible only due to economically viable and sustainable technology. Since oilseeds are considered as hardy crops, they are mostly grown under moisture and nutrient scarce conditions that may limit the crop productivity. In India, agro-ecological conditions are such which favour growth of nine oilseeds crops. These are seven edible oilseeds, namely groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame and niger and two non-edible castor and linseed, apart from a wide range of other minor oilseeds and oil bearing tree species. With a production of 24 million tonnes during 1996-97, the country accounted for 9.7 per cent of the global oilseeds production (about 250 million tonnes). Indian vegetable oil industry achieved domestic turnover of Rs. 35,000 crores compared to international trade in import of vegetable oil and exports of oil meals and castor oil, which accounts to Rs. 65,000 crores.

The expansion in area under oilseeds has been main reason of increase in oilseeds production, but further scope of area expansion is meagre. Therefore, the productivity growth should take a lead in bridging the demand and supply gap. However, there are several constraints in increasing the productivity of oilseeds. These may be biotic and abiotic, on-farm and off-farm, technological and non-technological. With about 25 per cent of the area under irrigation, oilseeds are subjected to vagaries of monsoon resulting in lower yields compared to irrigated wheat and rice. This warrants limited and protective irrigation at least during critical stages of crop growth. Besides, several other constraints like continuous cultivation of oilseeds without proper crop rotation, low level of management adopted by small and marginal farmers, poor post-harvest technology and inadequate marketing support and weak technology transfer add to the problems of low crop productivity. Researches are done to overcome most of the constraints related to technology, in term of genetic improvement, efficient agronomic management, pest management, and post-harvest technology and to improve oilseeds crop production. As per study based on the data available from the Frontline Demonstration Project under the Oilseeds Production Programme, the mean yield of improved technology of oilseeds realizable on farmers' field is 1545 kg/ha, while the national average yield is of the order of 794 kg/ha. There exists a realizable yield gap of 751 kg/ha, which accounts for nearly about 95 per cent of the existing national average yield. In other words, an additional production of the order 16.27 million tonnes need to be added to the current oilseeds production in the country from the existing area under oilseeds. Oilseeds remained almost neglected during the green revolution phase in India in terms of total output. The languid production of oilseeds has converged the attention of agricultural scientists to innovate and implement the improvised methods for boosting the yield through proper nutrient management. In this context, inorganic nutrients (concerned with acquisition of mineral elements from the soil) found to be immensely remarkable. The green revolution of India owes much to this form of nutrition. Now, when we are on the verge of entering in to the era of Ever Green

Revolution, the investigations regarding application of nutrients need to be thoughtfully considered, which has largely been ignored. It may be emphasized that work carried out in relation to nutrient is voluminous and it is known that application of only few essential nutrients like, N, P and K alter the availability and uptake of other nutrients. Among them nitrogen is a major nutrient and its availability in the rhizosphere has been found to enhance the yield and quality of seed crops (Ansari, 1990; Jeschke *et al*., 1992; Awasthi and Surajbhan, 1994; Sarkar *et al*., 1999; Khan *et al*., 2000; Dodd, 2001).

Plant hormones and inorganic nutrients share a common physiological function i.e. both of these growth factors influence the growth and development of plants. Plant growth regulators have been found to be engaged in enhancing growth and productivity of crop plants. There are many instances which suggest that growth regulators and nutrients can interact in a variety of ways. Deficient and toxic levels of nutrients can affect the concentration of specific hormones, and in turn, hormones have the capacity to direct the translocation and accumulation of nutrients in plants (Kuiper, 1988; Kuiper *et al*., 1989). Actually the nutrient status of a plant influences its metabolism and growth and can affect the synthesis and distribution of growth substances (Haru *et al*., 1982; Green, 1983). Considering the complex interactions of plant hormones and multiplicity of plant functions they control, the impact on nutrients on hormones is an important issue (Whenham *et al*., 1989; Thoresteinsen and Eliasson, 1990; Arshad and Frankenberger, 1991; Cao *et al*., 1993).

In the following pages, attempt has been made to cover aspects of interactions of nitrogen with ethylene sources application.

2. Interaction effect on growth characteristics

Growth of plant was found to be influenced by the interaction of hormones and nutrients. Retardation in the plant height of gobhi sarson (*Brassica napus* L.), with the foliar application of ethrel at all the levels of nitrogen was noted and the reduction was more pronounced in the absence of nitrogen (Grewal *et al*., 1993). Flower number of different crops was found to be positively responsive towards exogenous application of growth substances (Morgan *et al*., 1983; Friends, 1985). Grewal *et al*. (1993) noted that in a field grown *Brassica napus* L. foliar spray of 500 µL/L ethrel with basal 50 kg N/ha, resulted in more LAI, whereas at 100 kg N/ha, 1000 µL/L ethrel proved to be more beneficial. The findings are in close conformity with Bengal *et al*. (1982) and Singh *et al*. (1987). Ethrel spray (400 or 600 µL/L) along with basal (45 or 60 kg/ha) and foliar application of (0 or 10 kg/ha) of N, increased leaf area index and dry mass of mustard (Khan, 1996). In various studies on mustard, Khan *et al*. (2000), Mir (2002), Mir *et al*. (2008 a), Mir *et al*. (2009 a,b), Lone *et al*. (2010) and Mir *et al*. (2010 a,b) reported that at 0 or 40 kg N/ha, ethrel did not produce any significant effect, but at basal 80 kg N/ha, ethrel affected growth parameters like leaf area, LAI and total dry matter (Fig 1-2).

Fig.1. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on leaf area of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80, 100 and 120 DAS

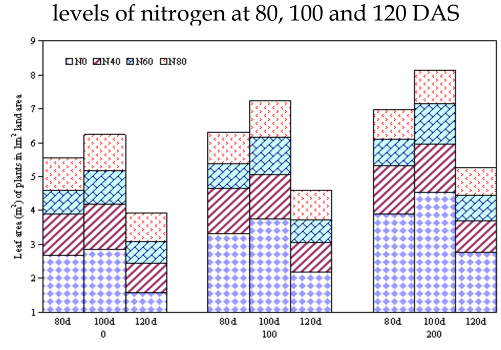
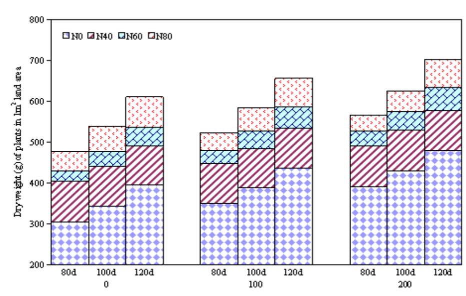


Fig.2. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on plant dry weight of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80, 100 and 120 DAS.



3. Interaction effect on physiological characteristics

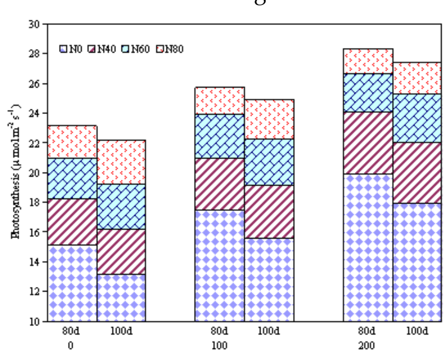
a. Chlorophyll content

Ethrel at 500 µL/L significantly improved the chlorophyll content in leaves of Brassica napus when 50 and 100 kg N/ha was applied. However, under no nitrogen application, higher dose of ethrel (1000 and 1500 µL/L) showed detrimental effects (Grewal *et al*., 1993). Grewal and Kolar (1990) reported that application of 500, 1000 and 1500 µL/L of ethrel reduced chlorophyll content when no N was applied but the reduction was only significant for 1500 µL/L ethrel at 0 and 50 kg N/ha. However, 500 and 1000 µL/L of ethrel at 100 kg N/ha significantly increased the chlorophyll content of leaves in *Brassica juncea* compared with water sprayed plants.

b. Photosynthesis

Grewal et al. (1993) observed indirect evidence of photosynthetic activities by enhancing chlorophyll content and retaining higher LAI with nitrogen (50 and 100 kg N/ha) and spray of ethrel (500 µL/L) in *Brassica napus*. Khan *et al.* (2000), Lone (2001) Mir (2002), Khan *et al*. (2007) Mir *et al*. (2008 a), Mir *et al*. (2009 a), Lone *et al*. (2010) and Mir *et al*. (2010 a,b) also reported that at basal 80 kg N/ha, ethrel spray improved LAI, thus resulting in more solar radiation being retained and enhanced net photosynthetic rate in Indian mustard (*Brassica juncea* L.) (Fig.3).

Fig.3. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on rate of photosynthesis of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80 and 100 DAS



c. Photosynthetically active radiation

Since the growth and crop productivity of crop species are governed to a great extent by its surrounding environment, hence any change in the quality of solar radiation would certainly influence the growth and productivity of several crop species in various agro-climatic zones (Parry, 1992; Sinha, 1992; Singh, 1997). The rate of photosynthesis and photosynthetically active radiation are highly influenced with leaf development and canopy structure (Ramanujan and Mohan, 1995). In absence of N, ethrel at 1000 and 1500 µL/L significantly reduced the interception of PAR, while increase in nitrogen application (50 and 100 kg N/ha) resulted in improvement in interception of PAR (Grewal *et al*., 1993). Similarly, in another study, Grewal and Kolar (1990) observed that increase in N (from 0 to 50 and 50 to 100 kg/ha) helped the crop canopy to trap more radiation. Ethrel at 500 µL/L concentration improved the radiation interception at 50 and 100 kg N/ha. At basal 60 kg N/ha and foliar 10 kg N/ha ethrel improved photosynthetic activities, improving crop canopy and retaining higher LAI during development phase of *Brassica juncea* (Khan, 1996).

d. Ethylene evolution

The plant regulator ethrel at 200 µL/L along with basal basal 80 kg N/ha significantly increased the 1-aminocyclopropane-1-carboxylic acid (ACC) content, ACC -oxidase activity and ethylene production in leaves of *Brassica juncea* (Mir 2002; Mir *et al*., 2008 b) (Fig. 4-6).

Fig.4. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on 1-aminocyclopropane-1-carboxylic acid (ACC) of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80 and 100 DAS

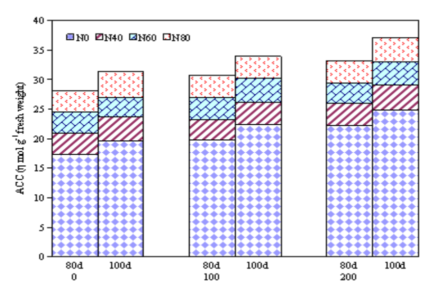


Fig.5. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on ACC oxidase of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80 and 100 DAS

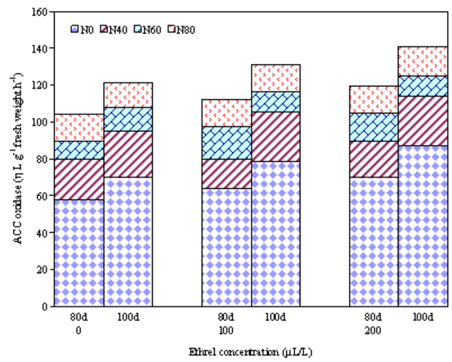
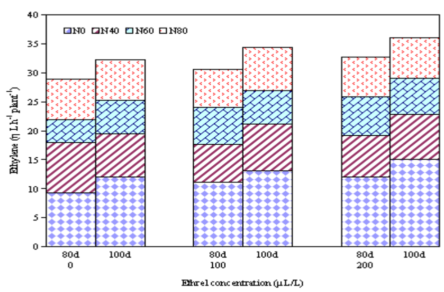


Fig.6. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on ethylene evolution of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen at 80 and 100 DAS

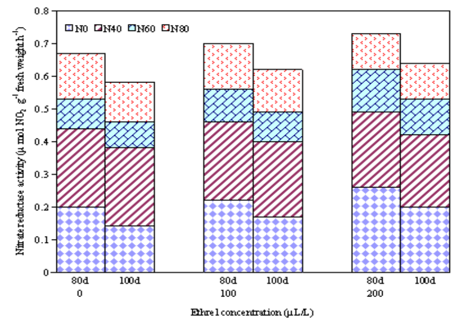


4. Interaction effect on Biochemical characteristics

a. Nitrate reductase activity

At basal 80 kg N/ha, ethrel 200 µL/L significantly increased the nitrate reductase activity (Fig. 7) in leaves of *Brassica juncea* (Mir 2002; Mir *et al*., 2008 a; Lone *et al*., 2010).

Fig.7. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on nitrate reductase activity of mustard (Brassica juncea L.) cultivar Alankar grown with four basal levels of nitrogen at 80 and 100 DAS



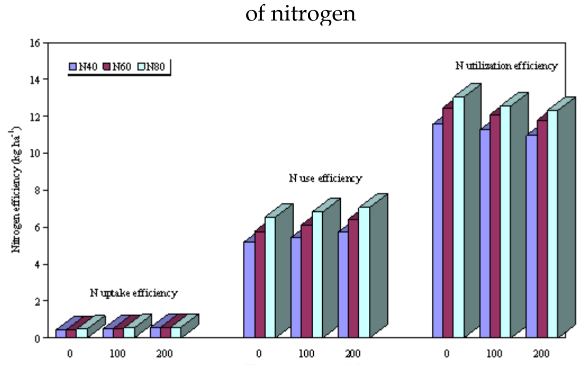
b. Nutrient accumulation

Salama and Bazas (1987) reported the significant interaction effect between growth regulators and N, P and K fertilizers on the copper content of sunflower on calcarcious sandy loam soils. Erdei and Dhakal (1980) reported that ethrel stimulated K uptake in wheat. In *Brassica juncea* increase in N and K uptake with ethrel and N application has been reported by Khan *et al*. (2000), (Mir, 2002), Khan *et al*., (2007) and Mir *et al*. (2009 a,b).

5. Interaction effect on nitrogen efficiency

Mir (2002) reported impressive increase in the nitrogen uptake efficiency, nitrogen use efficiency and nitrogen utilization efficiency of mustard in response to ethrel application at basal 80 kg N/ha (Fig. 8).

Fig.8. Effect of ethrel spray at 60d (post flowering stage) on nitrogen uptake efficiency, nitrogen utilization efficiency and nitrogen use efficiency of mustard (*Brassica juncea* L.) cultivar Alankar grown with four basal levels of nitrogen

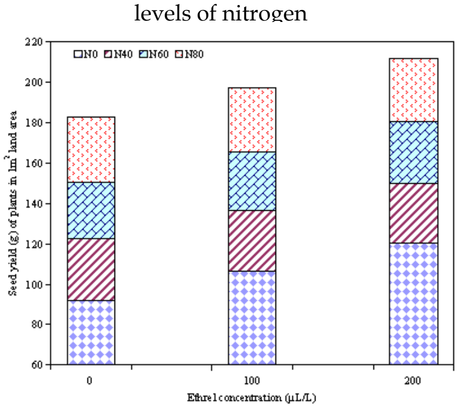


6. Interaction effect on yield characteristics

a. Seed yield

Enhanced seed yield in *Brassica napus* in response to N application was more pronounced with spray of ethrel. Application of 50 kg N/ha and spray of ethrel (500 µL/L) significantly improved the grain yield and further improvement was observed with 100 kg N/ha and 1000 µL/L ethrel (Grewal and Kolar, 1993). Khan (1996) reported that ethrel in association with nitrogen significantly increased pods per plant, seed per pod, 1000 seed weight, seed yield, oil content and oil yield in mustard. However, ethrel proved less effective at lower nitrogen dose because of insufficient availability of photosynthates. The number of pods per plant and number of seeds per pod increased sufficiently with 500 and 1000 µL/L ethrel only at 50 and 100 kg N/ha in *Brassica juncea*. At 50 kg N/ha, ethrel at 500 µL/L significantly improved seed yield and resulted in an increase in seed weight (Grewal and Kolar, 1990). Khan *et al*. (2000), Lone (2001) Mir (2002), Mir *et al*. (2008 a), Mir *et al*. (2009 b) and Lone *et al*., (2010) reported that ethrel enhanced pods per plant, seed yield (Fig. 9) and seed yield merit of Indian mustard. However, the response of mustard was greater with the application of 80 kg N/ha than 0 and 40 kg N/ha.

Fig.9. Effect of ethrel spray at 60d after sowing (DAS, flowering stage) on seed yield of mustard (Brassica juncea L.) cultivar Alankar grown with four basal levels of nitrogen



b. Biological yield

Biological yield and merit of genotype were enhanced by ethrel at 80 kg N/ha in mustard under irrigated and non- irrigated conditions (Khan *et al*., 2000; Mir 2002; Mir *et al*., 2009 b).

c. Harvest index

Exogenous application of ethrel (200 µL/L) along with basal 80 kg N/ha increased the harvest index in mustard (Khan *et al*., 2000; Mir 2002; Mir *et al*., 2009 b).

d. Oil yield

Khan (1996), Khan *et al*. (2000), Lone (2001), and Mir (2002) reported impressive increase in the oil yield of mustard in response to ethrel application at basal 80 kg N/ha.

7. Interaction effect on quality characteristics

Oil content, acid value, iodine value and saponification value were enhanced by ethrel at 200 µL/L along with nitrogen 80 kg N/ha in mustard under irrigated and non - irrigated conditions (Lone 2001; Mir 2002).

8. Conclusions

This study highlights the pivotal role played by the ethrel (ethylene sources) along with basal nutrients in the form of nitrogen on plant growth and development by affecting various growth characteristics like: plant height, leaf area, leaf area index, dry weight; physiological characteristics like chlorophyll content, photosynthesis, photosynthetically active radiation, ethylene evolution; biochemical characteristics like nitrate reductase activity, nutrient accumulation, nitrogen efficiency like nitrogen uptake efficiency, nitrogen use efficiency, nitrogen utilization efficiency in addition to yield characteristics like; seed yield, biological yield, harvest index, oil yield and quality characteristics like oil content, acid value, iodine value and saponification value.

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