Resistance inducing agent BION? and plant nutrition method CULTAN as alternative agricultural practice for stabilized yield in central Europe in high oleic sunflower (*Helianthus annuus* L.)

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Abstract

High oleic sunflower production shows an increasing trend worldwide. Although Germany has a high demand for this sunflower type, its production is variable as inappropriate agronomic practices cause yield instability. An integrated project was established in Germany to expand the production area through better agronomic practices and through breeding early maturing cultivars. Commercially available resistance inducing product BION? (Syngenta), controlled uptake long term ammonium nutrition (CULTAN) methods and their combinations were applied in different dosages and at different growth stages against *Sclerotinia sclerotiorum* (white rot) and *Botrytis cinerea* (grey mould). The results indicate that in certain varities BION? can lead to a significant decrease in disease development. CULTAN fertilization did not result in a significant improvement of plant health, but caused an increase in fungal infection rate in 2002.

Media Summary

Effects of selected agricultural approaches against fungal infections in high oleic sunflower agriculture which appears due to late harvesting in Central Europe are presented.

Key Words

High oleic sunflowers, BION?, CULTAN, Sclerotinia sclerotiorum, Botrytis cinerea, induced resistance.

Introduction

Worldwide high oleic oil production level is about 300.000 ton. In 1999 75.000 ton was produced in Europe of which 6000 ton in Germany. High oleic (HO) sunflower in Germany have a market potential of 800.000 ton / year (Kaeb, 2001). Sunflower production area in Europe is concentrated in Germany, France, Italy, Spain and some east European countries like Hungary. Recent research in Europe led to an increase of the monounsaturated fatty acid content of HO sunflower of up to 92%. Worldwide the HO sunflower oil has a high market volume in food industry. In Germany, sunflower oil with high oleic acid content takes an important place in oleo-chemical industry.

HO sunflower production area showed an increasing trend in 2000-2001 up to 7.000-8.000 ha in Germany. However the production level dropped down dramatically in 2002 and was estimated to be around 1.500-2000 ha for 2003. Although the HO type sunflowers have a comparable yield potential to the commercial type sunflowers, there are certain constraints that hinder its production in Germany. Cold and wet weather affect seedling establishment as well as harvest. Early maturing cultivars are lacking and fungal diseases, such as *Sclerotinia sclerotiorum* (white rot) and *Botrytis cinerea* (grey mould), are prevalent .

In most plants, low levels of a pathogen inoculum naturally trigger a resistance response – much like the human body's immune system mobilizes to fight a disease. In this way, BION? by Syngenta (acibenzolar-S-methyl) works like a vaccination for the plant. Induced resistance derived by BION? against number of fungal diseases was reported in several plant systems, and only some in sunflowers (Buschmann, 2002; Fan, 2003; Prats et al., 2002). Therefore it plays an important role in conducting better agricultural practices for HO sunflower cultivation in central Europe.

CULTAN stands for the expression “Controlled Uptake Long Term Ammonium Nutrition”. The nitrogen nutrition source for the plants with this method is ammonium instead of nitrate as common. Principally, ammonium is injected in liquid form 4-10 cm deeper, depending on the plant system, than the furrow at the root level (Kuecke, 2001). The plant builds a root bulb around this high concentrated ammonium depot and absorbs the nitrogen slowly over a longer time period. Therefore only one application at the beginning of the vegetation period is adequate. This relatively new plant nutrition method is believed to create more vital plant development in addition to its benefit hindering nitrate leaching and reducing plant nutrition costs.

An integrated project funded by the Agency of Renewable Resources (FNR) was initiated in 2003 to find possibilities to extend the production area of HO sunflowers in Germany. It is essential to develop agricultural approaches that promote healthy plant development in the predominantly wet autumn, since HO sunflowers mature later. There is also a need for new varieties that mature earlier and have faster seedling development. Next to plant production and breeding this integrated project deals also with analysis of the quality parameters of HO sunflower oil using near infrared spectroscopy (NIRS). In this report , we present the first results of improved agricultural practices.

Material and Methods

Field Experiments

Uncommon heavy rainfall was experienced in 2002, whereas 2003 was extraordinary warm and dry. The preliminary experiments in 2002 were restricted to the experimental fields of the Federal Agricultural Research Centre (FAL) in Braunschweig, a marginal site for sunflower cultivation. In 2003, an additional site in Southern Germany (near Eckartsweier) was set up. The plant activator BION? (acibenzolar-S-methyl at 50 mg/L active ingredient, Syngenta) and Controlled Uptake Long Term Ammonium Nutrition (CULTAN) were tested on three HO-sunflower varieties; Aurasol (Monsanto), Olsavil (Pioneer) and PR64H61 (Pioneer), representing different ripening classes. Acibenzolar-S-methyl was applied as seed treatment as well as leaf spray at five different developmental stages, emergence (BBCH-Code 09), 6 leaves unfolded (BBCH-Code 16), inflorescence emergence (BBCH-Code 51), full flowering (BBCH-Code 65) and end of flowering (BBCH-Code 69) using three dosage levels ; 10, 125 and 250 ppm BION?. CULTAN was applied as injection of a concentrated solution of urea ammonium sulfate and urea ammonium nitrate at 30 cm and 60 cm plant height and each application with 48 kg N and 60 kg N respectively. An evaluation of the natural disease development in the field was carried out in 3 weeks intervals.

Greenhouse Experiments

Additional to the field trials, a greenhouse experiment was established in 2003 in order to evaluate the effect of BION? on *Sclerotinia sclerotiorum* infection under standardized conditions. 125 ppm BION? was applied on varieties Aurasol and Olsavil as seed treatment as well as leaf spraying when the first pair of leaves was unfolded and 40 cm height respectively. The leaf test of Bertrand and Tourvieille (1987) was modified to determine the reaction of sunflowers to artificial infection by *Sclerotinia* . At seven different growth stages, with 2 weeks intervals, starting from the first leaf pair stage, the third fully grown leaf from the top was infected with *Sclerotinia* inoculum. The *Sclerotinia* culture was supplied by the State Plant Breeding Institute Research Station in Eckartsweier. One cm^2 was cut from the mycelial culture and placed at the extremity of the main vein, allowing the mycelium to contact the upper surface of lamina. The mycelium was fixed with an adhesive strip to the leaf. In order to keep the inoculum in a humid atmosphere, sprayed with about 10 ml water and covered with a transparent plastic bag. For data recording, the plants were observed for leaf lesions, diseased stems and the number of fully infected plants.

Results and Discussion

Field results

In 2002, only the spray application of the plant activator BION? showed an improvement of plant health in respect to the fungal infection, in different significance levels depending on the cultivated varieties in this study. The early maturing variety “Aurasol” (Monsanto) showed the best reaction to the BION? treatments and had significantly lower infection by both *Botrytis cinerea* and *Sclerotinia sclerotiorum*, irrespective of the application time and dosage applied (Figure 1). Relatively lower but statistically not significant fungal infection was observed on the Pioneer variety PR64H61 plots sprayed with BION? compared with control and fungicide applied plots, whereas the variety Olsavil showed no response to the application at all. Similar positive results upon BION? application to sunflowers against *Orobanche cumuna* were reported by Buschmann et al. (2002)

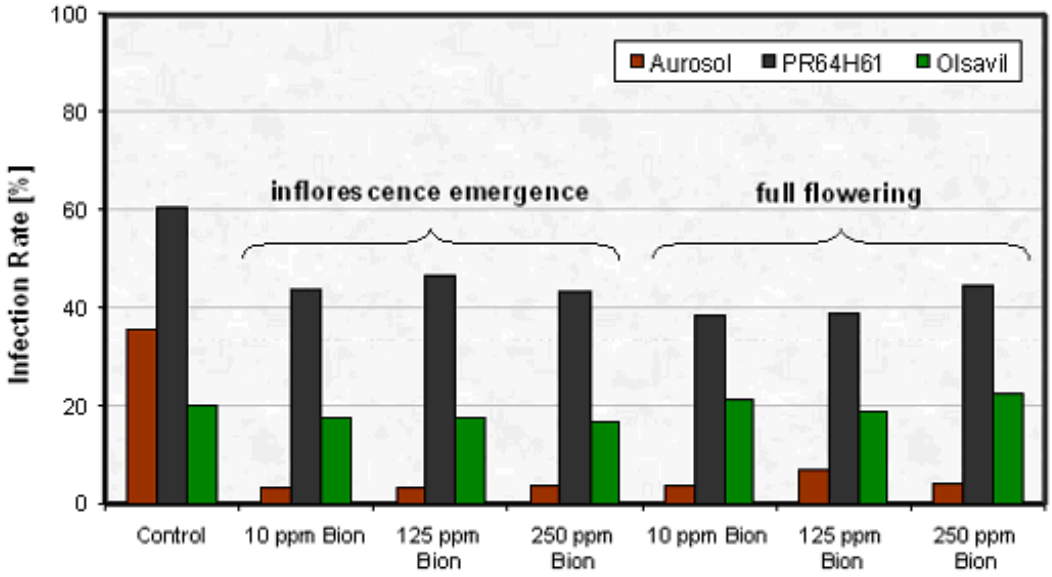

Figure 1. Effect of BION? spray application in different dosages at two different growth stages on *Sclerotinia sclerotiorum* and *Botrytis cinerea* infection rate of three high oleic sunflower varieties compared with control (60 kg N/ha) applied plots in 2002.

However, a change of N-supply to ammonium-based liquid fertilizer could not protect sunflower plants from fungal attack in 2002. Moreover, CULTAN application did lead to a significant increase of the fungal infection rate of the compared varieties. In contrast to our results, Sommer (2001) concluded that the CULTAN fertilization, in general, induces the plants to be healthier and stronger. Also Felgentreu (2001) confirmed that the liquid ammonium fertilization shows no negative effect on winter rape, in fact leads to an improvement of resistance to fungal diseases. Extremely dry weather conditions all over Germany in 2003 prevented most fungal infections in the field and obstructed any reliable statistical evaluation with relation to the tested cultivation measures for decreasing the fungal infection rate.

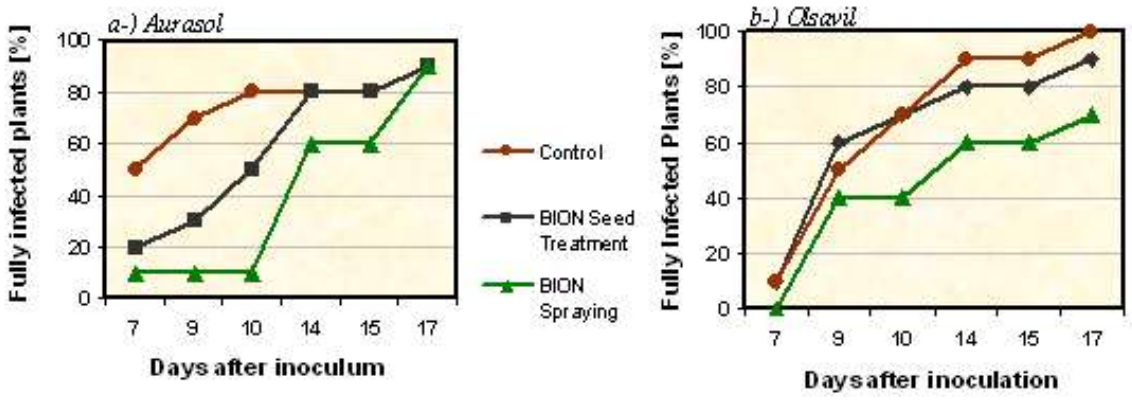

Figure 2.a-b. Fully infected plant rate after inoculation with *Sclerotinia sclerotiorum* mycelium at growth stage BBCH 19 in two high oleic sunflower varieties. BION was applied at growth stage of first pair of leaves unfolded.

Greenhouse results

The greenhouse experiments indicated that the two investigated sunflower varieties reacted positively to the BION? application by a lower lower infection rate when treated with this commercially available resistance inducing agent. The artificial infection by Sclerotinia mycelium proceeds faster in plants at early developmental stages. However at none of the compared growth stages BION? treatment could hinder a full infection of the HO sunflower varieties used in the greenhouse experiment by the *Sclerotinia sclerotiorum*. BION? was more effective when applied when the first pair of leaves unfolded in comparison to seed treatment. In contrast to the field trials in 2002, these first inoculation experiments indicated that the Pioneer variety Olsavil showed a better response to the BION? application.

Conclusion

The resistance inducing product BION? from Syngenta appears effective in controlling fungal infection in HO sunflower. Since chemical plant protection is not allowed on sunflower in Europe, BION? could become important for control of fungal pathogens in sunflower cultivation. CULTAN fertilization does not seem to have a promising future for sunflower health management according to the presented preliminary results. The evaluation of breeding lines and stocks showed clearly, that the variability for characters such as germination capacity as well as early seedling development at suboptimal temperatures is sufficient for improving available varieties for being cultivated under Central European climatic conditions. Further cultivation activities within the integrated project will focus on the use of BION? in combination with alternative agents against soil born pathogens.

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