LOW TEMPERATURE TREATMENT OF BRASSICA JUNCEA GROWN IN FIELD

Stefan Elf and Ingvar Ohlsson
Department of Plant Husbandry
Swedish University of Agricultural Sciences
S-750 07 Uppsala, Sweden

INTRODUCTION

At the northern extent of the growth area of Brassica oil crops in India sudden falls in temperature below freezing point quite often cause severe damage to the crops. Yield losses of 70 per cent are reported in Brassica (Yadava & Bhola, 1977). The damage is the result of ice formation in the plant tissues (Levitt, 1980).

Laboratory freezing methods have been developed to study the low temperature effects on different agricultural crops. However, exposing the plant stands to frost in their natural environment when growing in the field has become increasingly focused in order to obtain an assessment of the effects of freezing temperatures on the seed yields.

In India and in Sweden a joint approach is running in order to study low temperature effects on Brassica juncea. By using newly constructed movable freezing chambers, field experiments have been carried out in both countries.

The objective of the study was to estimate the losses in seed yield and the influence on seed quality factors of Brassica juncea exposed to low temperatures. The treatments were carried out at various stages of plant development, and in plant stands of different densities.

MATERIAL AND METHODS

Indian mustard (Brassica juncea cv. Varuna) was grown under field conditions at the Swedish University of Agricultural Sciences, Uppsala. The plant stands were exposed to low temperatures by using a movable freezing chamber (Ohlsson, 1985b, 1987).

The low temperature treatments were carried out in two stages of plant development, at flowering and at pod-filling. Flowering is defined in this paper as the development stage when about 70 per cent of all buds on the raceme are flowering or have flowered. Pod-filling is defined as a stage when all potential pods on the raceme are more than 2 cm long, and when most seeds in the pods are no longer translucent but clearly green without any signs of brownish spots.

Two different plant densities were used, 140 and 48 plants per m^2, named Swedish stand and Indian stand, respectively. In both cases the row space was 24 cm.

The freezing treatments were carried out by moving the freezing chamber into the stand, putting the detachable side panels into position, connecting the tubes from the refrigeration unit and running the apparatus according to the experimental plan. The plant stands were exposed to temperatures varying from + 2° C to - 7° C.

The selected temperature was reached in about one hour from the start and the treatment continued for three hours. The plant stand was then allowed to thaw for some time before the side panels and the tubes were disconnected, and the freezing apparatus was moved out of the treated plot.

The size of the treated plots was 1 m^2. Untreated plots of the same size were left within each type of plant stand.

RESULTS AND DISCUSSION

Seed yield

The yield results were evaluated statistically. As a result the following model, used for describing yield - temperature relationships, was obtained:

$$y = 100(1-A)\, e^{-\left[\left(\frac{X-M}{G-M} \right)^2 \ln[2(1-A)] \right]}$$

where y represents the yield reduction, M the lowest temperature of the function, A the function value at the temperature M, and G the temperature for 50 per cent yield reduction.

The developmental stage of the plants at treatment is of great importance in how a stand can survive low temperatures. Treatment in the flowering stage with low temperatures was found in earlier investigations (Ohlsson 1985a) to result in a 50 per cent yield reduction at a freezing temperature of -4° C.

The results of the present investigation at the same stage of development showed, however, that the 50 per cent yield reduction was obtained already at -1.2° C, probably largely a result of the very good growth conditions in 1986. The average yield of the untreated plants in the present investigation was 195 g per m2, which corresponds approximately to a yield of 2 000 kg per hectare.

When the freezing tests were conducted during the pod-filling stage a 50 per cent yield reduction occurred at -2.2° C, i.e., at about 1° C lower temperature than when the stand was in the flowering stage (Fig. 1). In addition, it was noted that a 100 per cent yield reduction occurred already at -4 ° C in the flowering stage. In the pod-filling stage, on the other hand, the yield reduction was only about 70 per cent even at extremely low temperatures (-7° C and -5° C). This clearly depends on the plants having proceeded so far in their development that despite being killed immediately by the treatment (or shortly after), seeds have already been formed and filled to such an extent that a certain yield level is always achieved. However, the quality of this yield is always poor, the seeds are small and wrinkled.

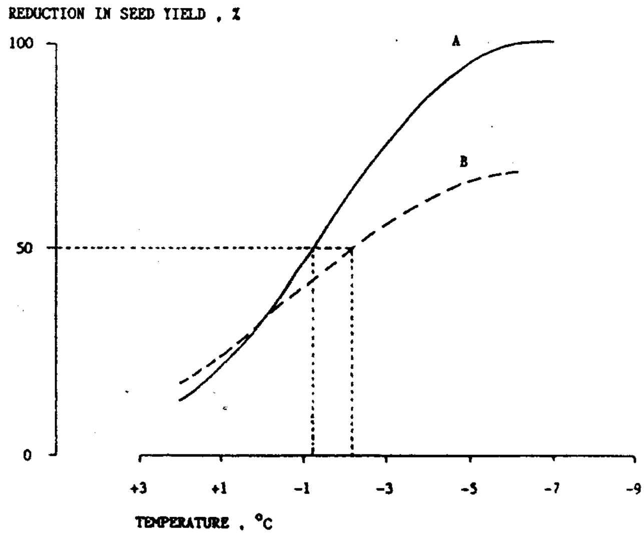

Figure 1. Low temperature treatment in the field of Brassica juncea. Percentage reduction in the seed yield after treatment at A. - flowering stage and B. - pod-filling stage.

In addition, it was found that the most radical change in yield reduction took place in the temperature range of ±0 to -2° C at both developmental stages.

In the Indian stand the untreated plots yielded, on average, 163 g per m2 of seed, which approximately corresponds to a yield of 1600 kg per hectare. Already a treatment at -1° C gave considerable yield reduction. The stand reacted very severely since the plants developed more or less normally at +1° C.

A yield reduction of 50 per cent in this stand was found at a temperature of -1° C, i.e., approximately the same temperature as in the Swedish stand in the same developmental stage (Fig. 2). This indicates that the stand density does not influence the ability of a stand to survive low temperatures.

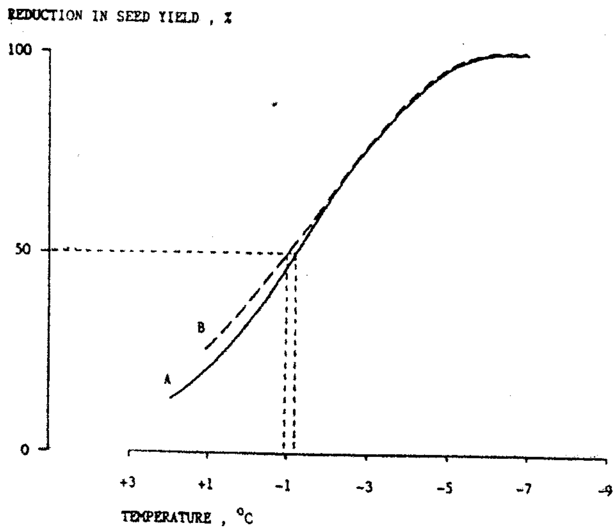

Figure 2. Low temperature treatment in the field of Brassica juncea. Percentage reduction in the seed yield after treatment of A. - Swedish plant stand (140 pl/m2) and B. - Indian plant stand (48 pl/m2)

In addition, it was found that the most radical change in yield level in this stand also occurred in the temperature range of ±0 to -2° C. At extremely low temperatures, i.e., lower than -5° C, the yield reduction was 100 per cent. This is in complete agreement with the situation in the Swedish stand at the same stage of development.

Plots which received the same treatment in the flowering stage showed that the yield of seed was higher following the earlier freezings. This may be explained by the phenomenon reported by Dhawan (1985) whereby the plants are more susceptible to frost in the intermediate and late flowering stages than in earlier flowering stages. In the Indian stand there was also some regeneration which naturally could continue over a longer period in the plots treated first. In such situations the new shoots in these plots could form pods and initiate seed development which then had a yield-promoting effect. This assumption is supported by the fact that the chlorophyll content of the seed yield was higher in plots where the regeneration was strongest.

The results obtained from treatments in the pod-filling stage show clearly that the effects of low temperature decrease with later treatments. This obviously depends on the assimilation in the seeds having proceeded for a longer period at the same time as the plants have become less susceptible. Examples of very late freezings show negligible yield reduction regardless of the freezing temperature. At the extreme temperatures of -7° C and -5° C the plants died almost immediately following the treatment but this did not influence the seed yield since almost maximum seed development had already been achieved. In these cases the freezing instead speeded up the ripening process.

QUALITY FACTORS

In the Swedish stand treated in the flowering stage there are no figures on quality factors at -5° C since these plots did not give any yield. The time for the treatment, i.e., the developmental stage, is of secondary importance for how Brassica juncea reacts qualitatively to freezing temperatures (Table 1). Crude fat content, thousand seed weight and germination capacity show clearly positive correlation with temperature. The chlorophyll content, on the other hand, increases when the stand is exposed to freezing treatments.

Seed quality factors	Untreated	Temperature, °C +1	-1	-3	-5
CRUDE FAT					
flowering stage	43.6 % = 100	95	91	75	-
pod-filling stage	43.6 % = 100	100	82	63	70
CHLOROPHYLL					
flowering stage	20 ppm = 100	255	368	-	-
pod-filling stage	17 ppm = 100	224	212	247	369
THOUSAND SEED WEIGHT					
flowering stage	4.7 g = 100	106	106	63	-
pod-filling stage	4.7 g = 100	102	70	48	47
GERMINATION CAPACITY					
flowering stage	97% = 100	96	85	53	-
pod-filling stage	98% = 100	97	76	37	31

Table 1. Low temperature effects on seed quality factors of *Brassica juncea* at flowering and pod-filling stages of development. Relative values.

In contrast to the case with the seed yield , the stand density has a clear influence on seed quality. The Indian stand has lower oil content and germination capacity but higher chlorophyll content than the corresponding Swedish stand. The pattern is, however, the same in both the Swedish and the Indian stand; the quality factors are influenced negatively by frost temperatures. The Indian stand suffered, however, the greatest damage at -1° C and -3° C whereas a treatment of -5° C did not reduce the seed yield to the same extent. This may be explained by the presence of a strong regeneration in the plots exposed to moderate freezing temperatures. The pods and seeds formed in this way did not have time to ripen before harvest which results in quality being influenced negatively at these temperatures. The chlorophyll content and the germination capacity are particularly influenced by this (Table 2).

Seed quality factors	Untreated	Temperature, °C +1	-1	-3	-5
CRUDE FAT					
Swedish stand	43.6 %= 100	95	91	75	-
Indian stand	35.4 %= 100	99	89	94	95
CHLOROPHYLL					
Swedish stand	20 ppm = 100	106	106	63	-
Indian stand	145 ppm = 100	113	235	229	113
THOUSAND SEED WEIGHT					
Swedish stand	4.7 g = 100	106	106	63	-
Indian stand	5.1 g = 100	97	74	89	113
GERMINATION CAPACITY					
Swedish stand	97 % = 100	96	86	53	-
Indian stand	98 % = 100	98	61	75	99

Table 2. Low temperature effects on seed quality factors of Brassica juncea. Treatments of Swedish plant stand (140 pl/m2) and Indian plant stand (48 pl/m2). Relative values.

SUMMARY

When growing in the field Brassica juncea cv. Varuna was exposed to low temperature at flowering and pod-filling stages using a movable freezing chamber. The plant stand was exposed to temperatures varying from -5° C to +1° C.

The study showed reduction in seed yield with increased freezing temperature. At pod-filling stage the plant stand was less sensitive to low temperature than at flowering stage. In both cases the most distinctive change in yield reduction was obtained in the interval of ±0° C to -3° C.

A 50 per cent reduction in yield was obtained at -1° C for the flowering stage, and at -2° C for the pod-filling stage.

Seed quality factors, e.g. contents of crude fat and chlorophyll, thousand seed weight and germination capacity, were negatively influenced by decreased temperature.

ACKNOWLEDGEMENTS

The authors wish to acknowledge financial support from SAREC through the Indo-Swedish Collaborative Research Program on Rapeseed/Mustard improvement. For valuable help in statistical evaluation gratitude is expressed to Dr Gunnar Ekbohm and Mrs Birgitta Vegerfors-Persson, Department of Economics and Statistics, SUAS.

REFERENCES

Dhawan, A.K., 1985. Freezing in oilseed Brassica spp: some factors affecting injury. - J. agr. Sci., Camb. 104:513.

Levitt, J., 1980. Responses of plants to environmental stresses.- Vol. 1. Chilling, freezing and high temperature stresses. A.P. New York.

Ohlsson, I., 1985a. Seed yield reduction by freezing Brassica juncea at flowering. - Proc. Joint Review Meeting, Indo-Swedish Collaborative Research Program on Rapeseed/Mustard improvement. NRL, New Delhi.

Ohlsson, I., 1985b. Movable freezing chamber for field studies of cold tolerance of plant stands. - Proc. Joint Review Meeting, Indo-Swedish Collaborative Research Program on Rapeseed/Mustard improvement. NRL, New Delhi.

Ohlsson, I., 1987. The movable freezing chamber - description and instructions for use. - The IAMFE Journal and Newsletter. Number 2.

Yadava, T.P. & Bhola, A.L., 1977. Research Achievements 1970-77. Oilseeds Section, Department of Plant Breeding, H.A.U., Hisar.