Research article

Ecology Journal

ISSN (Print): 2957-4471, ISSN (Online): 2708-6364, Website: https://journal.esbangladesh.org
Ecol. J. (2022) 4 (1) : 1-7

EFFECT OF BEE POLLINATION ON YIELD OF SESAME

Md. Zillur Rahman[1], Md. Elmur Reza[2*], Md. Shamim Hossain[3], Md. Razzab Ali[1] and Mohammed Sakhawat Hossain[1]

[1]Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, [2]Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna, Bangladesh, [3]Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

***Corresponding e-mail:** elmureza@gmail.com

Received: 26 October 2021, Revised: 09 May 2022, Accepted: 14 May 2022

ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka to observe the foraging behavior of *Apis mellifera* in sesame field. The treatments were T_1 (Caged with honeybees); T_2 (Caged without honeybees) and T_3 (Open plot). The result revealed that the highest number (101.8) of *Apis mellifera* pollinator visitation was in T_1 treatment. The highest number of pollinator visitation was recorded from 6:00 to 9:00 am in all the three treatments. Whereas, the lowest number of visitation was recorded in mid-day (2:00 to 3:00 pm). T_1 treatment caged with honeybee was the most effective in increasing flower number per plant (101.25), number of capsule per plant (86.5) and number of seeds per capsule (56.8) followed by the T_3 treatment, which was significantly different. The 1000-seed weight was the highest in T_1 (3.5 g) treatment followed by T_3 (3.20 g). Yield of sesame was the highest (1.2 t/ha) in Caged with honeybee followed by open plot. Insect of Hymenoptera order increased (38.0%) with increasing percentage of flowers. The majority of the sesame flower bloomed between third and fourth week and flowering lasted for 42-50 days. Most of the bees were recorded when the number of flowers per plant was maximum (83.5) at the fourth week of flowering. Bee population decreased with the diminishing of flowers per plant due to advancing age of the crops.

Keywords: Honeybee, pollination, pollinators, sesame, yield

Introduction

Sesame *(Sesamum indicum L.)* is an important oil seed crop belonging to the family Pedaliaceae. Sesame ranks after soybean and mustard as the third most important oil seed crop in the world. It is also third most important field oil seed crop in Bangladesh. Among the oil producing crops cultivated area in Bangladesh, about 69.9% is occupied by mustard and rapeseed and 8.9% by sesame covering an area of 93 thousand hectare of land having a production of 35 thousand metric tons (BBS 2019). Sesame is grown in both summer and winter season in Bangladesh. Its cultivation has great economic potential because of having great demand both nationally and internationally. The seeds, which contain about 50% oil, are the main reason for its cultivation, and may be used in the food, pharmaceutical and chemical industries (Blal 2013, Elleuch *et. al.* 2007, Namiki 2007).

Sesame is self-pollinating, although cross pollination have been reported. Both open pollination and bee pollination treatments were effective to increase the seed yield of sesame upto 22-33% over pollination without insect (Paleolog, 1988). In addition to increasing the yield, cross-pollination also helps to raise quality through a more unified ripening period and an earlier harvesting time. With regard to the pollination requirements of sesame, there is no consensus on the predominant type of pollination. According to Wiess (1983), this species is predominantly autogamous. Nevertheless, crossing rates reported in some studies ranged from 1 to 68% (Abdel *et al.* 1976, Ashiri 2007, Free 1993, Sarker 2004, Yermanos 1980) evidencing the need for further clarifications in this regard. Honey bees are good pollinators for many reasons. Their hairy bodies trap pollen and carry it between flowers. Sesame's blossom structure facilitates cross pollination, even though the crop is usually viewed as self-pollinating. The rate of cross-pollination lies between 0.5% and 65% depending on insect activity, environmental conditions and availability of other vegetation (Sharma and Kumar 2010). Since the average yield of sesame is low in

Bangladesh bee pollination may be an effective tool to increase the productivity. Therefore, this study was done to understand how the bee pollination affects the yield of sesame.

Materials and Methods

The experiment was conducted considering three treatments and laid out in a Randomized Complete Block Design (RCBD). Each treatment was allocated randomly in four replications. The unit plot size was 5.0 m × 4.5 m having 0.75 m space between the blocks and 1.0 m between the plots. Each plot contains two rows having 30 cm distance between the rows and that between plants was 5 cm. The variety BARI til-4 used in the experiment as test crop. Land preparation, fertilization, irrigation and intercultural operation was done as per recommendations of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur (Azad *et al*. 2019). Seeds were sown in the experimental field continuously in 2.0-2.5 cm deep furrows made by hand iron tine maintaining row spacing (30 cm). The rate of germination was found more than 95.0%. The management was not taken as the crops were not infested.

There were three treatment combinations tested in this experiment. T_1= Caged with honeybees: three framed bee box was used to observe honeybee pollination. The full plot was covered by net with managing bee foraging species. Artificial bee food also supplied at one week interval until the end of blooming period, T_2=Caged without honeybees: all plots of this treatment were only netted and therefore no bees could visit those plot, and T_3= Open plot: netting was not done and no managed bee boxes established in the open plot.

Ten plants were selected randomly from each plot at 30, 45 and 60 (at harvest) Days after swing to record the following data: number of flowers/plant; number of branches/plant; number of leaves/plant; number of capsule/plant; blooming period; number of seed/capsule; 1000 seed weight; and yield/plot.

The collected data on different parameters were statistically analyzed using the MSTAT-C computer package program. The mean differences among the treatments were adjusted by using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Insect pollination visitation in sesame field: Different pollinators' visitation in sesame field has been evaluated and presented in Table 1. The number of *Apis mellifera* was the highest (101.8) in T_1 treatment which was significantly different from T_2 (24.3) and T_3 (51.3) treatments. In terms of *Apis dorsata / Apis florea* species, no bee was found in T_1 treatment. But in T_2 and T_3 treatments was shown 12.3 and 18.0 number of *Apis dorsata / Apis florea* which were non-significant.

Another pollinator *Apis cerena* was nil in T_1 treatment that is caged with bees. In T_2 and T_3 treatments *Apis cerena* number was 8.0 and 12.8, respectively which were non significant. Only significant difference was found in T_1 treatment than T_2 and T_3 treatments. Another insect ant was counted in all three treatments. But no significant difference was found. The highest (61.9) ant was observed in T_3 treatment.

Table1. Number of different pollinators' visitation in sesame field

Pollination Condition	List of pollinators			
	Apis mellifera	*Apis dorsata / Apis florea*	*Apis cerena*	Ant
Caged with honeybees	101.8a	0.0b	0.0b	60.5a
Caged without honeybees	24.3c	12.3a	8.0a	52.3a
Open plot	51.3b	18.0a	12.8a	61.9a
$LSD_{(0.05)}$	16.8	6.3	5.9	17.8
CV (%)	16.4	36.0	48.9	17.7

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT). [T_1= Caged with honeybees, T_2= Caged without honey bees and T_3= open plot]

In the current study, four bee species namely *A. mellifera*, *A. dorsata*, *A. cerana* and *A. florea* were observed in sesame field which supported the findings of Viraktmath *et al.* (2001) who stated that those four bee species were attracted by sesame blossom. The findings of present study are not in accordance with that of Sachdeva *et al*. (2003) who found that *A. dorsata* was comparatively more abundant (7.5 bees/m^2/5minutes) than *A. mellifera* and *A. florea*. Das and Jha (2019) also found the similar results where *Apis dorsata* was the most predominant species with an average population of 2.5 insects per sq.m, followed by *A. mellifera.* On the contrary, Said *et al.* (2013) reported *A. mellifera* as the most abundant species with 14.6 bees/m²/5 min on sesame crop.

Time of visitation: There are three visitation time as presented in Table 2. The first visitation time was 6:00 am to 9:00 am. The number of pollinators was the highest (101.0) in T_1 treatment followed by T_3 (91.3) treatment, which was statistically identical between them. But in T_2 treatment that is caged without bees was shown the lowest (5.25) number of pollinators which was significantly different between T_1 and T_3 treatment. During mid-day (2:00 pm to 3:00 pm) comparatively all treatment shows the lowest number of pollinators. Among them T_1 showed the best (10.8) result which was significantly different with T_2 (1.0) treatment. In the afternoon (4:00 pm - 6:00 pm), the highest (75.3) number of pollinators was found in T_1 treatment followed by T_3 (7.3) treatment has no significant different.

The findings showed partial agreement with the results of Singh (2008) who studied the foraging behaviour of Himalayan honeybee (*A. cerana*) on flowering buckwheat. They observed two peaks of foraging activities of honeybee between 08:30 to 10:30 and 11:30 to 13:30. Said *et al.* (2013) found that foraging activity of bees on sesame flowers commenced at 9:00 - 11:00 am with 2.4 bees/m²/5 min but the maximum was attained at 1:00 - 3:00 pm with 9.8 bees/m²/5min.

Effects on yield attributes: The comparative effectiveness of three treatments on number of flowers per plant, number of capsules per plant, number of seeds per capsule, 1000-seed weight (g) and yield has been evaluated and presented in Table 3. In case of flower initiation of sesame plant, first flower initiation was observed in T_1 treatment. First flower initiation was started from May 15. After four weeks about 80% of flower was initiated. The highest (83.5/plant) number of flower per plant was recorded in T_3 treatment followed by T_1 (81.3/plant) and T_2 (78.5/plant), respectively (Table 3).

In respect to number of capsule per plant, the highest (86.5/plant) number of capsule per plant was recorded in T_1 treatment followed by T_3 (83.5/plant) and was nonsignificant , but T_2 treatment was significantly different between the two treatments. Production of capsule per plant was increased due to highest number of pollinators in T_1 treatment. Similar trend of results was found in number of seeds per capsule. Incase of 1000-seed weight, the highest (3.5 g) result was found in T_1 treatment (caged with honeybees) followed by T_3 treatment (3.2) that was open plot was significantly different. The lowest weight of 1000-seed was found in (2.9) T_2 treatment followed by T_3 treatment which was significantly different.

Table 2. Visitation time of different pollinators

Pollination Condition	Visitation time		
	6:00am – 9:00am	2:00pm – 3:00pm	4:00pm – 6:00pm
Caged with honeybees	101.0a	10.8a	75.3a
Caged without honeybees	5.3b	1.0b	2.8b
Open plot	91.3a	4.8ab	73.3a
$LSD_{(0.05)}$	29.3	9.3	22.3
CV (%)	25.7	16.9	25.6

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Table 3. Yield attributing characters of sesame

Pollination Condition	Number of flower per plant	Number of capsule per plant	Number of seeds per capsule	1000 seed weight (g) at harvest	Total yield (t/ha)
T_1	81.3a	86.5a	56.8a	3.5a	1.2a
T_2	78.5a	58.8b	45.8b	2.9c	0.8b
T_3	83.5a	83.5a	51.5c	3.2b	1.0a
$LSD_{(0.05)}$	18.6	10.1	3.7	0.2	0.2
CV (%)	12.1	7.7	4.2	4.2	9.6

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

The findings are in conformity with that of Blal *et al.* (2013) who observed higher capsule weight, number of seed/ capsule, weight of 1000-seed and seed yield/ plant of sesame in open pollination condition than non-opened pollination. They also reported no difference of the number of capsule per plant between open pollination and non-opened pollination treatments. According to the findings of Das and Jha (2019), open pollination condition of sesame showed higher seed yield than honey bee (*A. mellifera*) pollination, and both of them were significantly higher in comparison to pollinators excluded. This may happen because at open condition flowers are visited by composite natural pollinators which ensure more effective pollination. Mahmoud (2012) reported that insects' visit on sesame flowers resulted in significantly higher yield compared to plants from which insects were excluded. Rahman (2014) studied the effect of different modes of pollination in sesame and reported the similar findings. They observed that both open and caged pollination with honey bee significantly increased the number of capsule per plant, number of seeds per capsule and thousand seed weight (g) as compared to pollinators excluded condition. Whereas, the highest yield (1.2 t/ha) of sesame was found in T_1 treatment followed by T_3 treatment (1.0 t/ha) has significant difference with T_2 (0.8 t/ha) treatment. From the above findings it was revealed that in case of yield (t/ha) the plot that was caged with honeybees performed better than other plots.

Major insect orders visiting sesame plant during flowering period: Data were carried out on the major insect orders visiting sesame during flowering period from May 2013 to June 2013. Figure 6 revealed that four groups of pollinators visited the sesame belonging to order Hymenoptera, Diptera, Lepidoptera and Coleoptera of Class insecta during the flowering period. The number of Hymenoptera was higher, followed by Lepidoptera, and then both of Coleoptera and Diptera. The results indicated that hymenopterans and Lepidopterans were the major pollinators visiting sesame flowers.

Sintim *et al.* (2010) studied the insect spectrum of sesame field and recorded insect species belong to the orders Orthoptera, Lepidoptera, Hemiptera and Hymenoptera from the crop. Sanganna *et al.* (2015) reported a total of 14 insect visitors on sesame flower, out of which 10 species belong to Hymenoptera and 4 to Diptera. Among the observed Hymenopterans, there were four species of honey bee in their findings. The current results showed conformity to an extent with the reports of Das and Jha (2019) who found that Hymenopteran insects were predominant comprising of five species namely *A. dorsata*, *A. mellifera*, leaf cutter bee, wasp and ant. Said *et al.* (2013) and Kamel *et al.* (2013) also found that insect visitors on sesame flowers was the highest in Hymenoptera followed by Diptera, Lepidoptera and Coleoptera. Mahfouz *et al.* (2012) observed that among the insect pollinators of sesame the insect percentage of Hymenoptera was the highest, but the second highest was Lepidoptera, followed by Diptera and Coleoptera.

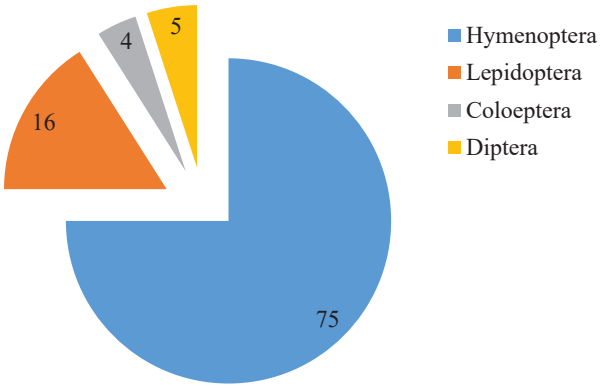

Figure 1. Percentage proportion of the major insect orders visiting sesame during flowering period.

Hymenopterans population during flowering period: Results in Figure 2 reveals that insects belonging Hymenoptera order increased with increasing the percentage of flowers. The majority of the sesame flower bloomed between third and fourth week and flowering lasted 42-50 days. Most of the bees were recorded when the number of flowers per plant was maximum (at the fourth week of flowering). Bee population decreased with diminishing of flowers per plant due to advancing age of the crops (Figure 2).

Mahfouz *et al.* (2012) reported that Hymenopteran insects showed the highest activity during the fourth week of flowering period of sesame. This happened because the number of flowers per plant was the maximum at the fourth week of flowering. They also observed that the abundance of bee decreased with time as the flower availability decreased at the later period of growing season.

Foraging activity of the major insect orders visiting sesame during flowering period: Data in Figure 3 showed the foraging activity of the major insect orders visiting sesame during flowering period. Peak of foraging activity was observed in Hymenoptera order during 9-11 am in our study. The comparison among number of different bee species clearly showed that the number and foraging activity of Hymenoptera was higher than Coleoptera, Diptera and Lepidoptera at all four time period i.e., 9-11 am, 11-1 pm, 1-3 pm and 3-5 pm (Figure 3). The maximum number of Hymenopteran was observed during 9-11 am and decreased with time during the day.

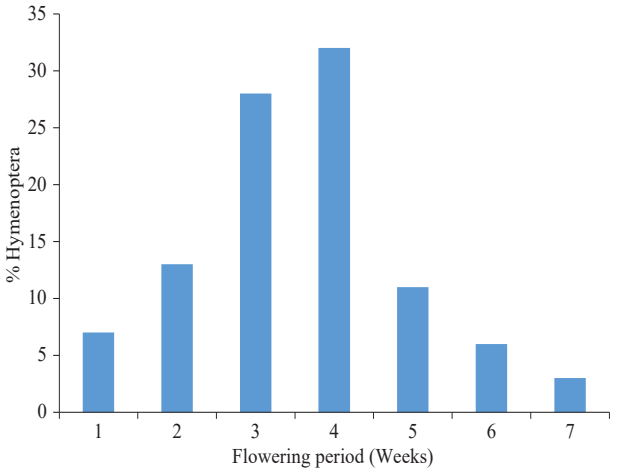

Figure 2. Fluctuation percent of Hymenopterous population during flowering period.

This is because nectar flow is copious in the sesame crop especially in the morning period; there after the nectar concentration gradually diminishes.

Mahfouz *et al.* (2012) found the similar trends where total number of pollinators in sesame field was the highest at 9-11 am, followed by 11:00 am-1:00 pm, 1:00 pm-3:00 pm and 3:00-5:00 pm. They included that the number of *A. mellifera* was the maximum at all time periods in their study. The peak foraging activity was noticed at 8:00-9:00 am on carrot by Munir and Aslam (2002). Andrade *et al.* (2014) stated that pollination between 7 and 11 hours ensures a greater fruit set in sesame and the presence of biotic pollinators enhances crop production by promoting cross-pollination.

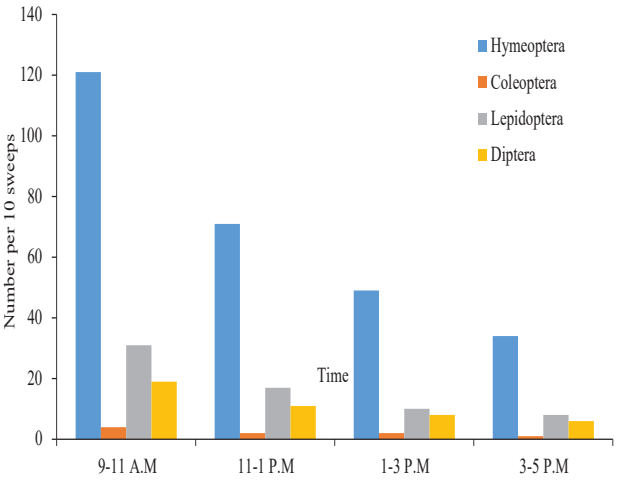

Figure 3. Foraging activity of the major insect orders visiting sesame during flowering period.

Conclusion

From the above findings it can be concluded that peak of foraging activity of *Apis mellifera* in sesame field is during 6:00-9:00 am. Interestingly, the types as well as the number of insect visitors changed with time during the flowering span of the sesame crop. The best yield performance was recorded in caged with honeybee plot. Number of flower, number of capsule, number of seeds per capsule, and 1000 - seed weight was increased in cage with honeybee plot.

References

Abdel A and Serry M. 1976. Some factors affecting self and artificial pollination in sesame, *Sesamum indicum* L. Agricultural Research Review, *54*: 155-159.

Andrade PBD, Freitas BM, Rocha EEDM, Lima JAD and Rufino LL. 2014. Floral biology and pollination requirements of sesame (*Sesamum indicum* L.). Acta Scientiarum. Animal Sciences, *36*: 93-99.

Ashri A. 2007. Sesame (*Sesamum indicum* L.). In: Genetic Resources, Chromosome Engineering, and Crop Improvement (Ed. Singh R. J.), Vol 4: Oilseed crops, CRC Press, Boca Raton, FL, USA. Pp. 231-289.

Azad AK, Ohab MA, Saha MG, Nesa J, Rahman ML, Rahman HH and Al-amin M. 2019. Krishi Projukti Hatboi (Handbook on Agro-Technology), 8th edition, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2019. Yearbook of Agricultural Statistics Divisiton, Ministry of Planning, Governmennt of the People's Repubic of Bangladesh, Dhaka. Pp. 52-57

Bilu A, Dag A, Elad Y and Shafir S. 2004. Honey bee dispersal of biocontrol agents: an evaluation of dispensing devices. Biocontrol Science and Technology, *14*: 607-617.

Blal AEH, Kamel SM, Mahfouz HM and Said M. 2013. Impact of opened, non opened pollination and nitrogen fertilizer on sesame production in the reclaimed lands, Ismailia Governorate, Egypt. Cercetari Agronomice in Maldova, *46*: 155.

Das R and Jha S. 2019. Insect pollinators of sesame and the effect of entomophilous pollination on seed production in new alluvial zone of West Bengal. International Journal of Current Microbiology and Applied Sciences, *8*: 1400-1409.

Elleuch M, Besbes S, Roiseux O, Blecker C and Attia H. 2007. Quality characteristics of sesame seeds and by-products. Food Chemistry, *2*: 641-650.

Free JB. 1993. Insect pollination of crops. 2nd Edition, Academic Press, London. P. 684.

Kamel SM, Blal AH, Mahfouz HM and Said M. 2013. The most common insect pollinator species on sesame crop (*Sesamum indicum* L.) in Ismailia Governorate, Egypt. Arthropods, *2*: 66-74.

Mahfouz HM, Kamel SM, Belal AH and Said M. 2012. Pollinators visiting sesame (*Sesamum indicum* L.) seed crop with reference to foraging activity of some bee species. Cercetări Agronomiceîn Moldova, *45*: 150.

Mahmoud FM. 2012. Insects associated with sesame (*Sesamun indicum* L.) and the impact of insect pollinators on crop production. Pesticide Phytomedicine (Belgrade), *27*: 117-129.

Munir A and Aslam M. 2002. Pollinators visiting carrot (*Dacus carota* L.) seed crop. Journal of Research (Science), *13*: 31-35.

Namiki, M. 2007. Nutraceutical functions of sesame: a review. Critical Reviews in Food Science and Nutrition, *7*: 651-673.

Paleolog J. 2009. Behavioural characteristics of honey bee (*Apis mellifera*) colonies containing mix of workers of divergent behavioural traits. Animal Science Papers and Reports, *27*: 237-248.

Rahman Z. 2014. Effect of bee pollination on the yield of sesame (*Sesamum indicum* L.). MSc Thesis, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Sachdeva Y, Bhatnagar P and Gulati R. 2003. Relative abundance and foraging behaviour of *Apis* spp. on sesamum (*Sesamum indicum*) flowers. Annals of Plant Protection Sciences, *11*: 281-283.

Said M, Kamel SA and Mahfouz ABH. 2013. Impact of insect pollinators on sesame production. Lap Lambert Academic Publishing, Saarbrücken, Germany. P. 92.

Sanganna MS and Eswarappa G. 2015. Sesame (*Sesamum indicum* L.) crop insect pollinators with special reference to the foraging activity of different species of honeybees. IOSR Journal of Agriculture and Veterinary Science, *8*: 9-14.

Sarker AM. 2004. Effect honeybee pollination on the yield of rapeseed, mustard and sesame. Geobros (Jodhpur), *31*: 49-51.

Sharma VP, Kumar NR. 2010. Changes in honeybee behaviour and biology under the influence of cellphone radiations. Current Science, *98*: 1376-1378.

Singh MM. 2008. Foraging behaviour of the himmalain honeybee (*Apis cerana* L.) on flowers of *Fagopyrum esculentum* M. and its impact on grain quality and yield. Ecoprint, *15*: 37-46.

Sintim HO, Tashiro T and Motoyama N. 2010. Insect spectrum of a mixed cultivar sesame field. Agricultura Tropica Et Subtrobica, *43*: 325-332.

Viraktmath SA, Patil B, Murasing S and Guruprasad GS. 2001. Relative abundance of pollinator fauna of cross-pollinated oilseed crops at Dharwad in Karnataka (India). Indian Bee Journal, *63*: 64-67.

Wiess EA. 1983. Sesame. In: Oilseed crops (Ed. Weiss EA). London: Longman. Pp. 282-340.

Yermanos DM. 1980. Sesame. In: Hybridization of crop plants (Eds. Fehr WR and Hadley HH). Madson: ASA. Pp. 549-563.