

Effect of Pollination on Qualitative Characteristics of Rapeseed (*Brassica campestris* L. var. *toria*) Seed in Chitwan, Nepal

R. Pudasaini, R. B. Thapa, P. R. Poudel

Abstract—An experiment was conducted to determine the effect of pollination on seed quality of rapeseed in Chitwan, Nepal during 2012-2013. The experiment was designed in Randomized Complete Block with four replications and five treatments. The rapeseed plots were caged with mosquito nets at 10% flowering except natural pollination. Two-framed colonies of *Apis mellifera* L. and *Apis cerana* F. were introduced separately for pollination, and control plot caged without pollinators. The highest germination percent was observed on *Apis cerana* F. pollinated plot seeds (90.50% germination) followed by *Apis mellifera* L. pollinated plots (87.25 %) and lowest on control plots (42.00% germination) seeds. Similarly, seed test weight of *Apis cerana* F. pollinated plots (3.22 gm/ 1000 seed) and *Apis mellifera* L. pollinated plots (2.93 gm/1000 seed) were and lowest on control plots (2.26 gm/ 1000 seed) recorded. Likewise, oil content was recorded highest on pollinated by *Apis cerana* F. (36.1%) followed by pollinated by *Apis mellifera* L. (35.4%) and lowest on control plots (32.8%). This study clearly indicated pollination increases the seed quality of rapeseed and therefore, management of honeybee is necessary for producing higher quality of rapeseed under Chitwan condition.

Keywords—*Apis cerana*, *Apis mellifera*, rapeseed pollination, seed quality.

I. INTRODUCTION

MAIN oilseed crops grown in Nepal include rapeseed, soybean, sunflower, sesame, groundnut, castor, linseed, and niger. Among them, rapeseed (*Brassica campestris* L. var. *toria*) is a dominant winter season oilseed crop of Nepal. Oilseed is one of the important cash crops of Nepal. It was cultivated on 213706 ha area, with production 176186 mt and productivity 0.82 mt/ha in 2010/2011, where as in 2011/2012 area increased to 214835 ha, production 179145 mt and productivity 0.83 mt/ha [1]. Rapeseed is a cross-pollinated crop. It requires sufficient pollinating agents for better pollination and seed production. The flowers of rapeseed are very attractive to bees and other many insect pollinators. Honeybees visit rapeseed flowers for collection of both pollen and nectar, which in turn results into florets cross-pollination. Honeybees are most important pollinating insect [2], [3]. The main significance of honeybees and beekeeping is pollination,

whereas the hive products (honey, wax etc.) are of secondary value [4]. Out of total pollination activities, over 80% is performed by insects and bees contribute nearly 80% of the total insect pollination and therefore, they are considered the best pollinators [5].

For the production of quality seeds of many vegetables, adequate cross pollination is essential. Cross pollination by honeybee is important because many of the vegetables crops are completely or partially self-incompatible and incapable of pollinating themselves. Activity of honeybee is largely governed by available bee forage and competition among bee species and other nectarivores.

Research on pollination ecology of seed production suggests the possibility of increasing yield with quality improvement by using honeybees as pollinators. As a result of bee pollination, somatic, reproductive, adaptive behavior or hybrid effects occur in the progeny either in single or in different combinations, which brings quantitative as well as qualitative changes in economic and biological aspects of plants. Such changes include improved fertilization, increased viability of seed, formation of more nutritious and aromatic fruits, faster growth, increased seed yield, increased fruit set and decreased fruit drop, increased oil content of oilseed crops and enhanced resistance to disease/pest or adverse environmental conditions.

Pollination process, spanning at least 100 million years, is believed to basic to the evolutionary history of flowering plants. Pollination is a prerequisite to pollen tube development and subsequent fertilization of ovules, leading to seed and fruit setting in flowering plants and insect pollinators play crucial role in this process [6]. Scientific evidence confirms that bee pollination improves the yield and quality of crops, such as fruits, vegetable seeds, spices, oilseeds and forage crops [7], [8]. The proper methods of utilizing pollinators are important for effective pollination and higher productivity of crops which are specific for honeybees, other bees and other insects [9]. It is reported that low pollinator abundance and diversity have started appearing in different area of world [10]. Similarly, farmers recognize that high level of pesticide application cause negatively impacted on insect pollinators and pollinator's deficit is a serious problem in Chitwan [11]. Hence, this study was conducted to see the effect of pollination effect on qualitative characteristics on rapeseed.

II. MATERIALS AND METHODS

An experiment was conducted at Jutpani VDC, Chitwan

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district, Nepal during October 2012 to February 2013. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and five treatments as pollination by *Apis mellifera* L.; pollination by *Apis cerana* F.; hand pollination; natural pollination and control (no pollination). The plot size of each treatment was 3 m x 5 m (15 m²) separated by 0.5m distance between plots and 1m between replications. Rapeseed variety Pragati was sown on 03 November 2012. The fertilizers were applied @ 15 ton/ha FYM, 60:60:40 kg NPK/ha and Sulphur 30 kg/ha. Full FYM, half nitrogen, full phosphorus and potassium were applied as a basal dose and remaining nitrogen as top dressing at 21 days after sowing (DAS). The seeds were sown at 3-4 cm depth of soil @ 6 kg / ha in well prepared field maintaining 20 cm x 5 cm spacing between row to row and plant to plant, respectively. Two intercultural operations were done to remove weeds during early vegetative growth period at 21 DAS and 35 DAS.

Native honeybee, *Apis cerana* F. exotic honeybee, *Apis mellifera* L., control and hand pollination treatments were covered with mosquito nets (5m×3m×2.5m size). The cages were erected on field plots when the crop reached at 5-10% flowering stage at 28 DAS. Thereafter, already produced four colonies of *Apis cerana* F. and four colonies of *Apis mellifera* L. with fully covered two- frame hives with a queen, and containing broods and eggs of each species were placed separately inside cage at 29 DAS on experiment field. The pollens were collected from border plants with the help of fine camel brush and pollinated between 8:00 am-10:00 am and hand pollination was conducted. Bee colonies were fed with 1:1 sugar syrup twice a week throughout the entire pollination period. These honeybee colonies and mosquito cages were removed at 65 days after sowing (DAS) from bee pollinated plots and at 100 DAS from no insect pollinated plots, respectively. One irrigation and remaining chemical fertilizer as half dose of nitrogen and sulfur were applied after first weeding. Two application of Neem oil based botanical insecticide- Niconeem were applied at 35 DAS and 60 DAS for aphid control.

For germination test, one hundred seeds from each experimental unit were counted and placed in Petridish with moist filter paper at the bottom and germinated seed were counted after five days and germination percentage was determined for each treatment separately. Similarly, samples of thousand seeds from each of the plot were weighed using electrical balance and analyzed with respect to different pollination treatments for to know the test weight. Finally, oil content was obtained by weighting 4-5 gm dried sample into extraction thimble. The mouth of thimble was plugged with cotton wool and placed in the Soxhlet extractor. A dry solvent flask was connected beneath the apparatus and required quantity of solvent (60 ml) was added and connected to condenser. Heating rate was adjusted to give a condensation rate of 2-3 drops per second and extracted for 16 hours. On completion, the thimble was removed and oil flask placed in hot water bath at 80 C for drying, the flask was cooled in desiccators and weighted. The EE% was calculated by the

following formula.

$$\text{Oil content (\%)} = \frac{(c-b) \times 100}{a}$$

where,

a=wt. Of the sample (g)

b= wt. Of the extractor beaker or empty oil flask (g) and

c= wt. Of flask + crude fat (g)

III. RESULTS AND DISCUSSION

Germination percent were recorded significantly different among the treatments. The highest germination percent was observed on *Apis cerana* F. pollinated plot seeds (90.50% germination) followed by *Apis mellifera* L. pollinated plots (87.25% germination), hand pollinated (83.00%), open pollinated (80.00 %) and the lowest on control plots (42.00% germination) seeds. [12] It is also recorded the higher germination of seeds obtained from pollination by trained bees (96%) followed by caged bees (88%), open pollination (84%), and caged without bees (44%), respectively [12]. Similarly, reported as increasing germination percentage of seeds, i.e. 83% in control to 93% germination of pollinated seeds by bees [13]. Germination for radish plants caged with an *Apis cerana* F. colony were 73% greater than open pollinated plants [14].

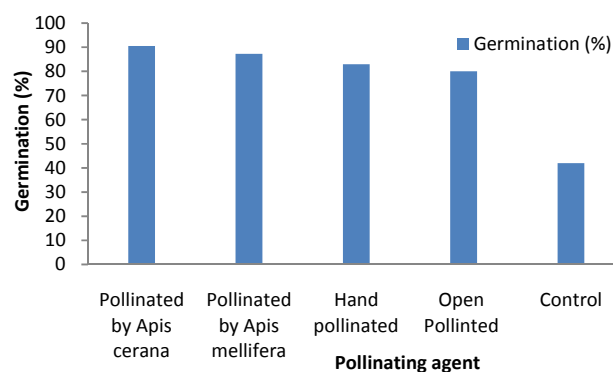


Fig. 1 Effect of pollination on germination percentage on rapeseed with different treatment in Jutpani VDC, 2012/013

TABLE I
QUALITATIVE EFFECTS OF *APIS CERANA* F. AND *APIS MELLIFERA* L.
POLLINATION ON RAPESEED IN JUTPANI VDC, CHITWAN 2012/013*

Treatments	Germination (%)	Test weight	Oil content (%)
Pollinated by <i>Apis cerana</i>	90.50a	3.222a	36.1
Pollinated by <i>Apis mellifera</i>	87.25b	2.95a	35.4
Hand pollinated	83.00c	2.625b	34.7
Open pollinated	80.00d	2.520bc	33.9
Control	42.00e	2.263c	32.8

* Means followed by the same letter in each column are not significantly different by DMRT at < 0.05 percent level.

Similarly, seed test weight of *Apis cerana* F. pollinated plots (3.22 gm/ 1000 seed) and *Apis mellifera* L. pollinated plots (2.93 gm/1000 seed) were significantly higher than hand pollinated plots (2.62 gm/ 1000 seed) followed by open pollinated plots (2.52 gm/ 1000 seed) and control plots (2.26

gm/ 1000 seed), respectively. It is reported that *Apis cerana* F. *indica* on cauliflower and cabbage showed increase in percent of seeds weight and percent germination as compared to open-pollination [15]. Similar results were reported on niger [16]-[18] on sesame and on mustard [19] which support to present findings.

The effect of pollination was non-significant on oil content. However, oil content was recorded highest on pollinated by *Apis cerana* F. (36.1%) followed by pollinated by *Apis mellifera* L. (35.4%) and lowest on control plots (32.8%). Similar result was reported by [20], as higher seed oil content when pollinated by honey bees. Similarly, the highest oil content was recorded with the honey bee + hand pollination (39.6%) and lowest on control plot without bees (31.6%) [21]. The highest oil content was obtained from the crop under hand + insect pollination and the lowest oil content was obtained in control [22]. Similarly, it is reported that highest oil content and highest seed weight due to bee pollination, as compared to hand pollination and without hand or bee pollination in sunflower [23]. Likewise, visits by *A. cerana indica* contributed to the increase in yield (40.30 per cent), weight of seeds/head (8.41 per cent), number of seeds/head (12.90 per cent) and oil content (9.09 per cent) [24]. The average weight of 100 seeds and oil content of seeds were significantly greater from muslin-bagged than from net-caged and open-pollinated flowers. Oil yield was 9.76 and 1.55 times higher under open pollination and net caging, respectively, than under muslin bagging [25]. Higher seed quality may be because in bee pollination, flowers are pollinated in the phase of fully functional generative organs producing better quality seeds. Hence, the honey bee pollination not only increased the yield but also improved the quality of the crop.

IV. CONCLUSION

This experiment shows that seeds not pollinated by bees resulted lower germinated capability, lower test weight and low oil content. Both species of honeybee improve quality of seed. Among the honeybees, *Apis cerana* F. was the most efficient pollinators that produce higher quality of rapeseed seeds than *Apis mellifera* L. Higher seed quality in bee pollination may be because, flowers are pollinated in the phase of fully functional generative organs producing better quality seeds. Hence, the study clearly indicated that there is deficit of pollinators and honeybees like *Apis cerana* F. and *Apis mellifera* L., being efficient pollinators of rapeseed their conservation and management is necessary for higher quality rapeseed production under Chitwan condition of Nepal by providing suitable hibernating places, less human intervention and less chemical pesticide.

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REFERENCES

- [1] MoAC, 'Statistical information on Nepalese agriculture.' Government of Nepal Ministry of Agriculture and Co-operatives Agri-Business Promotion and Statistics Division Singha Durbar, Kathmandu. Nepal. pp. 79, 2011/2012.
- [2] I. H. Williams, 'The dependence of crop production within the European Union on pollination by honey bees.' *Agricultural Zoology and Reviews*, vol. 6, pp. 229-257, 1994.
- [3] H. K., Sharma, J. K. Gupta and J. R. Thakur, 'Effect of bee pollination and pollinators proportion on apple productivity.' *Ac. Hort.* vol. 66, no. 2, 2451-454, 2004.
- [4] L. R. Verma, 'Beekeeping in integrated mountain development: Economic and scientific perspectives.' ICIMOD senior fellowship Series, No. 4 Oxford and IBH Publishing Company. Private. Limited, New Delhi, India, 1990.
- [5] W. E. Robinson and R. A. Morse, "The value of honeybees as pollinators of US crops." *American Bee Journal* vol. 129, no. 1, pp. 477-487, 1989.
- [6] G. C. Dhakal, 'A comparative study of *Apis cerana* F. and *Apis mellifera* L. on pollination of *Brassica campestris* Var. *toria* and *Fagopyrum esculentum* M. at Rampur, Chitwan." *M. Sc. Entomology Thesis* TU. IAAS Rampur, Chitwan, Nepal. pp. 76, 2003.
- [7] U. Partap, and T. Partap, 'Managed crop pollination.' The missing dimension of mountain crop productivity. Discussion Paper Series No. MFS 97/1, ICIMOD, Kathmandu, Nepal, 1997.
- [8] R. B. Thapa, 'Honeybee and other insect pollinators of cultivated plants: A review.' *Journal of Institute of Agriculture and Animal Science*, vol. 27, pp. 1-23, 2006.
- [9] R. C. Sihag, 'Management of bees for pollination.' In: M. Matska, L. R. Verma, S. Wongsiri, K. K. Shrestha and U. Partap (eds.) *Asian Bees and Beekeeping-Progress of Research and Development. Proceedings of Fourth Asian Apicultural Association International Conference, Kathmandu.* March 23-28, 1998. Oxford and IBH Publishing Company, Private Limited, New Delhi, India, 2000.
- [10] M. Kasina, M. Kraemer, C. Martius and D. Wittmann, 'Diversity and activity density of bees visiting crop flowers in Kakamega, western Kenya.' *Journal of Apicultural Research*, vol. 48, no. 2, pp. 134-139, 2009.
- [11] FAO, 'Protocol to detect and assess pollination deficits in crops: a handbook for its use.' Food and Agriculture Organization, Rome Italy. pp. 82, 2011.
- [12] NARC, 'Introduction of trained bees, *Apis mellifera* L. for quality seed and higher seed on mustard, *Brassica campestris* Var. *toria* in Nepalese condition.' Annual Technical Report 2006-2007. Entomology Division, Nepal Agriculture Research Council. Khumaltar, Lalitpur, Nepal. pp. 27-32, 2008.
- [13] P. G. Kevan, and D. Eisikowitch, 'The effect of insect pollination on canola (*Brassica napus* L. cv. O.A.C. Triton) seed germination.' *Euphytica*, vol. 45, pp. 39-41, 1990.
- [14] U. Partap, and L. R. Verma, 'Pollination of radish by *Apis cerana* F.' *Journal of Apiculture Research*, vol. 33, no. 4, pp. 237-24, 2010.
- [15] L. R. Verma, and U. Partap, 'Foraging behavior of *Apis cerana indica* on cauliflower and cabbage and its impact on seed production.' *Journal of Apiculture Research*, vol. 33, No. 4, pp. 231-236, 1994.
- [16] H. N. Sattigi, D. W. Rajasekar, and K. A. Kulkarni, 'Effect of attractants in enhancing the productivity of watermelon.' *Paper presented at the National Symposium on Environment and Evolutionary Biology.* pp. 24, 2001.
- [17] G. S. Guruprasad, 'Maximization of niger productivity through enhancement of bee pollination.' *M. Sc. Agriculture Thesis*, University of Agricultural Sciences, Dharwad, India, 2001.
- [18] B. S. Patil, 'Role of bee attractants in enhancing productivity and quality of sesame.' *M. Sc. Agriculture Thesis*, University of Agricultural Sciences, Dharwad India. pp. 93, 1999.
- [19] S. Murasing, 'Role of bee attractants in pollination and productivity of mustard (*Brassica juncea* L.)' *M. Sc. Agriculture Thesis*, University of Agricultural Sciences, Dharwad, India, 2000.
- [20] A. N. Mahmood, and B. Furgula, 'Effect of pollination by insects on seed oil percentage of oil seed sunflower.' *American Bee Journal*, vol.

- 129, no. 9, 663-667, 1983.
- [21] M. Rajasri, K. Kanakadurga, V. R. Durga., and C. Anuradha, 'Honeybees potential pollinators in hybrid seed production of sunflower.' *International Journal of Applied Biology and Pharmacology Technology*, vol. 3, no. 2, 216-22, 2012.
- [22] M. Kumar, H. Chand, R. Singh, and M. Ali, 'Effect of different modes of honeybee pollination on oil content in seeds of sunflower (*Helianthus annus* L.).' *Journal of Entomology Research*, vol. 26, no. 3, 219-221, 2002.
- [23] D. Rajagopal, R. N. Kanchraddi, and N. Nagraja, 'Utilization of honeybees in sunflower hybrid seed production.' In: M. Matska, L. R. Verma, S. Wongsiri, K. K. Shrestha and U. Partap (eds.). *Proceedings of Fourth Asian Bees and Beekeeping-Progress of Research and Development. Proceeding of Fourth Asian Apicultural Association International Conference, Kathmandu*. March 23-28, 1998. Oxford and IBH Publication Company Private Limited, India. pp. 283, 2000.
- [24] S. N. Kulkarni, and B. K. Dhanorkar., 'Effect of *Apis cerana indica* on niger seed production in Marathawada region.' Paper presented at FAO Workshop on Sustainable Bee Keeping Development, Dharwad, 1-5 August, 1998.
- [25] R. C. Mishra, and J. K. Gupta. 'The effect of mode of pollination on yield and oil potential of *Brassica campestris* L. var. *sarson* with observation on insect pollinators.' *Journal of Apiculture Research* 27 (3): 186-189, 1888.