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Relative Abundance Of Apis Species On Brassica Napus L. Bloom.

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ABSTRACT

Observations on the relative abundance of various species of Apis (A. mellifera, A. cerana, A.florea and A. dorsata) on parental lines of Brassica napus in hybrid seed production plots revealed that A.mellifera was the most abundant visitor thus excellent pollinator. Bee visitation was significantly more in case of experimental plots with male & female row ratio 2:4 followed by 1:4 and 1:8. So hybrid seed production plots with male to female row ratio 2:4 with A.mellifera beekeeping is suggested. Cytoplasmically male sterile flowers showed lesser bee abundance than that on flowers of restorer line, which was a limiting factor, for hybrid seed production. Further research work is required to select or develop CMS and R lines, which must be equally attractive to bees. The findings of the study will enhance the existing knowledge regarding honeybee management for pollination, hybrid seed production, pollinating efficiency of different types of honeybees and apiculture in general.

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I. INTRODUCTION

Honeybees are primary pollinators of rape (Nikitina, 1950 ; Hammer, 1952; Belozerova, 1960; Vesely, 1962; Radchenko, 1964; Pawlikowski, 1978; Williams, 1980). Deodikar and Suryanarayana (1972) showed that *Brassica napus* crop yield increased with bee pollination. An increase in seed yield with honeybee visitation has been reported in case of *B. napus* by many other workers (Fujita, 1939; Rhein, 1952; Demianowicz, 1968; Renard and Mesquida, 1987; Mahindru et al., 1995). Honeybees are the most efficient and abundant amongst insect pollinators, except under unusual circumstances. Bee colonies can easily be handled and manipulated and hence can be used effectively for pollination and hybrid seed production. They can be concentrated on crop bloom to the desired degree (Mc Gregor, 1976; Kevan, 1984). Free and Durrant (1966) reported that honeybees do not cleanse their bodies thoroughly to remove pollen between trips. Khan et al. (1986) stated that they are physically well suited for pollination purpose.Relative abundance of various insect species on bloom of a particular crop is an important factor to determine their pollination efficiency including different species of honeybees. Many researchers (Atwal, 1970; Free, 1970; Kapil et al, 1971; Sharma et al, 1974; McGregor, 1976) considered the relative abundance alone to compare pollination efficiency of various insect visitors. The pollination significance value of honeybees varies from one bee species to another, also from one crop to another and it largely depends upon abundance of foraging population. Relative abundance of different *Apis* species on particular crop depends upon many factors like population size, innate and thus unavoidable responses to different crops, even to different cultivars of same species, quantity and quality of available floral rewards, day hours as well as various environmental factors.The major aim of this study was to investigate comparative pollinating efficiency of different species of *Apis* including *A. mellifera, A. cerana, A.dorsata*, and *A.florea* on parental lines (cytoplasmically male sterile (TCMS-PR-05) and restorer (TFR-91) lines) of *Brassica napus* hybrid PGSH-51 in hybrid seed production plots by taking observations on relative abundance of different types of honeybees on male and female lines. Study will help to evaluate pollination efficiency of various *Apis* species.The expected outcome will help to enhance knowledge regarding pollination management technology and beekeeping in general.

II. MATERIALS AND METHODS

In order to conduct the study, seeds of cytoplasmically male sterile (CMS) line (TCMS - PR 05) and restorer (R) line (TFR-91) of *B.napus* hybrid PGSH-51 were obtained from Department of plant breeding, Punjab Agricultural University, Ludhiana (Punjab), Experimental plots were raised by following recommendations of PAU. The male to female row ratios selected were; 1:8, 1:4 and 2:4. In order to obtain synchronous flowering in two lines, early flowering male plants were detopped.Two colonies of each, *A.mellifera* and *A.cerana* were managed. Two colonies of *A.florea* were procured from other places and transplanted at suitable locations near experimental plots, so that no absconding took place at least during flowering season of crop. Enough activity of *A.dorsata* was observed and management of this bee species was not felt necessary.During flowering season of crop, daily observations on the number of bees of different *Apis* species present per meter row length/min. on each parental line (CMS and R line) were taken at 1000, 1200, 1400 and 1600 hours, with help of stop clock and meter rod. One meter length of each row was selected randomly. Starting of observations was done from plots of different row ratios alternately every day so that minimum error in terms of time of the day was committed. Various data collected were consolidated, tabulated, transformed wherever felt necessary and then subjected to analysis of variance and significance was tested at 5 per cent level. Results were calculated and conclusions were drawn.

III. RESULTS AND DISCUSSIONS

On an average *Apis* species according to their abundance on R line rows of *B.napus* / meter row length/min. may be shown as : *A. mellifera*. > *A.cerana* > *A. florea* > *A. dorsata* while in case of CMS rows bee species in descending order of abundance were *: A. mellifera* > *A. florea* > *A. cerana* > *A. dorsata*. Only minor and non significant variations in above mentioned sequences were observed at different day hours and among different M:F row ratio plots. Thus *A. mellifera* was the most abundant on both parental lines (Table 1-6).Maximum abundance of *A. mellifera* might be due to the presence of comparatively larger number of bees in their colonies kept for experiments and thus greater demand for nectar and pollen. On CMS rows *A. florea* was next abundant species. In plot of M:F row ratio of 1:8; it even outnumbered *A. mellifera* at 1200 and 1400 h. Its higher abundance may be attributed to the fact that this *Apis* species is a dominant nectar gatherer and female line provides only nectar. More nectar gathering behaviour of *Apis florea* was reported by Panda et al. (1995) on niger crop. *A. cerana* and *A.dorsata* were present comparatively in lesser number per unit row length per minute.Variations in the abundance of different bee species on the flowers might be due to number of factors such as: relative population size, quantity and quality of the available floral rewards in relation to the colony demands, innate behavioural response to flowers of the crop, duration of working, adjustment with prevailing environmental conditions etc. Informations regarding commencement of foraging activity later in the morning by *A. florea* (Tanda, 1984; Panda et al. 1991; Rao et al., 1995) and *A. dorsata* (Diwan and Satvi, 1965; Kapil and Kumar, 1975) are available in literature. Communication behavior of *A. dorsata* is not as perfact as that of *A. mellifera* and *A. cerana* (Lindauer, 1957).In the present study, it was observed that *A.mellifera* was comparatively more abundant on male as well as female rows of *B.napus* as compared to other three species. This observation is in agreement with those of Albore (1984), Ghoniemy and Abu-Zeid (1992) and Brunel et al. (1994) who found that *A.mellifera* was the dominant forager species on *B.napus*. It was also the dominant visitor on hybrid seed production plots of *B.napus* (Anon, 1999). Relatively higher abundance of *A. mellifera* was also reported in case of *Gossypium arboretum* (Tanda and Goyal, 1979) and on hybrid seed production plots of sunflower (Shinha and Atwal, 1996).In contrast to the present finding, Jhajj et al., (1996) observed that in case of raya crop various bee species in descending order of abundance were: *A.dorsata* >*A. mellifera* > *A. florea*. Panchbhavi and Rao (1978) and Panda, (1987) found that *A. florea* was dominant visitor on niger crop.Data regarding relative abundance on TFR-91 (Table 1,2 & 3) and TCMS-PR-05 (Table 4,5 & 6) lines of *B.napus* clearly showed that flowers of R line were much more attractive to honeybees than those of CMS line. The number of foraging bees of different *Apis* species per meter row length on R line per unit time was much higher as compared to the same on rows of CMS line. More attractiveness of honeybees to male-fertile than that to male-sterile plants might be due to the fact that their flowers are bigger, attractive, perfect and provide both types of rewards (pollen and nectar). In addition, difference in floral physiology, quantity and quality of nectar and aroma chemistry etc. might also played a role to make them more attractive. Nectar production was reported to affect the attractiveness of flowers to bees in case of *B.napus* (Renard and Mesquida, 1987; Mesquida et al., 1987), cauliflower (Woyke, 1989) and sunflower (Tepedino and Parker, 1982) Both the quantitative and qualitative differences in floral cues and rewards (pollen and nectar) affect the response of honeybees (Menzel and Shmida, 1993).

If honeybees have a choice, they will forage on those species or cultivars that provide the greatest caloric returns to them (Heinrich and Raven, 1972). Nectar secretion in cotton flowers and its relation to floral visits by honeybees was also worked out by Moffett et al. (1976). More attractiveness of male line flowers of *B.napus* to insect visitors has also been reported by many workers (Mesquida and Renard, 1979 a; Ohsawa and Nawal, 1988; Anon, 1999).Such characterstics of male line flowers in other crops have also been confirmed earlier(Funari et al., 1994; McGregor, 1976; Rarford and Rhodes, 1978; Delaude et al., 1979; Bond and Hawkin, 1967; Erickson and Peterson, 1979a; Erickson and Peterson, 1979b; Erickson et al., 1979 a; b) In hybrid seed production programmes using male-sterile and male fertile lines, discrimination of male-sterile flowers by honeybees due to lack of attractiveness was a restricting factor for pollination. Therefore, other essential factors for attractiveness of bees should be studied and incorporated into new hybrid system (Parker, 1981; Drane et al., 1982). In breeding index of a functional hybrid system, along with other characteristics, pollination and foraging cues must be included so that maximum possible success can be ensured (Stuber, 1980). In hybrid seed production plan, edaphic/climatic factors which also contribute to floral and bee responses should also be given due consideration (Rubis, 1970). Attempts to manupulate bee foraging behaviour by use of attractants have been found unsuccessful since bees learn to associate the attractant aroma with richness of reward (Burgstaller, 1990).In the present study, it was observed that lesser number of bees foraged on CMS (male-sterile) line flowers as compared to those of R (male-fertile) line flowers of *B.napus*. Thus a lower abundance of bee foragers on female flowers was a limiting factor for cross-pollination and hybrid seed production. Richness of rewards presented by the flowers and other secondary cues are important for attraction of insect pollinators. The apiculturists and plant breeders will have to collaborate to develop lines which show more attractiveness to bee visitors so that optimum pollination is to be ensured. It is inferred that work on pollination and breeding work for hybrid seed production has not progressed hand in hand and close collaboration between the two is essentially required. There are still many gaps in the information on pollination for hybrid seed production to increase yields by working out ways to achieve optimum pollination. Research work in this field is urgently required. Investigation revealed that in all the plots with different male-female row ratio, peak foraging activity of *Apis* species on male-fertile line of *B.napus* was at 1200 h. This may be due to the fact that most of the foragers on R line were pollen gatherers. Anthesis occurred in morning hours and newly opened florets were having copious pollen. It decreased towards the afternoon as mentioned by Tanda (1984) in case of raya crop. Other factors like time related floral physiology of male-fertile plants, environmental factors and innate responses of bees may also be responsible for peak foraging activity. Greater variation in temperature, light intensity and relative humidity also play their role in differential foraging activity of bees during different day hours. Heavy dew also effected foraging activity adversely in morning. Waller et al. (1985) found that the peak foraging activity of bees on R line flowers was before noon in hybrid seed production plots of cotton.The peak foraging activity of honeybees on CMS flowers of *B. napus* was recorded at 1400 h. It should be mentioned here that these flowers provide only nectar. The present observations are in line with several previous observations (Meyerhoff 1954; Radchenko,1964; Kapil et al., 1969; Waller et al., 1982; Thakur et al.,1982; Tanda,1984; Gupta et al., 1984;Sinha and Chakrabarti,1985; Kubisova et al. 1986; 1987) The hours of the day appeared to play a significant role in attracting bees for foraging as the nectar production or its concentration in male as well as in female line flowers and also the pollen dehiscence in male parent line are related with day hours or indirectly the prevailing temperature, humidity, light intensity and other environmental factors. The instinctive behaviour and biological clock of the bees might also be responsible for their activities. It seemed that floral rewards, environmental factors and innate behaviour of different *Apis* species have influenced the bee abundance on the parental lines.

IV. CONCLUSION

It may be concluded from above study that *A. mellifera* was the most abundant visitor on parental lines in experimental plots of all the row ratios therefore this bee species was the best suitable pollinator for hybrid seed production in case of *B. napus*. Abundance of all the bee species including *A.mellifera* was maximum on bloom of plots of male to female row ratio 2:4 followed by 1:4 and 1:8. So on the basis of present study hybrid seed production of rapeseed by using R and CMS line rows in 2:4 planting ,with *A. mellifera* beekeeping is recommended. Smaller size, inferior looks and limited floral rewards of female flower as compared to that of male flowers resulted in discrimination, selective foraging and significantly lower abundance on CMS line flowers. It was a limiting factor and major reason for not getting expected success in hybrid seed production. Further research work is required to select/breed lines that are equally attractive to honeybees, have synchronized flowering and provide floral rewards of equal value. Essential factors for bee attractiveness should be studied and incorporated into new hybrid system. Selection of plant stock on the bases of pollinator foraging cues is suggested.

Table-1 :Relative abundance of *Apis* species on R line of *B. napus* (male-female row ratio 1:8)

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	1.875 (1.695)	3.911 (2.214)	3.125 (2.030)	2.750 (1.936)	2.915 (1.969)
A. cerana	0.550 (1.243)	0.933 (1.383)	0.792 (1.338)	0.100 (1.048)	0.594 (1.253)
A. dorsata	0.225 (1.106)	0.489 (1.219)	0.479 (1.214)	0.100 (1.049)	0.323 (1.147)
A. florea	0.150 (1.072)	1.533 (1.588)	0.938 (1.392)	0.126 (1.061)	0.687 (1.278)
Average	0.700 (1.279)	1.716 (1.601)	1.334 (1.493)	0.769 (1.274)	1.130 (1.412)

$CD_{0.05}$

For *Apis* spp. 0.064
For day hours 0.064.
For interaction *Apis* spp. x day hours 0.128.
Figures in parenthesis are $\sqrt{n+1}$ transformations.

Table-2 :Relative abundance of *Apis* species on R line of *B. napus* (male-female row ratio 1:**4)**

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	1.608 (1.615)	3.492 (2.119)	3.483 (2.110)	1.885 (1.697)	2.617 (1.885)
A. cerana	0.333 (1.153)	0.951 (1.397)	0.783 (1.332)	0.077 (1.038)	0.536 (1.230)
A. dorsata	0.136 (1.066)	0.508 (1.228)	0.383 (1.174)	0.058 (1.028)	0.271 (1.124)
A. florea	0.098 (1.048)	0.705 (1.304)	0.667 (1.290)	0.096 (1.047)	0.392 (1.172)
Average	0.544 (1.220)	1.414 (1.512)	1.329 (1.476)	0.529 (1.202)	0.954 (1.353)

$CD_{0.05}$

For *Apis* spp. 0.050
For day hours 0.050.
For interaction *Apis* spp. x day hours 0.101.
Figures in parenthesis are $\sqrt{n+1}$ transformations.

Table-3 : Relative abundance of *Apis* species on R line of *B. napus* (male-female row ratio 2:4)

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	1.927 (1.706)	4.666 (2.378)	4.500 (2.343)	2.544 (1.881)	3.409 (2.077)
A. cerana	0.458 (1.207)	1.042 (1.425)	0.844 (1.356)	0.070 (1.034)	0.604 (1.256)
A. dorsata	0.052 (1.025)	0.142 (1.066)	0.123 (1.059)	0.026 (1.013)	0.086 (1.041)
A. florea	0.198 (1.094)	0.942 (1.391)	0.697 (1.302)	0.062 (1.030)	0.475 (1.204)
Average	0.659 (1.258)	1.698 (0.565)	1.541 (1.515)	0.676 (1.240)	1.144 (1.394)

$CD_{0.05}$

For *Apis* spp. 0.034
For day hours 0.034.
For interaction *Apis* spp. x day hours 0.068.
Figures in parenthesis are$\sqrt{n+1}$ transformations.

Table-4 : Relative abundance of Apis species on R line of B. napus (male-female row ratio 1:**8)**

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	0.203 (1.097)	0.475 (1.213)	0.497 (1.223)	0.372 (1.170)	0.387 (1.176)
A. cerana	0.084 (1.041)	0.280 (1.131)	0.284 (1.132)	0.125 (1.056)	0.193 (1.090)
A. dorsata	0.006 (1.003)	0.014 (1.007)	0.016 (1.008)	0.003 (1.002)	0.010 (1.005)
A. florea	0.056 (1.028)	0.552 (1.244)	0.560 (1.248)	0.053 (1.026)	0.305 (1.137)
Average	0.087 (1.042)	0.330 (1.149)	0.339 (1.153)	0.138 (1.063)	0.224 (1.102)

$CD_{0.05}$

For *Apis* spp. 0.022
For day hours 0.022
For interaction *Apis* spp. x day hours 0.044.
Figures in parenthesis are $\sqrt{n+1}$ transformations.

Table-5 : Relative abundance of *Apis* species on R line of *B. napus* (male-female row ratio 1:4)

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	0.264 (1.124)	0.578 (1.256)	0.629 (1.276)	0.462 (1.208)	0.483 (1.216)
A. cerana	0.084 (1.041)	0.258 (1.121)	0.267 (1.125)	0.019 (1.009)	0.157 (1.074)
A. dorsata	0.005 (1.002)	0.016 (1.008)	0.020 (1.010)	0.004 (1.002)	0.011 (1.006)
A. florea	0.077 (1.038)	0.471 (1.212)	0.604 (1.266)	0.038 (1.019)	0.298 (1.134)
Average	0.108 (1.051)	0.331 (1.149)	0.380 (1.169)	0.131 (1.060)	0.237 (1.107)

$CD_{0.05}$

For *Apis* spp. 0.017
For day hours 0.017
For interaction *Apis* spp. x day hours 0.033.
Figures in parenthesis are $\sqrt{n+1}$ transformations.

Table-6 :Relative abundance of *Apis* species on R line of *B. napus*(male-female row ratio 2:4**)**

Apis species	Day hours				
	1000 h	1200 h	1400 h	1600 h	Average
A. mellifera	0.208 (1.099)	0.446 (1.213)	0.451 (1.203)	0.320 (1.149)	0.356 (1.163)
A. cerana	0.037 (1.018)	0.092 (1.045)	0.094 (1.046)	0.014 (1.007)	0.059 (1.029)
A. dorsata	0.005 (1.003)	0.012 (1.006)	0.016 (1.008)	0.004 (1.002)	0.010 (1.005)
A. florea	0.099 (1.048)	0.216 (1.102)	0.398 (1.182)	0.026 (1.013)	0.185 (1.086)
Average	0.087 (1.042)	0.192 (1.088)	0.240 (1.110)	0.091 (1.043)	0.152 (1.071)

$CD_{0.05}$

For *Apis* spp. 0.022
For day hours 0.022
For interaction *Apis* spp. x day hours 0.043.
Figures in parenthesis are $\sqrt{n+1}$ transformations.

REFERENCES

[1]. Albore, G.R. (1984) observations on insect pollinators of some cruciferale (Sinapsis alba, Brassica napus Subsp Olifera, B. oleracea var. botrytis, B. rape) cultivated in a special area. Apicollore Moderno 75:257-264.

[2]. Anonymous (1999) Annual report, All India coordinated project on Honeybee Res. and Trg. C.C.S. HAU Hissar, PP 16-20.

[3]. Atwal, A.S. (1970). Insect pollinators of crops, (biology, ecology and utilization of insects other than honeybees in the pollination of crops) Final Res. Report, 1968-70. Punjab Agricultural University, Ludhiana. PP 116.

[4]. Belozerova, E.I. (1960) Bee increase seed crop from winter rape. Pchelovodstvo 37:38-40.

[5]. Bond, D.A. and Hawkins, R.P. (1967) Behaviour of bees visiting male sterile field bean (Vicia faba). J. Agri. Sci. 68:243-247.

[6]. Brunel, E., Mesquida, J., Renard, M. and Tanguy, X. (1994). Distribution of the pollinating insect fauna on flowers of rape (Brassica napus) and turnip rape (Brassica campestris). Apidologie 25:12-20.

[7]. Burgstaller, H.(1990). Importance of honeybees for the seed yield of sunflowers. Schweiz Bianen. 113:510-515.

[8]. Delaude, A., Tasei, J.N. and Rallier, M.(1979). Pollinator insects of sunflower (Helianthus annuus L.) in France. Pollination of male sterile lines for hybrid seed production. Proc. 4th Internat. Symp. Pollina., Mayland, USA, PP 29-40.

[9]. Demianowicz, Z. (1968). Biology of flowering and nectar secretion of five varieties of winter rape. Annls Univ. Mariae Curie – Sklodowska 23:241-263.

[10]. Deodikar, G.B. and Suryanarayana, M.C. (1972). Crop yields and bee pollination. Indian Farming 23:31-36.

[11]. Diwan, V.V. and Satvi, S.R. (1965). Some interesting behaviour features of Apis dorsata Fab. Indian Bee J. 27:52.

[12]. Drane, D., Macpherson, R. and White, K (1982). Pollination studies in hybrid sunflower seed production. Proc. 10th Internat. Sunflower Conf., Surfers Paradise, Australia. PP 16-20.

[13]. Erickson, E.H. and Peterson, C.E. (1979a). A synchrony of floral events and other differences in the pollinator foraging stimuli between male fertile and male sterile carrot inbreds. J. Amer. Soc. Hort. Sci 104:639-643.

[14]. Erickson, E.H. and Peterson, C.E. (1979b). A synchrony of floral events and other differences in pollinator foraging stimuli between fertile and male sterile carrot inbreds. J. Amer. Soc. Hort. Sci. 104:535-538.

[15]. Erickson, E.H., Peterson, C.E. and Werner, P. (1979a) Honeybee foraging and resultant seed set among male fertile and cytoplasmically male sterile carrot inbreds and hybrid seed parents. J. Amer. Sve. Hort. Sci. 104:635-638.

[16]. Erickson, E.H., Thorp R.W., Briggs, D.L., Estes, J.R., Daun, R.J., Marbs, M. and Schroeder, C.H. (1979b). Characterization of floral nectar by high performance liquid chromatography. J. Apic. Res. 18:148-152.

[17]. Free, J.B. (1970). Insect pollination of Crop plants. Academic Press, London and New York.

[18]. Free, J.B. and Durrant, A.J. (1966). The transport of pollen by honeybees from one foraging trip to next J. Hort. Sci. 41:87-89.

[19]. Fujita, M. (1939). Influence of honeybees on the fructication of rape. Bul. Imp. Zootech. Exp. Stn. Chiba-Shi. 34:1.

[20]. Funari, S.R.C., Silva, N.D., Carmo, M.C.T., Funari, A.R.M. and Souza, J.I.B. (1994). Collection activity of Africanized bees, Apis mellifera L. in fertile and cytoplasmically male sterile lines of cauliflower (Brassica Oleracea L.) and its influence on seed production, Boletim Industria Animal. 51:69-75.

[21]. Ghoniemy, H.A. and Abu-zeid, M.I. (1992) The pollination of swede rape (Brassica napus L.) with observations on insects as pollinators. Fayoum J. Agricult. Res. Develop. 6:57-67.

[22]. Gupta, J.K., Mishra, R.C. and Kumar, J (1984). Nectar sugar production and honeybee foraging activity in different cultivars of cauliflower, Brassica Oleracea var. botrytis. Indian Bee J. 46:21-22.

[23]. Hammer, O.(1952). Rape growing, bees and seed production. Dansk Landbr. 71:67-69.

[24]. Heinrich, B. and Raven, P.H. (1972). Energetics and pollination ecology Science 176:597-602.

[25]. Kapil, R.P. and Kumar, S. (1975) Foraging activity of Apis dorsata F. on Brassica Juncea. J. Bombay Nat. Hist. Soc. 71:327-331.

[26]. Kapil, R.P., Grewal, G.S. and Atwal, A.S. (1971) Insect pollinators of rapeseed and mustard. Indian J. Ent. 33:61-66.

[27]. Kapil, R.P., Grewal, G.S., Kumar, S. and Atwal, A.S. (1969) Insect pollinators of rapeseed and mustard. Proc. 56th Indian Sci. Cong., Ludhiana (Pb.) (Abstract).

[28]. Kevan, P.G. (1984) Bee botany : Pollination, foraging and floral calendars. Proc. Expert. Consult. Beekeep. Trop and Sub Trop. Asia. Rome. PP 51-56.

[29]. Khan, B.M., Shahid, M. and Chaudhry, M.I. (1986) Effect of honeybee pollination on the fruit setting and yield of loquat. Pak. J. for. 36:73-77.

[30]. Kubisova, S., Haslbachova, H. and Jamderkova, J. (1986). The pollinating activity of honeybees (Apis mellifera) on self incompatible lines of cabbage grown in isolation. Acta. Univ. Argic. Brno. A. 34:301-310.

[31]. Kubisova, S., Haslbachova, H. and Janderkova, J. (1987) Effectiveness of honeybee pollination with regard to crossing self-incompatible line of cabbage. Zahradnictui. 14:300-308.

[32]. Lindauer, M. (1957) Communication among the honeybees and stingless bees of India Bee World. 38:3-14.

[33]. Mahindru, N., Singh, G. and Grewal, G.S. (1995) Assessment of gains due to insect pollination in Sarson (Brassica campestris L. var. brown sarson). J. Res. Punjab Agric. Univ. 10:21-23.

[34]. McGregor, S.L. (1976) Insect pollination of cultivated crop plants. Agricultural Handbook No. 496. U.S.D.A., Washington, D.C.

[35]. Menzel, R. and Shmida (1993). The ecology of flower colours and natural colour vision of insect pollinators. The Israeli flora as a study case. Biol. Rev. 68:81-120.

[36]. Mesquida, J. and Renard, J. (1979a). Entomophilous pollination of male sterile strain of winter rapeseed (Brassica napus L. Metzger var. oleifera) and a preliminary study of alternating devices. In: Proc. 4th Internat. Symp. Pollin., Maryland, USA, 49-57.

[37]. Mesquida, J., Renard, M., Pollen-Delourme, Polletices, G. and Morice, J. (1987). Influence dessecretions nectarifers des lignes male steriles pour la production de Semences hybrids F, de calza, INRA, France. PP 269-280.

[38]. Meyerhoff, G. (1954). Investigation on the effect of bee visits on rape. Arch. Geflugelz. Klein tierk. 3:259-306.

[39]. Moffett, J.O., Stitch, L.S., Burkhardt, C.C. and Shipman, C.W.(1976). Nectar secretion in cotton flowers and its relation to floral visits by honeybees. Amer. Bee J. 116:32-36.

[40]. Nikitina, A.L. (1950). Honeybees raise seed yields of turnip and rutabaga. Pchelovodstovo. 5:271-274.

[41]. Ohsawa, R. and Nawal, H. (1988). Cross pollination efficiency of insect pollinators. Japanese J. Breeding. 38:91-102.

[42]. Panchabhavi, K.S. and Rao, K.J. (1978) Note on effect of mixed croping of niger on the activities of insect pollinators and seed falling of sunflower in Karnataka. Indian J. Agric. Sci. 48:254-255.

[43]. Panda, B. (1987). Foraging behaviour of honeybees and effect of Apis cerana Indica Fab. on sunflower and niger and niger yield. M.Sc. (Ag) Thesis, Orissa Univ. Agric. & Tech., Bhubaneswar, Orissa.

[44]. Panda, P., Panda, B. and Sontakka, B.K. (1991). Foraging behaviour of honeybees on sunflower (Helianthus annuus L.) sown on different dates. Indian Bee J. 1-4:44-49.

[45]. Panda, P., Rath, L.K., Padhi, J. and Panigrahi, D. (1995) Relative abundance and foraging behaviour of common bee species on niger in Phulbani district, Orissa, India. Indian Bee J. 57:10-14.

[46]. Parker, F.D. (1981). Sun flower pollination : abundance, diversity and seasonality of bees and their effect on seed yield J. Apic Res. 20:49-61.

[47]. Pawlikowski, T. (1978). Food relationship of Apoidea occurring on winter rape crops and other plants in the neighborhood of Torun. Polskie Pismoent. 48:267-277.

[48]. Radchenko, T.G. (1964). The influence of pollination on the Crop and the quality of seed of winter rape. Bdzhil 'nitstov 1:68-74.

[49]. Radford, B.J. and Rhodes, J.W. (1978). Effect of honeybee activity on the cross pollination of male sterile sunflower. Queensland J. Agric. Anim. Sci. 35:153-157.

[50]. Rao, G.M., Nadre, K.R. and Suryanarayana, M.C. (1995). Studies on pollination of male sterile line for foundation seed production in hybrid sunflower. Indian Bee J. 57:170-173.

[51]. Renard, M and Mesquida, J. (1987). Preliminary study on entomophilous pollination of male sterile rape in a mixed cultivation system comprising variable proportions of pollinizer plants Bull. Tech. Apicult. 14:99-104.

[52]. Rhein, W. Von (1952). Results of training bees by scent during the 1952 rape flow. Hess. Biene. 88:192-194.

[53]. Rubis, D (1970). Breeding insect-pollinated crops. Proc. Indispensable Pollin. 9th Pollin. Conf., Hot springs, Arkansas. PP 19-24.

[54]. Sharma, P.L. Dhaliwal, H.S. and Kakar, K.L. (1974). Insect visitors and pollinators of cauliflower (Brassica oleracea var. botrytis.) seed crop bloom. Himachal J. Agric. Res. 2:74-78.

[55]. Sinha, S.N. and Atwal, S.S. (1966). Pollination requirement in sunflower hybrid seed production : II effect of date of sowing and fertilizer on honeybee foraging behavior on parental lines. Seed Res. 24:110-115.

[56]. Sinha, S.N. and Chakrabarti, A.K. (1985) Studies on pollination by honeybees on early cauliflower and its effects on seed yield and quality. Seed Res. 13:115-119.

[57]. Stuber, C.W. (1980). Mating designs, field nursery layouts and breeding records. In: Hybridization of Crop plants. American society of Agronomy and crop science, Medison, Wisconsin.

[58]. Tanda, A.S. (1984). Foraging behaviour of three species of Apis on raya in relation to the sugar concentration in its nectar. Indian Bee J. 46:5-6.

[59]. Tanda, A.S. and Goyal, N.P.(1979). Insect pollination in Asiatic cotton (Gossypium arboreum). J. Apic. Res. 18:64-72.

[60]. Tepedino, V.J. and Parker, F.D. (1982) Interspecific differences in the relative importance of pollen and nectar to bee species foraging on sunflower. Environ. Entomol. 11:246-250.

[61]. Thakur, A.K., Sharma, O.P., Garg, R. and Dogra, G.S. (1982). Comparative studies on foraging behaviour of Apis mellifera and A. cerana indica on mustard. Indian Bee. J. 44:91-92.

[62]. Vesely, V. (1962) The economic effectiveness of bee pollination on winter rape (Brassica napus L. var. oleifera Metz). Minist. Zemedel lesn. A. vodniho Hospodar Ust. Vedtec. inform. Zemedel Ekon. 8:659-673.

[63]. Waller, G.D. (1982) Hybrid cotton pollination Amer. Bee J. 122:555-560.
[64]. Waller, G.D., Moffett, J.O., Loper, G.M. and Martin, J.H. (1985). An evaluation of honeybee foraging activity and pollination efficiency for male sterile cotton. Crop. Sci. 25:211-214.
[65]. Williams, I.H. (1980). Oilseed rape and beekeeping, particularly in Britain. Bee wld. 61:141-153.
[66]. Woyka, H.W. (1989). Honeybee foraging on the flowers of cauliflower F1 cultivar components. Proc. 31st Cong. Apic., Warsaw, Poland, PP. 360-364.

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