EFFECT OF POLLINATION BY INDIAN HONEY BEE, *APIS CERANA INDICA* FABR. ON YIELD , YIELD ATTRIBUTING CHARACTERS AND OIL CONTENT OF NIGER, *GUIZOTIA ABYSSINICA* CASS

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Abstract: The effect of pollination by Indian honey bee, *Apis cerana indica* were under taken on different quantitative and qualitative parameters of niger during 2011-12. The higher number of capitulum plant^{-1} was recorded in treatment total opened (35.17 capitulum^{-1}) however the lowest number of capitulum was recorded in treatment of total closed (28.32 capitulum plant^{-1}). The maximum capitulum weight was found in treatment control i.e. total opened (0.299 g) which was significantly superior but the mimnimum capitulum weight was observed in treatment, total closed (0.079 g). The maximum seed yield plant^{-1} was recorded in control (total opened 2.473 g plant^{-1}) but the least seeds yield plant^{-1} was recorded in treatment with total closed (0.606 g plant^{-1}). The sterility per cent was noticed significantly superior in treatment with total closed (97.09 per cent) however lower sterility per cent was recorded in treatment with total opened (4.92 per cent). The significantly higher per cent of healthy seeds were found in control plot, total open (95.06 per cent) but the minimum per centage of healthy seeds were found in treatment total closed (2.89 per cent). Maximum seed weight (1000 seeds) was recorded in treatment total open (4.89 g) however the treatment total closed had minimum seed weight (3.28 g). The significantly highest yield was found in treatment total open (353.25 kg/ha^{-1}) but the lowest seed yield was observed in treatment total closed (79.50 kg/ha^{-1}). Significantly higher oil content was recorded in treatment with total open (33.50 per cent) the lowest oil content was found in treatment with total closed (26.73 per cent). Significantly higher niger seed germination was recorded in treatment with control (80.25 per cent) The lowest germination was found in treatment with total closed (64.25 per cent).

Keywords : Indian honey bee, *Apis cerana indica*, Oil content, Pollination, Yield parameters, Niger

INTRODUCTION

In the agricultural economy of India, oilseeds are important next only to food grains in terms of area, production and value. The diverse agro-ecological conditions in the country are favorable for growing all the nine annual oilseeds, which include seven edible oilseeds, viz. groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and niger, and two non-edible oilseeds, viz. caster and linseed. Apart from annual oilseeds, a wide range of other minor oil-bearing plants of horticulture and forest origin, including coconut and oil palm are cultivated in the country. In addition, substantial quantity of vegetable oils is also obtained from rice bran and cotton seed and a small quantity of oil from corn and tobacco seed (Hegde, 2012).

Among the edible oilseed crops, the niger (*Guizotia abyssinica* Cass. Compositae) is an important oilseed crop cultivated in Ethiopia and India. It is a branched annual herbaceous plant, grows upto a height of 1.8 metre. The niger plant complete its life cycle in 3-4.5 months. The yellow flower heads of 2-3 cm develop in the leaf axil, in a cluster of two to five. Each head contains about eight ray florets and 40 to 60 hermaphrodite disk florets.

The seeds contain approximately 40 per cent oil, which is pale yellow with nutty taste and a pleasant odour. The oil and seeds are free from any toxin and oil taste is similar to *desi* ghee. The oil is used for culinary purposes, anointing the body, manufacturing paints and soft soaps and for lighting and lubrication. The niger oil is good absorbent of fragrance of flowers due to which it is used as a base oil by perfume industry. Niger oil can be used for birth control and treatment of syphilis. Niger seed cake is a valuable cattle feed particularly for milch cattle. Niger is also used as a green manure for increasing soil organic carbon. The fatty acid composition of 75-80 per cent linoleic acid, 7-8 per cent palmitic and stearic acids, and 5-8 per cent oleic acid, (Getinet and Teklewold, 1995).

Various workers have worked on various issues of pollination made by the honey bee and among the workers Howard *et al.* (1919) found that cross-pollination in niger was common. They pointed out that the stigma lobes rarely curled back sufficiently to touch their own style, indicating that the plants were self-sterile. Panda *et al.*(1988) observed that both open pollination and bee pollination treatments were effective to increase the seed yield of sesamum up to 22 to 33 per cent more than that in pollination without insects.

MATERIAL AND METHOD

The experiment was conducted at Raj Mohini Devi College of Agriculture and Research Station, Ambikapur of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during 2011-12. The

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crop was niger and the variety was JNC-9, plot size were 2 x 2 m^2. Six treatments four times replicated and the design was randomized block design. When the cages (Mosquito net) were opened once in a week, the Indian honey bee, *Apis cerana indica* only allowed visiting the crop, other insect pollinators/visitors were escaped with the help of hand net. The treatments which were totally closed with mosquito net, no any insect pollinators/visitors were allowed to visit inside the cage. In the control treatments (totally opened) all the pollinators/visitors were allowed to visit the niger crop.

All observations of the crop were made at the final stage of the crop.

Treatments Details

Treatments	Description
T_1	Open the cage between 0700 to1000hrs and1500 to1700hrs, Close between 1000 to 1500hrs.
T_2	Close the cage between 0700 to1000hrs and1500 to1700 hrs, Open between1000 to 1500hrs.
T_3	Close the cage between 0700 to 1200hrs Noon, and Open between 1200Noon to 1700hrs.
T_4	Open the cage between 0700 to 1200hrs Noon and Close between 1200Noon to 1700hrs.
T_5	Total closed (Total Net)
T_6	Control (Total Open)

(A) Quantitative Parameters

(I) Capitulum setting plant^{-1}: Ten plants were randomly selected from each pollinated situation in each replication and number of capitulum setting was counted. Then mean number of capitulum plant^{-1} was worked out.

(II) Seed yield plant^{-1}(g): Total 10 plants were used randomly for study under each pollinated situation in each replication. The capitula of all the plants were removed and seeds were separated from these capitulae, then seeds were weighed by electronic balance. Then mean seed yield plant^{-1} was worked out.

(III) Weight of capitulum^{-1}(g): Ten capitulum were used from each pollinated situation in each replication then by weighing the capitulum, average weight of capitulum were workout.

(IV) Sterility percentage: The chaffy seeds were observed and counted from ten capitulum. Then all seeds (number of healthy seeds + number of chaffy seeds) were determined from each treatment. Finally sterlity percentage was determined by the formula:-

$$\text{Sterility percentage (\%)} = \frac{\text{Number of chaffy (sterile) seeds capitulum}^{-1}}{\text{Total number of seeds capitulum}^{-1}} \times 100$$

(V) Test weight of seeds (g) :- Seeds samples were taken randomly from the produce of crop under six different pollinated conditions in each replication. After this 1000 seeds were counted treatment wise separately. Weight of 1000 seeds of each sample was recorded through electronic balance.

(VI) Seed yield (kg plot^{-1}/ kg ha^{-1}):- The crop harvested and tagged into bundles, all bundles were transported to threshing floor. These were kept on threshing floor for sun drying and after sun drying threshing was done plot wise manually. The mean weight of seeds plot^{-1} was taken and then converted into kg ha^{-1} **.**

(B) Qualitative Parameters

(I) Oil content of seeds (%) :- The samples of seeds from the produce of each treatment (20gms.) were collected and analyzed for per cent oil content by NMR (Nuclear Magnetic Resonance) with the help of scientists at Jawahar Lal Nehru Krishi Vishwavidyalaya campus, AICRP on Niger, Jabalpur (M.P.). Thus effect of pollination on oil content of seed was worked out.

(II) Germination percentage - The seeds were obtained from the produce of all the six treatments and their germination were tested by keeping 100 seeds of each treatment, in Petri dishes covered with moist filter paper. The filter paper was removed after germination was seen and thereafter germination was recorded. Finally germination percentage of seeds was determined by using the formula-

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds in patri dishes}}{\text{Total number of seeds used for germination}} \times 100$$

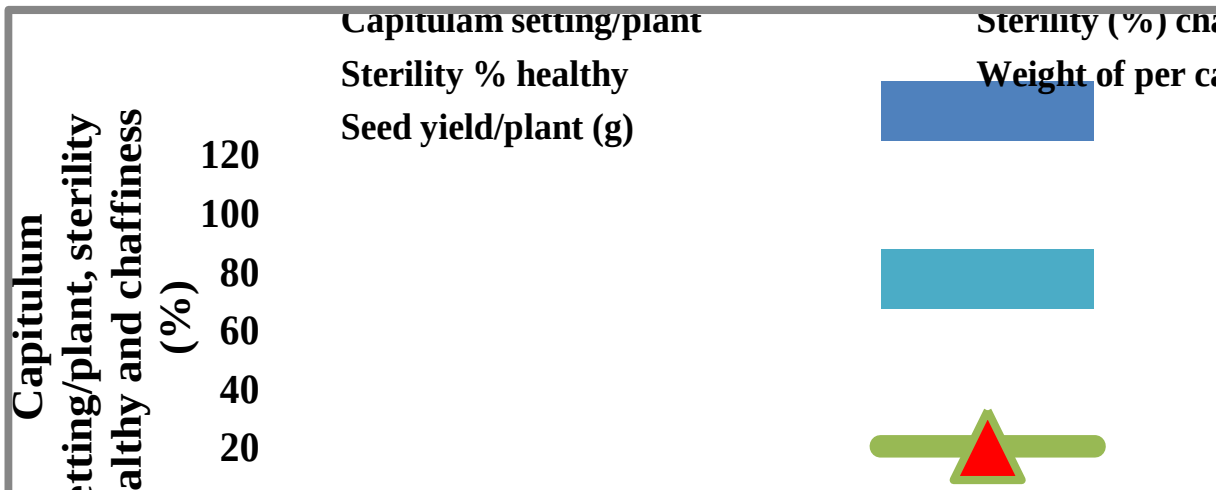

Fig 1. (a) Pollination by *Apis cerana indica* on yield attributing characters of niger during 2011-12

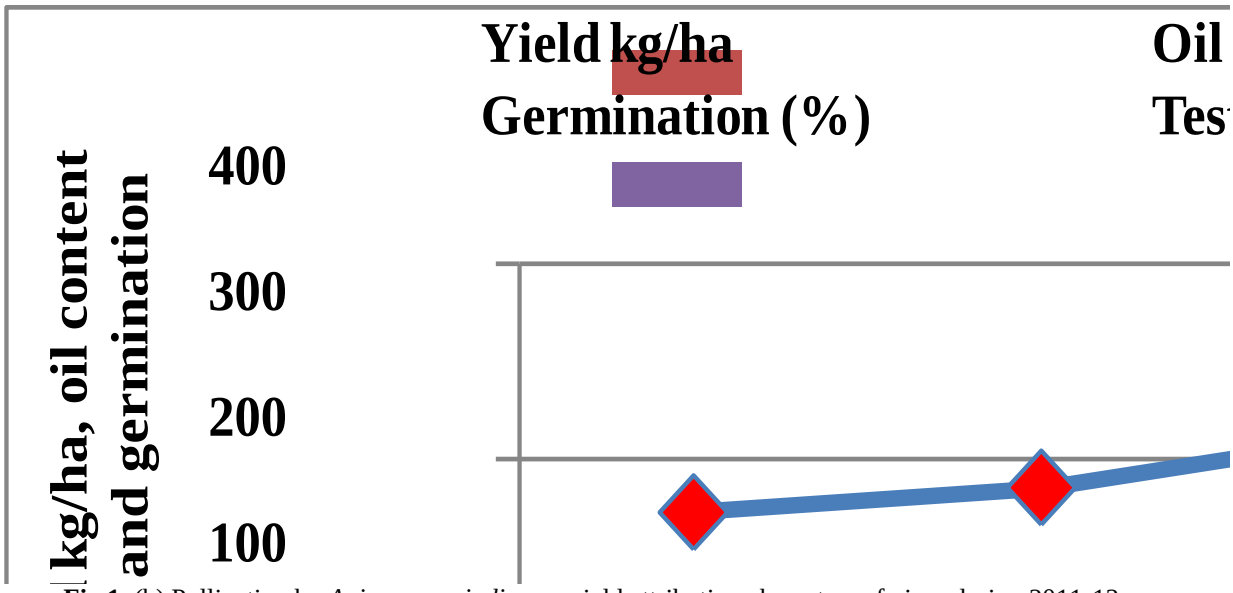

Fig 1. (b) Pollination by *Apis cerana indica* on yield attributing characters of niger during 2011-12

RESULT AND DISCUSSION

To determine the effect of pollination by *Apis cerana indica* in niger crop as compared to other modes of pollination, T1-Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs. T2-Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs. T3-Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs. T4- Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs. T5- Total closed (Mosquito net) and T6-Control (Total open) in respect of capitulum setting plant^{-1},number of seeds capitulum $^{-1}$, seed yield plant^{-1}(g), weight of capitulum^{-1}(g), sterility percent^{-1}, test weight of seeds (g), seed yield kg ha^{-1}, oil content of seeds(%), and germination (%) were depicted in (Table 1 and fig 1.a & b). It revealed from the data that there were marked variations among the different modes of pollination.

(A) Quantitative Parameters

(I) Capitulum setting plant^{-1} - Significantly higher number of capitulum plant^{-1} was recorded in treatment total opened (35.17 capitulum^{-1}) followed by treatment Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (34.97 capitulum plant^{-1}), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (33.42 capitulum plant^{-1}), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (32.95 capitulum plant^{-1}) and Open the cage between 0700 to 1200hrs Noon and Close between 1200 Noon to 1700hrs (32.95 capitulum plant^{-1}). The lowest number of capitulum was recorded in treatment of total closed (28.32 capitulum plant^{-1}). The present study is more or less in the conformity of earlier workers to Munawar

(2009) who recorded in canola rapeseed, *Brassica napus* with more number of pods developed in treatments plants caged with honeybees (81.00) and lowest in plants caged without honeybees (52.00). Duran *et al*. (2010) also reported in rapeseed, the number of siliques plant^{-1} which was highest in treatment with free pollination (291.17) followed by partial exclusion (224.83) and lowest in total exclusion (152.94).

(II) Weight of capitulum $^{-1}$ (g) - The maximum capitulum weight was found in treatment control i.e. total opened (0.299 g) which was significantly superior with remaining treatments except Close the cage between 0700 to 1000hrs and 1500 to 1700hrs Open between 1000 to 1500hrs (0.239 g), Open the cage between 0700 to 1200hrs, Noon and Close between 1200 Noon to 1700hrs (0.232 g), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (0.191 g) and Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (0.178 g). However, the mimnimum capitulum weight was observed in treatment, total closed (0.079 g). Treatments like Open the cage between 0700 to 1000hrs and 1500 to 1700hrs close between 1000 to 1500hrs (0.178 g), Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (0.232 g) and control, total opened (0.299 g) were found significantly superior with each other. There was no report on this line however Sarwar *et al*. (2008) reported the individual fruit weight of cucumber significantly increased due to the bee pollination. Thus these results are in the close agreement of the present finding.

(III) Seed yield plant^{-1} (g) - The maximum seed yield plant^{-1} was recorded in control (total opened 2.473 g plant^{-1}) followed by Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (1.838 g plant^{-1}), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (1.574 g plant^{-1}), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (1.192 g plant^{-1}) and Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (1.139 g plant^{-1}). However, there was no significant difference found between different treatments i.e. Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (1.139 g plant^{-1}), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (1.192 g plant $^{-1}$), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (1.574 g plant^{-1}). Treatments, Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (1.838 g plant^{-1}), Total closed (Mosquito net) (0.606 g plant^{-1}) and Control (Total open) (2.473 g plant-1). The least seeds yield plant^{-1} was recorded in treatment with total closed (0.606 g plant^{-1}). Pastagia and Patel (2008) reported in niger crop, where the highest seed yield was recorded in bee pollination with *Apis cerana* (40.07g) followed by open pollination (37.95g) and the lowest in pollination without insects(11.37g). Munawar *et al*. (2009) who reported in canola, highest yield in caged with honeybees (7.6g) and lowest was in caged without honeybees (1.51g).

(IV) Sterility/ chaffyness (%) - The sterility per cent was noticed significantly superior in treatment with total closed (97.09 per cent), followed by Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (26.28 per cent), Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (21.57 per cent), Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (17.98 per cent) and Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs(16.69 per cent). The lower sterility per cent was recorded in treatment with total opened (4.92 per cent). All the treatments were found significant and having significant difference with each other treatments. Dhurve (2008) also recorded the highest unfilled seeds in caged crop *i.e.* without bees (10.70 per cent) followed by the crop caged with bees, the open pollination without any spray and open pollination with water spray showed number of unfilled seeds were 7.87, 6.50, and 6.83 per cent, respectively.

(V) Healthy seeds (%) - The significantly higher per cent of healthy seeds were found in control plot, total open (95.06 per cent) followed by Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (83.26 per cent), Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (82.00 per cent), Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (78.41 per cent) and Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (73.70 per cent). However, the minimum per centage of healthy seeds were found in treatment total closed (2.89 per cent). There was significant difference observed among the treatments. Marabi (2003) who also observed maximum healthy seeds in crop exposed to all type of insect pollinators (48.33) whereas reduced healthy seeds capitulum^{-1} (40.50) was observed in crop pollinated by *A. mellifera*.

(VI) Test weight (1000 seeds) - Maximum seed weight (1000 seeds) was recorded in treatment total open (4.89 g) followed by Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (4.83 g), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (4.69 g), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (4.29 g) and Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (4.09 g). The treatment total closed had minimum seed weight (3.28 g). The treatments were

statistically non-significant with each other. Munawar (2009) reported the test weight of seed of canola, *Brassica napus* was with highest seed weight plants caged with honeybees (26.00g) and lowest was in plants caged without honeybees (9.30g). Mupade *et al.*(2009) reported highest test seed weight in one frame *A. florea* colony (7.10g) followed by four frame *A. c*. colony (6.60g), two framed *A. mellifera* colony (6.20g) and lowest in open pollination(5.5g).

(VII) Seed yield (kg ha^{-1}) - The significantly highest yield was found in treatment total open (353.25 kg/ha^{-1}), whereas other treatments were found statistically lower seed yield. The treatments like open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (271.75 kg/ha^{-1}), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (170.25 kg/ha^{-1}), Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (161.25 kg/ha^{-1}) Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (158.50 kg/ha^{-1}) were observed statistically lower seed yield. Treatments open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (271.75 kg ha^{-1}), Total closed (79.50 kg ha^{-1}) and Control (Total open) (353.25 kg ha^{-1}) found significant difference with each other. However, the lowest seed yield was observed in treatment total closed (79.50 kg/ha^{-1}). Cecan *et. al.*(2007) observed the highest seed yield caged with honey bee(46.2 kg ha^{-1}) followed by caged with bumble bee (37.3 kg ha^{-1}), open pollinated (25.7 kg ha^{-1}) and pollinator excluded (1.37 kg ha^{-1}) on white clover. Gaddanakeri *et al.* (2008) who also recorded the higher seed yield of sunflower (849 kg ha^{-1}) in intercropping system of sunflower + niger and lowest was in sole crop of sunflower (747 kg ha^{-1}) indicating the role of pollinators in both cross pollinated crops.

(B) Qualitative parameters

(I) Oil content (%) - Significantly higher oil content was recorded in treatment with total open (33.50 per cent), whereas other treatments were found significantly low oil content per cent. The treatments which had no significant difference were the Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (30.08 per cent) and Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (30.57 per cent). However, the treatments close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (32.14 per cent) Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (30.58 per cent) Total closed (26.73 per cent) and Control (33.52 per cent) were observed significant difference. The lowest oil content was found in treatment with total closed (26.73 per cent). Sattigi *et al.* (2005) who also reported in niger crop, the maximum oil content of seeds was in crop sprayed with 10 per cent sugar (38.81 per cent) and minimum oil content of seeds was in crop sprayed with 10 per cent jaggery (36.82 per cent). Dhurve (2008) who also reported the highest oil content in niger seed when sprayed with 10 per cent sugar syrup (40.10 per cent) followed by open pollination without any spray (40.00 per cent) and sugarcane juice 10 per cent (39.93 per cent) however the lowest oil content was in crop sprayed with Bee-Q 1.25 per cent(38.76 per cent).

(II) Germination per cent - Significantly higher niger seed germination was recorded in treatment with control (80.25 per cent). Other treatments like Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (74.75 per cent), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs (71.50 per cent), Close the cage between 0700 to 1200hrs Noon and Open between 1200 Noon to 1700hrs (68.50 per cent) Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (73.00 per cent) and Total closed (64.25 per cent) were found significantly low germination. The lowest germination was found in treatment with total closed (64.25 per cent). Dhurve (2008) who recorded highest germination in niger seed in treatment like open pollination with cacambe 10 per cent (81.00 per cent) and the least germination was in crop caged without bees (64.00 per cent). Mupade *et al*. (2009) recorded that the *Apis florea* colony with one frame having highest of germination (90.00 per cent) followed by four frame *A. carana* (89.00 per cent) and two frame *A. mellifera* colony (88.00 per cent).

Table 1. Effect of pollination by Indian honey bee, *Apis cerana indica* on yield, yield attributing characters and oil content of niger during 2011-12 .

Treatments	Capitulum setting plant^{-1}	Weight of capitulum^{-1}(g)	Seed yield plant^{-1}(g)	Sterility (%)		Test weight(1000 seeds) (g)	Seed yield (kg ha^{-1})	Oil content of seeds (%)	Seed germination (%)
				Chaffy seeds	Healthy seeds				
T1-Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs.	34.97	0.178	1.139	17.98 (4.28)	82.00 (9.08)	4.095	161.25	30.080	74.750
T2-Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, Open between 1000 to 1500hrs.	32.95	0.239	1.192	16.69 (4.13)	83.26 (9.15)	4.285	170.25	30.570	71.500
T3-Close the cage between 0700 to 1200hrs Noon and	33.42	0.191	1.574	26.28 (5.14)	73.70 (8.60)	4.697	158.50	32.140	68.500

Open between 1200 Noon to 1700hrs.									
T4- Open the cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs.	32.95	0.232	1.838	21.57 (4.69)	78.41 (8.88)	4.830	271.75	30.580	73.00
T5- Total closed (Mosquito net)	28.32	0.079	0.606	97.09 (9.87)	2.89 (1.83)	3.288	79.50	26.730	64.25
T6-Control (Total open)	35.17	0.299	2.473	4.92 (2.32)	95.06 (9.71)	4.890	353.25	33.500	80.25
SEM ±	1.37	0.0196	0.2299	0.1855	0.1107	0.6464	12.25	0.4013	0.9643
CD(p=0.05)	4.14	0.06	0.69	0.56	0.33	NS	36.92	1.21	2.91

NS- Non significant, Figures in parentheses are square root transformed value

CONCLUSION

The results obtained from this study, the various yield parameters were significantly increased due to honey bee pollination on different pollination situation. The maximum yield parameters were increased in control pollination (Total open) however the lowest was obtained in treatment Total closed.

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REFERENCES

Cecen, S.,Gosterit, A. and Gurel, F. (2007). Pollination effects of the bumble bee and honey bee on white clover (*Trifolium repens* L.) seed production. *J. Apicultural Res*. **46** (2): 69-72.

Dhurve, S.S. (2008). Impact of honey bee pollination on seed production of niger. *M.Sc.(Ag.) thesis Uni. Agril. Sci.* Dharwad.

Gaddanakeri, S.A., Biradar, A.P. and Balikai, R.A. (2008). Effect of niger as an intercrop in sunflower on the activity of honey bees and crop yield. *J. Eco-friendly-Agriculture* **3** (2):171-173.

Getinet, A. and Teklewold, A. (1995). An agronomic and seed quality evaluation of niger (*Guizotia abyssinica* Cass.) germplasm grown in Ethiopia. *Plant Breed* 114 : 375-376.

Hegde, D. M. (2012). Carrying capacity of Indian Agriculture : Oilseed. *Current Science* **102**(6) : 867-873.

Howard, A., Howard, G. L. C. and Rahman, K. A. (1919). Studies in the pollination of Indian crops. *India Dept. Agr. Mem. Bot. Ser* **10** : 195-220.

Marabi, R.S. (2003). Studies on foraging behaviour of Italian honeybees, *Apis mellifera* Lin. and its effect on pollination of niger (*Guizotia abyssinica* Cass.). *M. Sc.(Ag.) Thesis JNKVV*, Jabalpur (M.P.) PP-47-48.

Munawar, M.S., Raja, S., Siddique, M., Niaz, S. and Amjad, M. (2009). The pollination by honeybee (*Apis mellifera* L.) increases yield of canola (*Brasssica napus* L.). *Pak. Entomol* **31** (2) : 103-106.

Mupade, R.V., Kulkarni, S. N. and Kamte, G.S. (2009). Effect of honeybee pollination on qualitative characters of onion. *Ind J. Plant Protection* **37** (1/2) : 186-187.

Pastagia, J. J. and Patel, M. B. (2008). Effect of bee pollination on yield of niger, *Guizotia abyssinica* (L.F.) Cass. *Insect Environment* **14** (2). July-Sep. 53-55.

Sarwar, G., Aslam, M., Munawar, M.S., Raja, S. and Mahmood, R. (2008). Effect of honeybee (*Apis mellifera* L.) pollination on fruit setting and yield of cucumber (*Cucumis sativus* L.). *Pak. Entomol* **30** (2) : 185-190.

Sattigi, H.N., Gundannavar, K.P., Kambrekar, D.N. and kulkarni, K.A. (2005). Effect of bee pollination on niger quality. *Karnataka J. Agril. Sci* **18** (4): 1112-1113.