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Saboor Naeem
Department of Agriculture, Hazara University, Mansehra, Pakistan

Muhammad Abrar
Department of Entomology, The University of Agriculture, Peshawar, Pakistan

Muhammad Adil
Department of Agriculture, Hazara University, Mansehra, Pakistan

Muhammad Adil Younis
Department of Agriculture, Hazara University, Mansehra, Pakistan

Ayesha Riaz
Department of Agriculture, Hazara University, Mansehra, Pakistan

Correspondence
Saboor Naeem
Department of Agriculture, Hazara University, Mansehra, Pakistan

Role of pollinators in recommended and densely grown black cumin (*Nigella sativa* L.) yield at Dera Ismail Khan

Saboor Naeem, Muhammad Abrar, Muhammad Adil, Muhammad Adil Younis and Ayesha Riaz

Abstract
The current study was conducted at Agriculture Research Institute Ratha Kulachi, Dera Ismail Khan in 2014, to study the efficacy of pollinators on Black cumin yield, number of seeds/capsule, seeds/plant and capsules/plant and seed quality (size) grown in recommended (25cm) and dense (10cm) plant to plant distance. The experiment was performed in Randomized Completely Block Design (R.C.B.D) and was comprised of three treatments i.e. plants in recommended and caged condition (T1), Plants in recommended and open condition (T2) and plants in dense and open condition (T3), with four (4) replications. One treatment in each replication with recommended grown plants were caged with nylon cloth with mesh no. 49/cm^2. Seeds were collected and taken to the laboratory. It was found that yield (kg/ha), No. of seeds/capsules, No. of seeds/plant, No. of capsules/plant, 100 seed weight (gm) and seed quality i.e. size (length/width in "mm") were highest from T2 i.e. 1700, 95, 855, 9, 0.28 and 2.49/1.37 respectively, while lowest yield, 100 seed weight and seed quality were recorded from T1 i.e. 1050 kg/ha, 0.24gm and 2.44mm in length and 1.29mm in width respectively. Least number of seeds per capsule (56), number of seeds per plant (392) and number of capsules per plant (7) were collected from T3.

Keywords: Black cumin, pollinators, yield, nylon cloth

1. Introduction
The black cumin (*Nigella sativa*) plant is native to southwestern Asia, the Mediterranean and Africa [1]. It is now grown in many countries of the world like Egypt, India, Pakistan, Saudi Arabia, Syria and Turkey [2]. Black cumin is also called as black seed, black caraway, Roman coriander, Kalonji or fennel flower. It is an annual plant of the ranunculus family (Ranunculaceae) [1].

Black cumin plants grow from 20 to 60 cm (8 to 24 inches) in height. The branched stems bear fine, deeply divided leaves, and the plant has a developed taproot. The pale blue or white flowers have five petals, numerous stamens, and five or six elongated fused carpels. The black triangular or pyramidal seeds are borne in a capsule with five or six segments, each of which terminates in an elongated projection. The plants can grow in a variety of soils and readily reseed. It becoming weedy in some areas [3].

Black cumin has been grown for centuries for its aromatic and flavorful seeds that can be used as a spice or as an herbal medicine. Black cumin seeds and their oil are widely used in traditional Islamic and Indian medicine (Ayurveda) to treat a variety of ailments. The seeds are believed to stimulate lactation and have been used for menstrual and postpartum problems. They are commonly used to treat intestinal worms and are said to relieve digestive troubles. The seeds and oil are used to cure inflammation and are employed to reduce asthma and bronchitis symptoms and to treat rheumatoid arthritis. There is clinical evidence that the seeds have antimicrobial, antiparasitic and antifungal properties and some animal studies have demonstrated tumor suppression. In addition, there is evidence that black cumin may be effective against diabetes and hypertension and may be useful as an antiinflammatory

The seeds are commonly roasted and ground as a spice and are widely used in India, the Middle East, and parts of North Africa to season curries, rice, breads, and sweet confections. More ever, the plant is sometimes grown as an ornamental for its attractive flowers [1].

The pollinator population of an area is a great indicator of the overall health of an ecosystem. Insects and other animal pollinators are vital to the production of healthy crops for food, fibers, edible oils, medicines, and other products. The commodities produced with the help of pollinators generate significant income for producers and those who benefit from a productive agricultural community. Pollinators are also essential components of the habitats and ecosystems that many wild animals rely on for food and shelter. Worldwide, approximately 1,000 plants grown for food, beverages, fibers, spices, and medicines need to be pollinated by animals in order to produce the goods on which we depend [4].

Keeping in view the importance of Black cumin and Insect pollinators the study was conducted in order to motivate the people to grow Black cumin as it is produced in a very little amount at some areas of Southern districts i.e. Dera Ismail Khan, Bannu and Tank etc of Khyber Pakhtunkhwa province of Pakistan. Another reason of research was to educate the growers to know the importance of pollinators in the yield of growing plant.

2. Materials and methods

A 100 m^2 plot was selected for research purpose and the experiment was laid out in Randomized Complete Block Design (RCBD). Black cumin was sown in two type of plant population.

1. Recommended plants population with 25cm plant to plant distance [5].
2. Dense plants population with 10 cm plant to plant distance.

The experiment consists of three treatments and each treatment plot size was 2×3 m^2 and replicated four times. Treatments of the experiment were

T_1 Plants in recommended and caged condition.
T_2 Plants in recommended and open condition.
T_3 Plants in dense and open condition.

A buffer zone between replications and treatments were kept as 1m and 30 cm respectively. In each replication two treatments were left in open condition, free for pollinators to visit the flowers and one was caged with nylon net having mesh no. 49cm^2 before flowering stage to stop the pollinators from visiting the flowers. Standard agronomic practices were applied during the research work.

2.1. Yield (kg/ha)

Yield from both open and caged fields were determined and converted into kg/ha by using the equation;

$$\text{Yield (kg/ha)} = \frac{\text{yield (kg) from net plot}}{\text{Area harvested m}^2} \times 10{,}000\ \text{m}^2$$

Number of seeds/capsule, seeds/plant and capsules/plant were also recorded. Hundred seeds sample was taken from each open and caged plots and weight with electric balance. The quality (size) of seed was also determined with the help of micrometer screw gauge from each open and caged plots of Black cumin.

2.2. Statistical analysis

The recorded data was subjected to statistical analysis and tested at 5% level of significance by LSD test using statistics 8.1 software.

2.3. Experimental Layout

R1	R2	R3	R4
T3	T1	T2	T1
T1	T2	T3	T2
T2	T3	T1	T3

3. Results and discussion

3.1. Yield (Kg/h)

Fig.1 indicates the effect of insect pollinators on the yield (kg/ha) of Black cumin. According to Figure the bars show variation in yield (kg/ha) of three plots. Maximum yield (1700 kg/ha) was reported from the plots in which Black cumin were sown in recommended plant to plant distance and were un caged, because of pollinator visits to flowers and minimum yield i.e. 1050 kg/ha was obtained from recommended caged plots, due to avoidance of pollinator visits. The yield of densely grown and un caged was also less (1501 kg/ha) as compared to the yield from recommended and open plots, because of very little space between plants which effected the efficiency of pollinators to visit lower flowers but more than from recommended and caged plots of Black cumin.

When the data was analyzed with LSD test, significant difference was found between the yield (kg/ha) of all three plots of Black cumin (LSD = 24.833, d.f 11, $P \leq 0.05$).

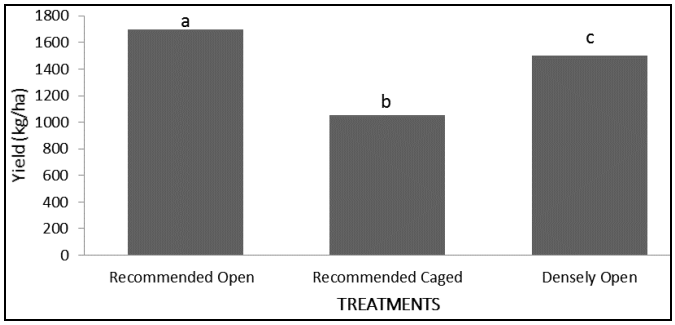

Fig 1: Effect of pollinators on Yield (Kg/ha) of Black cumin.

Bars in Fig.1 with different letter are significantly different at 5% level of significance (LSD Test). LSD value = 193.62.

3.2. No. seeds/capsule and seeds/plant

Table.1 shows the No. of seeds/capsule and seeds/plant of black cumin. According to Table.1, on average 95 seeds/capsule and 855 seeds/plant were recorded from T2 (Plants in recommended and open condition), while 61 and 56 seeds/capsule and 549 and 392 seeds/plant were collected from recommended caged treatment (T1) and dense open treatment (T3) respectively. The maximum seeds/capsule and seeds/plant were found in T2 because of pollination by insects as compared to other treatments, on the other hand minimum were reported from T3.

When the data was analyzed with LSD test significant difference was found in number of seeds/capsule and seeds/plant between all three plots of Black cumin (LSD = 13.65 and 244, d.f 11, $P \leq 0.05$).

3.3. No. Capsules/plant

Data regarding the number of capsules/plant of Black cumin are given in Table. 1 and revealed that 9 capsules/plant was observed in recommended caged plots i.e. T1 with the same numbers of capsules i.e. 9 in recommended open plots i.e. T2 but it was lower (7) in dense open plots (T3). Significant effect of pollinators was found on number of capsules/plant (LSD = 1.33, d.f 11, $P \leq 0.05$).

3.4. Weight of 100 seeds

Table.1 further shows the weight of 100 seeds of Black cumin. The seeds were collected from different plants weighted by electric balance. The weights were recorded 0.28, 0.24 and 0.25gm from recommended open, recommended caged and dense open plots respectively. A little enhancement was recorded in recommended open plots as compared to other plots. Statistical analyses of the data show significant effect on 100 seed weight of Black cumin (LSD = 0.0305, d.f 11, $P \leq 0.05$).

3.5. Quality (size) of seed

Data regarding the seed quality (size) of Black cumin indicates that the average seed size obtained from the plots in which Black cumin was sown in recommended and un caged conditions (T2) was 2.49 and 1.37mm in length and width respectively, while the average length and width of seed collected from the plots of T1 (Plants grown in recommended and caged condition) and T3 (Plants grown in dense and open condition) was 2.44mm, 1.29mm and 2.47mm, 1.34mm respectively and thus non significant effect of pollinators was observed on seed quality (size) of Black cumin (LSD = 0.374, 0.437, d.f 11, $P \geq 0.05$) (Table. 3).

Abrol (2007) [6] found that insect pollination contributes very much in the yield of rapeseed and mustard which shows concurrency to our result. The results show conformity with that of Zaitoun *et al*., (2008) [7], they reported the effect of insect pollinators and recorded more yield in open plots due to the pollinator visits and seed setting in Black cumin.

Garbaldi *et al*., (2009) [8] observed that in the absence of pollinators, yield is reduced by 95% in those crops which are highly pollinators dependent, while a decrease in production of the crops that are moderately dependent was 65% averagely and confirmed our findings. Munawar *et al*., (2009) [9] recorded the seed improvement in insect pollinated plots and founded a significant difference of 100 seed weight between different plots.

Our study shows concurrence with the findings made by Rashmi *et al*., in 2010 [10], they noticed maximum pod set, length and volume, seed and100 pod weight, seed size and number of seeds/pod of pigeon pea (CMS line) in open condition of plants. Pole *et al*., (2012) [11] concluded that the yield is highly dependent upon visiting of pollinator in the crop and thus have similar findings with ours. Mukherjee *et al*., in (2013) [12] performed the experiment and observed maximum seed production due to the pollination of insect pollinators. They further found that there is no significant effect of pollinators on seed quality (size) of Black cumin, which supported our conclusions.

Douka and Fohouo (2013) [13] reported highly improved fruiting rate, number of seeds and pods in flowers that was *accessed* by that pollinator. Our results are at par with findings made by Karanja *et al*., (2013) [14] who determined that pollinator has a great role in coffee production. Our results show an agreement with the findings of Irshad and Stephen (2014) [15]. They found that pollinators aid very much in sexual and augmented seed production and high yield.

Table 1: Effect of pollinators on No. seeds/cap, seeds/plant, cap/plant, 100 seed weight and quality (size) of Black cumin

Plots	No. Seeds/cap	No. Seeds/plant	No. cap/plant	100 seed wt (gm)	Seed size L/w (mm)
Recommended Open (T2)	95	855	9	0.28	2.49/1.37
Recommended Caged (T1)	61	549	9	0.24	2.44/1.29
Dense open (T3)	56	392	7	0.25	2.47/1.34
P- value	0.0007*	0.0096*	0.0370*	0.0282*	0.9429*/0.8646*

4. Conclusion and recommendations

Pollinators have a major role in yield of Black cumin at Dear Ismail Khan. They are also the important contributor in higher number of seeds/capsule and seeds/plant, capsules/plant, hundred grain weight and quality of seed (Size: length & width). Fewer yields with less other perimeters, mentioned were recorded from the plots where pollinators were prevented. Success of Black cumin depends upon the prevalence of insect pollinators in the fields. Growers are advised to sow the seeds in a recommended row to row distance and to evade all those practices which can harm and reduce the activity of pollinators. They should encourage bee keepers to place their bee hives near to their fields, such that to boost the pollination, more ever, biological control agents should be used by the farmers for the control of pests.

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Appendices

Appendix 1: Effect of pollinators on Yield (Kg/ha) of Black cumin

Source	DF	SS	MS	F	P
V0001	3	102217	34072	30.35	0.0007
V0002	2	760067	38033		
Error	6	75133	12522		
Total	11	937417			
Grand	mean	1431.7	CV 7.82		

Appendix 2: Effect of pollinators on number of seeds/capsule of Black cumin Randomized complete block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	729.00	243.00	30.19	0.0007
V0002	2	3602.67	1801.33		
Error	6	358.00	59.67		
Total	11	4689.67			
Grand	mean	71.167	CV 10.85		

Appendix3: Effect of pollinators on number seeds/plant of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	18601	6200	11.14	0.0096
V0002	2	443539	221769		
Error	6	119457	19910		
Total	11	581597			
Grand	mean	598.92	CV 23.56		

Appendix4: Effect of pollinators on number capsule/plant of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	20.9167	6.97222	30.19	0.0007
V0002	2	10.6667	5.33333		
Error	6	5.3333	0.88889		
Total	11	36.9167			
Grand	mean	8.5833	CV 10.98		

Appendix 5: Effect of pollinators on number capsule/plant of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF		SS	MS	F	P
V0001	3		0.16707	0.05569	0.06	0.9429
V0002	2		0.00555	0.00278		
Error	6		0.28058	0.04676		
Total	11		0.45320			
Grand	mean		2.4700	CV 8.78		

Appendix 6: Effect of pollinators on 100 seed weight of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	0.00033	0.00011	6.86	0.0282
V0002	2	0.00427	0.00213		
Error	6	0.00187	0.00031		
Total	11	0.00647			
Grand	mean	0.2533	CV 6.96		

Appendix7: Effect of pollinators on quality (seed length) of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	0.16707	0.005569	0.06	0.9429
V0002	2	0.00555	0.00278		
Error	6	0.28058	0.04676		
Total	11	0.45320			
Grand	mean	2.4700	CV 8.76		

Appendix 8: Effect of pollinators on quality (seed width) of Black cumin. Randomized Complete Block AOV Table for V003

Source	DF	SS	MS	F	P
V0001	3	0.23982	0.07994	0.15	0.8646
V0002	2	0.01905	0.00952		
Error	6	0.38355	0.06389		
Total	11	0.64222			
Grand	mean	1.3425	CV 18.83		