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Valuation of Pollination Service in Bitter Gourd (*Momordica charantia* L.) Seed Production

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ABSTRACT

The present investigation on the pollination biology was carried out at the University of Agricultural Sciences, Bengaluru, India during 2014 - 2015. Flowering of bitter gourd started 40 to 45 days after germination. Anthesis commenced around 2.00 am and continued till 8.00 am with the opening of staminate flowers followed by pistillate flowers. Anther dehiscence commenced immediately after opening of the flower. The ovary had three carpels, each with 16 to 20 ovules. Pollen viability and stigma receptivity coincided with peak activity of pollinators (*Apis cerana* and *A. florea*). Longevity of flowers was one day. The total yield when flower visitors were prevented was 0 tonnes / acre.However, the fruit yield and seed yield was high ingreenhouse + *A. cerana* pollinated crop (8.31 tonnes / acre and 6.43 quintals / acre) but B: C ratio was found to be low (1:3.57) compared to other treatments. The B: C ratio was found to be high in natural pollination + *A. cerana* pollination (1:8.69) followed by hand pollination (1:8.25) and natural pollination (1:7.40).

Pollination is most important service in the ecosystem for the maintenance biodiversity of plants on earth. Insects play a vital role for increasing quality and quantity of any crop production. Inadequate pollination not only results in reduced yield but also in high percentage of inferior fruits (Mc Gregor, 1976).About 75 per cent of the total crops depend on pollination through insects for their reproduction. 87 of the total food crops depend entirely on pollinators and therefore, 35 per cent of the global food production is from the crops which depend on pollinators (Klien *et al.,* 2007). Through insect pollination and good management of pollinators, yield of the crops can be increased up to 50 to 60 per cent, 45 to 50 per cent and 100 to 150 per cent in fruits, oil seed and cucurbitaceous crops, respectively. The pollinators are used for the most economical and environmental friendly approach towards the increase in the yield of cross pollinated crops. The insects of family Apidae are the most reliable agents for pollination. Among members of Apidae, honey bees are particularly important pollinators as they are capable of carrying pollen and in the process, the plants visited by them are benefited (Tewari and Singh, 1983).

Entomophily in the crop production is more significant in crops like bitter gourd belonging to cucurbits, which are monoecious (male and female flowers are borne at different positions on the same plant). It is also grown as an ornamental and used extensively in medicine (Deyto and Cervancia, 2009). The open position of the bitter gourd flowers makes them easy for the pollinators to access and exploit floral rewards. The high male to female ratio achieves the production of sufficient amount of pollen deposits, thus resulting in effective pollination (Goulson, 1999). Keeping in view the importance of Entomophily in the bitter gourd crop (variety: ArkaHarita) production the current study was carried out to evaluate economics of pollination services.

The present investigation was carried out at the University of Agricultural Sciences, Bengaluru, India during 2014 - 2015. A fixed number of flowers (n=100) were tagged and observations were made on the floral biology such as anthesis (time of opening of flowers), anther dehiscence (release of pollen grains), floral longevity, ratio between staminate and pistillate flowers, pollen viability and stigma receptivity. In order to workout cost economics involved in pollination service,four setsofrandomly selected 25 flowers were covered individually using paper packets. One set was opened for hand pollination and the other set was

allowed only for *A. cerana* pollination (1 colony) in the green house. Flowers of third set were tagged and left for open pollination. Flowers of fourth set were tagged and left for open pollination along with introducing an *A. cerana* colony. Observations were made on fruit weight, seed number, seed weight.

Floral biology: Bitter gourd plants started flowering 40 to 45 days after sowing and blooming period varied from 55 to 60 days. The male flower buds took an average of 17 to 19 days, whereas female buds took 5 to 7 days for their complete development. The male flowers dropped off on the same day at 6.00 pm to 7.00 pm while female flowers withered away next morning. The anthesis commenced around 2.00 am and continued till 8.00 am with the opening of staminate flowers followed by pistillate flowers. When the temperature is low, with high humidity, or the day is cloudy, opening is delayed and the flower closes permanently in the afternoon of the same day (McGregor and Todd, 1952). Anther dehiscence commenced immediately after opening of the flower. Pollen grains of bitter gourd were round in shape with three distinct germpores measures 0.060 mm in diameter. The ovary had three carpels each with 16 to 20 ovules. The maximum pollen germination was observed in 10 per cent sucrose solution with 0.01 per cent boric acid. Longevity of flowers was one day. Pollen viability and stigma receptivity was found maximum from 10.00h to 14.00h, coincided with peak activity of pollinators (*A. cerana* and *A. florea*).The male to female flower ratio was 18:1.

Economics and yield: The effect of different pollination treatments on the fruit yield and seed yield of bitter gourd was determined. There was no fruit set in controlled experiment, whereashand pollination and open pollination resulted nearly 100 per cent fruit set. However, fruit weight and seed numbers were significantly higher in greenhouse + one colony of *A. cerana* pollinated flowers (207.92g and 38.32seeds, respectively) when compared to those that allowed forhand pollination (165.72g and 32.00 seeds, respectively) followed byopenpollination + one colony of *A. cerana* (155.68g and 30.40). However, least fruit weight and seed numbers were recorded in open pollination alone (145.68g and 27.28 seeds, respectively) (Table II).

The total yield when flower visitors were prevented was 0 tonnes / acre. However, the fruit yield and seed yield were high in greenhouse + one colony of *A. cerana* pollinated crop (8.31 tonnes / acre and 6.43 quintals / acre) when compared to those that were allowed for hand pollination (6.62 tonnes / acre and 5.24 quintals / acre) followed by open pollination+ one colony of *A. cerana* pollination (6.22 tonne s/ acre and 5.04 quintals / acre) and least open pollination (5.82 tonnes/acre and 3.81 quintals/acre). Taking the current market price of bitter gourd of rupees 1200/- per kg of seeds the value of pollination service amounts to rupees 4,03,780/- (openpollination), 5,60,800/- (hand pollination), 6,03,393/- (greenhouse + one colony *A. cerana*) and 5,46,020/- (openpollination+ one colony *A. cerana*) in bitter gourd (Table II) after deducting the cost of cultivation (Table I).

The B:C ratio was found to be high in openpollination + one colony of *A. cerana* pollination (1:8.69) followed by hand pollination (1: 8.25) and open pollination (1: 7.40). greenhouse+ one colony of *A. cerana* pollinated crophad least B:C ratio (1: 3.57) (Table I). The pollinators are used for the most economical and environmental friendly approach towards the increase in both fruit yield and seed yield of cross pollinated crops (Free, 1970). The estimated B:C ratio of openpollination + one colony of *A. cerana* pollination was found to be higher compared to other pollination treatmentswhich suggest that use of *A. cerana* @ 2 hives / acre in open pollination is best in order to obtain high fruit yield and seed number (Table I) with low cost of cultivation.The present study implies that there is pollinators deficit in nature. Hence, there is a need to conserve and manage the native pollinator populations so that farmers can get good quality and quantity of bitter gourd fruits with high viable seeds.

TABLE I

Cost of cultivation of bitter gourd

Treatments / Particulars	Open pollination (Rs.)	Hand pollination (Rs.)	Greenhouse + 1 Colony *A. cerena* (Rs.)	Open pollination + 1 Colony *A. cerena*(Rs.)
Land/field preparation	7,000.00	7,000.00	7,000.00	7,000.00
Transplanting	8,000.00	8,000.00	8,000.00	8,000.00
Weeding	11,000.00	11,000.00	11,000.00	11,000.00
Irrigation	6,000.00	6,000.00	6,000.00	6,000.00
Plant protection	8,000.00	8,000.00	8,000.00	8,000.00
Fertilizers	8,000.00	8,000.00	8,000.00	8,000.00
Staking	7,500.00	7,500.00	7,500.00	7,500.00
Skilled labours(15 days)	-	13,500.00	-	-
Green house construction	-	-	1,61,167.00	-
Bee Hive	-	-	8000.00	8,000.00
Total (Rs.)	54,500.00	68,000.00	1,69,167.00	62,500.00

6 labours / acre employed for hand pollination and bagging @Rs. 150/- per day

Bee hive cost @ Rs. 4000/- per colony

TABLE II

Valuation of pollination service to bitter gourd

Treatments\	Fruit weight(g) (n = 25)	Seed number (n = 25)	Seed weight (g) (n = 25)	Fruit yield t/ac	Seed yield q/ac	Gross income (Rs.)	Cost of cultivation (Rs.)	Net income (Rs.)	B:C Ratio
Open pollination	145.68	27.28	0.35	5.827	3.81	4,58,280.00	54,500.00	4,03,780.00	1:7.40
Hand pollination	165.72	32.00	0.41	6.629	5.24	6,28,800.00	68,000.00	5,60,800.00	1:8.25
Greenhouse+ 1 Colony *A. cerana*	207.92	38.32	0.42	8.317	6.43	7,72,560.00	1,69,167.00	6,03,393.00	1:3.57
Natural pollination+ 1 Colony *A. cerana*	155.68	30.40	0.41	6.227	5.04	6,05,520.00	62,500.00	5,46,020.00	1:8.69

Yield obtained based on mean fruit weight and mean fruit number @ 6667 plants/acre
Price of seeds @ Rs.1200/kg of seeds

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