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BUMBLE BEES (*BOMBUS TERRESTRIS*) CAN BE THE EFFICIENT POLLINATORS OF COTTON CROP

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ABSTRACT

Cotton is self-pollinated crop but cross-pollination by insects can increase the yield. The potential of managed honey bees has largely been tested for cotton pollination whereas a little is known of bumble bees (*Bombus terrestris*). Current study aimed to evaluate the potential of bumble bees as cotton pollinator. Cotton varieties MNH-552 and MNH-633 were sown in greenhouse for bumble bee pollination experiment and in open field for open pollination. Hand pollination and control treatments were also maintained. The maximum number of seeds per boll was produced as a result of bumble bee pollination followed by hand pollination and open pollination. Bumble bee and hand pollination resulted in higher seed cotton weight per boll as compared to control. The overall results suggest that bumble bees can significantly improve cotton reproductive success and can further be explored for their potential as yield management strategy of cotton crop.

Keywords: Bumble bee, *Bombus terrestris*, cotton, pollination, yield

INTRODUCTION

Cotton is generally regarded as a self-pollinated crop (largely self-fertile), but often cross-pollinated (McGregor, 1976) and the majority of cultivars are a mixture of closely related pure lines. Insects are responsible for cross-pollination and introduction of insect pollinators (e.g. honey bees) into the crop during flowering has resulted in increased quality and quantity of cotton lint and seed (McGregor, 1976; Rhodes, 2002; Moffett *et al.*, 1975). The cross-pollination of 5 to 50 percent has been reported in cotton (Stephens and Finkner, 1953), depending on the location, pollinator species, the time period, and how measurements are taken. Cotton flower is available for pollination only for a day it opens (Rhodes, 2002). Floral nectaries are responsible for the attraction of pollinating insects (Rhodes, 2002). In order to produce a full complement of seeds, about 50 ovules must be fertilised; therefore, at least 50 viable pollen grains must contact the stigma (McGregor, 1976).

Bees (Apoidea: Hymenoptera) have been documented as the potential pollinating group for cotton plants (Moffett *et al.*, 1975; Rhodes, 2002; Naik *et al.,* 2011). Besides bees, it is visited by few heavy bodied bee mimic Diptera e.g. *Eristalinus* spp. (Naik *et al.,* 2011). Due to their fuzzy bodies and consistent flower-visiting behaviors, bees are usually the most effective pollinators of the numerous crops (Batra, 1995). Many bee species have been reported visiting cotton flowers e.g. honeybees (*Apis mellifera*, *A. dorsata*, *A. florea*, *A. cerana*), bumblebees (*Bombus* spp.), carpenter bees (*Xylocopa* spp.) and melissodes bees *(Melissodes* spp.) (Moffett *et al.,* 1975; McGregor, 1976; Rhodes, 2002; Naik *et al.,* 2011). Several authors have regarded honey bees as effective pollinators of cotton (Rhodes, 2002; Moffett *et al.,* 1975; Kaziev, 1960) however; the comparative efficacy of different bee species has not been tested yet.

Benefits of honey bee pollination on qualitative and quantitative traits of cotton have been documented since last few decades. Rhodes (2002) reported more boll setting, more seeds per boll, more seed cotton per boll and more seed cotton per flower. McGregor (1976) found improvements in lint quality characteristics such as fiber strength and length. Little is known about recommendations of managed honeybee pollination for cotton crop, except Ward and Ward (2001) who reported one hive per hectare and Rhodes (2002) who recommended 0.6 hives per hectare.

Bumble bees (*Bombus* spp.) have been documented visiting cotton flowers but their impact on cotton pollination has never been tested. *Bombus terrestris* is famous for its effectiveness

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for green house and open pollinated crops around the world. Their potential has been studied on many crops i.e. tomatoes, sweet peppers, strawberry, cucrubits, apples etc. (Dogterom *et al.,* 1998; Dimou *et al.,* 2008; Fisher and Pomeroy, 1989). Keeping in view their potential as effective pollinators for many crop plants, we explored their pollination potential as cotton pollinators in an effort to add some baseline data to future researches in this regard.

MATERIALS AND METHODS

The study was conducted at farmer's field in Yachon County, South Korea during cotton growing season of 2002. Two Pakistani cotton varieties MNH-552 and MNH-633 were sown in greenhouse and under open field condition on 15th April, 2002 for pollination experiments.

There were four pollination treatments *viz.* bumble bee pollination in greenhouse, hand pollination with pollen of several other plants, unrestricted pollination in open field (open pollination) and self-pollination without external vectors (control). There were three replications under Randomized Complete Block Design (RCBD). The plot size for each treatment was 15X35 feet. In greenhouse at the time of flower initiation (last week of August), three bumble bee (*Bombus terrestris*) colonies (one in each treatment) were introduced. Each colony had more or less 40 active workers. The bumble bee colonies were obtained from the laboratory of the Department of Agriculture Biology, Kyungpook National University, Taegu, Korea. Each bumble bee colony was replaced with a new one after one month of interval. The hand pollination and control treatments were caged with mosquito nets by the initiation of flowering. Hand pollinated treatments were re-caged after hand pollination on daily basis. Flowering and our pollination treatments lasted from August to November. Crop reproductive success was measured in terms of weight of seed cotton per boll and number of seeds per boll.

The data on reproductive success of cotton varieties was subjected to analysis of variance (ANOVA) and means were compared by using Tuckey's test at p=0.05. To see whether there was any impact of weight of seed cotton per boll on number of seeds per boll due to different pollination treatments, linear regression analysis was applied, taking weight of seed cotton per boll as predictor and number of seeds per boll as dependent variable. Statistical analysis was performed using the computer software XLSTAT (2009).

RESULTS AND DISCUSSION

In cotton varieties i.e. MNH-552 and MNH-633, there was a significant difference (F= 19.46 , df= 527 , p= 0.00 and F= 23.64 , df= 254 , p= 0.00, respectively) in average number of seeds per bolls among four pollination treatments (Fig. 1, 2). In both varieties, the maximum number of seeds per boll was recorded in bumble bee pollinated plants followed by hand pollinated and open pollinated plants. The minimum number of seed per boll were recorded in the plants which were excluded from pollinators (control) (Fig. 1, 2).

About 50 ovules must be fertilized if a full complement of seeds is to be produced; therefore at least 50 viable pollen grains must contact the stigma (McGregor, 1976). Insect mediated pollination can aid in this process. The pollen grains of cotton are sticky and having pronounced spines, with a mark tendency of group of pollen to clump together. These characteristics greatly reduce the opportunity of cotton to be windborne (Hutmacher *et al.,* 2006). Therefore insect mediated cross-pollination has shown to increase when higher populations of suitable pollinators are present in the field.

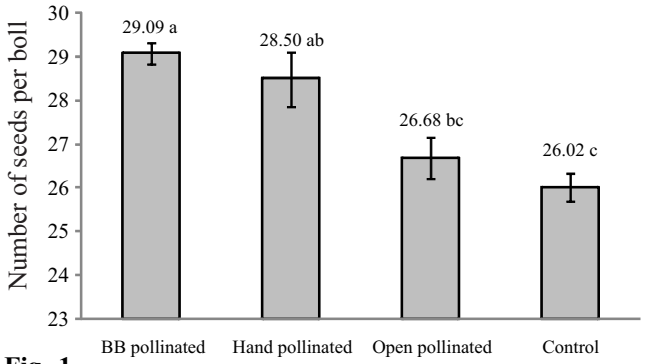

Fig. 1
Mean (±S.E) number of seeds per boll as a result of different pollination treatments in cotton variety MNH-552. Mean values sharing similar letters show non-significant difference according to Tukey at 5% level.

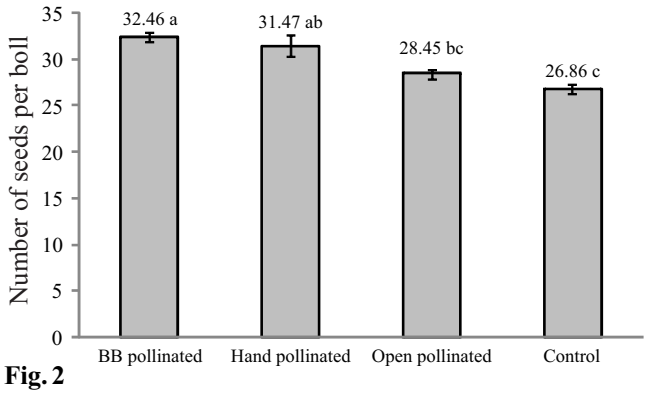

Fig. 2
Mean (±S.E) number of seeds per boll as a result of different pollination treatments in cotton variety MNH-633. Mean (values sharing similar letters show non-significant difference according to Tukey at 5% level.

The average weight of seed cotton per bolls was also statistically significant among the four pollination treatments for both varieties (F= 22.6, df= 527, p= 0.00 and F= 9.94, df= 254, p= 0.00 for MNH-552 and MNH-633, respectively) (Fig. 3, 4). In variety MNH-552, the highest seed cotton weight was recorded in bumble bee and hand pollinated plants (statistically similar) followed by open pollinated and control plants (Statistically similar). On the other hand in variety MNH-633, statistically similar seed cotton weight was recorded in bumble bee pollinated, hand pollinated and open pollinated treatments (Fig. 3, 4).

Several authors have shown the benefits of honey bee pollination i.e. increase in the percent fruit set, more seeds per boll, more seed cotton per boll and improvement in lint quality characteristics (Kazier, 1960; Moffett *et al.,* 1975; Rhodes, 2002). Rhodes (2002) found 16.5% higher seed set in the plots receiving highest number of bee visits compared to

the plots receiving the lowest number of bee visits. Our findings are also in the same line; as compared to control plants in varieties MNH-552 and MNH-633, there was 11.7% and 20.8% increase in number of seeds per pod in bumble bee pollinated plants, followed by hand pollinated plants (9.53% and 17.16%) and open pollinated plants i.e. 2.53% and 5.91%, respectively.

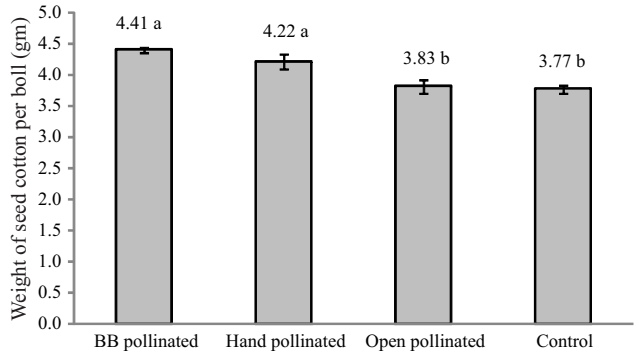

Fig. 3
Mean (±S.E) weight of seed cotton per boll as a result of different pollination treatments in cotton variety MNH-552. Mean values sharing similar letters show non-significant difference according to Tukey at 5% level. (BB pollinated: Bumble bee pollinated).

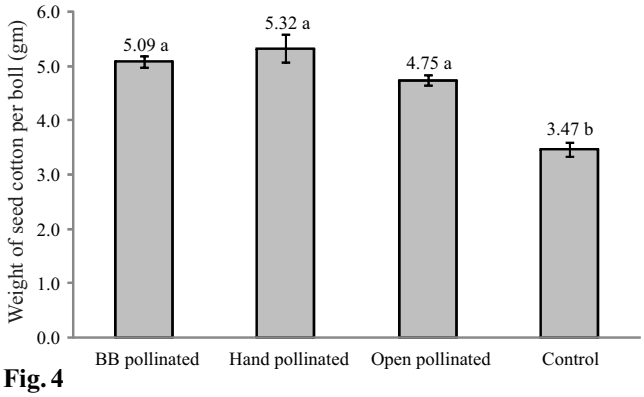

Fig. 4
Mean (±S.E) weight of seed cotton per boll as a result of different pollination treatments in cotton variety MNH-633. Mean values sharing similar letters show non-significant difference according to Tukey at 5% level.

Likewise, as compared to control, the percent seen cotton weight was also higher in different pollination treatments i.e. 16.97% and 46.6% increase in bumble bee pollinated plants and 11.93% and 53.3% in hand pollinated plants for MNH-552 and MNH-633, respectively. The influence on reproductive success by different pollination treatments may vary with varieties and type of pollinating insects. Meade (1918) suggested 10.96% and 5.31% increase in yield in cotton varieties Durango and Acala, respectively by insect pollination. There is need to compare different commercial and native bee species for their relative potential for cotton pollination.

There was a positive relationship between number of seeds per boll and seed cotton weight per boll. However, this relationship was stronger in variety MNH-522 than that of MNH-633 (Fig. 5, 6). This positive relationship further confirms the good impact of bumble bee pollination on weight of seed cotton and number of seeds per boll.

In conclusion, bumble bees can significantly increase the reproductive performance of cotton and their potential can further be explored in Pakistan, particularly in the areas where climate favors both cotton and bumble bees. For future studies, we recommend to explore the comparative efficacy of bumble bees and honey bees for cotton pollination in Pakistan.

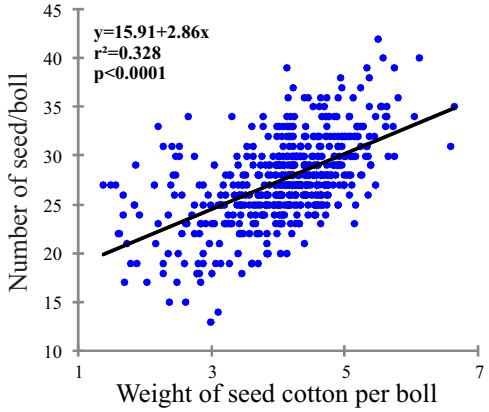

Fig. 5
Relationship between weight of seed cotton per boll and number of seeds per boll as affected by different pollination treatments in variety MNH-552 (n=531).

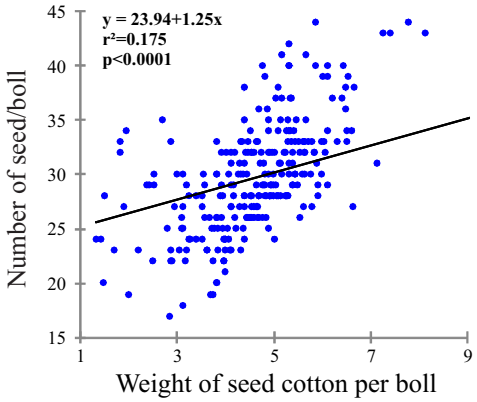

Fig. 6
Relationship between weight of seed cotton per boll and number of seeds per boll as affected by different pollination treatments in variety MNH-633 (n=258).

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