Effect of insect pollination on growth and yield of buckwheat (*Fagopyrum esculentum* Moench.) in Chitwan, Nepal

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Abstract

A field experiment was conducted to study the effect of insect pollination on growth and yield of common buckwheat (*Fagopyrum esculentum* Moench.) at farmers' field of Meghauli, Chitwan, Nepal during the winter season of 2012/13. There were 5 treatments consisting of open pollination, hand pollination, *Apis cerana* F. pollination, *Apis mellifera* L. pollination and control with four replications laid out in Randomized Complete Block Design (RCBD). The experimental results showed that there was significantly lower plant height (49.71 cm at peak flowering and 54.75 cm at harvest) and branch number (2.72) in *Apis cerana* F. pollinated plot followed by *Apis mellifera* L. pollinated plots (50.33 cm at peak flowering and 56.67 cm at harvest, branch number 2.89) compared to open pollination, hand pollination and control plot. Also, *Apis cerana* F. pollination increased grain set (36.37) in terms of total number of grains per plant followed by *Apis mellifera* L. pollination (34.83). *Apis cerana* F. and *Apis mellifera* L. pollination significantly increased the value of grain weight (137.25 g/m^2 and 123 g/m^2), straw weight (187.19 g/m^2 and 176.06 g/m^2), harvest index (0.43 and 0.42) and 1000 grain weight (26.18 g and 25.22 g), respectively when compared with control plot. Thus, the quality and quantity of buckwheat production get improved with bee pollination especially *Apis cerana* F. followed by *Apis mellifera* L. suggesting either use of additional pollinators or conservation of natural pollinators.

Key words:

pollination, *Apis cerana* F., *Apis mellifera* L., buckwheat, yield

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INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench.) is one of the important under exploited crops of Nepal which belongs to family Polygonaceae and is popularly known as "Pseudo cereal". It is a minor crop occupying 10,339 ha of land area, majority of which lies in mid-hills, with the production of 10,021 t and productivity of 0.97 t/ha (MoAD, 2012).

Common buckwheat is one of the best source of high quality, easily digestible protein, having a balanced amino acid composition (Eggum *et al.*, 1981) and a good source of minerals. It is cholesterol free and perfectly fits our modern low calorie, high nutrition diets (Francischi *et al.*, 1994). In alternative medicine, it is used for balancing the sugar and cholesterol level in the blood (Jiang *et al.*, 1995).

Buckwheat is cross pollinated and an entomophilic plant; honeybees are the major pollinators. The cultivation of buckwheat along with beekeeping may produce 50 to 100 kg of honey per hectare, due to its extended flowering period for more than 30 days (Rajbhandari, 2010).

Many factors, such as the floral physiology and morphology, pollinator characteristics, as well as effects of weather influence the success of pollination. Buckwheat pollen is not windblown; therefore insects are necessary for the transfer of pollen. Buckwheat flowers in the first sunshine and during which time it is highly attractive to bees (Phillips and Demuth, 1922) and most of the pollination activities occur. It is said that a single visit of buckwheat flower by a bee increases plant productivity by 25-30% (Grigorenko, 1979); three to four insect visits are enough to pollinate one blossom of buckwheat while bee visiting more than 5 times the productivity of plant decreases (Bjorkman, 1995).

In buckwheat, seed set is globally very low, around 15-30% which is the major constraint to buckwheat production worldwide. The farmers' knowledge and perception regarding the effect of pollination on vegetative characters and yield attributes of buckwheat has not well understood. So, this research investigates the role of pollination on the production of buckwheat (*Fagopyrum esculentum* Moench) at Meghauli, Chitwan, Nepal.

MATERIALS AND METHODS

The research was conducted during November 2012 to March 2013 in farmers' field at Meghauli-9, Dharampur, the western part of Chitwan district about 20 km from Bharatpur, Nepal. The experiment was laid out to fit the experiment into Randomized Complete Block Design (RCBD) with 5 treatments and 4 replications (blocks).

Land preparation was done by conventional tillage and harrowing. FYM were incorporated with the rate of 6 ton/ha and NPK of 30:20:10 kg/ha. Seeds were sown on 3rd week of November with crop geometry of 15 cm×10 cm and seed rate of 60 kg/ha. Plants were harvested manually with the help of sickle when grains at lower nodes turned brown. Plants were allowed to dry for easy threshing. Threshing was done by beating with sticks.

Experimental plots (12 plots) were caged with mosquito nylon net of 5×3m^2 size and 4 plots with same net of size 1×1 m^2. The plots assigned for control, *Apis mellifera* L. and *Apis cerana* F. pollination were caged with net of 5×3 m^2 and for hand pollination plot, caging was done in 1×1 m^2 area. The *A. mellifera* L. and *A. cerana* F. hive with 2 frame bees were kept within the cage. Within this area, 1×1 m^2 was taken as experimental unit for data recording. Caging was done at 5-10% flowering up to 90% flowering. Bee colonies were fed with 1:1 sugar syrup once in a week throughout the entire pollination period.

The plant height and yield attributes of the crop from experimental plots were recorded and analyzed by using the ANOVA procedure described by Gomez and Gomez (1984). When the F-test indicated statistical significance at the P = 0.01 and P = 0.05 level, the Duncan's Multiple Range Test was used to compare the difference of the means.

RESULTS AND DISCUSSION

Plant height

There was no significance difference on the plant height of buckwheat up to 45 DAS, i.e. before flowering. But, the plant height at peak flowering, i.e. 60 DAS and at harvest, i.e. 80 DAS were highly significant ($P\leq 0.01$). There was significantly higher plant height in control plot (65.75 cm at peak flowering and 73.29 cm at harvest) followed by hand pollination (57.97 cm at peak flowering and 62.50 cm at harvest) and open pollination plot (53.80 cm at peak flowering and 56.75 cm at harvest). The shortest plant height was observed in *Apis cerana* F. pollinated plots (49.71 cm at peak flowering and 54.75 cm at harvest) followed by *Apis mellifera* L. pollinated plots (50.33 cm at peak flowering and 56.67 cm at harvest) (Table 1).

Table 1. Effect of honeybee pollination on plant height (cm) at different stages of buckwheat (DAS) at Meghauli, Chitwan, Nepal, 2012/13

Treatments	One month after sowing (30 DAS)	Before flowering (45 DAS)	Peak flowering (60 DAS)△	At harvest (80 DAS)△
Open pollination	15.45	24.38	53.80^{bc}	56.75^{c}
Hand pollination	15.45	24.74	57.97^{b}	62.50^{b}
Pollination by *Apis mellifera* L.	14.93	23.95	50.33^{c}	56.66^{c}
Pollination by *Apis cerana* F.	15.97	25.83	49.71^{c}	54.75^{c}
Control plot	15.68	26.05	65.75^{a}	73.29^{a}
SEM ±	0.99	1.86	2.05	1.05
LSD	ns	ns	6.32**	3.24**
CV%	12.75	14.85	7.39	5.45

△ indicates value followed by the same letters in a column are not significantly different by DMRT at 5% level

** indicates P value with ≤ 0.01, DAS means Days After Sowing.

The non-significance on the plant height of buckwheat up to flowering, i.e. 45 DAS might be due to homogeneity in field and no treatment difference among the plots. The significant difference on the plant height of buckwheat among the treatments at peak flowering, i.e. 60 DAS and at harvest, i.e. 80 DAS might be due to the effect of insect pollination on buckwheat. This finding is in line with the result of Racys and Montviliene (2001) where they found that the plant height of buckwheat with open pollination was 19.6% and bee pollination was 16.8% shorter, respectively than control plot.

Yield attributes

Grain yield of buckwheat under different treatments were highly significant (P≤ 0.01). The highest grain yield was observed in *Apis* *cerana* F. pollination plot (137.25 g/m^2) followed by *Apis mellifera* L pollination (123.00 g/ m^2), open pollination (103.75 g/m^2), hand pollination (88.00 g/m^2), and control plot (16.50 g/m^2), respectively (Table 2).

Table 2. Effect of honeybee pollination on grain yield, straw yield, harvest index and 1000 grain weight of buckwheat at Meghauli, Chitwan, Nepal, 2012/13

Treatments	Grain yield (g/m^2)△	Straw yield (g/m^2)△	Harvest index△	1000 grain weight (g)△
Open pollination	103.75^b	164.49^b	0.39^c	23.68^a
Hand pollination	88.00^b	149.49^b	0.387^c	22.93^a
Pollination by *Apis mellifera* L.	123.00^a	176.06^a	0.42^b	25.22^a
Pollination by *Apis cerana* F.	137.25^a	187.19^a	0.43^a	26.18^a
Control plot	16.50^c	123.56^c	0.12^d	16.33^b
SEM ±	5.42	8.82	0.01	1.35
LSD	16.69**	33.00*	0.00**	4.15**
CV (%)	11.56	13.48	4.31	11.77

△ indicates value followed by the same letters in a column are not significantly different by DMRT at 5% level

** indicates P value with ≤ 0.01. *indicates P value with ≤ 0.05.

The higher significant difference on the grain yield of buckwheat under different treatments might be due to poor pollination on control plot with the lowest grain yield, straw yield, harvest index and 1000 grain weight, followed by hand pollination, open pollination, *Apis mellifera* L. pollination and *Apis cerana* F. pollination plot, respectively. Glukhov (1955) obtained buckwheat grain yield of 1,700 kg/ha at near to bee hive and only 500 kg/ha at away from the hive. Kopel'skievsky (1960) obtained 1,470 kg/ha grains adjacent to bee hive, but only 840 kg/ha away from the hive. Singh (2002/2003), and Racys and Montviliene (2001) found that the increament in harvest index by 239.94% and 12.13%, respectively in bee pollination over control. Dhakal (2003) demonstrated that the highest 1000 grain weight was in caged condition with honeybee (25±0.8 gm) than open and control pollination plot.

Similarly, the highest straw yield obtained in bee pollination as compared to open and control plot during the experiment might be due to shedding of leaves and branches of insufficiently pollinated crop from top succeeding to lower parts.

Bushels number, grain number, branch number and fresh weight

The number of bushels per plant was highly significant among the treatments (P≤ 0.01). The highest number of bushels per plant of buckwheat was observed in *Apis cerana* F. pollination plot (17.64), *Apis mellifera* L. pollination (15.78), open pollination (12.53), hand pollination (11.53) and control plot (7.73), respectively. Similarly, grain number per plant, number of branches at harvest and fresh weight per 10 plants were also found highly significant among the treatments (P≤ 0.01). The grain number per plant was the highest in *Apis cerana* F. (36.37) and *Apis mellifera* L. (34.83) pollination plots, followed by open pollination (27.05), hand pollination (24.89) and control (6.33), respectively. The highest number of branches at harvest was found in control (4.38), followed by hand pollination (3.54), open pollination (3.19), *Apis mellifera* L. pollination (2.89) and *Apis cerana* F. pollination (2.72), respectively. The lowest fresh weight per 10 plants was found on control plot (15.24 gm), followed by hand pollination (21.11 gm), open pollination (21.38 gm), *Apis mellifera* L. pollination (23.03 gm) and *Apis cerana* F. pollination plot (25.74 gm), respectively. The details of the results are given in Table 3.

Table 3. Effect of honeybee pollination on bushels number, grain number, branch number and fresh weight per 10 plants of buckwheat at Meghauli, Chitwan, Nepal, 2012/13

Treatments	Number of bushels per plant△	Grain number per plant△	Number of branches at harvest△	Fresh weight per 10 plants (gm)△
Open pollination	12.53[b]	27.05[b]	3.19[b]	21.38[b]
Hand pollination	11.52[b]	24.89[b]	3.54[ab]	21.11[b]
Pollination by *Apis mellifera* L.	15.78[a]	34.83[a]	2.89[b]	23.03[ab]
Pollination by *Apis cerana* F.	17.64[a]	36.37[a]	2.72[b]	25.74[a]
Control plot	7.73[c]	6.33[c]	4.38[a]	15.24[c]

SEM ±	1.02	2.03	0.34	0.94
LSD	3.13**	6.27**	1.04**	2.91**
CV%	15.58	15.71	20.14	8.87

△ indicates value followed by the same letters in a column are not significantly different by DMRT at 5% level.

** indicates P value with ≤ 0.01.

Leighty (1919) stated that the weight per bushel of buckwheat was heavier where the crop was worked heavily by bees. Dhakal (2003) demonstrated that the highest number of grains/plant was found in *A. cerana* F. pollinated crop followed by *A. mellifera* L. and open pollinated crop. Racys and Montviliene (2001) also reported that the number of branches at control, open pollination and the bee pollination plot were 6.4, 5.8 and 5.7, respectively.

CONCLUSIONS

The buckwheat plants freely visited by insect-pollinators were shorter than control and open pollinated plots. The lowest plant height and branch number was observed in *Apis cerana* F. pollinated plots followed by *Apis mellifera* L. pollinated plots, open pollination, hand pollination and control plot, respectively. Under the effect of insect-pollinators buckwheat set more seeds with higher 1000 seeds weight and hence more yields than control and open pollination. The highest grain yield, straw yield and harvest index were observed in *Apis cerana* F. pollination followed by *Apis mellifera* L pollination, open pollination, hand pollination, and control plot.

Thus, the quality and quantity of buckwheat production get improved with bee pollination especially *Apis cerana* F. pollination followed by *Apis mellifera* L. suggesting buckwheat production along with bee farming.

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