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# INSECT DIVERSITY AND POLLINATION EFFECT ON BUCKWHEAT (*Fagopyrum esculentum*) YIELD

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## Abstract

The experiment consisted of two different strategies of pollination treatment on buckwheat (*Fagopyrum esculentum*) flowers, viz. $T_1$=without netting and $T_2$= netting. Pair plot technique was adopted to layout the present experiment with 12 replications. The most abundant species were identified as *Apis cerana* F. (9.28±2.62) from Hymenoptera and *Menocheilus sexmaculatus* (8.36±1.05) from Coleoptera foraging the field at 11 A. M., while *Syrphus* sp. (2.53±1.1) found as dominant species from Diptera order visited the field early in the morning (7 A. M.). *Apis cerena* and *Apis mellifera* were found to stay more time on buckwheat flowers. The highest 1000-seed weight (18.39 g) of buckwheat was recorded from the plot without netting ($T_1$), whereas the lowest 1000-seed weight (9.17 g) was recorded from the plot with netting ($T_2$). The highest seed yield per plant of buckwheat was recorded 22.68 g when the plot was without netting ($T_1$) and the lowest was recorded 12.35 g when the plot was netted ($T_2$). The highest yield per plot was recorded (0.8258 kg) when the field was opened for pollinators ($T_1$) and the lowest yield per plot was recorded (0.399 kg) when the field was netted ($T_2$).

***Key words***: Buckwheat; Pollinators; Foraging; Yield.

## INTRODUCTION

Buckwheat (*Fagopyrum esculentum*) belonging to the family Polygonaceae is cultivated for its grain-like seeds and as a cover crop that is related to sorrel, knotweed and rhubarb, and is known as a pseudo cereal because its seeds' culinary use is the same as cereals, owing to their high starch content. It is an old World crop believed to have been originated in China (Ohnishi 1998) and was introduced into the New World by European settlers in the 17th century (Treadwell and Huang 2008). Once a commonly planted crop in the United States, buckwheat production sharply declined in the $20^{th}$ century due to the introduction of nitrogen fertilizer, which induce corn and wheat cultivation which become prevalent in the United States. In recent years, buckwheat has become more popular due to its newly discovered nutritional value (Cawoy *et al*. 2008). China, Russia, and Japan are currently the world’s top producers of buckwheat (Treadwell and Huang 2008). It remains important for food security in the temperate and hilly regions of countries in East Asia, East Europe and the Himalayan region (Arora 1995).

Buckwheat is not a cereal, but the seeds (strictly achenes) are usually classified among the cereal grains because of their similar usage. The grain is generally used as human food and as animal or poultry feed and the flour used in the preparation of pancakes, biscuits, noodles, cereals, etc. One cup of cooked buckwheat contains 155 calories, 6 g of protein, 1 g of fat, 33 g of carbohydrates, 5 g fiber, only

1.5 g of sugar, 86 mg manganese, 86 mg magnesium, 118 mg phosphorus, 6 mg niacin, 1 mg zinc, 34 mg iron, 0.13 mg vitamin $B_6$, 24 mg folate and 0.6 mg pantothenic acid (Mahata 2018). By supplying important vitamin and minerals buckwheat grains help to improve heart health like lowering down cholesterol, blood pressure level, prevent diabetes and ensure gluten free and non-allergenic. With the presence of a high content of fiber it helps to improve digestion and works surprisingly against aging and hair growth (Mahata 2018). Buckwheat produces flowers that are distylous and self-incompatible, and can be pollinated by wind or insects (Sasaki and Wagatsuma 2007).

Although pollination in buckwheat can occur by wind (Marshall 1969) most pollination is considered to be accomplished by insects, which may be necessary for successful pollination (McGregor 1976). Despite numerous insects being documented visiting buckwheat, the study of insect pollination and visitation on buckwheat is incomplete (Sasaki and Wagatsuma 2007) and findings appear to differ in various parts of the world. For this, an attempt was undertaken to study insect diversity and pollination effects on buckwheat yield in Bangladesh perspective.

## MATERIAL AND METHODS

The experiment was carried out during the period from November 2019 to March 2020 to find out insect biodiversity in the research farm of Sher-e-Bangla Agricultural University, Dhaka and determine the impact of pollinators on its buckwheat field. The experimental field was located at 90º33' E longitudes and 23º71' N latitude at a height of 8m above the sea level. The land of research area was medium high topography.

The buckwheat seeds were selected for this experiment. These seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The crop is cultivated in robi season. For this, the experimental plot was opened in the last week of October 2019 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilt. Weeds and stubble were removed, and finally obtained a desirable tilt of soil for sowing buckwheat seeds.

The experiment was conducted considering two treatments and laid out in a Pair plot technique with 12 replications, where the experimental area was divided into two equal blocks representing the replications. The unit plot size was 4 m×1.25 m having 1 m space between the replications and 0.4 m between the plots. Each plot contains 3 rows and row to row distance was 25 cm, and 20 cm between plants. During land preparation 40kg decomposed cow dung were mixed; 0.4kg, 0.8kg, 0.2kg TSP, MOP and Boric acid were applied respectively as the source of Phosphorus ($P_2O_5$), Potassium ($K_2O$) and Boron (B).

On November 13, 2019 the seeds were sown continuously in 4-4.5 cm deep furrows made by hand iron line maintaining desired row spacing. Before seed placement in rows small amount of water was applied in the furrows for easy germination of seeds. After placement, the seeds were covered with soil by hand. Within 14 days of sowing the germination was started and full germination was completed within 20 days after sowing the seeds.

Intercultural operations like thinning and weeding were done, as and when necessary, for the proper growth and development of the crop. Two times watering were done throughout the growing season. The mulching was also done by breaking the soil crust after irrigation properly. Irrigation was provided to maintain moist condition in the early stages to establish the seedlings and then irrigated, whenever necessary, throughout the entire growing period.

Five plants were randomly selected from each plot, then the number of insects visited the plants was recorded at different times of the day during the flowering of each plant, and then the means on the visits were calculated. The relative abundance of insect visitors was started 3 days after the flowering and data were collected at 7 AM, 9 AM, 11 AM, 1 PM, 3PM and 5 PM of each day and were continued for 20 sunny days.

For the determination of diversity index, some of the collected specimens were identified up to species level and the rest specimens were identified up to genus level using morphological technique. The biodiversity of the community was calculated using the Shannon-Weiner diversity index $H \ or \ H' = -\sum_{i=1}^{i=N} \mathrm{pi} \log 2 \ \mathrm{pi}$ where, *pi* is the proportion of each super family within the community, N expresses the total number of super families within the community.

Buckwheat grains harvesting is difficult in a particular time period due to its indeterminate growth habit. At the harvesting period, the seeds of all stages, namely mature seeds, immature seeds, and a few flowers, are present at the same time. The seeds were harvested by hand. Full harvest should begin when 70-75% of the seeds have reached physiological maturity. The harvested crops of each plot were bundled separately, properly tagged and brought to a shade. Care was taken for harvesting, threshing and also cleaning of buckwheat. The seeds were cleaned and finally their weight was recorded and converted into per hectare yield. The buckwheat of each plot was threshed separately, cleaned, sun dried, weighed and packed.

Data were analyzed by ANOVA techniques and using the STATISTIS 10 computer package program for proper interpretation. The data recorded on different parameters were separated by using Least Significant Difference (LSD) at 5% level of probability.

## RESULTS AND DISCUSSION

*Insect visitors on buckwheat flowers in open plot*

Different insect species visited the buckwheat flowers during blooming period are listed in Table 1. Total visiting insect species belonging to six genera under five families were recorded on the buckwheat flowers. Out of these, 2 belonged to Diptera, 2 to Coleoptera, and 5 species belonged to Hymenoptera. Among these, most frequent visitors were hymenopterans, whereas coleopterans and dipterans were less frequent visitors.

*Foraging frequency of different insects on buckwheat flowers in open plot*

Foraging frequency of hymenopteran insects on buckwheat flowers

Monitoring was done six times in a day, i.e. at 7 AM, 9 AM, 11AM, 1 PM, 3 PM and 5 PM during peak blooming stage. The number of *A. cerana* was the highest (9.28±2.62 and 6.57±2.72) at 11 AM and 1 PM, respectively, while the lowest number (0.92±0.83 and 0.85±0.94) of *A. cerana* was found at 5 PM and 7 AM, respectively. The number of *A. dorsata* was the highest (4.83±1.60 and 3±0.90) at 1 PM and 11 AM, respectively, while the lowest number of *A. dorsata* was found (0.67±0.81 and 0.58±0.69) at 3 PM and 9 AM, respectively and no foraging activity was recorded at 7 AM. The number of *A. florea* was the highest (2.45±0.64 and 1.25±0.72) at 11 AM and 1 PM, respectively, while the lowest number of *A. florea* was found (0.99±0.74 and 0.64±0.64) at 9 AM and 3 PM, respectively and no foraging activity was initiated at 7 AM and 5 PM. The number of *A. mellifera* was the highest (3.8±1.4) and (1.47±1.31) at 1 PM and 11 PM, respectively while the lowest number of *A. mellifera* was found (0.82±0.57and 0.8±0.7) at 3 PM and 9 PM, respectively and no foraging activity was seen at 7 AM and 5 PM.

**Table 1. List of insect visitors recorded on buckwheat flowers in open plot.**

| Common name | Scientific name | Family | Order |
|---|---|---|---|
| **Ant** | *Formica* sp. | Formicidae | Hymenoptera |
| **Indian Honey Bee** | *Apis cerana* | Apidae | Hymenoptera |
| **Giant honey bee** | *Apis dorsata* | Apidae | Hymenoptera |
| **Little bee** | *Apis florea* | Apidae | Hymenoptera |
| **European honey bee** | *Apis mellifera* | Apidae | Hymenoptera |
| **Syrphid Fly** | *Syrphus* sp. | Syrphidae | Diptera |
| **House fly** | *Musca* sp. | Muscidae | Diptera |
| **Ladybird Beetle** | *Menocheilus sexmaculatus* | Coccinellidae | Coleoptera |
| **Spotless lady beetle** | *Coccinella* sp. | Coccinellidae | Coleoptera |

There was no significant difference between the number of flowers visited by four species of honeybees, *A. cerana*, *A. dorsata*, *A. florea* and *A. mellifera*. The number of buckwheat flower visited by *Apis cerana* and *Apis florea* was the highest at 11 AM, while by *A. dorsata* and *A. mellifera* was the highest at 1 PM. But, for both species of honeybees it was the lowest at 7 AM and 5 PM (Table 2).

*Foraging frequency of coleopteran insects on buckwheat flowers*

The data on the foraging frequency of insect visitors of the day hours showed that *Menocheilus sexmaculatus* and *Coccinella* sp. were most frequent visitors in all days. The number of buckwheat flowers visited by *Menocheilus sexmaculatus* was the highest, whereas in case of *Coccinella* sp., it was the lowest in number (Table 2).

**Table 2. Foraging frequency of different insects on buckwheat flower per plant in the open plot.**

| Insect Species | Foraging Frequency | | | | | | LSD (0.05) | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | 7AM | 9AM | 11AM | 1PM | 3PM | 5PM | | |
| *Apis cerana* | 0.85±0.94 | 2.08±2.14 | 9.28±2.62 | 6.57±2.72 | 2.17±1.81 | 0.92±0.83 | 1.08 | 35.80 |
| *Apis dorsata* | 0±0 | 0.58±0.69 | 3±0.90 | 4.83±1.60 | 0.67±0.81 | 0.25±0.48 | 0.60 | 47.52 |
| *Apis florea* | 0±0 | 0.99±0.74 | 2.45±0.64 | 1.25±0.72 | 0.64±0.64 | 0±0 | 0.41 | 56.74 |
| *Apis mellifera* | 0±0 | 0.8±0.7 | 1.47±1.31 | 3.8±1.4 | 0.82±0.57 | 0±0 | 0.59 | 62.57 |
| *Menocheilus sexmaculatus* | 6.93±0.82 | 7.72±1.1 | 8.36±1.05 | 8.13±1.1 | 8.3±0.98 | 7.74±1.1 | 0.57 | 8.79 |
| *Coccinella* sp. | 1.42±0.79 | 1.5±0.7 | 2.24±0.7 | 1.96±0.6 | 1.94±0.5 | 0.02±0.5 | 0.49 | 32.15 |
| *Syrphus* sp. | 2.53±1.1 | 1.33±0.65 | 0.33±0.49 | 0.25±0.6 | 0.75±1.06 | 2.50±1.08 | 0.77 | 73.77 |

*Foraging frequency of dipteran insects on buckwheat flowers*

The number of *Syrphus* sp. was the highest (2.53±1.1 and 2.50±1.08) at 7 AM and 5 PM, respectively followed by (1.33±0.65) at 9 AM while the lowest number of *Syrphus* sp. was found (0.25±0.62 and 0.33±0.49) at 1 PM and 11 AM, respectively (Table 4).

*Time spent by honey bees per cluster*

For the time spent by the honey bee visitors, five different plants were selected randomly in every plot and observations were started 2-3 days after flowering. These observations were taken at 7 AM, 9 AM, 11 AM, 1 PM and 3PM of each day. In every sampling day, only one individual insect (*A. cerena /A. dorsata/A. florea/A. mellifera*) was observed per cluster and after 20 days observation data were calculated per insect per cluster. The data (Table 3) showed that at 7 AM, there was significant difference among the four species of honey bee. *A. dorsata*, *A. florea* and *A. mellifera* did not appear at 7 AM and *A. cerena* spent 2.85 sec per cluster. At 9 AM, there was no significant difference among the spending time of four honey bee species. *A. dorsata* and *A. mellifera* spent the same time (2.60 sec), whereas *A. florea* spent slightly more time (2.80 sec) than *A. cerana* (2.75 sec). At 11 AM, among four species of honey bee *A. melllifera* and *A. cerena* spent more time than *A. dorsata* and *A. florea*. At 1 PM, *A. mellifera* spent longest time (4.80 sec) per cluster than the other three species of honey bee. In this case, *A. cerena*, *A. dorsata* and *A. florea* spent 3.72 sec, 2.23 sec and 2 sec, respectively. There are statistically no significant differences between two species of honeybees on time spent per cluster on buckwheat flower. But, slightly more time was taken by *A. mellifera* than *A. cerana* per cluster visit.

*Apis cerana* bee spent, on an average, 1.95 seconds per cluster, while *A. mellifera* bee spent, on an average, 2.37 seconds per cluster of buckwheat. This finding corroborates with the findings of Aryal (2016) on the foraging behavior of native honeybee (*A. cerana*) and European honeybee (*A. mellifera*) on the flowers of common buckwheat (*Fagopyrum esculentum*) in Chitwan, Nepal. At 3 P.M, there was no significant difference among the four species of honey bee. But, *A. cerena* spent slightly more time (2.12 sec) than the other three species.

**Table 3. Time spent by honey bee species per cluster of buckwheat flowers.**

| Time | Time spent (sec) | | | | CV (%) |
|---|---|---|---|---|---|
| | *Apis cerena* | *Apis dorsata* | *Apis florea* | *Apis mellifera* | |
| 7AM | 2.85±0.41 | 0±0 | 0±0 | 0±0 | 28.93 |
| 9AM | 2.75±0.93 | 2.60±0.76 | 2.80±0.45 | 2.60±0.55 | 22.97 |
| 11AM | 3.77±0.66 | 2.65±0.49 | 2.40±0.89 | 3.80±0.84 | 23.86 |
| 1PM | 3.72±0.90 | 2.23±0.54 | 2.0±0.71 | 4.80±0.83 | 26.14 |
| 3PM | 2.12±0.93 | 1.66±1.12 | 1.40±0.89 | 2.40±0.89 | 36.27 |

*Diversity and abundance of pollinators on buckwheat flowers in open field*

A total number of six genera of pollinators was identified under 5 super families. There were nine species identified under six genera. The diversity of genus and species in Formicoidea was 1 and 1, respectively, in Apoidea 1 and 4, respectively, in Syrphoidea 1 and 1, respectively, in Muscoidea 1 and 1, respectively in Coccinelloidea 2 and 2, respectively (Table 4).

**Table 4. Total number of identified genera and species of pollinators in buckwheat flower.**

| Super Family | Genus (No.) | (%) | Species (No.) | (%) |
|---|---|---|---|---|
| Formicoidea | 1 | 16.67 | 1 | 11.11 |
| Apoidea | 1 | 16.67 | 4 | 44.44 |
| Syrphoidea | 1 | 16.67 | 1 | 11.11 |
| Muscoidea | 1 | 16.67 | 1 | 11.11 |
| Coccinelloidea | 2 | 33.34 | 2 | 22.22 |
| **Total** | **6** | | **9** | |

The most dominant super family of pollinator species individuals (44.44%) was observed in Apoidea followed by Coccinelloidea (22.22%) while in other three super families 11.11% each. The highest diversity in genera was obtained from super family Coccinelloidea 33.34% followed by other four Super families with similar diversity 16.67% each (Table 4).

*Diversity Index*

The Shannon-Wiener diversity index in buckwheat under open field condition for genus and species was 1.57 and 1.43, respectively with 9 species richness, where the evenness was 0.71 and 0.65, respectively. There were 50% and 67% community dominance for genus and species, respectively in buckwheat under open field condition (Table 5 and 6).

**Table 5. Biodiversity index assessment (genus).**

| Super Family | Genus | Pi | $log_2pi$ | $pilog_2pi$ |
|---|---|---|---|---|
| Formicoidea | 1 | 0.17 | -1.77 | -0.30 |
| Apoidea | 1 | 0.17 | -1.77 | -0.30 |
| Syrphoidea | 1 | 0.17 | -1.77 | -0.30 |
| Muscoidea | 1 | 0.17 | -1.77 | -0.30 |
| Coccinelloidea | 2 | 0.33 | -1.11 | -0.37 |
| Total | 6 | | 8.20 | -1.57 |
| Speices Richness (SR) | 9 | | | |
| H or $H'$ | 1.57 | | | |
| $H_{max}$ | 2.20 | | | |
| Evenness | 0.71 | | | |
| Community dominance | 50% | | | |

*Yield attributes*

Plant height

The plant height of buckwheat was significantly differed due to different conditions (Table 7). Numerically the tallest plant (95.14 cm) was recorded from netting plot ($T_2$) and the shortest plant (85.48 cm) was recorded from without netting plot ($T_1$). The pollinators had effects on plant height due to varietal traits (Table 7).

**Table 6. Biodiversity index assessment (species).**

| Super Family | Species | Pi | $log_2pi$ | $pilog_2pi$ |
|---|---|---|---|---|
| Formicoidea | 1 | 0.11 | -2.20 | -0.24 |
| Apoidea | 4 | 0.44 | -0.81 | -0.36 |
| Syrphoidea | 1 | 0.11 | -2.20 | -0.24 |
| Muscoidea | 1 | 0.11 | -2.20 | -0.24 |
| Coccinelloidea | 2 | 0.22 | -1.50 | -0.33 |
| Total | 9 | | 8.91 | -1.43 |
| Speices Richness (SR) | 9 | | | |
| H or $H'$ | 1.43 | | | |
| $H_{max}$ | 2.20 | | | |
| Evenness | 0.65 | | | |
| Community dominance | 67% | | | |

*Number of primary branches per plant*

The number of primary branches grown per plant of buckwheat was not significantly influenced by the percentage of different insects due to the open and netted conditions. The results of the experiment revealed that the maximum number of primary branches grown per plant (5.63) was recorded in without netting ($T_1$) condition and the minimum number of primary branches grown per plant (5.58) was recorded from when the plot was netted ($T_2$). There was no significant effect on branches number plant$^{-1}$. So, under present study no significant difference among pollination modes was found (Table 7).

**Table 7. Effect of different pollinating conditions on the plant height, branches plant$^{-1}$ and flower plant$^{-1}$ of buckwheat crop.**

| Treatments | Plant Height | Branches/Plant | Blossoms/Plant |
|---|---|---|---|
| Without netting ($T_1$) | 85.483 b | 5.6358 a | 1651.0 a |
| Netting ($T_2$) | 95.142 a | 5.5800 a | 1614.5 a |
| LSD(0.05) | 7.6811 | 0.7095 | 61.579 |
| CV (%) | 9.47 | 14.08 | 4.20 |

*Number of blossoms per plant*

The number of blossoms per plant of buckwheat was not affected significantly by different conditions. The results of the experiment revealed that the maximum number of blossoms per plant (1651.0) was recorded in without netting ($T_1$) condition and the minimum number of blossoms per plant (1614.5) was recorded from the netted plot ($T_2$) (Table 7).

*1000-seed weight*

Different pollination condition significantly affected the 1000-seed weight of buckwheat crop. The highest 1000-seed weight (18.39 g) was recorded from without netting ($T_1$) and the lowest 1000-seed weight was recorded (9.17 g) from netting ($T_2$) condition (Fig. 1). From the Fig. 2 it was revealed that 1000 seed weight of buckwheat per plot was the highest in plots without netting.

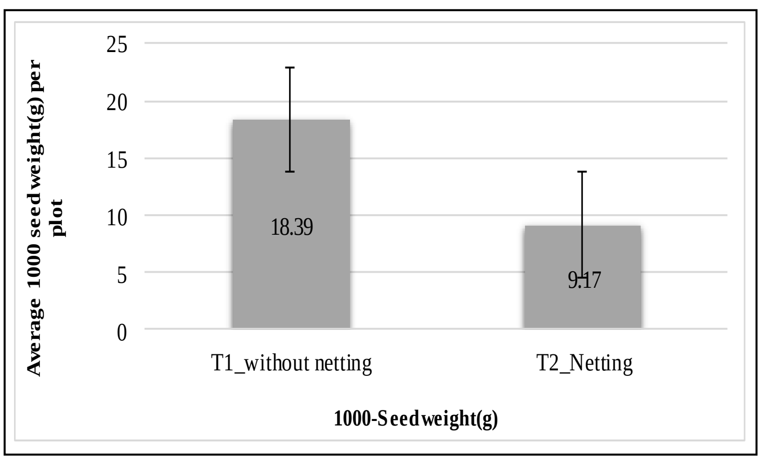


Fig. 1. Thousand (1000) seed weight per plot in two different treatments ($LSD_{(0.05)}$=0.27).

*Seed yield per plant*

The highest seed yield per plant of buckwheat was recorded 22.68 g when buckwheat field was left without netting ($T_1$). On the other hand, the lowest seed yield per plant of buckwheat was recorded 12.35 g when buckwheat field was netted ($T_2$). They were statistically different from each other (Fig. 2). It was revealed that pollinators helped the pollination of buckwheat that increased the mean seed yield per plant of buckwheat than netting field.

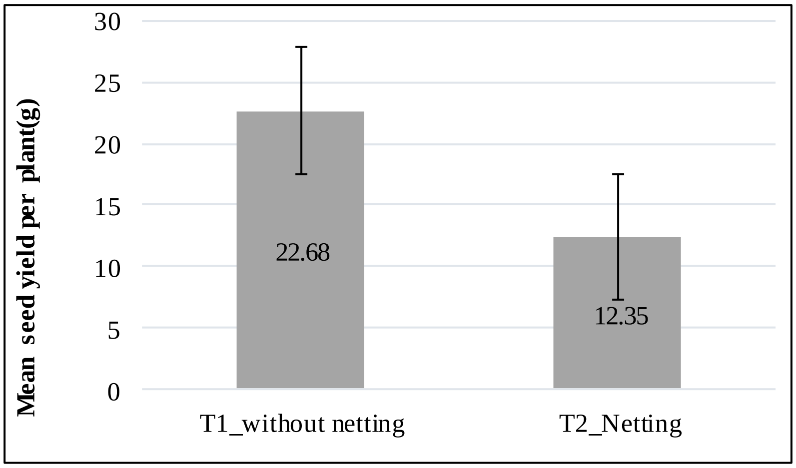


Fig. 2. Mean seed yield per plant in two different treatments (LSD $_{(0.05)}$ =0.75).

*Seed weight per plot*

The highest yield per plot of buckwheat was recorded 0.8258 kg when the buckwheat field was left open for pollinators ($T_1$). On the other hand, the lowest yield per plot of buckwheat was recorded 0.399 kg when the field was netted ($T_2$). They were statistically different from each other (Fig. 3). From the Fig. 3 it was revealed that pollinators helped the pollination of buckwheat and increased the yield of buckwheat per plot than netted plots.

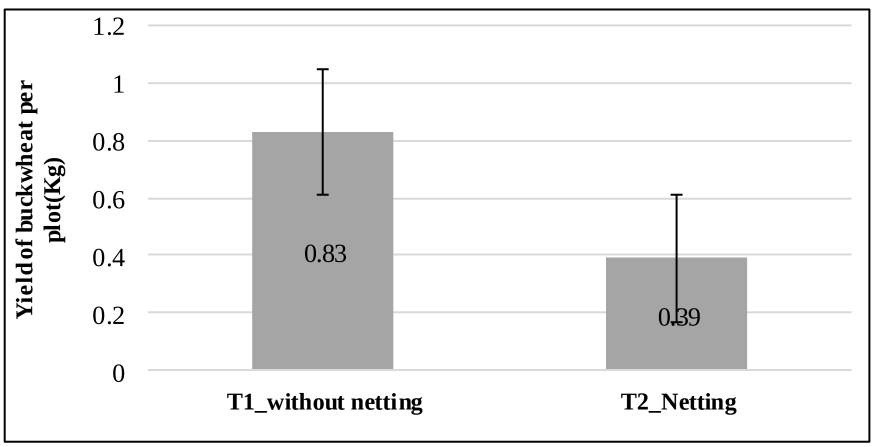


Fig. 3. Yield of buckwheat per plot in two different treatments(LSD $_{(0.05)}$ =0.031).

*Seed yield*

The yield per plot of buckwheat showed statistically significant variation in two different treatments. The highest yield per hectare was recorded from $T_1$ (1.67 ton), whereas the lowest yield per hectare was recorded from $T_2$ (0.73ton) treatment. The seed yield of buckwheat can be more than 2t/ha under optimal soil and especially climate condition. However, under unfavorable condition, it will remain below 1t/ha (Varga1966). According to FAO data the seed yield of buckwheat ranged from 0.35t/ha (1992) to 1.5 t/ha (1997) in Hungary during the period from 1992 to 2008 (FAOSTAT 2010).

*Unfilled grain percentage*

Experimental results showed that the highest number (1558.7) of total seed per plant was recorded in $T_1$ treatment, whereas the lowest total number (1313.1) of seed per plant was recorded in $T_2$ treatment which was statistically not similar with each other (Table 8). In term of the number of unfilled grain per plant, experimental results showed that $T_2$ treatment recorded the maximum unfilled grain per plant (362.50), whereas $T_1$ treatment recorded the minimum number (35.42) of unfilled grain per plant.

**Table 8. Unfilled grain percentage in case netting and without netting.**

| Treatment | Number of grain /plant | Number of unfilled grain/plant | Percentage of unfilled grain |
|---|---|---|---|
| Without netting ($T_1$) | 1558.7 | 35.42 | 2.3200 |
| Netting ($T_2$) | 1313.1 | 362.50 | 28.00 |
| LSD(0.05) | 67.152 | 18.070 | 2.6563 |
| CV (%) | 5.20 | 10.11 | 19.49 |

Again considering the unfilled grain percentage, the minimum unfilled grain (2.32 %) found in plot without netting ($T_1$) treatment, whereas the maximum unfilled grain (28.00 %) was recorded in netted ($T_2$) treatment.

## REFERENCES

Arora, R. K. 1995. Buckwheat genetic resources in the Himalayas: their diversity, conservation and use. *Curr. Adv. Buckwheat Res.* **1**(3): 39-46.

Aryal, L. N. 2016. Foraging behavior of native honeybee (*Apis cerana*) and european honeybee (*Apis mellifera*) on flowers of common buckwheat (*Fagopyrum esculentum*) in Chitwan, Nepal. *Int. J. Appl. Sci. Biotechnol*. **4**(2): 236-239.

Cawoy, V., J. Kinet and A. Jacquemart. 2008. Morphology of nectaries and biology of nectar production in the distylous species *Fagopyrum esculentum*. *Ann. Bot.* **102**: 675-684.

FAOSTAT. 2010. Available online http://faostat.fao.org/site/567/Desktop Default. 567 pp.

Mahata, D. 2018. Importance of buckwheat (*Fagopyrum esculentum* Moench) Uttar Banga Krishi Viswavidyalaya, Department of Agronomy, Pundibari, Cooch Behar, West Bengal, *India*. *Int. J. Che. Stu*. **6**(5): 2121-2125

Marshall, H. G. 1969. *Description and Culture of Buckwheat*. Bulletin 754. Pennsylvania State University, College of Agriculture, Agricultural Experiment Station, University Park, Pennsylvania. 26 pp.

McGregor, S. E. 1976. *Buckwheat. Insect Pollination of Cultivated Crop Plants*. Agricultural Research Service, United States Department of Agriculture. Agricultural Handbook No. 496.

Ohnishi, O. 1998. Search for the wild ancestor of buckwheat III. The wild ancestor of cultivated common buckwheat, and of tartary buckwheat. *Econ. Bot.* **52**: 123-133.

Sasaki, H. and T. Wagatsuma. 2007. Bumblebees (Apidae: Hymenoptera) are the main pollinators of common buckwheat, *Fagopyrum esculentum,* in Hokkaido, Japan. *Appli. Entomol. Zool.* **42**: 659-661.

Treadwell, D. and P. Huang. 2008. *Buckwheat: a cool-season cover crop for Florida vegetable systems*. University of Florida IFAS Extension Document HS1135. 6 pp.

Varga, J. 1966. Kisebb Jelentusegu Gabonafelek, Phanak. In: G. Lang (ed.). *A Novenytermesztes KezikonevyI*. Mezogazdasagi Kiado, Budapest, Hungary., pp.173-176

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