A ON-FARM STUDY ON EFFECT OF HONEY BEE IN ONION SEED PRODUCTION

A Thesis Submitted In partial fulfillment of the requirement for the degree of Master of Science in Biotechnology and Genetic Engineering.

Submitted By

Audity Chokrabarti

Batch No. 12th

DEPARTMENT OF BIOTECHNOLOGI AND GENETIC ENGINERING

FACULTY OF LIFE SCIENCE

UNIVERSITY OF DEVELOPMENT OLTERNATIVE

FEBRURAY 2016

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Supervisor

Prof. Dr. Rownak Jahan

Chairman,

Department of Biotechnology and Genetic Engineering

Department of Molecular Medicine and Bioinformatics

FACULTY OF LIFE SCIENCE

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Co-Supervisor

Dr. Ansar Ali

Director (Research)

BANGLADESH RICE RESEARCH INSTITUTE (BRRI)

GAZIPUR, BANGLADESH.

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Co-Supervisor

Ferdous Mohammod Safiul Azam

Faculty and Co-ordinator,

Department of Biotechnology and Genetic Engineering

FACULTY OF LIFE SCIENCE

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ABSTRACT

Onion is an important spice crop in Bangladesh. It ranks first in production (88,90,00 MT) and second in area (12,51,01 ha) among the spices. It covers almost 36% of the total areas under spices. Nowadays the natural habitat is disturbed for many reasons and the vegetation cover is declining worldwide. Agriculture plays a role in declining native pollinators through the modification and elimination of pollinator habitats and the use of agricultural chemicals. We know that honeybees are responsible for 70-80% of insect pollination. At present, the need for onion seed production is highly demanding and nationally it becomes an important research area to increase onion seed production. Onion seed is imported from abroad with hard foreign currency. Insufficient pollination caused difficulties in onion hybrid seed production because of low quality seed (Free, 1993). Thus, this experimental design was set to investigate the effect of honey bee vector on seed production of onion (*Allium cepa*) in Natore district, a rainfed area of Bangladesh. There were two types of treatments used which were treated plot (with honey bee vector) and Control plot (without honey bee vector). We set 2 treatment plots: T1: three clusters as plot A, plot B, plot C got honey bee box and T2: one cluster was without honey bee box as control plot D. In treated plots, we found that tallest main scape height D (74±1.4cm) from without honey bee plot. In control plot D, we obtained the highest umbel diameter (6.1±0.1cm) from without honey bee plot than the treated plots. From treated plots, the abortive flower per umbel was counted A (34±2.2), B (23±1.5) and C (30±2.3) and from the control plot D (31±2.0). On an average, the highest number of abortive flower was observed from plot where honey comb was not used. The highest weight of 1000 seed (2.828g) was recorded from with honey bee treatment (A). The highest seed yield per plant (1.621gm) was recorded from plot A (honey treated). The highest seed yield was produced from plot A (0.0375t/ha) where with honey bee was used. We have found a significant effect from our treatments of pollinator on onion seed production and it showed positive role in improving onion seed production. It is recommended that effective implantation of pollination vector in onion field could play an important role to increase the seed yield of onion which might help our grass-root farmers to produce their own seed in farmland with low-cost that could put away their seed cost.

ACKNOWLEDGEMENT

At the outset, the author wishes to express his deepest sense of gratitude to Almighty GOD, Whose boundless blessings enabled him to successfully complete the research work and prepare this thesis. The author takes this opportunity to express his profound appreciation and heartfelt gratitude to his reverend supervisor Prof. Dr. Rawnak Jahan, Charman, Department of Biotechnology and Genetic Engineering and Molecular Medicine and Bioinformatics, University of Development Alternative (UODA), Dhaka, for his patient guidance, intense supervision, untiring assistance, constant encouragement, worthy suggestions, constructive criticism and inestimable help during every phase of this research work and preparation of this thesis. The author is obliged to his co-supervisor Dr. Ansar Ali, Director (Research), Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh, for his untiring assistance, guidance and helpful suggestions as well as reviewing the dissertation critically. The author fells proud to express his deepest sense of gratitude and profound appreciation to his respected co-supervisor Fardous Mohammad Safiul Azam, Faculty and Coordinator, Department of Biotechnology and Genetic Engineering, University of Development Alternative (UODA), Dhaka, for his constant supervision, scholastic guidance, valuable suggestions, constructive criticisms and kind help throughout this research work and in preparing the manuscript of this thesis. Thanks are extended to Zillur Rahaman, Research Officer, SAFBIN Caritas Rajshahi Region, Bangladesh, Md. Ekramul Haque, District Research Officer, SAFBIN Caritas Rajshahi Region, Boraigram, Natore, and Dr. Zullfikar Ali, Faculty of Soil Science Department, Dhaka University, Bangladesh, for their time-to-time cooperation, advice and suggestions throughout this research work. Special thanks are extended to my beloved friends, Classmate, all member of PTC-lab of Department of Biotechnology and Genetic Engineering and nicely co-operate Auditi, Bappy, Faisal, Urme, Mehedi, Ruddro, Sharif, Hazrat, Nirob and Mujibibur Rahman for their co-operation during the research work. The author is grateful to all the Village Field Assistants (VFA) of the SUFBIN Project of CARITAS BANGLADESH at Boraigram, Natore, Rajshahi, Bangladesh, for their sincere co-operation in completion of this work. Above all, the author reserves his boundless gratitude and indebtedness to his family members for their patience, sacrifices and constant encouragement for successful completion of the research work and the thesis.

THE AUTHOR

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CHAPTAR: 1

1.0 Introduction

1.1 Agriculture of Bangladesh

Bangladesh is primarily an agrarian economy. Bangladesh economy draws its main strength from agriculture sector. The sector contributes 19.10% to GDP (at current prices) and employs 50.28% of the labour force. Despite increase in the shares of fisheries, livestock, and forestry, crop sub-sector alone accounts for 60.83% share of agricultural GDP (BBS, 2008). Bangladesh is the largest producer of World's best Jute, which also known as natural jute or raw jute. Rice being the staple food, its production is of major importance. Rice production stood at 20.3 million tons in 1996-97 fiscal years. Crop diversification program, credit, extension and research, and input distribution policies pursued by the government are yielding positive results. The country is now on the threshold of attaining self-sufficiency in food grain production. Crop agriculture in Bangladesh is, however, constrained by a number of challenges every year. Major challenges include 1) Loss of Arable Land, 2) Population Growth, 3) Climate Changes, 4-6) Inadequate Management Practices (Fertilizer, Water, and Pests & Diseases), 7) Lack of Quality Seeds, and 8-10) Inadequate Credit Support to Farmers, Unfair Price of Produces and Insufficient Investment in Research. Bangladesh has lost about l million ha of arable land from 1983 to 1996. Virtually, no step has been taken by the government to arrest this loss. The land use policy prepared by the government several years back has not yet been implemented. Population growth poses another great threat to crop productivity. Besides, crop agriculture in Bangladesh has become regularly vulnerable to the hazards of climate change–flood, drought, salinity in particular. In addition, poor management practices, especially those of pests and diseases, fertilizer, water and irrigation have largely contributed to significant decline in crop productivity. Small and marginal farmers that constitute majority of farm population are constrained by poor financial resources and cannot, therefore, afford high management costs of high input technology. Major objective of this review article is to discuss the challenges of crop agriculture of Bangladesh and suggest possible opportunities to address the issue that may assist the policy makers to develop policy guidelines (Mondal, M.H. 2010)

1.2 Effect of Climate change in Agriculture

Atmospheric CO_2, CH_4, SO_2, N_2O, etc. are mainly responsible for temperature increase resulting in the rise of sea level. Temperature rise by 1.00 C would inundate 18% area of Bangladesh as indicated by different studies. At the same time, the country is affected frequently by flood, drought, cyclone, and

salinity due to climate change. As a result, soil fertility, crop productivity, and food security would be seriously threatened. Climate change has also accelerated hunger, poverty, malnutrition and incidence of diseases, especially in developing countries (IPCC, 2007). It is basically the poor that would be worst victims of climate change. Profit driven mode of production by corporate agencies and their over extraction and consumption of fossil fuels (coal, oil) has also hastened global warming.

In Bangladesh, about 1 million ha of the coastal region is saline. But very few varieties are available for combating salinity. Drought affects annually 2.5 million ha in kharif and 1.2 million ha in dry season. Kharif drought affects T. aman rice severely. Besides, about 2.6 m ha are affected by flood in a normal year (Karim, 1997). The devastating flood of 2004 inundated 40 districts and caused considerable loss of crops and human life. But very limited technologies are available that are tolerant to flood and drought. According to Intergovernmental Panel on Climate Change (IPCC, 2007), coastal area of Bangladesh may go under saline water by 2050. Due to the rise in temperature, crop production will be reduced by about 30%. Climate change, especially temperature rise would decrease the yield of Boro rice by 55-62% and wheat by 61% by 2050 in Bangladesh (New Age, 2008). Frequent felling of green trees by the influential, especially in coastal belts for building shipyards has also become a threat to climate change.

1.3 Adaptation to climate change in Agriculture

Bangladesh Rice Research Institute (BRRI) has developed BRRI dhan 40, 41, and 47 that are salt tolerant. The varieties should be introduced and disseminated in the area after necessary testing. More heat tolerant varieties of wheat need to be developed. CIMMYT and BARI may be urged to develop tropicalized wheat varieties. It is also necessary to use biotechnology or gene transfer technology to develop varieties tolerant to salinity, flood, and drought. There is also a need to develop HYVs in pulses, oilseeds, spices, and fruits since improved technologies in these areas are few. Country does not have its own supply of hybrid varieties of rice, vegetables, and other crops. In the circumstances, the government should urge BRRI, BARI, and other NARS institutes and private companies & NGOs to develop their own hybrid variety programmes of these crops within the country. Climate change is a development issue and therefore, the change must be integrated into national development plan of the government. Besides, political commitment must be ensured to mitigate the problems– flood, sea level rise, and salinity intrusion of agricultural land in particular. It is emphasized that mitigation measures rather than adaptation practices may be considered as better solutions to the problem. Mitigation measures include the use of renewable energy, reduction, and efficiency in the use of fossil fuels, afforestation, early warning system to disaster management, preventing felling of green trees, especially in coastal areas, etc.

The Government of Bangladesh is yet to make an estimate on resources required to overcome climate change impacts. However, to implement "Climate Change Strategy and Action Plan 2009", Ministry of Agriculture has recently estimated a demand of $5 billion to address the problem for the next 5 years. Success of the plan largely depends on the commitment of the government since its implementation is dependent on several ministries. It is also extremely important that both Poverty Reduction Strategy Paper (PRSP-II) and Sixth Five-year Plan under formulation contain clear provisions to address the issue.

1.4 Onion and its production in Bangladesh

Onion is an important spice crop in Bangladesh. It ranks first in production (889000 MT) and second in area (125101 ha) among the spices (BBS, 2008). It covers almost 36% of the total areas under spices. The mean yield of onion in Bangladesh is very low (4 t/ha) compared to world average of 17.27 t/ha (FAO, 1998). During winter, onion is widely cultivated all over Bangladesh. Farmers generally follow traditional method for cultivating onion in Bangladesh. Area and production of onion in Bangladesh during the last five years are given below; Although production of onion is increasing day by day, but in a land hungry country like Bangladesh it may not be possible to meet the domestic demand due to increase in population. There is an acute shortage of onion in relation to its requirement. Every year, Bangladesh has to import a big amount of onion from neighbouring and other countries to meet up its demand. Total import of onion stood at 55499 metric tons in 2005 (BBS, 2007).

Table 1. 1. Area and production of onion in Bangladesh.

Year	Area ('000 ha)	Production ('000 MT)
2003-04	52.0	272.2
2004-05	86.4	589.4
2005-06	115.6	768.6
2006-07	129	894
2007-08	125	889

The high demand of onion can only be met by increasing its production vertically. Efficient use of resources can provide the farmers to have higher production from the available resources. The situation is particularly critical in a country like Bangladesh where per hectare recommended amount is seldom used in production (Jabbar and Alam, 1979; Jabbar and Alam, 1981). As a result, farm level yield of onion is very low compared to their recommended yield. Farmers in the study areas also follow different levels of

management depending upon their infrastructural facility and socio-economic conditions which ultimately results variability in yields. Few studies (Awal *et al.*, 2004; Saha and Elias, 1990) have been conducted on onion cultivation. But the information on production and input use pattern in onion cultivation is still scarce. Lack of farm level information on onion cultivation frequently prevents researcher from undertaking priority research areas.

Ullah *et al.*, (2008), among the spice crops grown in Bangladesh onion ranks second in acreage and first in production. Onion production of our country does not meet up the domestic demand. The total onion production is about 589.41 thousand metric tons in an area of 86.43 thousand hectares of land (BBS, 2007). Where the national demand is about 687.65 thousand metric tons (FAO, 2005). The national average yield, of onion per hectare is only 6.91 tons, but the world average yield is about 17 t/ha (FAO, 1999). There is an acute shortage of onion in relation to its requirement. Due to limitation of land, it is not possible to raise the area and production of the crop horizontally. The high demand of onion can only be meet up by increasing its per hectare yield. This can be done by many ways of which the most important are the judicious application of fertilizers, introduction of high yielding varieties and proper management practices. Onion storage is important to provide product for fresh market, export and processing. Storage potential of onions mainly depends on the cultivar, climate conditions during growing season and storage methods (Adamicki, 2005). Storage of onion bulbs in the country is a serious problem for both growers and consumers. Rahim *el al.* (1983) reported that in some exotic cultivars, storage loss is even 100%. The neck thickness and storability decreased with increasing levels of sulphur (Kumar *el al.*, 2002). Therefore, the present study was undertaken to find out the optimum sulphur dose for increasing bulb yield and storability of onion.

1.5 Importance of honeybees for onion seed production

Nowadays the natural habitat is disturbed for many reasons and the vegetation cover is declining worldwide (Kearns *et al.*, 1998). Agriculture plays a role in declining native pollinators through the modification and elimination of pollinator habitats and the use of agricultural chemicals (pesticides, herbicides and fertilizers) (Donaldson, 2002). Free (1993) stated that clean and intensive cultivation of land may affect wild insect pollinators. He mentioned practices such as destruction of hedgerows and rough verges which destroyed many natural food sources and nesting sites of wild pollinating insects. Generally it has been concluded that habitat degradation, pesticide misuse, diseases and intensive cultivation of lands may be the causes of decline in managed honeybees and wild pollinators (Collette, 2008; Davila and Wardle, 2008; Gross, 2001;

Morandin and Winston, 2005). When many hectares are occupied by a single crop and certain localities are selected for growing particular cultivars there may be too few insect pollinators due to the factors mentioned above and it may be necessary to enhance pollinators in that area (Du Toit, 1988).

Honeybee pollinators are estimated to be involved in producing up to 30 % of the human food supply directly or indirectly; farmers rely on managed honeybees throughout the world to provide these services (Greenleaf and Kremen, 2006; McGregor, 1976). In the United States, the annual value of increased agricultural production in yield and quality that is attributed to honeybee pollination varied from US$9.3 billion in 1989 to US$14.6 billion in 2000 (Morse and Calderone, 2000). In Western Cape (South Africa) the deciduous fruit industry which is entirely dependent on honeybees as pollinators generates R1 billion per year and creates job opportunities for 80,000 people (Picker *et al.*, 2004). Honeybees are responsible for 70-80% of insect pollination (Johannsmeier and Mostert, 2001). The contribution of managed honeybee pollination to crop production and quality has been estimated to be more than the value of honey and wax production (Shrestha, 2004).

At present, the need for onion seed production is highly demanding and nationally it becomes an important development component since the release of Adama Red Cultivar (Lemma and Shimeles, 2003). Onion is an important condiment and vegetable crop in Ethiopia. It is a cash crop and serves as a spice for flavoring local dishes and hence it is a highly valuable crop throughout the country. It fetches a very high price during rituals and holidays.

Inadequate pollination of the onion plant may result in deformed, smaller seeds which have low germination capacity (McGregor, 1976). Insufficient pollination caused difficulties in onion hybrid seed production because of low quality seed (Free, 1993). This is because the onion pollen usually sheds before the female part is respective (protandry) (Lema, 1998). Several pollination factors could be taken into consideration for agricultural production such as wind, hand pollination, some pollen dispenser methods and insects, but wind has little effect on onion pollination because of its sticky pollen (McGregor, 1976). McGregor (1976) reported that honeybees were effective pollinators on onion because both pollen and nectar are available from the plant.

Onion seed is imported from abroad with hard foreign currency. Buyers of the seed are facing the problem of germination and imported seeds are susceptible to disease (Lemma, 1988). The productivity of the crop is very low and the low seed yield of self-pollinated onion has been reported from small scale producers and state farms everywhere in the world (Yucel and Duman, 2005).

This study was designed to examine the role of managed honeybee pollinators in increasing seed yield and germination percentage of the on plant and to identify insect visitors other than honeybees. In addition, the research described in this project aimed to improve the understanding of the use of managed honeybee colonies in cultivated crop pollination. The findings of this project will therefore contribute to the definition of general guidelines to maintain or improve onion crop pollination. Totals of 1748 insect visitors in the open pollination (CTL) and 1548 honeybee visitors in the caged treatment (HB) were recorded (Table 1). The onion visitor community was diverse, including insects from four orders. Hymenopteran visitors belonged to the families Apidae, Sphecidea and Halictidae, while Dipteran visitors were identified as Tabanidae, Lepidoptera as Nymphalidae and Coleoptera as Scarabaeidae and Meloidae. Hymenoptera constituted the highest percentage of insects, while Coleoptera and Lepidoptera were the least abundant orders in the open pollination.

Table 1: Total number of insect visitors in the open pollination treatment (CTL)

Insect order	**Family name**	**Species name**	**Number**	**Percent**
Hymenoptera	Apidae	*Apis mellifera*	881	50
Diptera	Tabanidae	*Philoliche rostrata*	725	41
Hymenoptera	Sphecidae	*Dasyproctus bipunctatus*	11	1
Lepidoptera	Nymphalidae	*Danaus chrysippus*	28	2
Hymenoptera	Apidae	*Maliponula*	39	2
Coleoptera	Scarabaeidae	*Mausoleopsis amabilis*	54	3
Coleoptera	Meloidae	*Decapotoma lunta*	1	0
Hymenoptera	Halictidae	unknown	9	1

1.6 Honey bee biology and behaviour

Western honey bees are managed in almost all countries. They are kept in areas where their hives are covered by snow in the winter and in high temperatures in the tropics. This ability to survive extremes of temperature is a function of the way the bees manage the internal temperature of their hive and their food reserves, rather than because of human assistance. Because of this, they can be imported and used for pollination almost anywhere a crop is grown. Most honey bee colonies are managed; however, they also live as feral colonies.

Feral honey bee colonies live in cavities in trees, caves, buildings, and other man-made structures. They are usually smaller than managed colonies, swarm more often, and are often more aggressive. Feral colonies can add significantly to pollination if there are enough of them present but there are problems associated with relying on them for pollination. It is difficult to assess whether there are enough feral colonies in the vicinity to pollinate a crop until after the crop has started flowering. At that stage, it may be too late to introduce managed colonies if there are too few feral colonies. Feral colonies also cannot be manipulated to improve their pollination in the way that managed colonies can. Better and more reliable pollination can usually be achieved by introducing managed colonies.

A beehive is the man-made structure that a managed honey bee colony lives in. It usually consists of a floorboard that the boxes sit on, one or more boxes and a hive lid. There are usually between six and 12 frames inside each box. The frames carry the honey comb, developing larvae, pollen, and honey stores. Beehives will also often contain a feeder so that the beekeeper can feed the colony sugar syrup if they do not have enough stored honey.

A honey bee colony usually consists of three castes of bees - a queen, drones and many thousands of workers. Queen bees are reproductive females. There is usually only one queen in a hive. She will often live for two or three years, although many beekeepers replace queens yearly. The queen lays all the eggs needed to produce the other castes of bees. She can lay over 1000 eggs in a day. The queen will usually only leave the hive on her mating flight, if the colony swarms, and then finally when she dies. If a queen dies and the colony or beekeeper cannot replace her, the colony will also eventually die.

Beekeepers replace queens by removing or killing the old queen and either releasing a new queen from a cage or installing a queen cell containing a queen that is about to emerge. The new queen will start laying soon after she is released. If the old queen is replaced with a new queen, there should be little interruption with egg laying. However, if the old queen is replaced with a queen cell, it may take several weeks for the queen to emerge, mate and start laying, which will slow down the development of the hive. In this case there may be times when there are no larvae in the colony, which will reduce the amount of pollen the colony collects. For this reason, beekeepers should not replace queens with queen cells when the hives are introduced to a crop for pollination as it may cause an interruption in brood rearing and reduce pollen collection.

A drone is a male bee. The drone's only function is to mate with a queen when it goes on its mating flight. They are only present in the hive in the spring, summer and autumn. The workers evict the drones in the autumn. As they do not visit flowers and cannot feed themselves, the drones starve. They have no role in pollination.

Worker bees are non-reproductive females. There may be more than 60,000 workers in a very large honey bee colony. Everything done in and outside the beehive, except laying eggs, is done by the worker bees. This includes making wax, building comb, feeding larvae, keeping the hive clean and warm, defending the hive and foraging. The jobs they do depend in part on their age. They start carrying out tasks inside their hive and are referred to as house bees. They then graduate to guard bees that defend the colony, and lastly to foragers. A worker may live for only six weeks in the summer when it is very active or six months during the winter. When the queen lays a worker egg, it takes three days to hatch into a larva. The larva is fed by the workers for the next four days. The cell is capped over and the larva spins a cocoon. The larva turns into a pupa under the capping. This cannot be seen unless the cell capping is removed. The fully formed worker bee emerges from its cell 21 days after the egg is laid.

In the spring, summer and autumn, a colony will normally consist of all three castes of bees and all stages of developing bees including eggs, larvae, pupae and fully formed bees. In temperate countries, they are normally at their maximum population in the late summer. However, they can be managed to have large population sizes at other times of the year. Workers forage for water, propolis, pollen and nectar.

It must always be remembered that honey bees are not domesticated. All we do is provide them with a suitable nesting site and encourage them to stay. If they consider a person or other animal a threat to their colony, they may attack them. When they sting, it is generally in defence of their colony. Their propensity to sting depends on a number of factors; one of which is their race. The least aggressive strains may only consider a person to be a threat if they place their fingers in the entrance of their hive but other strains may attack anybody within 20 m. Beekeepers often select strains of bees with reduced aggression However, colonies placed in crops for pollination may range from very docile to very aggressive so all colonies should be treated with caution. Even the more docile bees can be provoked to attack by loud noises, bumping hives, or opening hives without a smoker. Honey bees are also very sensitive to weather. On a pleasant sunny afternoon when the colony is collecting nectar, it may be quite docile. However, the same colony may be aggressive in the early morning, evening or during bad weather when its bees cannot forage.

Bees are very aggressive at night. Although the bees will not usually fly at night unless you shine a light on the hive, they will crawl. Even the most docile colony in daylight will only have one thought at night, which is to sting whoever is disturbing them. Bees will also usually be more aggressive on the day they are moved into a crop. Bees will sting if they become caught in clothing, or hair, which may happen if you are standing in their flight path. If caught in hair, the bee needs to be removed, and killed as quickly as possible as they will usually sting if not removed.

To minimizes the chance of being stung:

- Don’t stand in the colony’s flight path.
- Don’t open, knock or interfere with the beehive.
- Avoid mowing close to hives.
- If you need to work close to hives talk to the beekeeper first.

The aggressiveness of a colony can be temporarily reduced using the same method that a beekeeper uses. This is by blowing smoke into the hive entrance. As the colony has to be approached closely before doing this, the beekeeper should be consulted beforehand. The beekeeper might also be able to provide protective clothing and a smoker. People’s reactions to

stings vary considerably. The sting should be removed as soon as possible. This is best done by scraping the sting out with a fingernail. Squeezing the sack on the bee sting will not increase the amount of venom injected. For most people, the only effect of a sting is a sharp pain and possibly some localized swelling. Localized swelling is usually not a life threatening problem unless you are stung on the throat or tongue. However, more generalized symptoms can be more serious. The symptoms generally appear within a few minutes, but in some cases may be delayed for as long as 24 hours.

The following are the symptoms of a serious reaction:

- Severe rapid swelling around the sting site but extending to other areas (e.g., around eyes, lips and general puffiness of face).
- General rash.
- Breathing difficulty, choking sensation, asthma, lips turning blue.
- Vomiting.
- Collapse and loss of consciousness.

As these symptoms can lead to death, administer oral antihistamines if possible and get the person medical assistance as soon as possible. When summoning assistance it is important to stress the urgency of the situation. It is good practice to check with staff and anyone else working in the crop during the time the hives is there for pollination to see if they are allergic to bee venom. If they are allergic, they should seek medical advice as there is a chance that they may be stung.

Honey bees swarm as a normal part of their colony's reproductive cycle. The colony produces a new queen to head the colony while the old queen leaves with half the bees to form a new colony. This usually happens in spring when the colony is collecting small amounts of nectar. A colony may also swarm if it runs out of space in its hive. A colony can swarm several times in a season. The swarm will usually hang from a tree or other object within 100 m of the parent colony and stay there while bees from the swarm hunt for a suitable cavity. The swarm may stay in the same place for a few hours through to several weeks. If a swarm cannot find a suitable

cavity to occupy, it may set up home where it is hanging, build comb and rear larvae. In warm climates, these colonies may survive the winter.

When a swarm leaves its parent hive, the workers gorge themselves with honey hence for the first few days are usually docile and unlikely to sting people. However, the swarm can become aggressive if it has been present for a longer time and has begun to get hungry. Bees from a swarm will visit flowers for nectar. However, as they have nowhere to store the nectar they will collect much less nectar than a similar sized colony. They do not normally collect pollen as they have no larvae to feed. Because of this, swarming is usually detrimental for pollination. The beekeeper should be asked to replace any hive that swarms. Beekeepers can usually minimizes swarming by ensuring colonies have spare room in their hive and that the queen is less than one year old. Some strains of bees are more likely than others to swarm. If a swarm has landed in an inconvenient location, a beekeeper will be needed to remove it. If they are not causing problems they can be left alone and will usually fly away after a few days.

Unfortunately, any discussion of honey bee biology would not be complete without including varroa. Varroa is a mite that evolved on *Apis cerana* where it infests drone brood. Sometime before 1940 varroa jumped species onto the Western honey bee that had been introduced into Asia. It has spread since then to almost all countries, and can be found in all beehives in New Zealand. If colonies are not treated with miticides twice a year, varroa will usually kill them. This has added significantly to the cost of keeping bees, and much of this cost has been added onto the cost of providing hives for pollination. In most countries, varroa have developed increasing resistance to the chemicals used to control them, which has resulted in higher hive losses and increasing costs in maintaining hive numbers and providing pollination services.

Honey bees are very efficient at exploiting the flowers surrounding their hive. Most bees forage within a 1 km radius of their hive but they will fly in excess of 5 km to exploit a very rich patch of flowers. A colony may therefore have a foraging range of more than 70 square kilometers. The workers from a colony are consistently sampling the flowers within the colony's foraging range and moving the colony's foraging effort to the most attractive flowers. When a colony is moved to a crop, its bees usually forage on flowers from the crop as these are the first ones found. However, if the colony can find more rewarding flowers, it may move its foragers from

the crop onto these new flowers. The attractiveness of a group of flowers depends on a number of factors. These include the distance the bees have to fly to reach it, the number and density of flowers, the amount and attractiveness of pollen, the amount and the sugar concentration of the nectar, and what the colony requires. Competing flowers can be a major problem for some crops. Honey bee colonies may be introduced to the crop in very high densities but if the flowers are not very attractive and there are large numbers of more attractive flowers surrounding the crop, the bees may desert the crop completely.

If you check flowers of a crop at different times of day, you'll find large variations in the number of honey bees visiting flowers. This is because of variations in the time of day that pollen and nectar are produced by the flowers. If honey bees are not foraging at a particular time of day it is usually because there is no pollen or nectar available rather than that the bees are ignoring the reward the flowers are offering.

Honey bees will not usually readily forage below 15°C. However, for most plants, cold weather will stop flowers producing pollen and nectar before it will stop bees from flying to visit flowers. Honey bees do not forage in heavy rain.

For a colony to survive, its workers must look after the larvae in the hive and forage for nectar, pollen. Honey bee swarm on a traffic sign. Up to a certain size, the colony has to manage these competing demands on the worker bees. The more larvae they have to feed, the more pollen and nectar they need to collect. However, as the number of bees in a colony increases there will be more worker bees than is required for the colony to meet its daily demand for nectar and pollen. These surplus bees will devote their time to collecting nectar, which will be turned into honey to be stored for the winter. For this reason, beekeepers normally want their colonies to have as many workers as possible when they are using them to collect a honey crop. The makeup of a colony therefore has a large effect on what the worker bees collect. The more brood in a colony, the more pollen the bees will collect. However, as the ratio of bees to brood increases, the amount of nectar a colony will collect increases.

Individual honey bees normally exhibit floral constancy while foraging. In a paddock of clover and dandelions, some bees will visit all clover flowers while other bees will visit all dandelion

flowers. Very few will visit flowers of two different species during the same foraging trip. According to the famous naturalist Charles Darwin, this behaviour enhances pollination as it reduces the chance of pollen being carried to the wrong flower species. However, the behaviour can have a negative effect on crop pollination. Artificial selection to develop a plant species into a commercial crop often produces male flowers that look significantly different (in the eyes of the honey bee), from the female flowers to which the pollen needs to be moved. This may limit the amount of movement between the flowers if bees start to treat the different sexes of flowers as though they are different species; which is an issue in some hybrid carrot and radish varieties.

Rather than foraging randomly over a patch of flowers, individual honey bees tend to have foraging areas. These are groups of flowers from the same plant species that a bee will come back to on successive foraging trips. The size of these foraging areas depends on the density of flowers and the amount of nectar and pollen per flower. These foraging areas are reached by the bees flying over the crop rather than by visiting flowers on the way. Foraging areas are an important consideration because they affect the movement of bees in a crop and the likelihood that a bee will encounter a pollinizer (The New Zealand Institute for Plant & Food Research Limited).

1.7 Rational of the Study:

Keeping in view the above related facts, the present study was undertaken with the following objectives:

i. To know the existing agronomic practices of onion cultivation
ii. To know the pollination behavior of bee
iii. To study the effect of honey bee on onion seed production and its yield.
iv. To investigate the growth parameter of onion and bulb yield.
v. To investigate the pollinator of onion flower other than honey bee.

CHAPTER 2
2.0 REVIEW LITERATURE

2.1 Comparative performance of honeybees (*Apis mellifera* L.) and blow flies (*Phormia terronovae*) in onion (*Allium cepa* L.) seed testing.

The experiment was laid out in a randomized complete block design with three treatments (caged plants with honeybee, caged plants with blow flies and caged plants without pollinators-control) and four replications each. Number of seed sets from 10 umbels, one from each replication were counted and weighed. The number of seed sets in caged plants with honeybees was maximum as compared to plants caged with blow flies and control. The same treatment also produced maximum seed weight as compared to other treatments. The results revealed that onion seed setting is dependent on insect pollination. The weight analyses were significantly different in all treatments. It is concluded that honeybees visitation to the flowers is important for pollination but blow flies can be used as an alternate pollinator when honeybees are not available. Blow flies are equally good candidates for experimental purposes for pollination (**Munawar, *et al*., 2011**).

2.2 The pollination biology of onion (*Allium cepa* L).

Managed pollination is an essential input in enhancing the crop productivity. In recent years, there has been an increase in the accumulation of data to indicate that seed yields of insect pollinated crops may often be lower than the expected, not because of adverse climatic, edaphic or cultural factors, but simply because the number of certain pollinators is inadequate. In absence of pollination in many entomophilous crops, fruit or seed set is affected adversely even if all the cultural practices are followed meticulously. Insect pollinators set a greater proportion of early flowers of the crop and increase quality and quantity of the seed yield. Before the use of managed pollination, it is necessary to have a basic knowledge of factors which influence pollinator activity and preference of the pollinators for different crops. This review summarizes the pollination biology of the important vegetable crop, *Allium cepa* L., commonly known as onion (**Devi, *et al*., 2015.**).

2.3. Managed honeybees (*Apis mellifera* L.) increase onion (*Alliun cepa*) seed yield and quality.

Nearly 75% of the world's flowering plants are dependent on insects for pollination, with honeybees being well known for their importance for several crops. The effect of managed honeybee pollination on onion seed yield and quality was investigated through pollinator exclusion and pollinator surveys on onion field. The treatments were: plots accessible to all flower visitors (CTL); plots not accessible to any insects – the plots were covered with an insect proof mesh cage before the ray florets started opening (NI); plots accessible only to honeybees – the plots were covered with an insect proof mesh cage and a honeybee colony with four frames was placed inside the cage during the flowering peak

(HB). Honeybee colonies used in this experiment received supplementary feeding (dissolved sugar) and water before and after they were placed in the cages. Open pollination treatments especially with honeybees increased onion seed quantity and quality (**Gebreamlak and Kiros., 2014**)

2.4. Effect of different modes of pollination on yield parameters of *Allium cepa L*.

Investigations on the effect of different modes of pollination on yield parameters of *Allium cepa* L. showed that maximum seed were set per umbel under Open-pollination + hand-pollination (1430 seeds) followed by Open-pollination (1247 seeds), Bee-pollination (1217 seeds) and Hand-pollination (959.6 seeds). The least number of seed set (90) was observed in those plants from which the pollinators have been excluded by covering the umbels with the help of cage (Self-pollination). Percent relative seed setting per umbel depicted a contribution of 29, 25, 25, 19 and 2 per cent with open-pollination + hand-pollination, open-pollination, bee pollination, hand-pollination and self-pollination, respectively. Average seed weight was maximum (28.37 g/5 umbels) under Hand-pollination + Open-pollination. The number of germinated seeds showed more number of seeds (109 seeds) under Hand-pollination + Open-pollination. The average seedling length and root length were highest in bee pollination. (**Devi *et al*., 2015).**

2.5. Effects of seed onion pollination by red mason bee females *Osmia rufa* L. (Apoidea; Megachilidae) with different body weights

The study was aimed at determining the impact of body weight of red mason bee *Osmia rufa* L. females on the pollination efficiency of seed onion *Allium cepa* L. and the quality of seed yield. The results obtained demonstrated that the body weight of *Osmia rufa* females used for onion pollination had no significant effect on the pollination efficiency nor the quantity or quality of seeds. It can be observed that the percentage of fruits set compared to the number of flowers in an inflorescence tended to decrease with smaller body weights of the bee females from particular experimental groups. In addition, the other experimental results (total seed yield, germination energy and capacity) confirmed that weaker parameters of pollination efficiency and seed quality were achieved in the case of onion pollination by females with the lowest body weight. (**Giejdasz *et al*., 2005**).

2.6. Effects of insect pollinators on onion seed production quality and Quantity.

To evaluate the effects of presence of insect pollinators on quantity and quality of seeds of two common cultivars of onion (*Allium cepa* L.), namely Red Azar Shahr and Yellow Sweet Spanish, an experiment. Bulbs of equal size were planted with plant to plant 35 cm and row to row 50 cm spacing. At each site, experimental groups differ only in pollination method. About a week before flowering start, at each site 3 groups of 10 individual inflorescences as block replications of each treatment combination (pollination × cultivar) were selected randomly and marked. For each onion cultivar, half of the plants were left uncovered (free pollination), whereas the other ones were isolated from insect

pollinators by using wooden cages covered with cloth net. When about 10 percent of black seeds were visibly exposed in the umbels, harvest was done. After drying, the number and weight of seeds produced per inflorescence as well as 1000 seed weight was measured for each treatment combination. Four weeks after the harvesting date the germination test of seeds produced in each treatment combination was evaluated. Non availability of insect pollinators during the flowering period of onion caused substantial reduction on seed number and seed weight per umbel. Also, free pollination flowers showed higher germination capacity than those isolated from insect visitors. However, varieties as well as experimental sites did not show significant influences on seed setting of onion. (**Adel *et al.*, 2013**)

2.7. Honey bee management and wild bees for pollination of hybrid onion seed.

Onion (*Allium cepa* L.) seed yields, particularly hybrid seed, are heavily dependent on bee pollinator activity for pollination, seed set and adequate yields. In commercial production of seed, the industry depends on the honey bee (*Apis mellifera* L.) for pollination. Mere placement of colonies of honey bees in or adjacent to onion seed fields does not guarantee bees will work the field. Onion seed yields vary enormously depending on the number of honey bees accomplishing pollination. Application of materials to attract more honey bees into the fields was tested using Bee Scent, Bee-Here, Fruit Boost and Jack Daniels whiskey. We investigated serial introduction of honey bee colonies into the same onion field, feeding honey bee colonies onion syrup, stripping colonies of nectar and pollen, using the Hi-Line onion- collecting honey bee strain, and conducted preliminary selections for colonies that preferred foraging on onion. Experiments with the onion crop were overhead irrigation to dilute the nectar and interplanting onion seed with alfalfa to attract bees to the field. We investigated bumble bees (Bombus occidentalis Greene), alfalfa leafcutter bees (Megachile rotundata (Fabr.)), the blue orchard mason bee (Osmia lignaria Say), the horned mason bee (Osmia cornifons) and the alkali bee (Nomia melanderi Cockerell) for pollination of onion seed none of the experiments effectively increased numbers of honey bees n or the wild bees, and none greatly improved onion seed yield. (**Mayer and Lunden, 2001**).

2.8. Indirect effects of field management on pollination service and seed set in hybrid onion seed production.

Productivity in many agricultural crops depends on reliable pollination service; however, pollination may fail if crop management practices interfere with the attraction and retention of pollinators. Farmers must balance optimizing management decisions such as insecticide use and irrigation frequency for pest and disease management versus their potential to interfere with the pollination process. We investigated these issues in hybrid onion seed production, where previous research has shown that high insecticide use interferes with honey bee (Apis mellifera) attraction. We conducted field surveys of soil moisture, nectar production, honey bee visitation, pollen-stigma interactions and

seed set at multiple commercial fields across two years. We then examined how management decisions, such as irrigation and insecticide use could affect the pollination process. We found that onion flowers produced maximum nectar at intermediate levels of soil moisture, and that high nectar production was positively related to honey bee attraction. Insecticide use was reduced compared to previous studies, and showed weaker effects on honey bee visitation. Similarly, there were weaker effects of insecticides on pollen-stigma interactions, but we did find that sites that were sprayed close to bloom had reduced pollen germination and pollen tube growth. Ultimately, neither soil moisture nor insecticide use directly affected seed set– rather there was a high correlation between honey bee visitation and seed set, suggesting that crop management practices will ultimately affect yields via indirect effects on the pollination process (**Long *et al.*, 2014**).

2.9. Patterns of floral nectar production of onion (*Allium cepa* L.) and the Effects of environmental conditions.

Successful pollution of onion (Allium cepa L.) flowers greafly depends on adequate nectar production. I order to understand the nectar production dynamics of onion flowers, nectar was collected at regular intervals during a 24-hour period. Hourly nectar volumes were compared to a variety of environmental conditions, including amount of solar radiation, relative humidity, temperature, wind speed, and evapotranspiration. Production patterns showed mid-to late-morning peaks and late-evening peaks in nectar volume. Nectar appeared to be reabsorbed by the flowers during the afternoon and overnight hours. Individual flowers produced the highest amount of nectar several days after initially opening. Nectar production was significantly and inversely related to humidity while the effects of temperature, evapotranspiration, wind speed and solar radiation on nectar production were not significant in this study (**Silva and Dean, 2004**).

2.10. Pollinator Community of Onion *(Allium cepa L.)* and its Role in Crop Reproductive Success.

Investigations to identify the pollinator community of insects and its role in onion (*Allium cepa* L.) pollination were carried out at the research farm of University College of Agriculture, Bahauddin Zakariya University, Multan, Pakistan. The community of pollinators was composed of two bees (Order: Hymenoptera) and eight true flies (Order Diptera). Among bees, *Apis dorsata* proved to be an abundant pollinator (2.85±1.57 individuals/25 plants) while among true flies *Episyrphus balteatus* (Syrphidae) had the maximum abundance of 14.00±4.61 individuals/25 plants. All the insect pollinator species reached peak activity during 10:00 to 12:00 h. *Eupeodes corollae* (Syrphidae) exhibited the most efficient foraging behavior by visiting 17.14±1.38 flowers in 147.5±8.14 seconds on an umbel. *A. dorsata* was revealed as the most effective pollinator, however, based on seed setting results for visits by single species over 20 minutes and which produced 506 seeds/umbel/20 minute visit (**Sajjad *et al.*, 2008**).

2.11. Foraging and pollination activity of Apis mellifera adansonii Latreille (Hymenoptera: Apidae) on flowers of *Allium cepa* L. (Liliaceae) at Maroua, Cameroon

To evaluate the impact of Apis mellifera adansonii (Hymenoptera: Apoïdae) on fruit and seed of Allium cepa its foraging and pollinating activities were studied in Maroua, from November 2010 to April 2011 and 2012. Treatments included unlimited floral access by all visitors, bagged flowers to avoid all visits and limited visits of A. m. adansonii. Observations were made on 120 flowers per treatment. Flowers of Al. cepa were prospected four days per month, between 07.00 and 18.00 h, for recording of the nectar and/or pollen foraging behavior of each pollinator. The worker bee's seasonal rhythm of activity, its pollination efficiency, the fruiting rate, the number of seeds per fruit and the percentage of seeds well developed were recorded. Results show that honey bee intensely and preferably foraged for nectar, almost throughout the day, with a peak between 8 and 9 am. The foraging speed was 47.12 ± 7.19 flowers per minute. Individuals from 22 species of insects were recorded on flowers of Al. cepa. A. m. adansonii was the most frequent with 40.62% and 51.48% of visits in 2010 and 2011 respectively. Its foraging resulted in a significant increase in the fruiting rate by 62.5% in 2010 and 53.8% in 2011, as well as the number of seeds per fruit by 86.44 in 2010 and 89.77% in 2011, and the percentage of normal seeds by 63.26 in 2010 and 59.78% in 2011. The use of A. m. adansonii colonies is suggested to increase fruits, seeds and honey production (**Tchindebe and Fohouo, 2014**).

CHAPTER III

3.0 MATERIALS AND METHODS

The study was conducted at the experimental field of "Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)" is a collaborative project lead by Caritas Austria under the supervision of Caritas Bangladesh, Project number of European Commission: DCI-FOOD 2010/230-309 at Baraigram, Natore, Rajshahi-6000 during the winter season (from 05 Nov 2014 to 05 April 2015) with a view to investigate *"Performance assessment of honey bee on pollination of onion flower".*

This experimental design was set to investigate the effect of honey bee vector on seed production of onion (*Allium cepa*) in rainfed area.

There were used two types of treatments which were Treated plot (with honey bee vector) and Control plot (without honey bee vector). There were 2 treatment plots: T1: three clusters as plot A, plot B, plot C got honey bee box and T2: one cluster was without honey bee box as control plot D). A significant response of onion seed production to different treatment (with honey bee and without honey bee) was observed. In this chapter, details of different materials used, methodologies used for the experiment and processing the data have been presented.

3.1. Experimental site

3.1.1. Location

All experimental sites were located in villages of Kumrul, Joari union, Baraigram upazilla at Natore districts of Rajshahi division. The experimental sites are situated in the agro-ecological zone (AEZ) FAO-3 that lies between 24.3083°N latitude and 89.1708°E longitude. The elevation of the experimental site was 15m above mean sea level.

Fig: 3.1. Location map of experimental fields on Onion

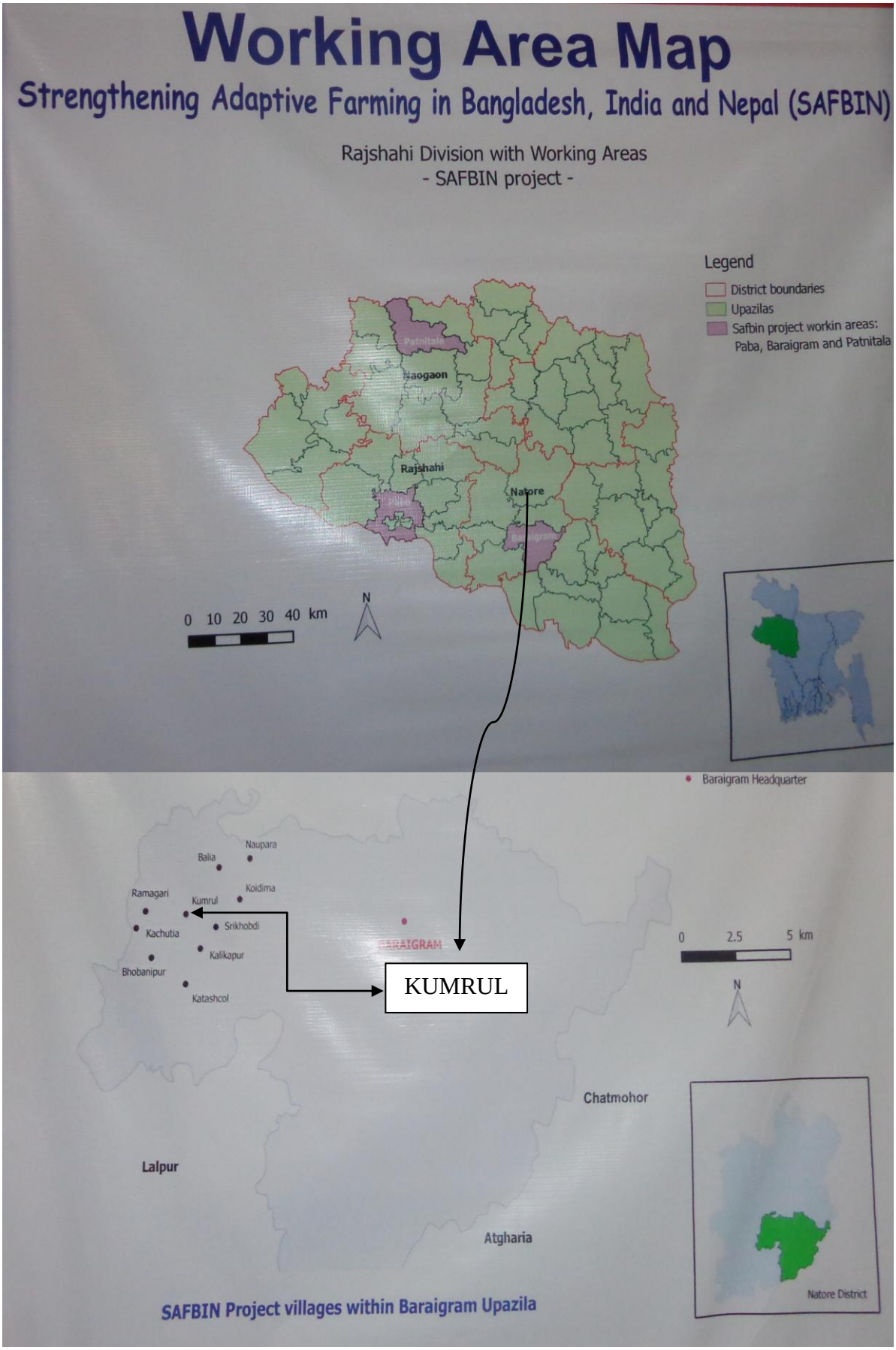


Fig: 3.2. Sources of SAF-BIN Project, Boraigram, Natore, Rajshahi.

3.1.2. Soil

The soil of the experimental field belongs to Lower Atrai Basin with silt loam underlain by sandy loam. Some physical properties of the soil were determined which are listed in (**Table 3.2**).

Table: 3.2. Some properties of the soil in the experimental field

Sand (%)	Silt (%)	Clay (%)	Textural class	pH	Total N (%)	Particle density (g cm-3)	Bulk density (g cm-3)	Soil porosity (%)
54.32	**38.25**	**7.43**	**Sandy loam**	**8.20**	**0.118**	**1.67**	**1.21**	**79.33**

*Data from, Soil Research Development Institute (SRDI), Dhaka, Bangladesh.

3.1.3. Climate

The climate of the experimental site falls under the sub-tropical, which is characterized by high temperature, high humidity, and average rainfall of 1862 mm with occasional gusty winds in kharif season (April - September). Whereas, less rainfall associated with moderately low temperature exits during the winter season (October–March). Weather information on rainfall, temperature, relative humidity, at the experimental site during the period of the study is presented in Table 3.2.

Table: 3.3. Weather data of the experimental site during the cropping period (December 2014 to March 2015).

Parameters	Months					
	December	**January**	**February**	**March**	**April**	**May**
Rainfall (mm)	10.6	11.3	17.5	24.8		
Mean maximum air temperature (°C)	25.8	24.5	27.7	33.1		
Mean minimum air temperature (°C)	17.8	11.0	11.0	13.1		
Mean average relative humidity (%)	78	78	71	63		

*Data from (Metrological Department), Dhaka, Bangladesh.

3.2. Land Preparation

The land of the experimental field was first opened on the experimental field is different filed of shown in the (**Table. 3.4**) November 2014 with a tractor. Then the field was dried for some days to reduce moisture content. Later on, the land was ploughed (with local farmer practices) and cross ploughed four times with a power tiller to obtain a good tilth condition. The size of per plot was 10 decimal and there were two treatments used. All the weeds and stubbles were removed from the field and thus, the land was made ready for sowing. Prior to sowing the whole experiment at field was (T1) divided into three plots (3 plots in the same place called treated plots using honey bee vector) and another one was situated in different place which was (T2) one plot(without honey bee vector). In the all plots the big clods was broken into small.

Table: 3.4. Cultivated on the experimental field for land preparation date

Treatment			
T1 (With Honeybee)			T2 (Without Honeybee)
A	B	C	D
02/11/14	02/11/14	01/11/14	07/11/14

3.3. Treatment design of the experimental area

The experimental plots were laid out with local farmer's practices. There were two treatments using honey bee box and without honey bee box according to the farmer's practices. T1: Three clusters as plot A, plot B, plot C got honey one bee box as treated and T2: one cluster D was without honey bee box as control. All of these events were randomly chosen to avoid any biasness towards the selection. For all hydrological information and soil information, the weather station at Bangladesh Metrological Department and Soil Research Development Institute, near the experimental site was consulted.

3.4. Selection of onion variety

The experimental variety was the bulb of "*Taherpuri* onion" which is a local cultivar. Taherpuri is the onion growing area under Boraigram, Upazila in Rajshahi district. Onion is well grown in this area, According to the name of Taherpur area; this variety is called Taherpuri. It has some special characteristics, such as highly pungent, shiny; narrow necked, hat shape, very high keeping quality and compact single bulb (Asaduzzaman *et al.*, 2012).

Fig: 3.1. Seeds of Taherpuri Onion

Table: 3.5. Calendar of intercultural operations for the experimental plots

Activities	Date			
	T1			T2
	A	B	C	D
Bulb sowing	10/11/14	10/11/14	06/11/14	12/11/14
1st Weeding	28/12/14	28/11/14	25/11/14	20/12/14
1st Irrigation	22/12/14	29/11/14	27/12/14	28/11/14
2nd Irrigation	10/01/14	08/01/14	18/01/15	07/01/15
3rd Irrigation	25/02/15	25/02/15	25/02/15	07/01/15
Harvesting	25/03/15	25/03/15	25/03/15	05/04/15

3.5.2. Fertilizer doses

During the land preparation Cowdung 120kg for 10 decimal land use of 50% dose fertilizers Urea: 10kg, TSP: 8kg, MoP: 6kg, Urea two third Nitrogen (N) and total amount of fertilizers

were applied at sowing and the remaining Nitrogen (N) and MoP was top dressed after second and third irrigation.

3.6. Bulb sowing

Bulb sowing was done by after land preparation. Field was formed and planting was done by prior land preparation. Field was consisted by rows depending on the crop on raised. Bulb to bulb spacing was 15cm and Line to line spacing was 30cm. For sowing the bulb in rows 2-3 cm deep line were made manually by using single tine and rakes.

3.7. Gap Filling

Some extra bulbs were also planted at the border of the experimental field. This was done to replace rotten bulbs of experimental plots by healthy ones according to the treatments from the border within 7 days of planting of the experimental field.

3.8. Cultural practices

A pre-sowing irrigation was applied for proper seed germination. A high yielding local variety Taherpuri was sown in the experimental plots on 6 November 2014 with the help of farmer’s practices. Bulb was done by land preparation with line to line. Field was formed and bulb was done with prior land preparation. Field was formed line to line accommodating onion. Field depth was 12-13 cm. Irrigation water was applied to fields. Ploughing and leveling were done through one local farmers practice and used in farmer's practice for bulb sowing.

Two–thirds of N and MoP total fertilizers were applied top dressed after first and second irrigation. At maturity, 4 samples of Treated and Control treatment on 25 March 2015 and 05 April, 15 were harvested. After threshed and cleaned, seed yields were recorded at 12% moisture content. Data on other plant characteristics during harvesting from each of the experimental plot were recorded, Plant height (cm), Scape length (cm), Number of umbels per plant, Umbel diameter (cm), Thousand seed weight, Germination percentage and grain yield were recorded. Data were subjected to analysis of variance to sort out significant difference among treat.

3.9. Staking

Staking was provided by using dhaincha sticks to keep the scape erect and to protect them from lodging by strong wind and storm.

3.10. Intercultural operations

3. 10.1. Weeding

After sowing the bulbs, continuous observation was maintained to keep required number of plants in each treatment. During sowing bulbs were sown carefully. In these places thinning were done after 10 days of sowing.

Weeds grown in the experimental plots were uprooted by weeding. First weeding was done 10 days after sowing. Subsequent weeding was done followed by application of irrigation water. There was no significant infestation of pests and diseases in the fields and hence no control measure for this purpose was required. Various intercultural operations were undertaken during the crop growing period as presented in (**Table 3.3**).

3. 10.2. Harvesting and crop sampling

The matured umbels were harvested from treated plots(A,B,C) on 25 March, 2015 after 145 days of sowing and the control plot (D) on 04 April,2015 when the fruits had exposed black seeds (Meer *et al.,* 1968). Umbels were harvested in the morning with a small portion of flowering stalk to prevent shattering of the seeds. At the time of harvesting 10m² area was harvested separately for research purpose.. Randomly 30 plants were collected for taking experimental data. The harvested umbel of each treatment was packed separately and tagged properly. Harvest dated on represent (Table 3.5) Calendar of intercultural operations for the experimental fields.

3.11. Experimental data recording

After recording of data on plant height, scape length, umbel per plant, umbel diameter, seed yield per plant, seed yield per hector, and scape diameter, thirty umbel from each plot collected from field during harvesting period and then dried in the sun. Each umbel was separately packed because of seed loss. Threshing, cleaning and drying of umbels for 7 days (approx.) or until the seed came out from umbels after slightly rubbing, and collected seed from each plot were done carefully. Seed from each umbel collected very carefully and counted seed number per umbel then packed seeds got per umbel separately. Finally, the seed yield and yield contributing parameters were recorded separately. The following data were recorded from onion plant

1. **Length of scape (cm):** Length of scape of the sample plants was measured from ground level to tip of the tallest flower scape when all flowers were bloomed the average was taken as the height of the flowering scape.

Fig: 3.1. Measurement of scape length

2. **No. of Abortive Flowers:** The data recorded from visually counted randomly 30 umbels in the field visited.

3. **Scape diameter (cm):** Diameter of flowering scape was measured at the neck with a slide calipers at harvest and their average was taken as the flowering scape diameter and was recorded in cm of 30 sample scape of onion plants.

4. **Flowers per umbel:** The data recorded from visually counted randomly 30 umbels in the field visited.

Fig: 3.2.

5. **No. of scape/bulb:** Number of scape per bulb was recorded as the average of randomly selected thirty (30) bulbs from each plot.

Fig: 3.3.

6. **Main Scape length(cm):** Length of main scape of the sample plants was measured from ground level to tip of the tallest flower scape when all flowers were bloomed the average was taken as the height of the flowering scape and was recorded in cm of 30 sample main scape of onion/plots..

Fig: 3.4.

7. **Bulb weight (gm):** It was recorded from selected 100 bulbs, it was expressed in gram.

8. **Seed yield /umbel (cm):** It was recorded from randomly selected 30 umbels visually counted.

9. **Umbel Diameter/(cm):** Umbel size was determined by measuring the diameter of the umbel. Average diameter was recorded from the sample plants.

Fig: 3.5.

10. **1000- Grain weight (gm):** One thousand grains were randomly counted and selected from the stock seed and weighed by digital electric balance. It was expressed as 1000-seed weight in gram (gm).

11. **Seed yield per plant (gm):** It was recorded from randomly selected 30plants and was expressed in gram.

12. **Seed yield (ton/hectare)**

3.12. Laboratory experiment

Collection of data:

1. **Number of seeds per flower:** Number of 30 flowers after harvested from plant was recorded.

2. **Seed yield / plant (g):** The weight of seeds harvested from the tagged plants was recorded and then seed yield per plant was determined.

3. **Seed yield per hectare (kg):** The weight of seeds harvested from each plot was recorded and then seed yield per hectare was calculated.

4. **The data on thousand seed weight**

5. **Harvested Bulb sizes** viz. small (10±1g), medium (15±1g) and large (20±1g).

3.13. Statistical analyses of crop data

The growth and yield parameters of wheat recorded during the study were tabulated for statistical analyses. An analysis of Variance (ANOVA) was done.

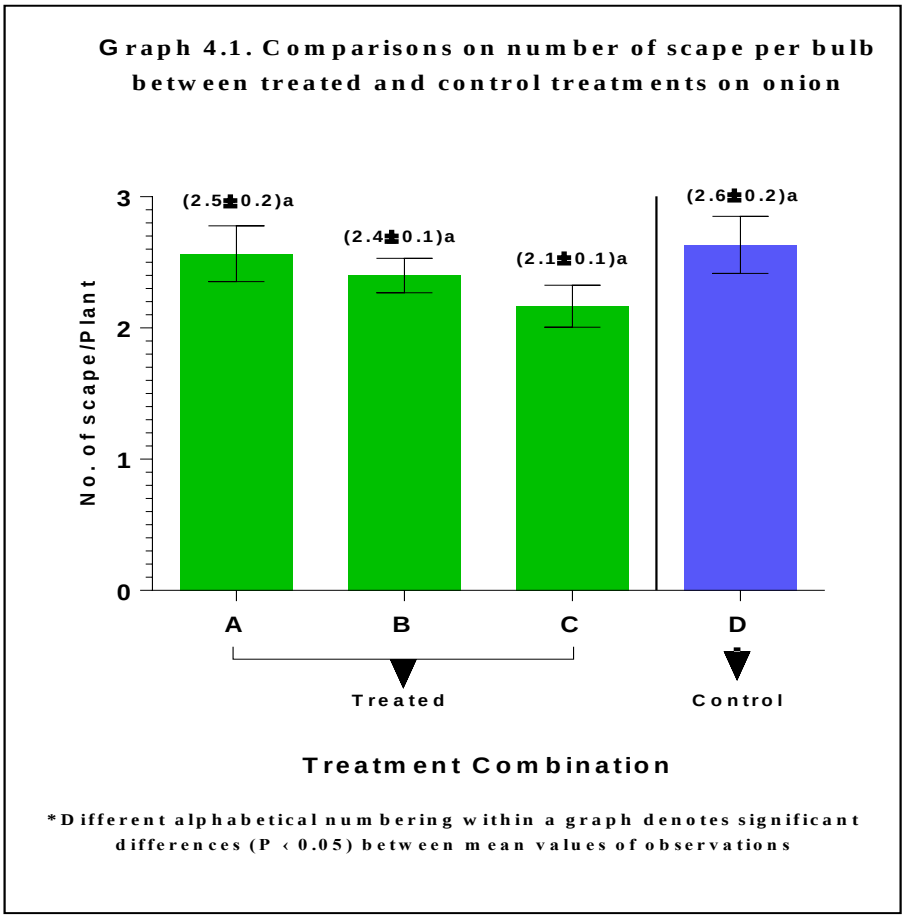
CHAPTER IV

RESULTS AND DISSCUSSION

In general, seed production of onion in fact did not perform promising in rainfed ecosystem. Usually every 10 to15 day's interval irrigation is required to obtain good build as well as seed yield. In this investigation, we studied the effect of honeybee on onion pollination on seed setting with analysis of variance (ANOVA) statistically. Our hypothesis was a in this study clearly indicated that honey bee vector had clear positive effect on onion seed production. Onion seed production should be promoted in irrigated ecosystem rather in rainfed ecosystem. Since, onion is a cross pollinated crops and seed is highly expensive therefore use of honey bee vector for onion seed production should be promoted and The result obtained from this study have been presented, interpreted and discussed in this chapter.

4.1. Effect of treatments on number of scape per bulb

In set of experiment, the data recorded showed that number of scape per bulb at treated plots with honeybee were counted on an average of 2.5±0.2, 2.4±0.1 and 2.1±0.1 in plots A, B and C, respectively, whereas it was better in control plot (D, 2.6±0.2) which was lack of honey bee treatment ((**Table: 4.1, Graph: 4.1**). However, lowest number of scape per bulb was recorded from the treated plot C (2.1±0.1) in our present study among the treated plots. Statistical analysis of the data exposed showed that there is no significant differences among the treatment plots of A, B, C and D which revealed that there were no effect in number of scape on basis of locations of our experimental plots. In other views, El-Helaly and Karam (2012) found that his experiment showed the highest significant value of scape number which is better than our present investigation of onion seeds production. Meanwhile, Ibrahim *et al.* (1996) found that average number of scape were not markedly affected his experiment, but highest than our present experiments.

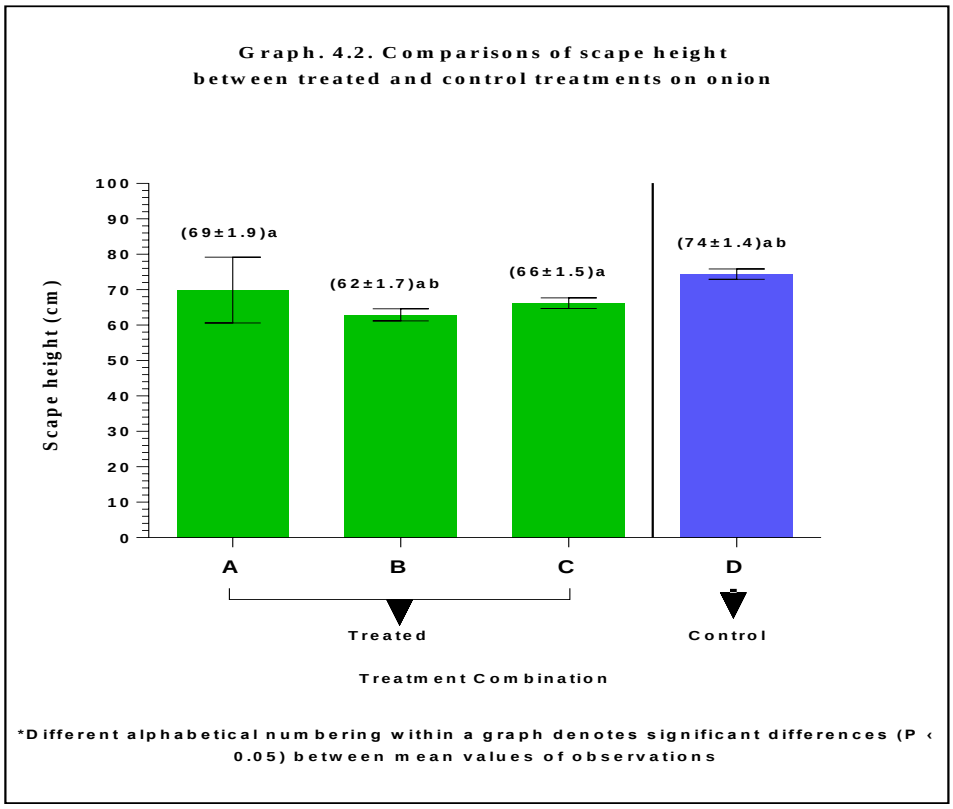


Grpah. 4.1. Number of scape per bulb was influenced by the treated and control plots on onion field.

4.2. Effect of treatments on height of scape

In comparison, the present investigation showed significantly difference in scape length between treated plots (A, B and C: with honeybee) and control plot (D, without honeybee) (**Table: 4.1**). In treated plots, we found that tallest main scape height D (74±1.4cm) was obtained from without honey bee plot where average length was 69±1.9, 62±1.7cm, 66±1.5cm in plots containing honey bee (A, B and C, respectively) (**Graph: 4.2, Figure: 1**). The shortest scape height was recorded from our present treatment on honey bee which was B (62±1.7cm). For instance, Abdel and Al-Juboori, (2006) were found that supplementary irrigation highly increased plant height but in our present investigation scape height were found significantly higher than his findings. In other case, the shoot height increased gradually after planting regardless of paclobutrazol (PBZ) concentration and increase in PBZ concentration reduced significant shoot height throughout the growth period observed by Ashrafuzzaman *et al.* (2009) which was lower than our present investigation. Our present

treatments revealed through statistical analysis of the data exposed that height of main scape was significantly affected by the treatments for A, B, C and D plots.



Graph. 4.2. Scape height was influenced by the treated and control treatments on onion

Figure 1: Collection of measurement on scape length of Onion.

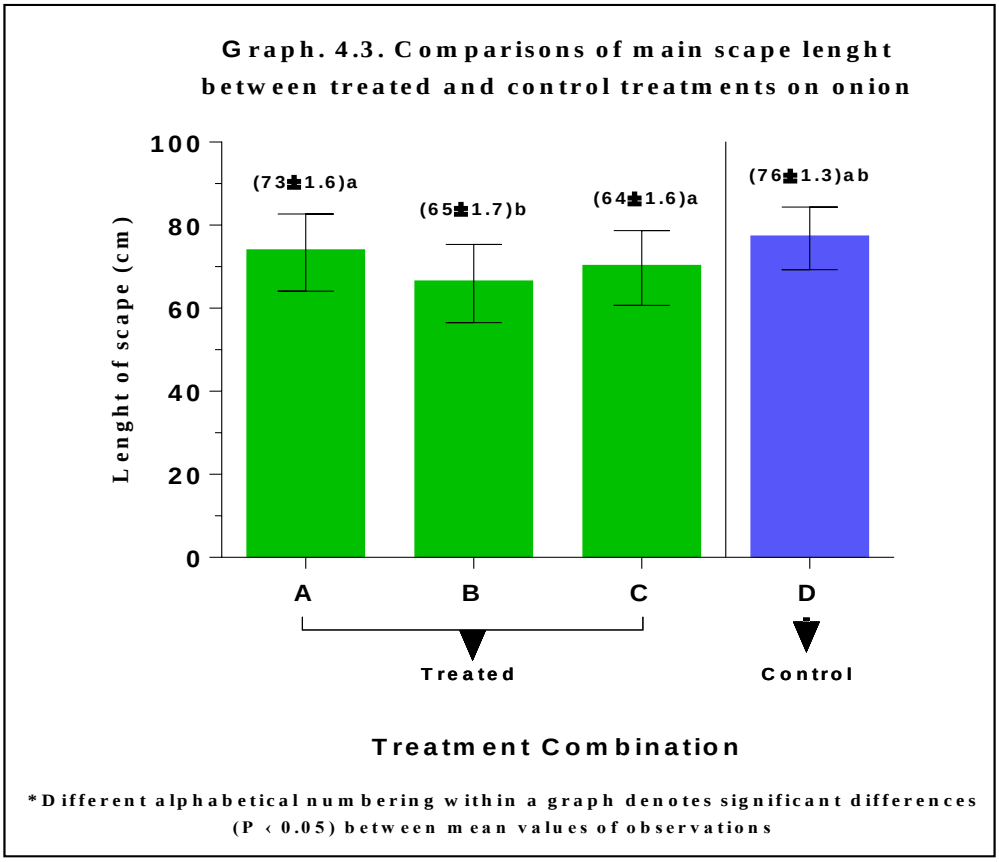
Table. 4:1. Yield and yield contributing parameters of onion as used by pollination vector (honey bee) and control during 2014-2015

Plot`s Name		Scape height (cm)	No. of Abortive Flowers	Scape diameter (cm)	Flowers per umbel	No. of scape/bulb	Main Scape length(cm)
Treat. No. Plots		**01**	**02**	**03**	**04**	**05**	**06**
	A	(69±1.9)a	(34±2.2)a	(1.2±0.08)a	(148±17)a	(2.5±0.2)a	**(73±1.6)a**
T1	**B**	(62±1.7)ab	(23±1.5)b	(1.3±0.06)a	(145±13)a	(2.4±0.1)a	**(65±1.7)b**
	C	(66±1.5)a	(30±2.3)ab	(1.2±0.05)a	(148±18)a	(2.1±0.1)a	**(64±1.6)a**
T2	**D**	(74±1.4)ab	(31±2.0)ab	(1.3±0.06)a	(171±14)a	(2.6±0.2)a	**(76±1.3)ab**

4.3. Effect of treatments on main scape length

The main scape length per plant was significantly varied in different treatment plots. The dissimilarities in main scape length for treatment plots (A, B, C and D) were found to be statistically noteworthy (**Table. 4.1**). A significant difference between treated plots (A, B, C with honeybee) and control plot (D, without honeybee) was found from the resulted data. In treated plots, the main scape lengths were 73±1.6cm, 65±1.7cm, 64±1.6cm counted from plot A, B and C; respectively and from the control plot (D) it was 76±1.3cm which was the highest length of main scape per bulb in our experiment that was from without honey bee plot (**Graph: 4.3**). The lowest main scape was recorded from the treated plot B (65±1.7cm) in our present study. Moreover, Ali *et al.* (2015) has tested that there was significant variation in scape length due to bulb size.

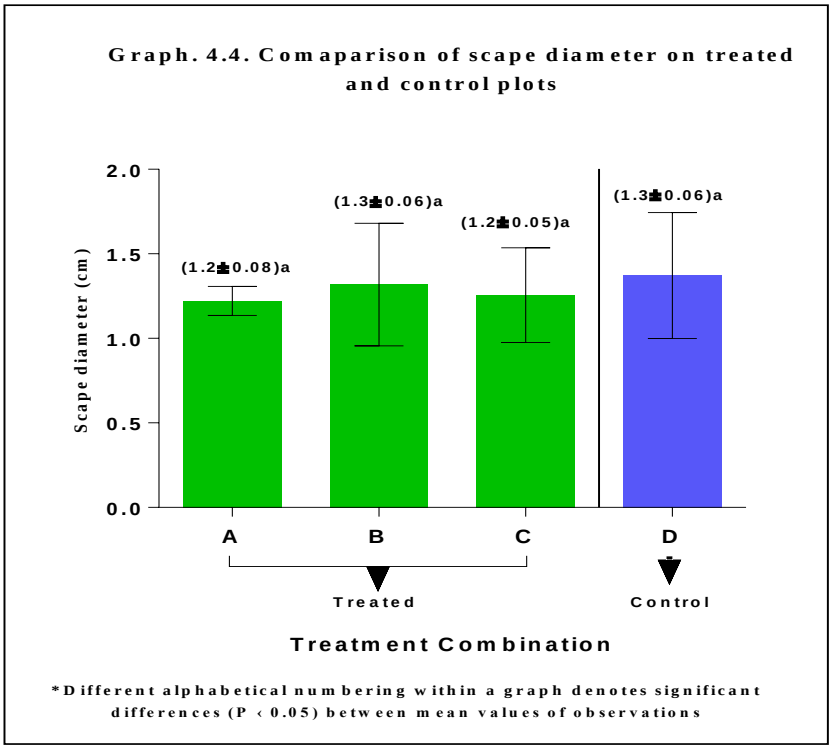
The highest scape length was found in medium size bulb and small size bulb produced the lowest scape length. Similarly, Asaduzzaman *et al.* (2012) and Farag and Koriem (1996) also reported that three times field experiment on onion but our present investigation highest scape length were found. Statistical analysis of the data revealed that treatment was significantly affected and showed significant variation on length of main scape between A, B, C and with D plots.



Graph: 4.3. Main scape length of onion treated and control experimental field

4.4. Effect of treatments on scape diameter

The treatment plots did not show any considerable influence on the scape diameter of onion. It means the factors involved in scape diameter were even and homogenous. The scape diameters for different treatment plots were statistically insignificant (**Table. 4.1**). In treated plots, 1.2±0.08cm, 1.3±0.06cm and 1.2±0.05cm were the average diameter of scape in plot A, B and C, respectively. Meanwhile, it was same in B (treated) and the plot without honey bee (1.3±0.06cm) (**Graph: 4.4, Figure: 2**). The lowest scape diameter was recorded from the treated plot C (1.2±0.05cm) in this present investigation. In the other case, Ashrafuzzaman *et al.* (2009) tested that the highest scape diameter was recorded in plants having larger and medium-sized bulbs, while this value was the lowest in the smaller-sized bulb and scape diameter was significantly reduced in case of smaller sized bulb.



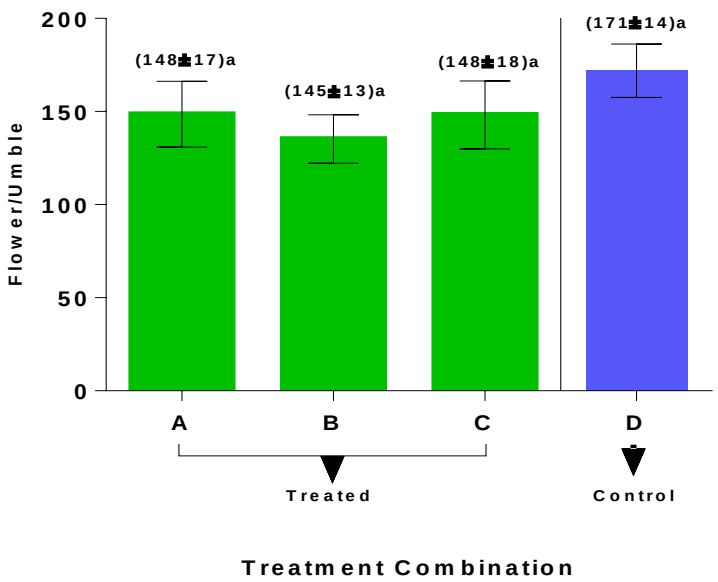
Graph 4.4. Scape diameter was influenced by the treated and control treatments on onion fields

Figure 2: Measurement of scape diameter (cm).

4.5. Effect of treatments on flowers per umbel

Number of flowers per umbel varied considerably due to use two types of treatments. Reduced number of flowers per umbel was found without using honeybee box. Maximum number of flowers observed with using honey bee box in the plots A, B and C. In comparison, the results obtained from the experimental findings showed that insignificant differences in affected flowers per umbel of onion between treated plots (A, B, C with honeybee) and Control plot (D, without honeybee) (**Table: 4.1**). In, treated plots) the flowers per umbel of onion was counted A(148±17), B(145±13), C(148±18), respectively and from the Control plot D (171±14) the flowers per umbel was obtained from without honey bee plot (Graph: 1.1). Although, highest number of flowers per umbel was recorded from the control plot D(171±14) to our present study (**Graph: 4.5**). In the other cases, Asaduzzaman *et al.* (2012) was resulted insignificant effect of interaction maximum number of flowers per umbel, while small bulb size and minimum spacing produced minimum flowers. Statistical analysis of the data exposed that amount of flowers per umbel was insignificantly affected by the treatments for A, B, C and D plots.

Graph. 4.5. Comparative study of flowers of umble between treated and control treatments on onion

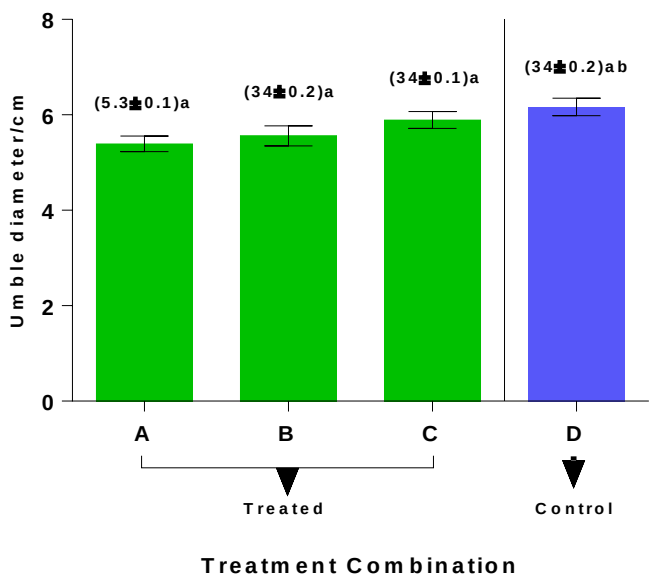


*Different alphabetical numbering within a graph denotes significant differences (P ‹ 0.05) between mean values of observations

4.6. Effect of treatments on umbel diameter

A significant difference between treated plots (A, B, C with honeybee) and control plot (D, without honeybee) was found. In treated plots, A (5.3±0.1cm), B(5.5±0.2cm), C (5.8±0.1cm) were the umbel diameter counted. Control plot D (6.1±0.1) was the highest umbel diameter found from without honey bee plot (**Table. 4.2**) than the treated plots. The lowest umbel diameter was recorded from the treated plot A (5.3±0.1cm) from our present study (**Graph: 4.6**). In a previous experiment, Ali *et al.* (2015) was found a significant differences in umbel diameter of onion and there was significant variation in umbel diameter due to bulb size. The highest umbel diameter was found in medium size bulb, which was followed by large and small size bulb. This might be due to higher supply of food materials to the umbel by larger bulb size. His experimental results were in harmony with us. Asaduzzaman *et al.* (2012) revealed that plants from large bulbs produced the highest umbel diameter while the smallest bulb size produced the lowest diameter. Results of our present experiment was lower than the investigations of Ali et al. (2015) and Asaduzzaman et al. (2012). Statistical analysis of the data revealed that treatment was significantly affected and showed significant variation on umbel diameter between A, B, C and with D plots.

Graph 4.6. Comparisons of per umbel diameter between treated and control treatments on onion



*Different alphabetical numbering within a graph denotes significant differences ($P < 0.05$) between mean values of observations

Table. 4:2. Yield and yield contributing parameters of onion as used by pollination vector (honey bee) and control during 2014-2015

Plots Name		Number of Seed /umbel (cm)	Umbel Diameter(cm*	1000-seed weight (gm)	Seed yield per plant (gm)	Seed yield t/ha	Average Bulb weight (gm)
Treat. No. Plots		**08**	**09**	**10**	**11**	**12**	**07**
	A	(145±13)a	(5.3±0.1)a	2.828	1.621	(19±0.9)a	**0.0375**
T1	**B**	(105±10)a	((34±0.2)a	2.336	0.913	(15±0.7)b	**0.0325**
	C	(156±12)a	(34±0.1)a	2.789	1.181	(16±0.6)a	**0.0175**
T2	**D**	(183±22)ab	(34±0.2)ab	2.819	1.536	(13±0.5)bc	**0.0325**

4.7. Effect of treatments on abortive flowers per umbel

The present investigation has significantly affected flower status of onion at treated plots (A, B, C with honeybee) and Control plot (D, without honeybee) (**Table: 4.1, Figure: 3**). In treated plots, the abortive flower per umbel was counted A (34±2.2), B (23±1.5) and C (30±2.3) and from the Control plot D (31±2.0) which was the highest number of abortive flower obtained from plot where honey comb was not used (Graph: 1.1) than the treated plot. The lowest number of abortive flower was recorded from the treated plot B(23±1.5) in our present study. Statistical analysis of the data exposed that abortive flowers per umbel was significantly affected by the treatments for A, B, C and D plots (**Graph.4.7**).

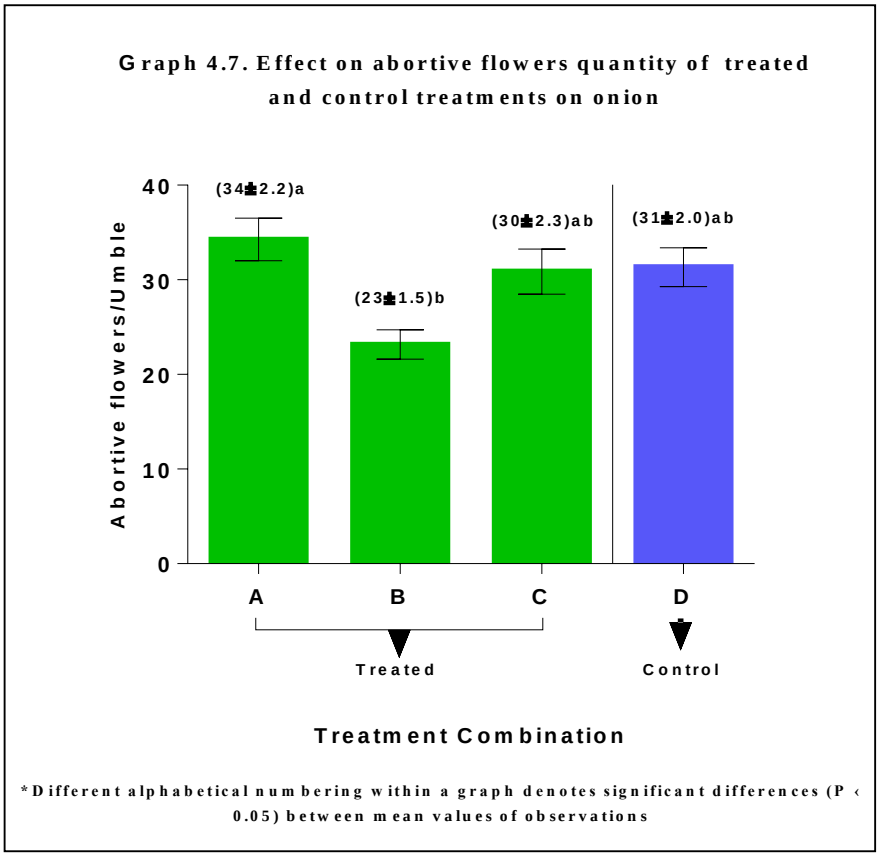


Figure 3: Field observation of abortive flowers an onion flowers treated field.

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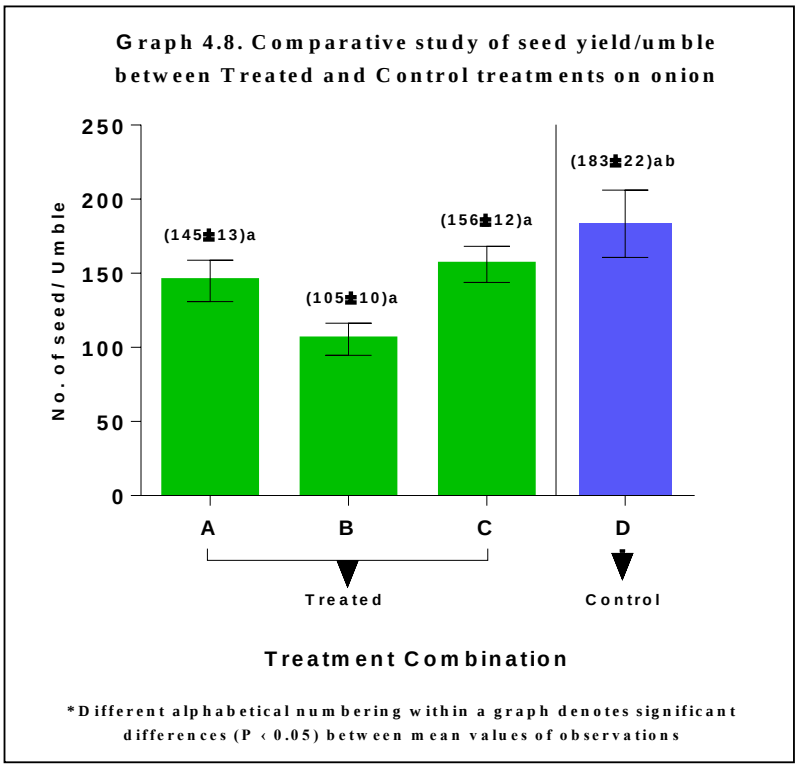
4.8. Effect of treatments on seed number per umbel

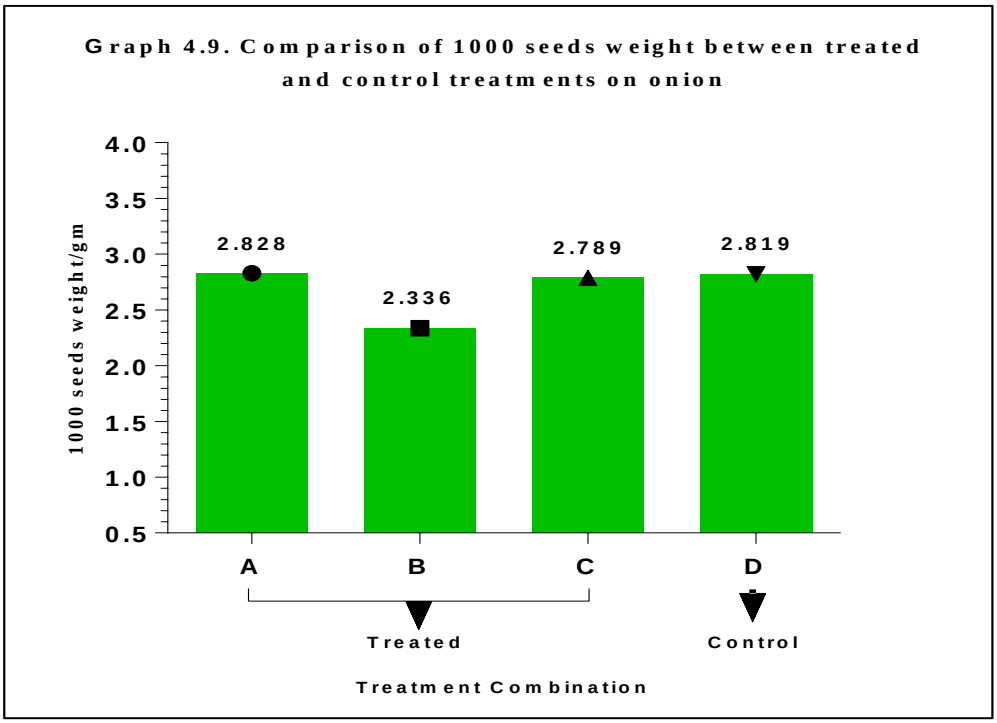
Number of seed per umbel yield was also significantly varied due to different treatments among the honeybee and without honeybee containing plots (**Table.4.2**). The results revealed that the highest seed yield per umbel was obtained from control D (183±22) plot. In comparison to that lowest seed yield per umbel was obtained from treated plot B (105±10). More number of flowers per umbel and flowers per plant caused by the using pollinator as honey bee increased the seeds per umbel. Significant difference between treated plots for plots the seed yield per umbel was 145±13, 105±10, 156±12 in A, B and C and control plot (D, 183±22) was found (**Graph: 4.8**). In our present treatments, statistical analysis of the data exposed that number of seeds per umbel was significantly affected by the treatments for A, B, C and D plots.



4.9. Effect of treatments on thousand seed weight

Seed size is an important parameter of seed quality because bigger seed encourages better seedling establishment in the field. Thousand seed weight had effect on seed weight (**Table.4.2**). However the highest weight of 1000 seed (2.828g) was recorded from with honey bee treatment (A) and the lowest weight of 1000 seed (2.336g) was recorded from with

honey bee treatment (B) (**Graph. 4.9, Figure: 4**) than the control plot which was without honeybee.. These results agree with earlier reports (Kimani *et al*., 1994; Loper and Waller 1982; Rizk *et al*., 1996).



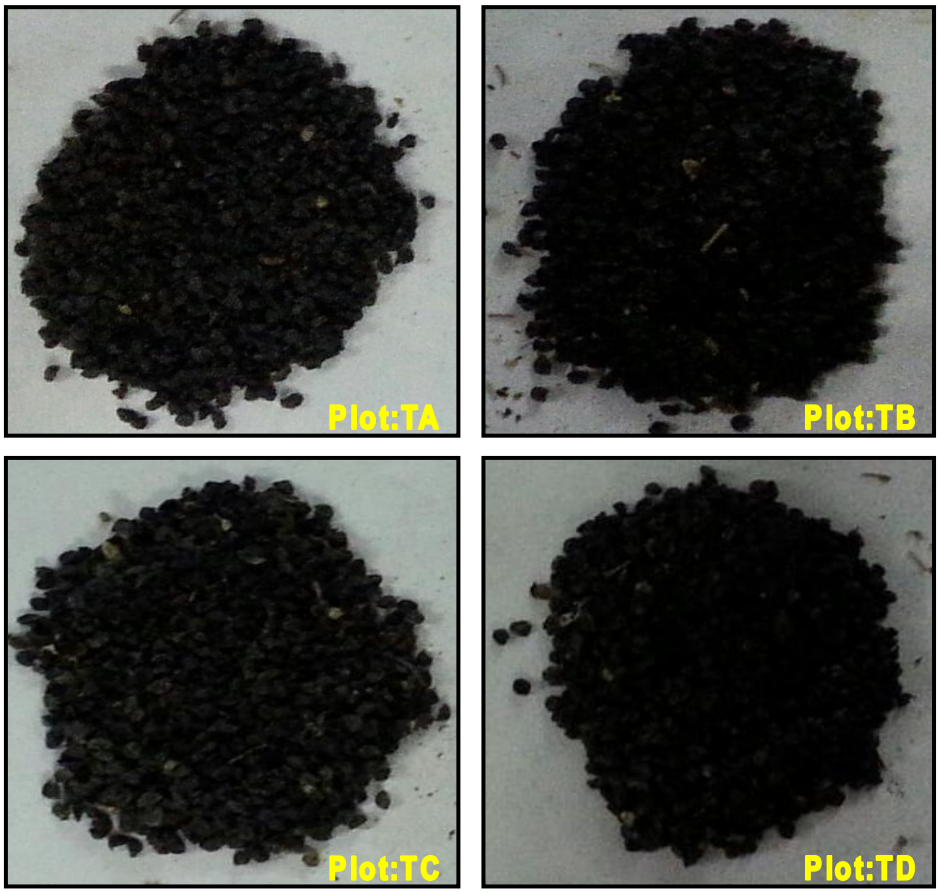
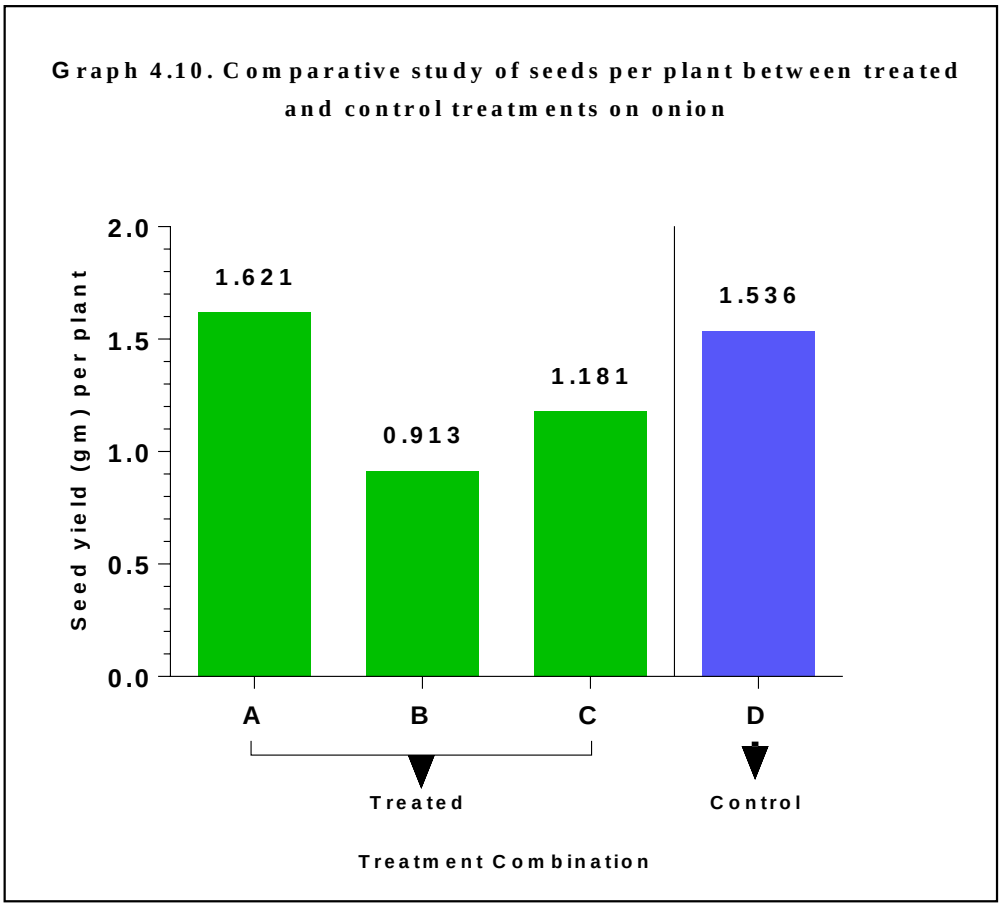


Figure: 4. 1000 seeds of onion in different plots (variety: *Thaherpuri*)

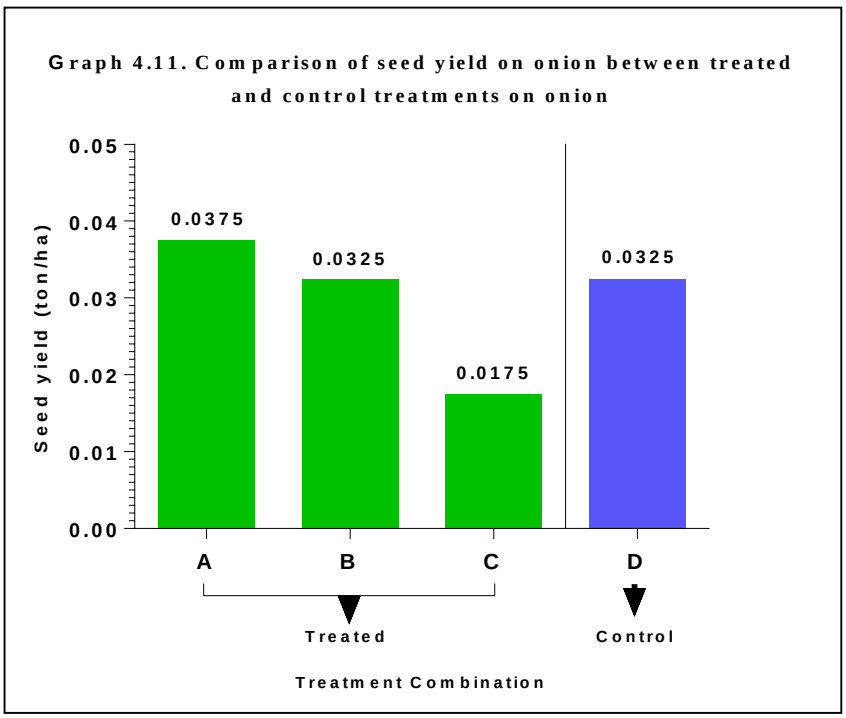
4.10. Effect of treatments on Seed yield per plant

The seed yield per plant was significantly influenced by using pollinator vector (with honey bee and without honey bee) in our present investigation. A trend of increased seed yield per plant was recorded with the use of honey bee. The highest seed yield per plant (1.621gm was recorded from plot A and the lowest seed yield observed in treated plot B (0.913gm) and C (0.913) (**Table. 4.2**) (**Graph. 4.10**). From our present investigation, control plot D was found to be increasing seed yield per plant (1.536), might be due to availability of more moisture, nutrient, space and light at wider spacing. In contrast, among the treated plots, B and C were over crowed with weeds which thus may lead to reduced umbel diameter, reduced flower per umbel as well as lower seed yield per plant. In consensus, another experiment by Mahadeen (2004) found that highest seed yield per plant was produced by planting large bulbs at low plant density.



4.11. Effect of treatments on seed yield t/ha

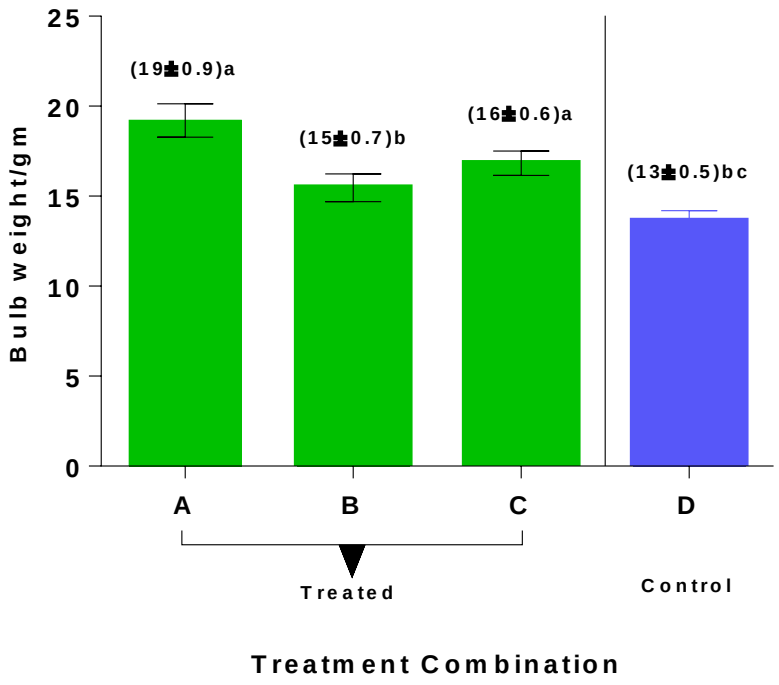
Through use of pollution vector of honey bee a significant increase in seed yield per hectare was observed treated (A) (**Table. 4.2**). In addition to that bulb size decreased in honey bee plot which was associated with a significant increase in seed yield. Interactive effects of honey bee on seed yield per ha was significant. The highest seed yield was produced from plot A(0.0375t/ha) with honey bee and lowest seed yield was produced from plot C.. Each increase in seed weight was accompanied by an increase in seed yield per plant and per hector (**Graph. 4.11**). These results are in harmony with those obtained by other authors (Naik and Srinivas, 1992; Levy, *et al*., 1981; Currah, 1981). On the other hand, there was a progressive reduction in seed yield in honey bee in the present investigation from the plot C which may accopained with the explanation of reduced seed yield per plant. These results are in general agreement with results of Sing and Rathore (1976), Levy *et al.* (1981) and Vik (1992) who reported that higher onion seed yields. Analysis of the data exposed that seed yield ton per ha was affected by the treatments with honey bee and without honey bee for A, B, C and D plots.



4.12. Effect of treatments on bulb weight

The present investigation was significantly affected bulb weight of onion in both treated plots (A, B, C with honeybee) and control plot (D, without honeybee) (**Table: 4.2**). At treated plots A(19±0.9gm), B(15±0.7gm) and C(16±0.6gm) the bulb weight of onion was counted, respectively and from the control plot D (13±0.5gm) the lowest bulb weight was obtained from without honey bee plot (**Graph: 4.12**). The highest average bulb weight was recorded from the treated plot A(19±0.9) in our present study. In other view, Abdel and Al-Juboori, (2006) experiment was statistically showed significant variation, and higher of bulb weight recorded compare with our present treatments. In our present treatments, statistical analysis of the data exposed that plant height was significantly affected by the treatments for A, B, C and D plots.

Graph. 4.12. Comparison of bulb weight (after harvesting) between Treated and Control treatments on onion



*Different alphabetical numbering within a graph denotes significant differences (P ‹ 0.05) between mean values of observations

4.13. Bee Visiting Rate on Onion Flower:

We have counted the number of flower visited by an individual bee in 5 minutes of period. Our counting was conducted from 7:30am to 11:30am during flowering of onion and the counting was done for 4 consecutive days in plot A, B and C (**Graph: 4.13; Figure: 5**). Not only that, we set up the same counting procedure in the control plot but did not get any bee visiting the flowers. In total 34 times we undertake this observation for the study plots. We observed one bee for at least 5 minutes and counted the number of flower it traveled during this period.

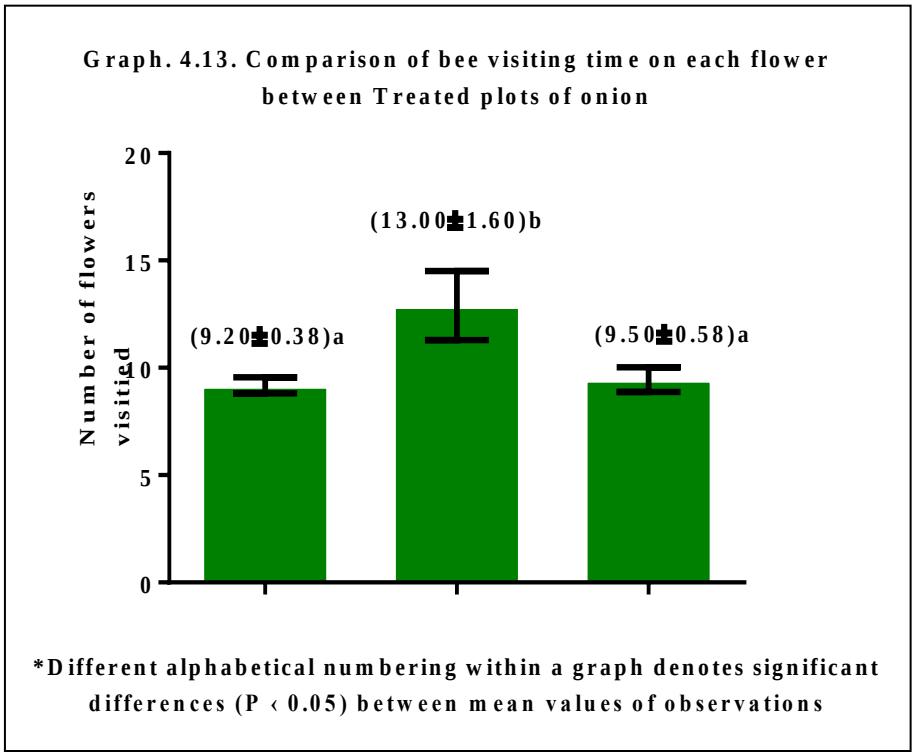


Figure 5: Honey Bee visiting on Onion flower.

CHAPTER 6

SUMMARY AND CONCLUSION

Bangladesh is primarily an agrarian economy. Bangladesh economy draws its main strength from agriculture sector. The sector contributes 19.10% to GDP (at current prices) and employs 50.28% of the labour force. Despite increase in the shares of fisheries, livestock, and forestry, crop sub-sector alone accounts for 60.83% share of agricultural GDP (BBS, 2008). Atmospheric CO_2, CH_4, SO_2, N_2O, etc. are mainly responsible for temperature increase resulting in the rise of sea level. Temperature rise by 1.00 C would inundate 18% area of Bangladesh as indicated by different studies. At the same time, the country is affected frequently by flood, drought, cyclone, and salinity due to climate change. As a result, soil fertility, crop productivity, and food security would be seriously threatened. The Government of Bangladesh is yet to make an estimate on resources required to overcome climate change impacts. However, to implement "Climate Change Strategy and Action Plan 2009", Ministry of Agriculture has recently estimated a demand of $5 billion to address the problem for the next 5 years.

Onion is an important spice crop in Bangladesh. It ranks first in production (889000 MT) and second in area (125101 ha) among the spices (BBS, 2008). It covers almost 36% of the total areas under spices. The mean yield of onion in Bangladesh is very low (4 t/ha) compared to world average of 17.27 t/ha (FAO, 1998). Every year, Bangladesh has to import a big amount of onion from neighbouring and other countries to meet up its demand. Total import of onion stood at 55499 metric tons in 2005 (BBS, 2007). Ullah *et al.,* (2008), among the spice crops grown in Bangladesh onion ranks second in acreage and first in production. There is an acute shortage of onion in relation to its requirement.

Nowadays the natural habitat is disturbed for many reasons and the vegetation cover is declining worldwide (Kearns *et al.,* 1998). Agriculture plays a role in declining native pollinators through the modification and elimination of pollinator habitats and the use of agricultural chemicals (pesticides, herbicides and fertilizers) (Donaldson, 2002). Honeybees are responsible for 70-80% of insect pollination (Johannsmeier and Mostert, 2001). At present, the need for onion seed production is highly demanding and nationally it becomes an important development. Inadequate

pollination of the onion plant may result in deformed, smaller seeds which have low germination capacity (McGregor, 1976). Insufficient pollination caused difficulties in onion hybrid seed production because of low quality seed (Free, 1993). Onion seed is imported from abroad with hard foreign currency. Buyers of the seed are facing the problem of germination and imported seeds are susceptible to disease (Lemma, 1988). Honey bees are very efficient at exploiting the flowers surrounding their hive.

The study was conducted at the experimental field of "Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)" is a collaborative project lead by Caritas Austria under the supervision of Caritas Bangladesh, Project number of European Commission: DCI-FOOD 2010/230-309 at Baraigram, Natore, Rajshahi-6000 during the winter season (from 05 Nov 2014 to 05 April 2015) with a view to investigate *"Performance assessment of honey bee on pollination of onion flower".* This experimental design was set to investigate the effect of honey bee vector on seed production of onion (*Allium cepa*) in rainfed area. There were used two types of treatments which were Treated plot (with honey bee vector) and Control plot (without honey bee vector). There were 2 treatment plots: T1: three clusters as plot A, plot B, plot C got honey bee box and T2: one cluster was without honey bee box as control plot D). A significant response of onion seed production to different treatment (with honey bee and without honey bee) was observed.

After recording of data on plant height, scape length, umbel per plant, umbel diameter, seed yield per plant, seed yield per hector, and scape diameter, thirty umbel from each plot collected from field during harvesting period and then dried in the sun. Each umbel was separately packed because of seed loss. Threshing, cleaning and drying of umbels for 7 days (approx.) or until the seed came out from umbels after slightly rubbing, and collected seed from each plot were done carefully. Seed from each umbel collected very carefully and counted seed number per umbel then packed seeds got per umbel separately. Finally, the seed yield and yield contributing parameters were recorded separately.

The growth and yield parameters of wheat recorded during the study were tabulated for statistical analyses. An analysis of Variance (ANOVA) was done.

In set of experiment, the data recorded showed that number of scape per bulb at treated plots with honeybee were counted on an average of 2.5±0.2, 2.4±0.1 and 2.1±0.1 in plots A, B and C, respectively, whereas it was better in control plot (D, 2.6±0.2) which was lack of honey bee treatment. In treated plots, we found that tallest main scape height D (74±1.4cm) was obtained from without honey bee plot where average length was 69±1.9, 62±1.7cm, 66±1.5cm in plots containing honey bee (A, B and C, respectively). the main scape lengths were 73±1.6cm, 65±1.7cm, 64±1.6cm counted from plot A, B and C; respectively and from the control plot (D) it was 76±1.3cm which was the highest length of main scape per bulb in our experiment.

In comparison, the results obtained from the experimental findings showed that insignificant differences in affected flowers per umbel of onion between treated plots (A, B, C with honeybee) and Control plot (D, without honeybee). Control plot D (6.1±0.1) was the highest umbel diameter found from without honey bee plot (**Table. 4.2**) than the treated plots. The lowest umbel diameter was recorded from the treated plot A (5.3±0.1cm) from our present study. In treated plots, the abortive flower per umbel was counted A (34±2.2), B (23±1.5) and C (30±2.3) and from the Control plot D (31±2.0) which was the highest number of abortive flower obtained from plot where honey comb was not used.

The results revealed that the highest seed yield per umbel was obtained from control D (183±22) plot. However the highest weight of 1000 seed (2.828g) was recorded from with honey bee treatment (A) and the lowest weight of 1000 seed (2.336g) was recorded from with honey bee treatment (B). The highest seed yield per plant (1.621gm was recorded from plot A and the lowest seed yield observed in treated plot B (0.913gm) and C (0.913). The highest seed yield was produced from plot A(0.0375t/ha) with honey bee and lowest seed yield was produced from plot C. The highest average bulb weight was recorded from the treated plot A (19±0.9) in our present study. Highest number of flower visited in every 5 minutes was recorded from plot B as 13.00±1.60.

It is to recommend that the honey had played a potential role in seed yield of onion. Now, it would be need to examine the pollination behavior more in depth to reveal how honey and other pollinator can effectively implanted to increase the seed yield and improved germination capacity..

CHAPTER 5

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