CHAPTER 2

RESEARCH AND DEVELOPMENT OF ONION: BANGLADESH PERSPECTIVE

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Introduction

In Bangladesh, onion (*Allium cepa* L.) is a high value spice crop. It ranks first in production among the spice crops cultivated in the country. It is used as salad while in green stage cooked in various ways in all curries. It is also used in pickles, chutney, stew, cooked vegetables or sauces, and for the preparation of certain other products. It contains little vitamin 'B' and 'C' and traces of iron and calcium. Besides, it has many medicinal values too. In Bangladesh the total production of onion is 18.72 lakh mt with an average yield of 10.54 t/ha which is very low as compared to the world production. The average world production of bulb onion in the last three years was approximate 73 million mt (FAO, 2010). In terms of productivity among major onion producing countries, Korean Republic tops the list with 67.25 t/ha followed by USA 53.91, Spain 52.06, Japan 47.55, Netherlands 43.13, Iran 34.0, Egypt 32.18, Mexico 29.13, Turkey 26.76 and Brazil 21.38 t/ha, respectively (FAO, 2008). But in terms of total production China ranks first followed by India (Asrey *et al.*, 2008). The yield of onion seed varies from 370 to 500 kg/ha in Bangladesh which is very low compared to 1,000 to 1,200 kg/ha in other countries of the world (Brewster, 1994).

Several factors are responsible for low productivity in onion *viz.* low yielding variety compared with other onion producing countries, lack of variation in local cultivar, lack of hybrid as well as open pollinated (OP) high yielding varieties, low keeping quality of summer onion, disease and insect attack, adverse climate, non-availability of seeds etc. Considering the above, a long term research program was undertaken at the Spices Research Centre, Shibganj, Bogra, Bangladesh with several objectives to create genetic variability, increase shelf life, tolerance to

purple leaf blotch, searching male sterile line for hybrid seed production and to develop superior variety(s) with higher yield.

Background of Spices Research in Bangladesh

Research on spice crops was not emphasized in earlier in Bangladesh. During 50th decade a temporary research project of 3 year duration was undertaken with the financial assistance of the Agriculture Funding Coordinated Project (FACP). At the end of 60th decade-another project-"Black and White Pepper Scheme" was initiated with the financial assistance of Agricultural Research Coordination Project (ARCP) which ended in 1966. After 15 years, another spice research scheme named, "Collection and Evaluation of Spices and Culinary Herbs of Bangladesh" was initiated with the financial assistance of the Bangladesh Agricultural Research Council (BARC). In that period, a survey was conducted for collection of germplasm and to document information on farmer's practices of spice crops. This scheme ended in June, 1986. Thereafter, the research activities on spice crops continued in a very limited scale during 1987-1994.

Research and Technology Development of Onion in Bangladesh

Research in private sector: The limited research has been done on onion in the private sector. Recently, Lal Teer, Suprim Seed and ACI companies have started research in onion on a small scale. Lal Teer recently developed one winter onion variety named Taherpuri King through selection. Recently, some of the private seed companies have established research and development (R&D) divisions for different crop research. Yet, no variety was released. Hence, research information on these aspects is still in infancy.

Research in public universities: Many agricultural universities in Bangladesh have initiated research on vegetables, fruits, flowers, pulses, oils and grain crops. Among them, Bangladesh Agricultural University (BAU), Mymensingh is conducting research on soil and fertilizer management, water requirement, agronomic practices, insect and disease management of onion through M.Sc. and Ph.D. research programmes.

***Research in Spices Research Centre (SRC)*:** SRC established in 1995 under the Bangladesh Agricultural Research Institute (BARI) is mandated for spices research and development. SRC has developed 16 varieties of 8 types of spices and a number of technologies (210) on varietal improvement, soil and fertilizer management, water requirement, agronomic practices, insect pest and disease management, post-harvest storage and processing of different spice crops.

Goals of Spice Research Centre (SRC)

- To increase spices production through varietal improvement and development of production technologies
- To introduce new lines/races of different spices from exotic sources
- To reduce import of spices and save foreign exchange

Research and development areas of SRC

- Variety development
- Crop management
- Disease and insect management
- Seed production and distribution
- Socio-economic studies
- Technology validation and transfer and impact study at the farmers field level

Research objectives of SRC

- Collection, evaluation and conservation of different indigenous and exotic germplasm of spices crops.
- To develop high yielding varieties of different spices crops having high degree of tolerance/ resistance to common insect pests and diseases.
- To develop somaclonal variation, diseases free plantlet production, haploid production for hybridization program, virus cleaning through meristem culture of different spices crops using biotechnology.

- ❖ To develop appropriate and improved sustainable production technologies of spices crops including cultural, soil, water, disease and insect pest management.
- ❖ To develop improved post harvest handling, processing and preservation technologies of different spice crops.
- ❖ To strengthen farm research of newly released varieties in different agro-ecological zones for transfer of technologies to end users.
- ❖ To strengthen adaptive research of newly released spices varieties in different agro-ecological zones.
- ❖ Breeder seed production and distribution for Bangladesh Agriculture Development Corporation (BADC).

Technologies Developed

***Variety development / improvement*:** Variety of any crops is a key factor in crop cultivation and directly related to its productivity. SRC developed six onion varieties through conventional breeding, including selection. Among them, two are winter varieties (BARI Onion-1 and BARI Onion-4), three are summer varieties (BARI Onion-2, 3 and 5) the other one is BARI Pata Piaj-1. Salient features of those varieties are presented in Table 1.

***Breeding program*:** The objective of this program was to create genetic variability, increase shelflife, tolerance to purple leaf blotch and identify male sterile lines of onion. During the last two years, there were no remarkable findings but some inbred lines developed were used as good breeding materials. Different breeding programs-mass selection, modified mass selection, family selection, hybridization addressing increased shelflife, yield potential, insect and disease tolerant are also in progress.

In Bangladesh the onion growers use the available open pollinated local varieties *viz*. Taherpuri, Faridpuri, Jitka, Suksagar etc. All the open pollinated varieties are low yielders. Hybrid technology by utilizing CMS mechanisms is being used worldwide for improvement of yield in onion. There is also a scope of development of high yielding hybrid varieties in tropical onion. Considering the scope, problems and necessity of hybrid variety, a series of experiments have been

conducted both on station of SRC and the farmer's field. It was noted that about 70-80% male sterility was found in the onion growing region of Faridpur, Rajshai and Pabna districts of Bangladesh. Thirty onion germplasm were collected from home and abroad in 2011-2013 for male sterility study. Salient features of those germplasm are presented in Table 2. To develop the male sterile lines, it was observed that spraying with GA_3 (500 ppm) at 30,45 and 60 days after sowing showed about 30-50% male sterility in BARI Onion-1, 3 and 4. Spraying with MH (150 ppm) at 30, 45 and 60 days after sowing showed about 60-70% male sterility in BARI Onion-1, 2 and 5.

Table 1. Main characteristics of released onion varieties

Sl. No.	Name of variety	Main Characteristics
1	BARI Onion-1	i) Winter variety ii) Flat and medium size (30-40 g) iii) Thin neck iv) Long shelflife and high pungency v) Yield:12-16 t/ha (bulb), 800-1,000 kg/ha (Seed) vi) Crop duration: 120-140 days (Seed-bulb)
2	BARI Onion-2	i) Round with reddish colour ii) High yield potential iii) Year round production iv) Keeping quality very low v) Yield:10-13 t/ha (bulb), 600-700 kg/ha (Seed) vi) Crop duration : 60-70 days (Seedlings-bulb)
3	BARI Onion-3	i) Oblong with reddish colour ii) High yield potential iii) Year round iv) Keeping quality very low v) Yield:10-12 t/ha (bulb), 600-700 kg/ha (Seed) vi) Crop duration : 60-70 days (Seedlings-bulb)
4	BARI Onion-4	i) Winter variety, reddish in colour ii) Globular and big size (70-80g) iii) Thin neck and longer shelflife iv) Yield :18-20 t/ha (bulb), 700-900 kg/ha (Seed) v) Crop duration : 130-140 days (Seed-bulb)

5	BARI Onion-5	i) Lower portion flat, upper portion slightly elongated ii) Bulbs are dark red, globular with tight skin, moderately pungent iii) High yield potential and year round production iv) Low keeping quality v) Matures in 65-75 days after transplanting in kharif-1 vii) Average yield 12-16 t/ha in kharif-1 viii) Matures in 90-120 days after transplanting in kharif-2 ix) Average yield 22-25 t/ha in kharif-2 x) Suitable for fresh market xi) Seed yield 500-700 kg/ha xiv) Recommended for *kharif* season (summer)
6	BARI Pata Piaj-1	i) No bulb formation ii) Year round for leaf production iii) Tolerant to purple leaf blotch disease iv) Leaf yield 15-20 kg/ha v) Seed yield 1,000-1,200 kg/ha vi) Commercial cultivation :Throughout the country

Table 2. Main characteristics of germplasm of onion in Bangladesh

Germplasm	Bulb Characters	Male sterility (%)	Germination (%)
ON0297	Flat, large size, brownish	20	90
ON0298	Flat, medium size, light reddish	30	75
ON0299	Flat medium size, light reddish	15	72
ON0300	Flat, large size, brownish	18	80
ON0301	Upper portion elliptical-lower portion flat, medium size, brownish	25	75
ON0302	Upper portion elliptical-lower portion flat, medium size, pinkish	15	72
ON0303	Upper portion elliptical, medium size, pinkish	20	80
ON0304	Lower portion flat, medium size, pinkish	25	83
ON0305	Round shape, brownish	10	75

ON0306	Elliptical, brownish with reddish	15	92
ON0307	Round, brownish	20	80
ON0310	Round, medium size, brownish to reddish	25	72
ON0311	Round, medium size, brownish to reddish	15	80
ON0312	Lower portion flat, brownish	10	83

For increasing the shelflife, BARI Piaj-2, 3 and 5 (summer onion) was crossed with BARI Piaj-1 and 4 (winter onion). In this year F_1 bulbs have been planted to produce bulbs for the shelflife study. To create genetic variation, crossing was made in full diallel fashion with BARI Piaj-1 and 4 (winter onion) and 2, 3 and 5 (summer onion) in 2011-2012. From this study some variation has been found in respect of bulb colour, shape and size. The existing winter variety BARI Onion-4 has higher bulb yield potential than BARI Onion-1 but shorter shelflife. Due to low shelflife farmers cannot store these varieties for long time. BARI Onion-1 has longer shelflife than BARI Onion-4. BARI Onion-4 has thick necked bulb with high moisture percentage resulting in rotting and poor keeping quality. In view of this random crossing was made between above mentioned varieties in previous years and advancing up to F_4 generation with six types (F_4-1, F_4-2, F_4-3, F_4-4, F_4-5 and F_4-6). It was found that F_4-3 generation gave the highest bulb yield (22.68 t/ha) and zero rotten percentage (From April to 20 October 2014).

Development of Production Packages

Cultural management as well as production practices are very important for higher yield, quality seed and bulb production in onion. The production technology is key factor for increased the onion production and the following production practices have been developed.

For bulb production:

- Seeds should be sown on November in seed beds for raising seedlings for winter bulb production
- Seedlings are transplanted at 40-45 days

- Seedlings were transplanted on 20 December to 10 January along with 10 cm x 8 cm or 7.5 cm x 7.5 cm spacing increased bulb yield
- The land should be fertilized with cow dung 10 t/ha and N_{120}, P_{50}, K_{75} and S_{20} kg/ha
- Irrigation should be applied at 30, 50 and 70 days after planting for quality bulb production.
- After bulb formation forced toppling should be done to stop the growth up to 7 - 10 days before harvesting
- After harvest, bulb should be kept in shade for 5-7 days for curing

For seed production

- Bulb to seed method for seed production
- Disease free single bulb with thin neck should be selected for quality seed production. Split/double bulb should be discarded
- Medium size bulb of 15-20 g for BARI Onion- 1, 2, 3 and 5 and 25-30 g for BARI Onion-4 increase seed yield.
- Dipping and spraying of summer onion bulb in GA3 solution at 50 and 100 ppm, respectively, favours uniform bolting, bursting, increasing number of stalks and seed weight/plant.
- Traditionally, mother bulbs are planted at the end of October. However, due to change in environmental temperature the planting time is to be shifted to 10-20 November results in increased seed yield. Early planting reduces the number of flowering stalks and florets in the umbel. Late planting (December) retards the vegetative growth and reduces the number of florets in the umbel, increase incidence of purple blotch disease and thrips infestation resulting poor seed quality. Moreover, the crop may be damaged by hail storm.
- The highest seed yield was recorded with the spacing of 20 cm x 15 cm.
- Efficient and balanced nutrient management is needed for good seed yield of onion. Cow dung (5 t/ha) with N_{115}, P_{54}, K_{75}, S_{20}, Zn_3 and B_2 kg/ha increase seed yield.
- Seed plot must be kept weed free. Three hand weeding at 20-25, 35-45, and 60-75 days after emergence reduce the weeds infestation. Infestation of *Cyperus rotundus* is a serious problem for onion seed crops. Onion is a

shallow rooted crop so frequent weeding may damage the root system and thus hamper growth and reduce yield.

- Irrigation at vegetative + scape initiation + flowering + milking stage is the best option in respect of seed yield and economic performance
- Flowering stage is the critical for irrigation of onion seed production
- Poultry manure at 3 t/ha as side dressing increase yield of onion by 12-20 % and also increase keeping quality.
- Diseased and unhealthy plants with slender flower stalks should be rouged out before flowering
- To avoid lodging of flower stalks due to strong wind and irrigation, support should be provided with bamboo stick and nylon rope.
- When temperature rises at flowering, seed crops are attacked by thrips that suck the sap from flower stalk and florets resulting in poor seed set and deteriorate the seed quality, hence effective control measures should be under taken to control thrips.
- The seed should be harvested when the fruit opens and exposes the black seed. According to Howthorn and Pollard (1954), a field is considered ready to harvest when about 10 % of the heads have exposed black seed. At this stage practically all the seed is well matured to give a good germination. Two to three pickings may be necessary to harvest the heads.
- After harvest seed heads should be properly dried, threshed and seeds are cleaned
- Before storage the seed must dried at 6-8 % moisture content.

For bulblets production

- Seeds at 10 g/m^2 are seeded on flat beds.
- The best time of sowing seed for getting quality bulblets is mid February to beginning of March depending upon the area.
- The plants are left in nursery bed up to April-May till there is top fall. Carbandazim has to be sprayed at 0.1% at 10-20 days before harvesting to reduce decay in storage bulblets.
- Harvesting is done along with the tops and selected bulblets are stored by hanging method till September- October in a well ventilated house. The large size (4-10 g) bulblets are used for seed production and small size (1-3

g) bulblets are used for fresh bulb production in *Kharif-2* season (July-September).

Others Technologies

- ❖ Intercropping onion with aroids was economically profitable. Farmers may get 60,000 to 70,000 Taka/ha as additional income.
- ❖ Cultivation of turmeric with lalshak-yardlong bean - bottle gourd and turmeric with summer onion-snake gourd-country bean are the best intercrop/companion crop combinations in respect of yield and economics. It will give 39 % additional profit than mono crop system.
- ❖ Cultivation of ginger with summer onion-yardlong bean-bottle gourd and ginger with chilli-yardlong bean-bottle gourd are the best intercrop combinations in respect of yield and economics. It will give 44% additional profit than mono crop system.

Disease Management

Onion is attacked by 66 diseases including 10 bacterial, 38 fungal, 6 nematode, 3 viral and 1 phytoplasma, 1 parasitic and 7 miscellaneous diseases and disorders (Mohan and Moyer, 2004). In Bangladesh the common diseases such as purple leaf blotch (*Alternaria porri*), stemphylum leaf blight, downy mildew (*Peronospora destructor*), and basal/ stem rot (*Fusarium* spp., *Sclerotium* spp., *Rhizoctonia* spp.), damping off. Purple leaf blotch, stemphylum leaf blight and damping off in the seedling stage are the most destructive and reduce the bulb and seed yield, sometimes up to 100%. These diseases occur in both seasons, *Rabi* (October-March) and Kharif I (April-June) and II (July-September). Some of the research findings on disease management are as follows:

- ❖ Rubral at 2g/l of water at 15 day intervals has been effective for the management of purple leaf blotch disease.
- ❖ Stemphylium blight can be controlled by using Ridomil MZ at 2g/l of water at 10 days intervals.

- For controlling seedlings disease, the seed should be treated with Provex (carboxin + thiram) at 2 g/kg of seed before sowing.
- The seed bed should be drenched with Provax at 2 g/l of water at fortnightly intervals.
- Application of bio-control agent (*Trichoderma viride)* in the seed bed or main field can reduce the disease.
- Bavistin at 2-3 g/l of water at 15 days intervals after sowing effectively reduced the damping off in the seed bed.

Insect Management

Thrips are the major insect pest in onion. Other insects such as white fly, head borer, onion maggot, and army worm are occasional problems. Thrips cause significant yield loss during heavy infestation on bulb and seed production. Control of this sucking insect is very difficult during flowering stage because spraying insecticides at this stage may reduce pollinators or wash out viscosity attributes of the gynoceum that reduce pollen receptivity. Some of the research findings on insect and pest management are as follows:

- Botanical insecticides and entomo-pathogenic fungal (EPF) insecticides are highly effective, safe and ecologically acceptable (Nathan *et al.*, 2004)). A study has been undertaken to find out the best performing organic insecticide against thrips in onion and found that Tobacco leaf extract treated (12 thrips/plant) and neem seed extract (12 thrips/plant) reduce the thrips infestation
- ONO 281 showed minimum thrips infestation and gave identical bulb yield.
- Carrot and Safflower were most effective in controlling thrips on onion.
- Spinoside (Tracer 45SC) at 0.4 ml/l of water performed best in controlling thrips in onion.
- In integrated management aspect sticky white trap+ Fipronil (Tracer 45SC) have been found most effective in controlling thrips in onion with higher yield and highest marginal benefit cost ratio (MBCR)
- Temperature was positively correlated with thrips population in onion and garlic. Thrips population increase rapidly from mid February to mid March

when temperature rises above 30^0c with lower relative humidity. During this period onion should be sprayed with Karate (lambda-cyhalothrin) at 1 ml/l or Admare at 0.5 ml/l at 7-10 days intervals for controlling thrips infestation.

Pollination

Onion is a highly cross pollinated and pollinators are essential for higher seed set and increased seed yield. Honey bees, blow flies, syrphid flies and house flies are the common insect pollinators of onion. Pollination of onion seed crops has been studied in India. *Trigona iridipennis*, a stingless bee, *Apis cerana* and *A. florea* and two tropical bees were the principal onion pollinators (Rao and Lazar, 1983). Onion nectar is rich in potassium and its viscosity tends to increase as the temperature increases. So, bee prefers alternate nectar source. Spices Research Centre has found that sowing one/two lines coriander, dill or fennel around the border or every 10 alternative rows of onion can increased seed setting to about 67-69 % compared to control (55 %). Dill and fennel should be planted at the time of onion planting and coriander should be planted 18 days after onion planting (Uddin *et al.*, 2011; 2012). Supplementary pollination using honey bee hives in the seed fields cross-pollinated by insects ensure good seed set and increased seed yields.

Harvesting and Drying

Harvesting of onion is critical and crucial for obtaining good quality seed. In early harvest, some seeds remain immature, light weight, poor vigour or non-viable. If harvesting is delayed some seed may fall by shattering. Harvesting is commonly done when 10% of the heads have black seed exposed (Howthorn and Pollard, 1954) or 20-25% capsule in each umbel expose black seed. Two to three picking is needed to collect the whole seed head. The harvested umbels are thoroughly dried on a tray (made of wood with net at the base) or on a canvas before threshing. The seeds can be separated by floating or by rubbing by rubber sole over gunny bags. The seeds are then dipped into water for few seconds to remove dust or empty seed and sun dried for 2-3 days under mild heat. The moisture content of the seed should be 5-6 % before packaging. After drying and

cooling (shade) they are packed in moisture proof package like aluminium foil or in opaque plastic drum.

Constraints for Quality Bulb and Seed Production

- Lack of indigenous and exotic germplasm
- Lack of variation in local cultivars
- Inadequate lands under spices production
- Inadequate supply of seeds at farmer's level
- Lack of storage facilities and technical know-how at farmer's level
- Very little scope to collect exotic germplasm
- Problems of thrips at flowering stage.
- Scarcity of insect pollinators.
- Thrips- white fly - sooty mold complex.
- High seedling mortality during summer onion bulb production.
- Lower storability/shelflife of summer onion.
- Purple blotch-*Stemhylium* blight complex.
- Rainfall/storm during harvest of bulb and umbel.
- Seed drying problem in cloudy weather.
- Poor water management in farmer's field.
- Varietal admixture at farmers level
- Premature bolting

Future Plan

- Development of specific purpose varieties (high pungency, heat and drought tolerant etc.)
- Development of improved varieties against thrips and purple leaf blotch
- Marker assisted breeding for identification of duplicate germplasm
- Variety development through biotechnological approaches
- Participatory research approaches for quality seed production
- Postharvest management
- Development national seed production system
- Increasing supply the breeder/ foundation seed for the BADC

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