

Project ID 804

Competitive Research Grant

Sub-Project Completion Report

on

**Improvement of spices varieties cumin, sweet pepper,
chilli, turmeric and black pepper through induced
mutation**

Project Duration

01 April 2017 to 30 September 2018

Horticulture Division
Bangladesh Institute of Nuclear Agriculture (BINA)
BAU Campus, Mymensingh



Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215



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National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Executive Summary

Nuclear techniques were used to develop desirable mutants of cumin, sweet pepper, chilli, turmeric and black pepper with acceptable yield. Different genotypes (total germplasm=33) of cumin, sweet pepper, chilli, turmeric and black pepper were collected from home and abroad. Radio-sensitivity test of the genotypes of cumin, sweet pepper, chilli, turmeric and black pepper were conducted to establish the LD₅₀/GR₅₀ (Chilli = 75 – 100Gy ,Capsicum= 75-105 Gy, Turmeric= 2-3 Gy, Cumin= 3-5 Gy) for the highest frequency mutation induction. Mass seed irradiation of mentioned spices at estimated LD₅₀ dose was carried out to generate mutants. Sweet pepper (M₁), chilli (M₆), turmeric (Advanced line) and black pepper (M₁) experiments were harvested for developing desirable mutants. Multi-location trials of promising mutants and advanced line were conducted and evaluated of mutants.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Improvement of spices varieties cumin, sweet pepper, chilli, turmeric and black pepper through induced mutation
2. Implementing organization: Horticulture Division
Bangladesh Institute of Nuclear Agriculture (BINA)
BAU Campus, Mymensingh, Mobile: 01711931506, E-mail: islamdr.rafiqul@yahoo.com
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):
 - i) **Principal Investigator:** **Dr. Md. Rafiqul Islam**
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 - ii) **Co-principal investigator:** **Dr. Md. Shumsul Alam**
Senior Scientific officer, Horticulture Division
Bangladesh Institute of Nuclear Agriculture (BINA)
BAU Campus, Mymensingh,
Mobile: 01711124722
4. Sub-project budget (Tk):
 - 4.1 Total: 1800000/- (Eighteen lakh)
 - 4.2 Revised (if any): Not applicable
5. Duration of the sub-project: From 01 April 2017 to 30 September 2018
 - 5.1 Start date (based on LoA signed): 05-07-2017
 - 5.2 End date : 30 September 2018

6. Justification of undertaking the sub-project:

Spices cultivation area is reducing due to pressure of major food crops. The yield of different spices of Bangladesh is not satisfactory compared to other countries. Coverage of cumin, sweet pepper, chilli, turmeric and black pepper are very low because of the lack of improved varieties at farmer level. Farmers of Bangladesh are using low yielding local varieties. Lack of inadequate varieties of cumin, zinger, onion, garlic and black pepper, high pest prevalence and extreme temperatures, uneven rainfall and humidity are the major problems in Bangladesh. As a result the country faces a serious shortage of spices crops. Consequently, large quantities of these spice are imported every year at the cost of huge amount of foreign currency. Cultivation of inferior genotypes with traditional production practices and climate are considered to be the main causes for low yield of cumin, sweet pepper, chilli, turmeric and black pepper spices crop. The most important flavors in Bangladeshi cuisine garlic, onion, ginger, lime, coriander, cumin, turmeric, chili, cardamom, cinnamon are the natural flavors. The quantity required for the 160 million people of Bangladesh is really great; many of the spices are imported, as the local production is not sufficient to meet the huge requirement of spices. Area under spices cultivation is not increasing rather it is reducing. Growers of improved variety are very low because of improved variety is not still introduced at farmers level. The best alternative way to improve variety of mentioned spices using induced mutation technologies, development of appropriate management practices and production and quality seeds are important to reduce the existing wide gap between consumption and production of spices. No such attempt has been taken yet to develop spices particularly through mutation breeding in Bangladesh. Mutation technologies have become a proven way of creating variation within a crop variety. Mutation technology for the improvement of crops is an active area of research at BINA. This project will help to develop desirable mutants of the mentioned spices. There are numerous research works being carried out in the developed countries like India, Syria, Iran and Turkey but the climate of Bangladesh, duration of growing

seasons are quite different from them. That is why a separate study under Bangladesh climatic condition is needed.

7. **Sub-project goal:** : Improvement of spices crops cumin, sweet pepper, chilli, turmeric and black pepper to enhance spices production for food security.

8. **Sub-project objective (s):**

- i. Collection of local and exotic germplasm of cumin, sweet pepper, chilli, turmeric and black pepper.
- ii. Screening of the collected germplasm of these spices and irradiation of the seeds for generating mutants.
- iii. Selection and evaluation of desirable mutants for developing varieties with high yield potential, good aroma and flavour.

9. **Implementing location (s):** BINA head quarter farm, Khagrachari, Magura, Comilla, and Rangpur sub-station farm.

10. **Methodology in brief:** Induced mutation techniques were used to develop desirable mutants of cumin, sweet pepper, chilli, turmeric and black pepper with acceptable yield through gamma irradiation (Gamma rays)/ mutagen (EMS). Genotypes of cumin, sweet pepper, chilli, turmeric and black pepper were collected from home and abroad. Radio-sensitivity test of the genotypes of cumin, sweet pepper, chilli, turmeric and black pepper were conducted to establish the LD_{50}/GR_{50} for the highest frequency mutation induction. After radio-sensitivity test, mass seed irradiation of cumin, sweet pepper, chilli, turmeric and black pepper seeds with selected dose of gamma ray was applied to develop desirable mutants. The irradiated seeds were used for generating desirable mutants.

11. Results and discussion:

Work plan :
A. Germplasm collection
B. Radio-sensitivity Test i) Seedling emergence ii) Seedling characters iii) Estimation of LD ₅₀ , GR ₅₀ iv) Field survivility
A. Mass seed irradiation for advancement of mutant population and screening
B. Mutant selection

A. Collection of germplasm: Seeds of cumin (10 germplasm), sweet pepper (5 germplasm), chilli (10 germplasm), turmeric (10 germplasm) and black pepper (6 germplasm) genotypes were collected.

Germplasm collection : Total collected germplasm 33

List of collected germplasm of cumin, sweet pepper, chilli, turmeric and black pepper				
Cumin	Chilli	Turmeric	Black pepper	Sweet pepper
Accessions=7 (i) Local-1 (Bhola) (ii) Local-2 (Bhola) (iii) Local-3 (Bhola) (iv) Local-4 (Bhola) (v) Local-1 (Charfashon) (vi) Local-1 (Jessore) (vii) Irani	Accessions=10 (i) Bogura (ii) Super hot master (iii) Black Diamond (iv) Pashapashi Seed (v) Bangkim (vi) China Seed (viii) Char Feson (ix) Indian morich (x) Kamranga Morich	Accessions=11 i) Mala-1 (Modhupur) ii) Mala-2 (Modhupur) iii) Mala-3 (Modhupur) v) Dimla (BARI-1) vi) Sinduri (BARI-2) (vii) Patnaiya Adijat (Modhupur) (viii) BADC (Modhupur) (ix) Indian -1 (x) B. Baria Local-1 (xi) B. Baria Local-2	Accessions=2 i) Sylhet Jointa ii) Khagrachari	Accessions=3 i) Holud Capsicum ii) BARI misti morich-2 iii) Surjomukhi

B. Radio-sensitivity test

Radio-sensitivity test is the first step to develop desirable mutants of crops. Seeds/Rhizomes of cumin, sweet pepper, chilli, turmeric and black pepper were irradiated by gamma ray for the test of radio-sensitivity. Radio sensitivity test was conducted to estimate LD₅₀ and GR₅₀ for the

highest frequency of mutation induction. Seeds/rhizomes of cumin, sweet pepper, chilli, turmeric were irradiated by gamma ray at different doses (0, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600 Gys) for the test of radio-sensitivity. The seeds/rhizomes were irradiated with gamma rays with the help of ^{60}Co irradiator at BINA, Mymensingh. Irradiated fifteen seeds/rhizomes per dose and per genotype were sown in soil boxes in a glass house. Germination data were recorded for each genotype 1st seven DAS and seedling height data were taken at 14th days after germination. Data were recorded on seedling emergence percentage, seedling height, reduction of seedling height (%), Survivability (%), lethal dose and growth reduction at 50% (LD₅₀ or GR₅₀). Dose range at LD₅₀ or GR₅₀ was estimated for getting highest frequency of mutation. Mass irradiation of seeds/rhizomes at estimated GR₅₀ dose were carried out.

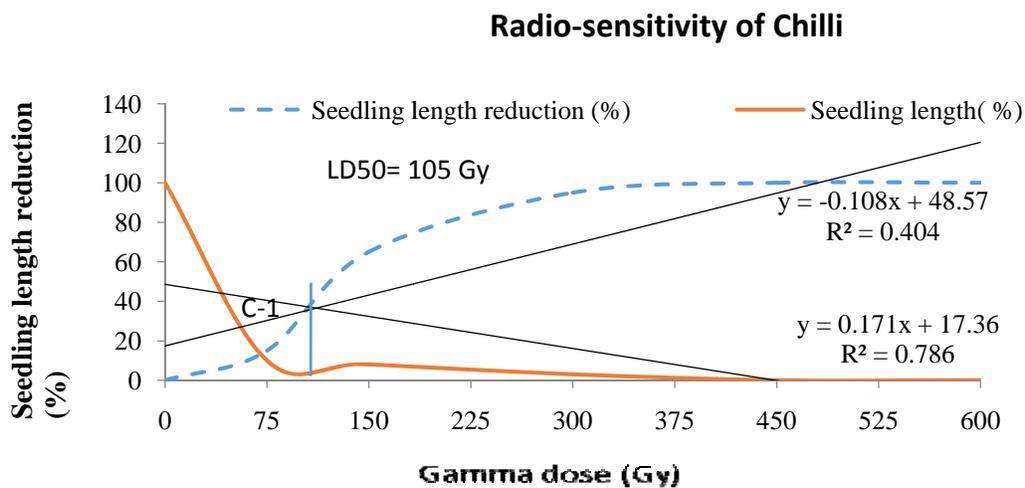


Fig 1. Radio-sensitivity of chilli at different doses of gamma irradiation

Radio-sensitivity of Chilli : Seedling height reduction percentage was found the highest at 300 Gy doses of gamma radiation in all the genotypes of chilli. Seedling height was reduced with the increasing doses of gamma ray. As gamma radiation effects significantly on the emergence (%), seedling height of irradiated plant, so it could be expected that there occurred mutation.

Growth reduction at 50% was estimated from the reduction of seedling height (%) (Compared to control) graph and found the value 75-100 Gy for Chilli genotypes. (Fig. 1).

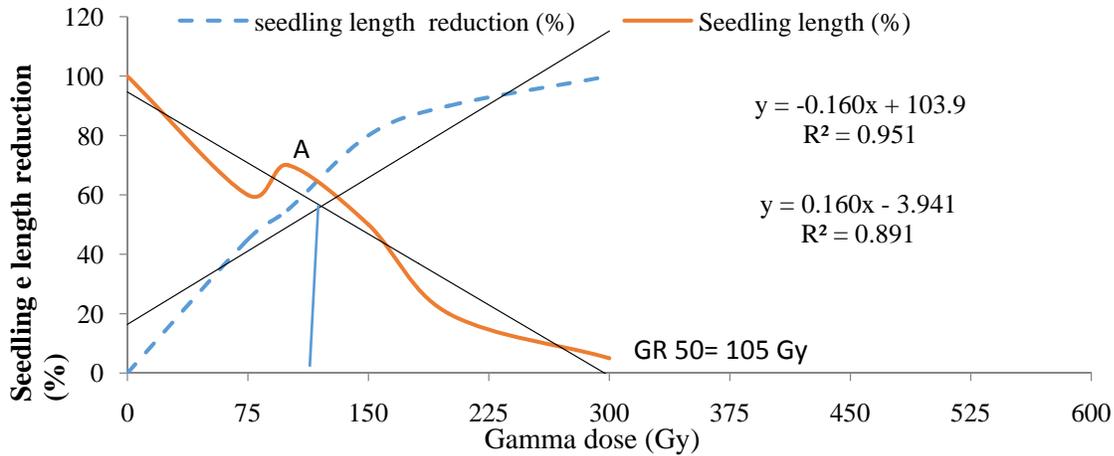


Fig 2. Radio-sensitivity of Capsicum annum at different doses of gamma

Radio-sensitivity of Capsicum annum: Seedling height reduction percentage was found the highest at 300 Gy doses of gamma radiation in all the genotypes of capsicum. Seedling height was reduced with the increasing doses of gamma ray. As gamma radiation effects significantly on the emergence (%), seedling height of irradiated plant, so it could be expected that there occurred mutation. Growth reduction at 50% was estimated from the reduction of seedling height (%) (Compared to control) graph and found the value 75-105 Gy for Capsicum genotypes. (Fig.2).

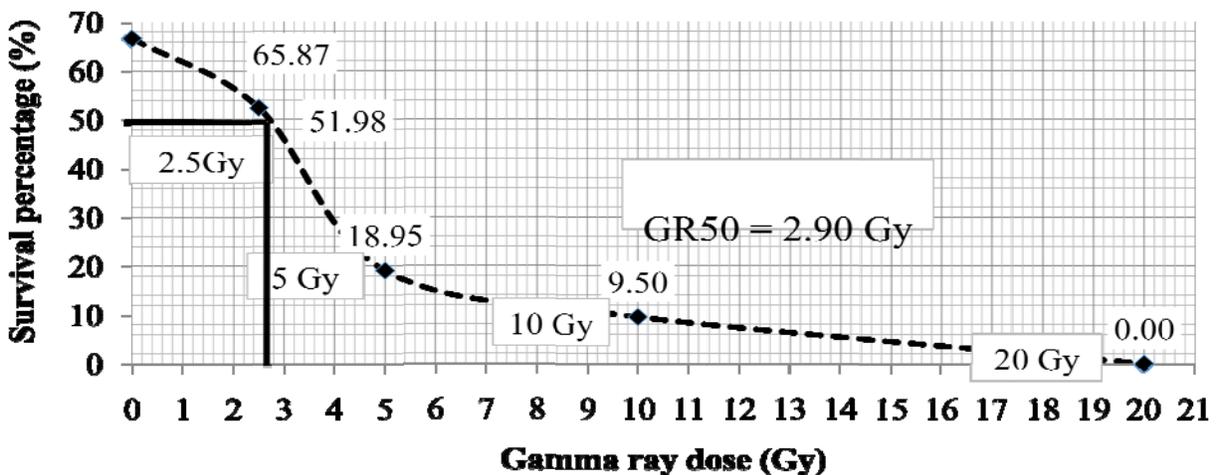


Fig 3. Radio-sensitivity of turmeric at different doses of gamma

Radio-sensitivity of turmeric: Seedling height reduction percentage was found the highest at 20 Gy dose of gamma radiation in all the genotypes of turmeric. Seedling height was reduced with the increasing doses of gamma ray. Growth reduction at 50% was estimated from the reduction of seedling height (%) (Compared to control) graph and found the value 2.0 -3.0 Gy for turmeric genotypes. (Fig 3).

C. Mass seed irradiation for advancement of mutant population and screening

Cumin, sweet pepper, chilli, turmeric and black pepper seeds/rhizomes were irradiated at LD₅₀ dose which contributed to mutation induction for generating mutants.

Advanced yield trials of the Turmeric genotypes during season of 2017-18

The advanced yield trial was conducted with the Turmeric genotypes BARI Halud-5, BHL-3 , BHL-2 and advanced line BHL-1 during Karif season from April 2017-18 at Mymensingh and Magura. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. Unit plot size was 3.0 m × 4.0 m and spacing maintained for Turmeric 50cm apart with plant to plant distance 25 cm. Recommended doses of fertilizers and manures were applied to ensure normal plant growth and development. Data on various characters such as; plant height, no. of plant/hill, no. of leaves/plant, no. of primary finger/hill, rhizome fresh wt, rhizome yield (t/ha). Data were compiled and analyzed and the mean values were adjusted through DMRT. Significant variations were observed in all characters of Turmeric grown in the field experiments of two locations (Table 1, Table 2 and Table 4).

Mymensingh, HQ farm :

The tallest plant height (130.26 cm) was recorded in BHL-1 genotype of turmeric in Mymensingh while the second highest was found in BARIhaulud-5 (122.15 cm). The maximum fresh weight of rhyzume (985.62 g/plant) was found in BHL-1 followed by BARIhaluad-5

(764.35 g/plant). The highest number of primary finger per plant was recorded (54.32/pant) in BARIhalud-5 where the second highest was BINA advanced line BHL-1(38.82). The highest rhizome yield was recorded in BHL-1 ranged from 31.65-34.15 t/ha in all the experiments (Table 1, 2 & 3).

Table-1. Yield and yield parameters of the BHL-1 of turmeric grown in Mymensingh, HQ farm during 2017-18

Genotypes	Plant height (cm)	NO. of plant/hill	No of leaves/plant	No. of primary finger/hill	Fresh Rhizome wt./plant (g)	Dry Rhizome wt./plant (g)	Rhizome yield (t/ha)
BHL-1	130.26	7.26	30.25	38.82	985.62	246.41	31.65
BHL-2	114.65	6.32	23.36	19.98	563.58	140.88	18.63
BARI halud-5 (Check)	122.15	6.25	25.68	54.32	764.35	191.09	19.65

Table2. Yield and yield parameters of the advanced line BHL-1 of turmeric grown in at Sutiakhali field , Mymensingh during 2017-18

Genotypes	plant height (cm)	NO. of plant/hill	No of leaves/plant	No. of primary finger/hill	Fresh Rhizome wt./plant (g)	Dry Rhizome wt./plant (g)	Rhizome yield (t/ha)
BHL-1	132.62	7.98	33.62	37.65	1065.62	266.4	33.20
BHL-2	114.65	6.86	25.31	20.35	652.41	163.15	19.38
BARI halud-5 (Check)	131.32	7.05	26.35	57.32	785.63	196.41	23.50

Table3. Yield and yield parameters of the advanced line BHL-1 of turmeric grown in Magura farm during 2017-18

Genotypes	plant height (cm)	No. of plant/hill	No of leaves/plant	No. of primary finger/hill	Fresh Rhizome wt./plant (g)	Dry Rhizome wt./plant (g)	Rhizome yield (t/ha)
BHL-1	145.50	8.50	34.50	37.26	1105.0	395.50	34.15
BHL-2	120.35	6.95	20.25	21.35	815.0	198.00	22.50
BARI halud-5 (Check)	133.50	8.00	28.50	42.60	980.0	253.00	26.90

Performance of promising mutants (M₆) of Chili

The experiment was conducted to observe the performance of the mutant (M₆) of chilli genotype. Farmer's yield trial and on station trial with desirable mutants has been done at BINA HQ and Sutiakhali farmer's field, Mymensingh. Selection and harvest of M₆ populations with desirable characters were done during rabi season, 2017-18. Seedlings of the mutant plants were transplanted during 2nd week of November, 2017. The experiment was laid out in row planting with spacing 50cm × 40cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken from each mutants. The results showed that the mutants CM₆D₇₅P₁ (35.28 tha⁻¹), CM₆D₁₅₀P₃₉ (29.18 tha⁻¹), CM₆D₁₅₀P₇₇ (28.57 tha⁻¹), CM₆D₃₀₀P₉₃ (28.68 tha⁻¹) produced high yield potential in respect of yield, height, no. of branch etc, where as the mutant CM₆D₇₅P₈ (Pungent; 14.12 tha⁻¹) produce lowest yield (Table 4).

Table 4. Yield attributes of promising mutants (M₆) of Chilli during Rabi, 2017-18

Mutant/ Variety	Plant height (cm)	Branch plant ⁻¹ (no.)	Fruits plant ⁻¹ (no.)	Yield plant ⁻¹ (gm)	Yield (tha ⁻¹)
CM ₆ D ₇₅ P ₁	70.12	8.00	56.58	678.00	35.28*
CM ₆ D ₁₅₀ P ₃₉	52.07	8.00	60.60	583.60	29.18*
CM ₆ D ₁₅₀ P ₄₆	59.00	9.00	45.13	434.00	21.70
CM ₆ D ₁₅₀ P ₄₉	56.73	10.00	48.00	439.00	21.95
CM ₆ D ₁₅₀ P ₇₇	61.00	11.00	62.67	571.33	28.57*
CM ₆ D ₁₅₀ P ₈₁	53.27	9.00	33.07	404.00	20.20
CM ₆ D ₃₀₀ P ₉₃	60.33	8.00	50.53	573.67	28.68*
CM ₆ D ₇₅ P ₈ (Pungent)	51.93	7.00	29.27	282.33	14.12
SD(±)	6.04	1.97	12.11	128.90	5.62

Farmer's Yield Trial

The experiment was conducted at Sutiakhali farmer's field to observe the performance of M₆ generation of chilli. Significant variation was found in respect of yield, height, no. of branch etc. Results showed that the mutants CM₆D₇₅P₁ (31.28 tha⁻¹), CM₆D₁₅₀P₃₉ (28.07 tha⁻¹), CM₆D₁₅₀P₇₇ (28.23 tha⁻¹), CM₆D₃₀₀P₉₃ (27.97 tha⁻¹) produced high yield potential where as mutant CM₆D₇₅P₈ (Pungent; 16.61 tha⁻¹) produce lowest yield (Table 5).

Table 5. Yield attributes of promising mutants (M₆) of Chilli during Rabi, 2017-18

Mutant/ Variety	Plant height (cm)	Branch plant ⁻¹ (no.)	Fruits plant ⁻¹ (no.)	Yield plant ⁻¹ (g)	Yield (tha ⁻¹)
CM ₆ D ₇₅ P ₁	66.25	9.00	60.52	625.53	31.28*
CM ₆ D ₁₅₀ P ₃₉	47.13	8.00	60.17	561.49	28.07*
CM ₆ D ₁₅₀ P ₄₆	55.32	9.00	50.52	483.48	24.17
CM ₆ D ₁₅₀ P ₄₉	51.96	9.00	44.25	438.08	21.90
CM ₆ D ₁₅₀ P ₇₇	56.28	10.00	61.85	564.69	28.23*
CM ₆ D ₁₅₀ P ₈₁	47.85	10.00	37.89	442.18	22.11
CM ₆ D ₃₀₀ P ₉₃	54.89	9.00	48.52	559.44	27.97*
CM ₆ D ₇₅ P ₈ (Pungent)	46.32	8.00	32.15	332.11	16.61
SD(±)	6.56	0.76	11.04	94.78	4.74



Fig. 4: Experiment field of chilli & capsicum



Fig. 5: Experiment of turmeric in BINA HQ field



Fig. 6: Black pepper is in growing stage for screening



Fig. 7: Yield trial of advanced line of turmeric (BHL-1) and BARI Turmeric-5



Fig. 8: Mutant development of Capsicum

12. Research highlight/findings:

- 33 germplasms were collected
- LD50/GR50 was estimated for Chilli = 75 – 100Gy, Capsicum= 75-105 Gy, Turmeric= 2-3 Gy
Cumin= 3-5 Gy , Black Pepper= Grow up.
- Advanced line of turmeric (BHL-1), Chilli (M6 pungent,), turmeric (M₂) were harvested and black pepper and capsicum mutants were grown up
- Two experiments were conducted at BINA HQ farm and Sutiakhali farmer's field, Mymensingh to see the pungency of M6 mutant population of chilli. Among the three mutant lines the mutant CM₇D₃₀₀P₈ produced high yield (43.32tha⁻¹) which was almost similar to CM₇D₃₀₀P₉₃ (41.38 tha⁻¹) and CM₇D₃₀₀P₄₉ (41.09 tha⁻¹).

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment (Laptop & Printer)	2.00	75000/-	2.00	75000/-	Completed
(b) Lab & field equipment					
(c) Other capital items					

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop (Male & female)	100	-	100	1 day	Completed

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	126675/-	126675/-	126675/-		100	
B. Field research/lab expenses and supplies	1100000/-	1000376/-	998100/-		90	
C. Operating expenses	155000/-	85000/-	85000/-		100	
D. Vehicle hire and fuel, oil & maintenance	45000/-	22000/-	22000/-		100	
E. Training/workshop/seminar etc.	130000/-	130000/-	130000/-		100	
F. Publications and printing	93325/-	93325/-	0	93601/-	0	
G. Miscellaneous	75000/-	25000/-	25000/-	2000/-	90	
H. Capital expenses	75000/-	75000/-	75000/-		100	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Collection of local and exotic germplasm of cumin, sweet pepper, chilli, turmeric and black pepper	33 germplasms were collected	Desirable spices mutants were identified . Trained scientists use their acquired knowledge/skill in new field of spices viz. induced mutations.	Identified germplasm
Screening of the collected germplasm of these spices and irradiation of the seeds for generating mutants	Advanced yield trials of selected mutants including lines for high yield potential	Desirable five mutants of each studied spices were identified having high yielding, good aroma, pungent and flavor	Identified germplasm for yield potential
Estimate of radio-sensitivity	LD50/GR50 was estimated for Chilli= 75 – 100Gy, Capsicum annum= 75-105 Gy ,Turmeric= 2-3 Gy ,Cumin= 3-5 Gy ,Black Pepper= Growing up	Estimated dose for mutation induction	Bulk seed irradiation for mutant development
Selection and evaluation of desirable mutants for developing varieties with high yield potential, good aroma and flavour.	i)Turmeric (BHL-1), Chilli (M6 pungent,), turmeric (M ₂) were harvested and black pepper and capsicum annum were grown up. ii)Two experiments were conducted at BINA HQ farm and Sutiakhali farmer's field, Mymensingh to see the pungency of M6 mutant population of chilli. Among the three mutant lines the mutant CM ₇ D ₃₀₀ P ₈ produced high yield (43.32tha ⁻¹) which was almost similar to CM ₇ D ₃₀₀ P ₉₃ (41.38 tha ⁻¹) and CM ₇ D ₃₀₀ P ₄₉ (41.09 tha ⁻¹).	Desirable mutants of sweet pepper (M ₁), chilli(M ₆), turmeric (advanced line) and black pepper (M ₁) were developed	High yielding Turmeric line BHL-1 was developed which is waiting for variety release

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Commodity technology (Turmeric and chili variety) were developed

ii. Generation of new knowledge that help in developing more technology in future

New knowledge on radiation technologies for variety development were generated and mutants with high yielding variety was developed

iii. Technology transferred that help increased agricultural productivity and farmers' income

New high yielding variety of turmeric and chili technologies were transferred to the farmers that would be helpful to productivity and farmers income

iv. Policy Support

Import of turmeric and chilli would be reduced and save foreign currency

G. Information regarding Desk and Field Monitoring

- i) **Desk Monitoring:**

- ii) **Field Monitoring (time& No. of visit, Team visit and output): BARC (1 time) and BINA (3 times) monitoring team visited experiments**

H. Lesson Learned/Challenges (if any)

- i) Scientists and students learned on mutants development with radiation technology
- ii)
- iii)

J. Challenges (if any)

Signature of the Principal Investigator
Date

Seal

Counter signature of the Head of the
organization/authorized representative
Date

Seal

G. Information regarding Desk and Field Monitoring

- i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):
- ii) Field Monitoring (time & No. of visit, Team visit and output): BARC (1 time) and BINA (3 times) monitoring team visited experiments

H. Lesson Learned/Challenges (if any)

- i) Scientists and students learned on mutants development with radiation technology
- ii)
- iii)

J. Challenges (if any)



Signature of the Principal Investigator

Date 22/09/2019

Seal **Dr. Md. Rafiqul Islam**
Principal Scientific Officer & Head
Horticulture Division
BINA, Mymensingh-2202



Counter signature of the Head of the organization/authorized representative

Date 22/09/2019

Seal **Dr. Md. Rafiqul Islam**
Principal Scientific Officer & Head
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BINA, Mymensingh-2202